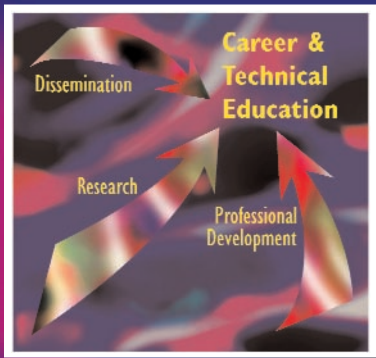

Early Measure of Student Progress in Schools With CTE-Enhanced Whole-School Reform:

Math Course-Taking Patterns and Student Progress to Graduation

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EARLY MEASURES OF STUDENT PROGRESS IN SCHOOLS WITH CTE-ENHANCED WHOLE-SCHOOL REFORM: MATH COURSE-TAKING PATTERNS AND STUDENT PROGRESS TO GRADUATION

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ABSTRACT

This report provides 3rd-year findings from a 5-year longitudinal study. The study examines diverse and promising programs for integrating career and technical education (CTE, previously called vocational education) with whole-school reform in schools that serve predominantly disadvantaged students. This interim report provides early measures of academic progress for students attending schools with CTE-enhanced reforms. It examines the progress to graduation and the mathematics course-taking patterns of students at CTE-enhanced schools, compared to demographically and geographically similar students at control schools without such reforms. For each measure, percentage difference was computed, along with 95% confidence intervals for this difference.

With respect to progress to graduation, two of the three CTE-enhanced schools had more students on target or 1 year behind (but still attending school) than the control schools. This is a positive record of persistence at the CTE-enhanced high schools. With respect to overall student outcomes in mathematics, we are cautiously optimistic that students at the CTE-enhanced high schools fared better on many measures of mathematics coursework than their counterparts at the control schools. For example, students at the CTE-enhanced schools stayed in their schools' mathematics sequences longer than students at the control schools.

Analyses and refinement of student outcome data continue, as 2 additional years of student data are being collected. Results presented in this report are necessarily preliminary. Within this caution, the findings to date appear promising for improving student outcomes in schools implementing CTE-enhanced whole-school reform.

EXECUTIVE SUMMARY

This report presents the 3rd-year findings from a 5-year longitudinal study that has been designed to examine diverse and promising programs for integrating career and technical education (CTE, previously called vocational education) with whole-school reform. The study is focused within feeder patterns of middle schools, high schools, and community colleges in communities that serve high percentages of families that are economically or socially disadvantaged. Students from these families are, therefore, at risk of not completing high school. The schools participating in this study have implemented CTE-enhanced whole-school reforms to try to improve the educational chances of concentrated groups of highly disadvantaged students.

Based on the literature reviewed and previous work that describes the promise of CTE-enhanced whole-school reform efforts, the research team hypothesized that students in high schools that have infused their reforms with CTE themes would exhibit better student outcomes than students in high schools that have not incorporated career and technical themes into their reform efforts. This interim report provides early measures of progress such as student progress to graduation and mathematics course-taking patterns.

The larger study was conceived as a way to identify CTE-based reform practices that have been successful in educating disadvantaged students so that they become engaged in school, achieve academically, complete high school prepared for postsecondary education, and succeed in postsecondary education and/or work. As part of that endeavor, the research team compared the mathematics course-taking patterns of students at each of three CTE-enhanced high schools with the mathematics courses taken by students at three respective control high schools. Specifically, the present analysis addresses the following questions:

- What are the differences in progress to graduation among students in the CTE-enhanced high schools and the comparison high schools?
- What are the differences between mathematics course-taking and course-completion patterns among students in the CTE-enhanced high schools and the comparison high schools?

Mathematics coursework was selected for analysis for several reasons. First, mathematics participation and achievement are gateway indicators for positive post-high-school outcomes such as postsecondary education attainment and labor market success. Second, the mathematics course sequence in high school is usually well-defined, and thus a good way to begin student transcript analysis. That said, analyses of course-taking patterns in English and science are underway.

Study Sample

The schools selected for inclusion in the study are located in various parts of the country. They are involved in different comprehensive school reform designs, in several CTE reform efforts, and they serve a range of at-risk populations. Included in the study is a comprehensive, grades 9–12 high school that 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. There is a vocational high school participating in the study. Vocational High School is a member of the High Schools That Work reform design network. Finally, this study includes a high school divided into three academies, encompassing the entire high school. Academy High School is also implementing Urban Learning Centers, a comprehensive school reform design.

Working with the local school districts of the study schools or with neighboring districts, the research team identified matched control schools for each high school. At all control schools, the research team is gathering the same systems-level data that are being collected at the study schools.

