Math Course Taking for CTE Concentrators: Evidence from Three Studies of the Impact of a Decade of Education Reform

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Abstract

This paper presents an argument supported by evidence that the positive effects of education reform legislation take time to accumulate, and, given time, have the power to bring about improvement. Specifically, the course-taking patterns in mathematics of CTE students in the years following the 1990 Perkins II Act and 1994 School-to-Work Opportunities Act clearly show that these students are taking part in an increasing number of higher mathematics courses, while at the same time decreasing the number of lower-level math courses taken (Levesque, 2003). These trends have developed over a number of years, accentuating the necessity of allowing for the passage of time before evaluating whether a particular reform movement has been successful.

Background

In the early 1980s, the academic performance of America's youth became the focus of federal policy initiatives. In response to criticisms of the shortcomings of our national education system–such as *A Nation at Risk* (National Commission on Excellence in Education, 1983), federal legislation began to focus on improving the academic performance of all students, including vocational (or career and technical education) students. Consideration of academic subjects importance was highlighted by the 1991 Secretary's Commission on Achieving Necessary Skills (SCANS, 1991). The SCANS report argued for workforce development beginning in the nation's classrooms and outlined the skills most desired by employers. These skills fell into two categories: foundation skills, such as those taught in a traditional curriculum, and workplace competencies, such as time management, teamwork, and communication skills (Secretary's Commission on Achieving Necessary Skills, 1991). Made explicit in the report was the need to improve youths' mastery of essential academic content in math, science and communications.

In this paper, we seek to investigate the trends in math course taking that followed nearly two decades of education reform targeted at two distinct but demographically similar groups of high school youth: Career and Technical Education (CTE) concentrators and general concentrators—this latter defined as high school students who have committed to neither an academic nor a CTE scholastic path. Three important federal legislative acts were part of the education reforms of the 1990s. Each of these addressed on important goal of high school education: the preparation of adolescents for successful transition into the workplace. Two–the Perkins II Act and later the Perkins III–were revisions of existing federal CTE legislation. The third—the School-To-Work Opportunities Act—was an attempt to foster better alignment among education systems and the workplace within states.

Preparing Today's Youth for Tomorrow's Careers

Rosenbaum (2002) has shown that high school achievement is highly predictive of long-term outcomes. Even after controlling for educational attainment, high school grades predicted long-term earnings. A rise of one letter grade, from C to B, was associated with a 12.8% increase in earnings at age 28 for youth who held no college degree.

In the U.S., there is a widespread belief that higher wages are associated with higher levels of educational attainment. It follows that getting youth to attain more education is in the best interest of society. Logic suggests that this knowledge should motivate youth to do better in school and to acquire more of it. Indeed, the U. S. Department of Education's Office of Vocational and Adult Education–OVAE– has stressed that,

> given the changing nature of work, the shift in demographics, and the economic rewards that flow to well-educated individuals and the companies fortunate enough to employ them, it is critical to the well-being of the nation that U.S. high schools rise to the challenge of preparing all students for this new economic reality (Mandel & Dykman, 2003, p. 3).

Despite nearly 20 years of reform efforts, neither student's self-interest nor the pressures of societal well-being have been sufficient to improve academic performance. In a climate that calls for increasing levels of academic skills, our students are falling drastically short of meeting this need. Large percentages of 12th-graders are performing below the proficiency marks on the National Assessment of Educational Progress (NAEP) in academic subjects; in the year 2000, 83% failed to reach the proficiency mark in mathematics for example (National Education for Education Statistics, 2000). In the global arena, American students ranked near in the middle on achievement in math and science out of the 21 countries participating in the Third International Mathematics and Science Study (TIMSS) in 1995 (Takahira, Gonzales, Frase, & Salganik, 1998). The OVAE summed the issue: "These are not the marks of a world-class workforce or a world-class education system" (U. S. Department of Education, n. d., p. 3).

Levesque (2003) noted that this underachievement is consistent with the course taking patterns of high school students. Forty-three percent of high school graduates in 1998 were general concentrators, a track known for its less-than-rigorous curriculum and that fails to prepare students with the skill requirements necessary to be successful in either post-secondary education or in the workplace. Levesque pointed out, however, that the higher academic standards that have been imposed by many states in response to these dismal scores may have been having some effect by the late 1990s, when students completed far more advanced math courses than they did in 1982. Further, these trends were not limited to the college-bound students in the academic tracks, but also applied to students who majored in CTE (Levesque, 2003). Despite these well-intentioned efforts to promote the integration of more rigorous academic requirements into CTE programs, little is known about the effects that these reforms have had in promoting real gains in student learning and skill acquisition.