Method

The larger 5-year study examines processes and outcomes through a combination of qualitative and quantitative methods. The longitudinal component of the study involves following the progress of three cohorts of students as they proceed through the schools at the longitudinal sites. Cohorts chosen for the study include students who were in 7th, 9th, and 11th grades during the 2000–2001 school year, at both study and control schools. For the present report on high school achievement, participants included students from both sets of schools who were in the 9th or 11th grade during the 2000–2001 school year (the Class of 2004 and the Class of 2002), and who were not participating in Special Education.

Measures

The present report focuses on progress to graduation and mathematics course-taking patterns. Specific measures include whether the student was on track to graduate on time, mathematics course participation, mathematics course completion, level of mathematics course difficulty, and progression through the school's mathematics sequence. For each measure, percentage difference was computed, along with 95% confidence intervals for this difference.

Results by School

Academy High School had a particularly strong effect on student outcomes in mathematics coursetaking and overall progress to graduation. While we cannot assign causality to the results, it is certainly plausible that the academic and personal supports of the Urban Learning Centers design and the strong academic focus helped students succeed at Academy High School. The strong career themes at Academy High School may also be contributing. Career academies allow students to participate in work-related activities while in high school. Students with definite career ambitions may have found the academies interesting and motivating, and a reason to continue through an academically challenging curriculum in order to achieve their career goals.

The story at Vocational High School appears to be one of parity with a college preparatory high school in some areas such as progress through the school's math sequence, while the results favor the control high school on most measures. However, the percentage of students taking higher-level math courses at Vocational High School is unlikely to exceed that of a college-preparatory comprehensive high school. Parity of outcomes is a positive result for a vocational high school with high numbers of initially-low-achieving incoming freshmen, and where the faculty has struggled to increase the academic achievement of its students.

Pathways High School appears to have a good math pipeline in effect. A larger percentage of students in both cohorts took high-level math classes at Pathways compared to the control high school. With respect to progress to graduation, more students were staying in school at Pathways High School than at the control school, even if they were a year behind in credits earned. It is plausible that the greater persistence at Pathways High School can be attributed to the career pathways structure, which encourages students not only to plan, but also to work toward, their futures. Interviews with students there revealed that they were very knowledgeable about the amount of postsecondary education or training needed to pursue the careers of their choice. These students appear to have realized that if they want to attend college, they would need to continue to take math classes throughout high school. Even if students' goals did not include college, they appeared to see the value of finishing high school, as evidenced by Pathways High School having the lowest "not in school" rate among all the high schools in the study.

Cross-Site Analysis

With respect to progress to graduation, two of the three CTE-enhanced schools had more students on target to graduate or 1 year behind (but still attending school) than the control schools. This is a positive record of persistence at the CTE-enhanced high schools.

With respect to overall student outcomes in mathematics, we are cautiously optimistic that students at the CTE-enhanced high schools fared better on measures of mathematics coursework than their counterparts at the control schools. We can conclude that math course participation is generally better at the CTE-enhanced high schools than at the control schools. This is true of both cohorts at Academy High School, but only for the Class of 2002 at both Vocational High School and Pathways High School. Therefore, fewer students in the Class of 2002 opted out of math during their senior year at all three study sites than was the case at their control schools.

In terms of math course completion, significantly more students in every cohort at the study schools (with the exception of the Class of 2002 at Vocational High School) passed more courses than their control-school counterparts in 2000–2001. These advantages tended to flatten out in the 2001–2002 school year, especially at Vocational High School and Pathways High School. Academy High School retained its strong advantage in terms of math course completion compared to its control school.

Generally, it appears as if the students in the CTE-enhanced schools are taking higher-level math courses than their control-school peers. This is certainly the case for both grade cohorts at Academy High School and Pathways High School. In the Vocational High School comparison, there are differences in the two grade cohorts. The Class of 2002 saw significantly more students taking higher level math at the control high school than at Vocational High School. This is understandable, given the very different goals of the two schools, where the control school is a college preparatory high school and Vocational High School prepares students for careers, some of which require postsecondary education and others of which do not. However, Vocational High School has been upgrading its academic curriculum in response to state accountability requirements, and the data from the Class of 2004 suggest that the improvements to the math curriculum might have the intended effect of preparing higher numbers of students to enroll in higher levels of mathematics.