Teaching the Necessary Skills for Today's Labor Market

Data computed from the Bureau of Labor Statistics (2001) suggest that one-half to two-thirds of the new jobs will be created at the bottom of the wage scale, mainly in jobs that require a lower level of education such as a high school diploma or short-term to moderate-term training (Hecker, 2001). However, there are segments of the labor market that run counter to these averages. A 2001 survey of manufacturers conducted by the National Association of Manufacturers (*The Skills Gap 2001,* National Association of Manufacturers, Andersen, & Center for Workforce Success, 2001) reported a severe skills deficit, with 80% of the respondents indicating a "moderate to serious" shortage of qualified job candidates. In particular, about a quarter (24.7%) of the businesses responded that the math skills of their workforce were insufficient. Important for this study, 26.2% of responding businesses listed inadequate math skills as one of the top three most serious skill deficiencies in their current employees. While a relatively small percentage of the manufacturing companies responding indicated that they provided courses or programs that teach math skills to employees (15.8% provide instruction in basic math; 7.0% provide advanced math instruction), the remainder of the businesses are relying on the educational system to equip their workforce with these necessary skills. They appear to believe, however, that, to a large extent, schools are failing. The category of math and science was listed by the largest percentage (42.0%) of respondents as one of the top three areas of greatest deficiency that local K-12 schools have in preparing students for the workplace.

Federal Support for CTE Students' Academic Performance

In the decade of the 1990s, the federal government passed three laws that were intended to, among other outcomes, improve the academic performance of high school youth who "majored" in CTE. The Carl D. Perkins Vocational and Applied Technology Education Act of 1984 revisions in 1990 (Perkins II) and 1998 (Perkins III) reflected a philosophical shift in the goal of vocational education (or CTE), from a narrow focus on occupational preparation for special populations to a more academically rigorous program that prepared students for participation in industry as well as for postsecondary education.

Perkins II mandated that, in order for CTE programs to receive federal funds, they must integrate vocational and academic curricula, promote work-related experience, and be held accountable for the efficacy of these programs (Stone, 2002). In line with this new emphasis on accountability, the legislation identified six outcome areas for evaluation: enrollment, academic skills, occupational skills, school completion, job placement, and wages or job retention (Stecher, Farris, & Hamilton, 1998, as cited in Stone, 2002). The Perkins II reform effort had the effect of serving special populations of students not considered likely to attend college.

With the Perkins III legislation, an increased importance was placed on integration of CTE and academic education. In addition, four new areas of accountability were highlighted: student achievement; credential acquisition; transition to and completion of postsecondary education, advanced training, or employment; and nontraditional types of training and employment (Bragg, 2000). Clearly the trend in vocational education legislation is from specialized occupational training for special populations toward integrated academic and broad-based career training for a wider variety of students.

Midway through the 1990s, the U.S Congress, influenced in part by the SCANS report, passed the School-to-Work Opportunities Act that provided nearly $2 billion to support programs that combined academic and vocational curricula by presenting academic instruction in real-world contexts (Stern et al., 1995, as cited in Griffith & Wade, 2001).

The Effects of a Decade of Education Reform

In addition to the federal legislation targeted at CTE students, state governments implemented many strategies designed to improve academic performance of all students. The "back to basics" reform movement called for an increasing emphasis on academics, including math in the educational system. Data from the *High School and Beyond* study (National Center for Education Statistics, 2003a), the *High School Transcript* study (Roey et al., 2001), the *National Education Longitudinal* study (National Center for Education Statistics, 2003b), and the National Center for Education Statistics show that the average number of academic Carnegie units earned by high school students have increased from 14 to 18 units from 1982 to 1998. The average number of math units earned has increased from 2.63 to 3.40 during the same time period.

Given the increase in math course taking, one would expect students' math scores to increase. The National Assessment of Educational Progress has measured student achievement in math, reading and science for the last 30 years. Since 1973, math achievement has been measured in two- to four-year increments. By measuring student achievement for ages 9, 13, and 17 over the course of 30 years, the NAEP has compiled data illustrating trends in student math performance. When comparing data across years, math scores for 17 year olds changed only from 302 in 1988 to 308 in 1999, with scores for each intervening data collection period varying by 2-3 points. Since 1990, scores have remained relatively steady and varied by no more than three points (Campbell et al., 2000).

The NAEP results demonstrate that simply increasing the number of math credits in a student's high school career alone may not affect students' math ability. To improve math scores, a different, more targeted approach is needed. Educational reforms, designed to improve the academic rigor CTE students' high school programs, have been put into place, but have yet to be assessed for their impact in the long-term.

RESEARCH QUESTIONS

If the CTE focused reforms of the1990s, especially as they relate to improving academic performance, have had an impact, then changes should be now observed in course taking behavior in academic areas, especially in mathematics. We focus in particular on three of the CTE reform models—Career Academies, Career Pathways and High Schools That Work. To this end we examine three sources of data, described later in this paper, to address two important questions:

1. Have CTE concentrators' course taking in math changed during the period defined by Perkins II and Perkins III federal legislation? More specifically, how does CTE concentrators' course taking in math compare with that of general concentrators?

2. What has been the impact of new school reforms encouraged by the reform legislation of the 1990s on students' math course taking patterns, particularly in the three reform models that are the focus of this research—Career Academies, Career Pathways, and High Schools That Work?

METHOD

We examine the research questions in this study by drawing from three sources: a) current reports generated by the National Center on Educational Statistics (NCES); b) an on-going National Research Center for Career and Technical Education (NRCCTE) analysis of the National Longitudinal Survey of Youth 1997 (NLSY97); and c) the "What Works" data, an on-going NRCCTE study of three CTE reform efforts. These three data sets offer two unique perspectives on the questions of interest in this study: the student and the system. While the NCES and NLSY97 are national probability surveys, the former uses schools as the sampling frame and transcripts as the data source. The NSLY97 uses households as the sampling frame and youth interviews as the data source. Both of these data sets permit analysis of the effect of concentrating in CTE. The What Works data set samples and analyzes at the program level within carefully selected schools, allowing for a comparison of specific CTE-based, whole-school education reforms. Multiple methods of data collection are employed in this study. Each of these is described in more detail in the following section (see Appendix Table A).

Data Sources

Data used in these analyses were derived from three sources: the National Center for Educational Statistics; the National Longitudinal Survey of Youth 1997; and the What

Makes it Work Longitudinal Survey. The latter two are part of studies conducted through the National Research Center for Career and Technical Education.

NCES Data. The Carl D. Perkins Vocational and Applied Technology Act Amendments of 1998 (Perkins III) required that the National Center for Education Statistics (NCES) collect and report information on vocational/technical education. Expanding on the data published in the NCES report *Vocational Education in the United States: Toward the Year 2000* (Levesque et al., 2000), the *Trends in High School Vocational/Technical Course taking: 1982-1998* report (Levesque, 2003) examined vocational/technical course taking among public high school graduates by focusing on trends in three areas: a) vocational/technical course taking overall; b) technology education and computer-related course taking; and, c) the integration of vocational/technical and academic course taking. These trends were analyzed by examining high school transcripts for the graduating classes of 1982, 1990, 1992, 1994, and 1998.

The surveys for the NCES reports came from a) the *High School and Beyond* (HSB) study Sophomore Cohort—First Follow-up Survey, and *High School Transcript Study* (HSTS), 1982; b) the *National Education Longitudinal Study of 1988* (NELS:88)—Second Follow-up Survey, and *High School Transcript Study*, 1992; and, c) the National Assessment of Educational Progress (NAEP) *High School Transcript Studies* of 1990, 1994, and 1998.

In each survey, the sample was restricted to a sub-sample of students who were public high school graduates and who had a complete set of transcripts. To make the samples comparable across the five trend years, graduates with special education diplomas were excluded from the HSTS samples.

The HSB survey number of cases included in the report was 9,858 public high school students who graduated in 1982. The report also included 11,788 public high school students from the NELS:88 who graduated in 1992. Finally, from the NAEP transcript studies the analysis samples were 16,507 (1990), 23,706 (1994), and 23,176 (1998). For a more complete discussion of the methodologies employed in this study, refer to Levesque (2003).

NLSY97 Data. As one of the National Longitudinal Surveys (NLS), the National Longitudinal Survey of Youth 1997 (NLSY97) is a study that measures variables that contribute the youth's transition from school to the labor market. Data from the third round of interviews conducted in 1999 ("Round 3") was used primarily for these analyses. However, data were also used from the first and second rounds of interviews ("Round 1" and "Round 2"), conducted in 1997 and 1998 respectively, in order to keep an appropriate frame for socio-economic status or to complete the analyses.

NLSY97 Round 3 data were collected in 1999-2000 from 8,209 youths, or 91.4% of the original sample (Bureau of Labor Statistics, 2002; p. 24). As in the first two rounds, the survey was administered through personal interviews with the youths and gathered extensive information on their education and training, among other variables, such as work-based learning activities participation and curriculum concentration. Refer to Stone and Aliaga (2003) for more detailed information on the methodology for this data source.

To understand what the NLSY97 data can tell us about the research questions in this study, it is important to note that the sample members began graduating from high school in 1998. That is, their secondary schooling was influenced by Perkins II and STWOA. Perkins III (The Carl D. Perkins Vocational and Technical Education Act of 1998)—which further encouraged many of these same initiatives—had just been enacted at the time these data were collected, and for that reason its effects on these students' responses are yet to be seen. Thus, we should think of this longitudinal data set as one that can give us insights into trends and relationships in the midst of an education reform era.

What Works Data. The *What Makes it Work Longitudinal Survey* ("What Works") study data used in this paper addressed math course participation, math course completion, level of math course difficulty, and progression through the math sequence for various types of high schools in low-income neighborhoods. One school was selected for each type of reform investigated in this study. The three reform models selected for this multi-method, longitudinal study included career academies, career pathways, and high schools that work. The "Academy High School" is located in a major urban area in a western state. The "Career Pathway High School" is located in a semi-rural area in the northwestern United States. The "Vocational High School" (or high school that works) is located in a northeastern U.S. city. For each school in the study, there was a comparison school serving similar students but not implementing these reforms. The Vocational High School's comparison school was a comprehensive high school in the same community.

The math variables of interest in this on-going study were measured in a variety of ways. *Math course participation* was evaluated by analysis of course taking data for the 11th grade cohort. *Math course completion* was evaluated by observing the student's overall math grade for a particular school year. *Progression through the math sequence* was evaluated by observing the student's math course in the first and second years and comparing these courses with the math sequence provided by the student's school. After taking a math course in 2000 (the first year), a student could fall into one of three categories: advancing to a higher math course, repeating the previous math course, or taking no math course. For a more complete discussion, see Castellano, Stringfield and Stone (2002).

Defining the Population

One of the methodological challenges in addressing the questions of this study is defining who is a CTE concentrator and who is not. CTE concentrators, referred to as "Occupational concentrators" by the National Center for Education Statistics, can be defined as students who take 3.0 or more credits in one of 10 broad occupational areas, specifically agriculture, business, marketing, health care, protective services, technology, trade and industry, food service and hospitality, child care and education, and personal and other services (Levesque, 2003). According to Levesque, CTE concentrators comprise 25% of the students participating in CTE coursework in 1998, and earned 4.39

credits per year in their area of concentration in 1998. However, when students' self report of curriculum participation are used, the estimates of curriculum concentration participation changes. Stone and Aliaga (2003) reported that, by 1999, only 4.8% of students identified themselves as CTE concentrators in the National Longitudinal Survey of Youth data (NLSY97). Stone and Aliaga discuss the implications of this definitional issue at length. In this paper, we use the researcher imposed definitions. In the NCES transcript studies, we use the Levesque (2003) transcript-based definitions. In the NLSY97 analyses, we use student self-reports. In the What Works analyses, we use the researcher's definitions that are based on pathway or academy participation.

Reform Descriptions

Since the current research also focuses on school reforms, below are brief descriptions of each school selected for the reform group: career academy, vocational, and career pathways (see Castellano, Stringfield, & Stone, 2002, for a more detailed account of each school). To protect anonymity, school names are pseudonyms, and all sites are disguised without altering the general characteristics of the schools or communities.

The *Academy High School* (AHS) is an Urban Learning Center. This reform design includes three main components: a) teaching and learning integration, b) governance and management by all staff and school stakeholders, and, c) on–site learning supports, such as health services, social services, and parent education.

Urban Learning Centers create a K-12 "learning community", housing all grades and administered by one principal. With a strong career and college preparatory focus, Academy HS structured its curriculum around career academies. English and social studies teachers work with career subject teachers in these academies, aligning curriculum, discussing student progress, and jointly evaluating student interdisciplinary projects. When students apply to AHS, they and their parents sign a pledge that they will commit to taking the course of study that makes them eligible to apply to the state university system. They also pledge to apply to college. Ninety-eight percent of the 1999 graduating class of AHS was admitted to a postsecondary institution, two thirds of whom were admitted to four-year colleges and universities.

The *Vocational High School (VHS)* was in danger of losing its accreditation before embarking on its reform agenda. Adult authority had broken down, gang members openly sold drugs on the school premises, and teachers were afraid for their safety. In 1994, new leadership came in and succeeded in making the school once again a gang-neutral place where young people could learn. The school joined the High Schools That Work network, which advocates rigorous academic coursework for CTE students, preferably including integrated curriculum. VHS staff added higher-level academic courses and also targeted students who were coming to high school below grade level. VHS, as a vocational high school, did not traditionally offer a college preparatory curriculum or any Advanced Placement courses. Now, however, VHS students must meet the same state-mandated academic standards as all comprehensive high schools in the state. One aspect of this school makes it unique in this study. As the only vocational high school serving this community, it has become what some refer to as a "dumping ground" for many students the other, comprehensive high schools do not want. Thus more than 60% of incoming freshmen read at or below a fourth-grade reading level, and they have a disproportionate number of students identified as special populations.

The *Pathways High School* (PHS) has organized its curriculum around career pathways, or clusters of occupations that require similar skills and knowledge, although they may differ in terms of length of education and training required. For example, a cluster such as Engineering, Manufacturing, and Industrial Technology can provide students with a broad introduction to many fields, including machinist or engineer. This organization of curriculum, sometimes called career majors, replaces traditional tracks such as the college preparatory, vocational, and general tracks.

Students choose from among five pathways at the end of their 9th-grade year. Starting in the sophomore year, the student electives are comprised of pathways classes, while students' academic classes are not specific to career pathways. Teachers do attempt to incorporate pathways where possible, and encourage student assignments and projects to be based on each student's pathway. Schools implementing a pathways model need to have strong connections with business and industry and with postsecondary education in order to give students internships or other applied experiences. The model is also intended to provide a rigorous, coherent program of study that includes high-level academics in addition to technology applications and work-based learning.

NCES Math Course Categorization

In the NCES data, mathematics courses were divided into eight levels: a) no math, b) nonacademic, c) low academic, d) middle academic I, e) middle academic II, f) advanced I, g) advanced II, and h) advanced III. For the purposes of reporting, these categories were condensed into four: the first three levels were collapsed into "low mathematics" and the last three into "advanced mathematics." Middle academic I and II were kept as originally defined—although with different labels. Below is a list of the courses included in each of the four categories:

- *Low mathematics*: no math; remedial-level math; general, basic or consumer math; technical or vocational math; low-level "academic" math, such as pre-algebra, or algebra I taught over two academic years, and informal geometry

- *Lower-middle mathematics*: algebra I; plane and/or solid geometry; and unified mathematics 1 and/or 2

- *Upper-middle mathematics*: algebra 2 and unified mathematics 3

- *Advanced mathematics*: algebra 3; trigonometry; analytical geometry; linear algebra; probability; statistics; pre-calculus; introduction to analysis; and calculus.

Students were placed into the category under which they completed the highest level of mathematics; for instance, if a student was enrolled in both technical math and algebra 2 (a hypothetical example for purposes of explanation), s/he would be considered to belong in the upper-middle math category, as this is the highest level in which this individual qualifies.

FINDINGS

The following discussion draws from the three principal sources of data described above. However, before we compare and synthesize the data from these three sources, we must first analyze the appropriateness of our comparison groups: CTE concentrators and general concentrators.

Why Compare CTE and General Concentrators?

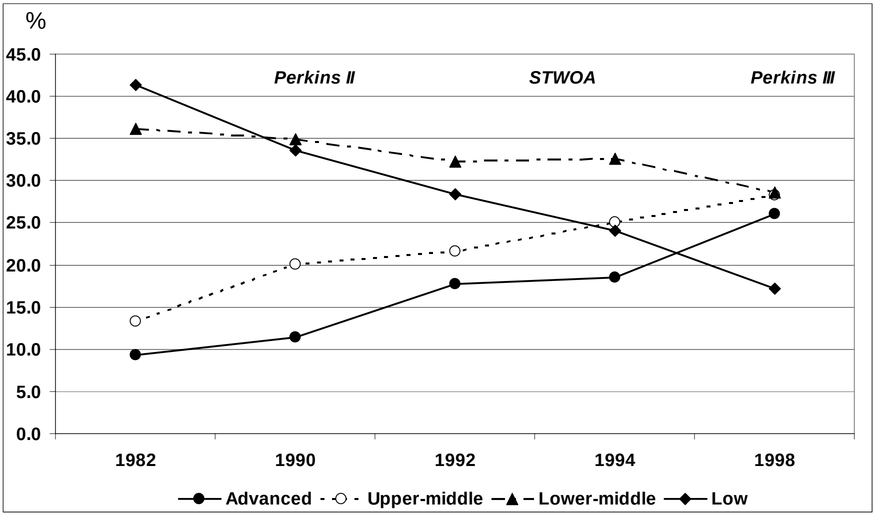
To begin, a discussion of our comparison groups and the rationale behind selecting these two groups in particular is necessary. The CTE concentrator and the general concentrator groups are demographically similar in key variables, including gender, household income, age, math participation and CTE course enrollment. Slight statistical differences exist in geography, and level of urbanization of neighborhood. The most profound difference, based on our statistical analyses, can be found in the racial variable. Students identified as CTE concentrators are more likely to be black, whereas general concentrators are more likely to be white (Stone & Aliaga, 2003).

The fact that these two groups enter high school with similar measures of key socio-economic variables, especially measures of academic achievement, allow for a critical comparison on student academic attainment, including math enrollment, involvement, and participation. This type of comparison demonstrates the impact of CTE enrollment programs. This comparison is a more accurate way of assessing CTE impact than prior studies that have compared CTE students with a group of "all" students, including academically-focused students (Levesque, 2003). More importantly, by removing the academically-oriented students, CTE can be assessed for impact to the population it has historically targeted: those not academically-oriented in the traditional sense.

NCES Data

Data from the National Center for Education Statistics spanning the years 1982 through 1998 present a clear trend in the course taking patterns of occupational concentrators in the direction of increasingly advanced mathematics (see Figure 1). In 1982, 41.3% of occupational or CTE concentrators took low math; 36.1% took lower-middle math and only 13.3% took upper-middle math and 9.3% took advanced math. As the chart illustrates, the 1990s saw a dramatic shift in the pattern of course taking by CTE concentrators. By 1998, over half of CTE concentrators took math courses at the advanced and upper-middle levels (54.3%), as opposed to the 22.6% of CTE concentrators that took math classes at these levels only 16 years before. Less than a fifth of CTE concentrators took low math in 1998. Even though CTE concentrators still fall short in advanced mathematic course taking when compared to all non-concentrators (26% and 42.4% respectively), gains in CTE student advanced math participation since 1990 is noteworthy, suggesting that the various reforms efforts during that decade were beginning to have an impact in improving the rigor of CTE students' high school experience.

Figure 1. Math Course Taking, CTE Concentrators: 1982-1998 (Percentages)



NLSY97 Data

In the analysis of course taking behavior, we compared two groups of students who resembled each other in several key characteristics: CTE and general concentrators, and academic and dual concentrators. We found there are statistically significant differences between youth in both comparisons.

Overall, CTE concentrators reported taking more math courses than did general concentrators (Table 1), although slightly more CTE concentrators reported taking no math at all. We found that 28.1% of CTE concentrators reported taking two or more math courses, compared with 23.7% of the general concentrators. Our comparison of academic and dual concentrators show that 33.9% of dual concentrators and only 28.7% of academic concentrators report taking two or more math courses. Similar to the previous comparison, more dual concentrators than academic concentrators report taking no math.

When we compared the kinds of math courses taken by CTE and general concentrators, we found that a higher proportion of general concentrators reported taking general math or Algebra I than did CTE concentrators (see Table 2). More CTE concentrators reported

Table 1. *Summary Table of Chi-Square Analyses of Math Course Taking Behavior by Participation in Curriculum Concentration, NLSY97, Round 3 (Percentages)*

Number of high school math courses taken and completed since date of last interview*	All	Curriculum Concentration			
		General	Academic	CTE	Dual
0	7.3	8.8	3.9	10.6	8.3
1	66.6	67.4	67.5	61.4	57.8
2	17.8	17.0	18.2	18.5	22.6
3	5.2	4.8	5.8	5.2	6.4
4	2.4	1.4	3.5	3.7	3.0
5	0.6	0.4	0.6	0.7	1.8
6	0.2	0.1	0.4	0.0	0.0
7	0.0	0.0	0.1	0.0	0.0
8	0.0	0.0	0.0	0.0	0.1
9	0.0	0.0	0.1	0.0	0.0

Note. The "All" column reflects the composition of all currently enrolled students in grades 9 through 12 for each category. Percentages for concentrations are a distribution within each concentration. Analysis is performed for those students in grades 9-12 enrolled at the time of the interview. Each of the categories (i.e., gender, age, race, ethnicity, etc.) was analyzed independently for each of the curriculum concentrations.
*$p<0.05$

Table 2. *Summary Table of Chi-Square Analyses of Participation in Math Subjects by Curriculum Concentration, NLSY97, Round 3 (Percentages)*

Variable	All	Curriculum Concentration			
		General	Academic	CTE	Dual
Math					
General, basic or vocational math *	20.9	25.6	13.3	21.7	20.9
Algebra I or elementary algebra *	42.9	46.4	38.3	38.8	45.6
Geometry *	25.4	21.0	31.6	22.4	33.1
Algebra II or intermediate algebra	21.4	15.5	30.1	22.9	22.5
Trigonometry *	6.0	3.3	10.7	3.5	5.5
Pre-calculus or advanced algebra *	4.7	2.3	9.0	3.2	2.2
Calculus *	0.8	0.4	1.5	0.5	0.7
Other advanced math *	2.0	1.7	2.5	2.6	2.0
Other math class *	7.7	8.4	4.7	16.6	11.6
No math *	7.2	8.7	3.9	10.6	8.3

Note. The "All" column reflects the composition of all students enrolled in grades 9 through 12 for each category. Percentages for concentrations are a distribution for each course within the corresponding concentration only. Analysis is performed for those students in grades 9-12 enrolled at the time of the interview. Each of the courses was analyzed independently for each of the curriculum concentrations.
*$p<0.05$

taking geometry and high level math than did general concentrators. These data suggest that when CTE students took math, they took more difficult math than their general concentrator counterparts. In our second comparison, we found that more dual concentrators reported taking general math or algebra I than did academic concentrators. We also found that more CTE and dual concentrators took "other math" classes than did general concentrators. This may reflect the implementation of such courses as applied math or tech prep math (contextual learning), described by Meyer (1999). These data do not allow us to determine this.

What Works Data

The three study schools were chosen as exemplars of somewhat different models of CTE. While methods will be explored to combine results from the three sites, the three will be examined separately.

Math Course Participation. Not every student takes a math course each year. Table 3 partitions the sample into students who took math every year and those who did not. More students from Academy HS took math courses than students in the control school for both the 9th and 11th grade cohorts.

Table 3. *Summary Table of Chi-Square Analyses of Math Course Participation, What Works Data*

School	Took math every year			
	Cohort		Control	
	n	%	*n*	%
Academy High School				
Grade 9	198	99.0***	972	93.0
Grade 11	79	68.7***	295	48.0
Vocational High School				
Grade 9	217	88.6***	344	98.6
Grade 11	156	83.9***	176	74.6
Pathway High School				
Grade 9	390	86.7	319	85.3
Grade 11	167	51.2***	81	33.2

Note. Significance tests compare cohort and control schools, within grade groups.
***p<.001

In the Vocational High School, 10% fewer 9th graders took a math class every year than in the control group. The situation reversed for the 11th grade cohort where 9% more students took math than their control HS counterparts.

Pathway High School students in the 9th grade cohort showed no difference in math course taking, but like the vocational high school, significantly more 11th graders took math every year than did students in the comparison school.

Math Course Completion. For this analysis, we examine two years of data for the original 9th and 11th grade cohorts of 2000-01 (Table 4). In 2001-02 the original 9th grade cohort is now in 10th grade and the original 11th grade cohort is now in 12th grade. For both the 9th and 11th grade in the Academy High School cohorts a significantly greater percentage of students passed their math classes than did students in the comparison school for the 2000-01 school year. This was true only for the 11th grade cohort (now 12th graders) the next year.

Table 4. *Summary Table of Chi-Square Analyses of Math Course Completion, What Works Data*

School/Grade	Passed math 2000-2001		Passed math 2001-2002	
	N	%	*N*	%
Academy High School				
Grade 9				
Cohort	123	60.9***	127	67.6
Control	478	50.9	515	66.8
Grade 11				
Cohort	91	81.3**	70	94.6**
Control	367	71.0	164	83.2
Vocational High School				
Grade 9				
Cohort	133	61.1**	100	54.1**
Control	186	53.5	173	64.1
Grade 11				
Cohort	127	70.9***	117	84.2
Control	194	84.0	124	86.7
Pathway High School				
Grade 9				
Cohort	346	81.2***	284	78.9
Control	205	64.1	237	78.7
Grade 11				
Cohort	250	87.4***	116	82.3
Control	124	67.8	72	84.7

**p<.01, ***p<.001.

We show similar findings for the Vocational High School students in both cohorts in the 2000-01 school year. However, in this school, fewer 9th graders passed math in their

10th grade year than did students in their comparison school. There was no difference for the 11th grade cohort.

Levels of Math Difficulty. Tables 5 and 6 display math courses aggregated according to difficulty into low, medium, and high classifications. Table 5 shows the 2000-2001 school year and Table 6 shows the 2001-2002 school year.

Table 5. Summary Table of Chi-Square Analyses of Levels of Math Difficulty, 2000-2001, What Works Data

School/Grade	Math Course Difficulty Level			
	No math	Low[a]	Medium[b]	High[c]
Academy High School				
Grade 9				
Cohort	0.0***	0.0***	99.0***	1.0
Control	5.6	11.2	83.2	0.0
Grade 11				
Cohort	2.6***	0.0	23.5***	73.9***
Control	13.6	1.9	79.1	5.4
Vocational High School				
Grade 9				
Cohort	9.6***	0.0	90.4***	0.0
Control	0.3	0.0	99.7	0.0
Grade 11				
Cohort	3.9	0.0	94.4**	1.7***
Control	2.1	0.0	86.8	11.1
Pathway High School				
Grade 9				
Cohort	2.5	15.9***	81.4***	0.2
Control	6.2	49.9	42.5	1.5
Grade 11				
Cohort	8.4***	0.3***	38.2***	53.1***
Control	21.5	12.9	47.2	18.5

Note. Significance tests compare cohort and control schools, within grade cohort.
[a]Below Algebra I. [b]Algebra I, geometry, algebra II. [c]Trigonometry, math analysis, calculus.
**p<.01, ***p<.001.

Table 6. *Summary Table of Chi-Square Analyses of Levels of Math Difficulty, 2001-2002, What Works Data*

School/Grade	Math Course Difficulty Level			
	No math	Low[a]	Medium[b]	High[c]
Academy High School				
Grade 9				
Cohort	2.1	0.5	89.5***	7.9***
Control	2.4	1.9	95.1	0.6
Grade 11				
Cohort	30.2***	0	5.7***	64.2***
Control	56.2	0	36.7	7.1
Vocational High School				
Grade 9				
Cohort	2.6	0	96.8	0.5
Control	1.5	0	98.2	0.4
Grade 11				
Cohort	13.7***	0	63.4***	23.0***
Control	28.1	0	27.0	44.9
Pathway High School				
Grade 9				
Cohort	11.7	8.2	58.3***	21.9***
Control	11.1	3.2	82.1	3.5
Grade 11				
Cohort	49.1***	0.0	9.8***	41.1***
Control	61.5	0.4	27.9	10.2

Note. Significance tests compare cohort and control schools, within grade cohort.
[a]Below Algebra I. [b]Algebra I, geometry, algebra II. [c]Trigonometry, math analysis, calculus.
***p<.001.

It can be seen from these tables that students at Academy High School generally took higher-level math courses; these students took higher-level math courses in 9th grade and continued to take higher-level courses in the upper grades. AHS students also opted out of the math sequence less often than did students at control high school. By the 2001-2002 school year, 64% of AHS students who had been juniors the year before took a high-level math course, and by contrast, 56% of students in the high school control group took no math course at all (see Table 6).

Students from the high school control group generally were more advanced in their math course taking patterns than their counterparts in the Vocational High School. To illustrate, 10% of VHS 9th graders took no math course in 2000-2001, as compared to less than 1% of the control high school's 9th graders (see Table 5). Forty five percent of the control high school's 11th graders took a high-level math course during the 2001-2002 school year, compared to 23% of VHS's juniors (see Table 6). Although students at the control school outperform students at VHS in math course taking rigor, it is important to put these findings in the context of stark differences in the "input" or characteristics of incoming 9th graders.

Students at Pathways High School generally took math at higher levels than did students at the control high school, in both cohorts and for both years. In the 9th grade cohort, differences were largest in the medium level for 2000-2001; this difference led to a significant difference in high-level course taking for 2001-2002. For the 11th grade cohort, differences were greatest in high-level math courses for both years, with students at CHS also significantly less likely to opt out of the math sequence.

DISCUSSION

Can we conclude that the Perkins and STWOA legislation met the desired outcomes of increasing the academic rigor of students who participate in CTE? Our analyses of data from three kinds of studies: national transcript studies, a national youth survey, and longitudinal case studies shows a convergence of evidence strongly suggestive that the CTE reforms of the 1990s are beginning to have a positive impact on the math course taking of CTE students.

That the same trend is showing through the analyses using the three data sources is indeed promising. We show that CTE students are taking more math classes than before the onset of the 1990s CTE reforms. We show that that when CTE students take math, they are taking more difficult or higher level math classes than an academically comparable group of students. And we show that CTE oriented reforms like career academies and career pathways improve math attainment. We don't know yet if these changes in course taking will result in improved academic performance, but most educators would argue that taking more math, and more rigorous math will improve academic performance. Evidence presented here suggests that the federal CTE reforms have, at least in part, begun to have the sustained impact envisioned by their creators.

In the current debate over continued federal involvement in high school CTE, it is widely acknowledged that only a small percentage of vocational education funds are federal. However, Gray (2002) argues that, without federal funds to leverage state and local funds, CTE programs will gradually disappear. This scenario is all the more likely if the Bush administration's proposal for reauthorization of the Carl D. Perkins Vocational and Technical Education becomes reality. The administration's proposal, the *Secondary and Technical Education Excellence Act* is the result of its desire to revamp the CTE model, given the belief that Perkins hasn't effectively met its performance outcomes (U.S. Department of Education, 2003).

Our findings presented here suggest that CTE is meeting its performance outcomes with respect to math achievement. These findings coupled with the demonstrated economic benefit of CTE (see Bishop and Mane, 2004) and the impact of CTE on reducing high school drop outs (see Plank, 2001) make a strong argument for continued federal involvement in and support of high school career and technical education.

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