The major finding with respect to student progression through a math sequence is that students at the CTE-enhanced schools are staying in their schools' math sequences longer. This advantage is not reflected in the results for the Classes of 2004, but these data are from those cohorts' freshman and sophomore years, during which time the effects of attending a CTE-enhanced high school may not have become evident. However, the better progression through the math sequence is especially apparent for the Class of 2002 at all three study schools. These cohorts were far enough into their high school experience during the 2 years of data collection to have experienced the CTE-enhanced reforms. Students in these cohorts had progressed far enough in the high school experience that many were probably able to opt out of math if they desired. However, despite mathematics being optional for many seniors, we found that at the study high schools, students continued to make better progress through the sequence than at the control schools.

Most of the positive outcomes occurred in the Class of 2002, which was in its junior and senior years in the school years 2000–2001 and 2001–2002, respectively. This is to be expected under the hypothesis that a CTE-enhanced curriculum increases student outcomes, since students do not normally experience these CTE-enhanced curricula until after their freshman year. In addition, it is in the last 2 years of high school that many students choose to opt out of math, having taken their required number of courses. That we see strong mathematics outcomes in those 2 years adds to the strength of the hypothesis. More data in future years will further confirm this hypothesis, as we expect that the more homogeneous comparisons currently reported for the Class of 2004 will turn into advantages at the CTE-enhanced high schools by the time this class reaches its senior year.

Analyses and refinements of student outcome data continue, as 2 additional years of student data are being collected. Results presented in this report are necessarily preliminary. Within this caution, the findings to date appear promising for improving student outcomes in schools implementing CTE-enhanced whole-school reform.

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INTRODUCTION

This report presents the 3rd-year findings from a 5-year longitudinal study that has been designed to examine diverse and promising programs for integrating career and technical education (CTE, previously called vocational education) with whole-school reform. The study is focused within feeder patterns of middle schools, high schools, and community colleges in communities that serve high percentages of families that are economically or socially disadvantaged. Students from these families are, therefore, at risk of not completing high school. The schools participating in this study have implemented CTE-enhanced whole-school reforms to try to improve the educational chances of concentrated groups of highly disadvantaged students. This interim report provides early measures of progress such as student progress to graduation and mathematics course-taking patterns.

The larger study was conceived as a way to identify CTE-based reform practices that have been successful in educating disadvantaged students so that they become engaged in school, achieve academically, complete high school prepared for postsecondary education, and succeed in postsecondary education and/or work. As part of that endeavor, the research team compared the mathematics course-taking patterns of students at each of three CTE-enhanced high schools with the mathematics courses taken by students at three respective control high schools. Specifically, the present analysis addresses the following questions:

- What are the differences between mathematics course-taking and course-completion patterns among students in the CTE-enhanced high schools and the comparison high schools?
- What are the differences in progress to graduation among students in the CTE-enhanced high schools and the comparison high schools?

Mathematics coursework was selected for analysis for several reasons. First, mathematics participation and achievement are gateway indicators for positive post-high-school outcomes such as postsecondary education attainment and labor market success (National Research Council, 1989; U.S. Department of Education, 1997). Second, the mathematics course sequence in high school is usually well-defined, and thus a good way to begin student transcript analysis. That said, analyses of course-taking patterns in English and science are underway.

CONCEPTUAL BASE

Several research strands provide the conceptual underpinnings for the larger study. These include research on disadvantaged youth and attempts to enhance their engagement and success in school; studies of whole-school reforms and their roles in school change and student achievement; and the literature on a broader conceptualization of career and technical education, which provides an important tool for engaging students in high school.

The first important background frame for the larger study relates to research on the challenges faced by disadvantaged students who are at risk of dropping out of high school and, therefore, need to recognize the concrete benefits of remaining in school. Diverse groups define disadvantaged in somewhat different ways. Various authors prefer the terms *disadvantaged*, *at risk*, *placed at risk*, and *placed at promise* to describe such students (Stringfield & Land, 2002). Without denying the existence of this debate, we use the terms interchangeably to describe students who, through no fault of their own or of their families, are at risk of not thriving in traditional education. In this study, we adhere to the definitions provided by Natriello, McDill, and Pallas (1990) and Land and Legters (2002). These authors include persons who are economically disadvantaged (e.g., students eligible for free or reduced-price school meals) and students who are members of groups that have traditionally been regarded as having been discriminated against in United States society (e.g., African Americans, Latinos, and immigrant groups for whom English is not their native language). Both sets of authors note the existence of *concentration effects*, especially in large United States cities, where many high schools are likely to serve high percentages of poverty-level students, racial and ethnic minority students, and non-English-proficient students (Edwards, 1998). While approximately 11% of all young people between the ages of 16 and 24 throughout the United States have not completed high school or its equivalent (Kaufman, Kwon, Klein, & Chapman, 2000), the dropout rate in central city high schools is closer to 19% (Hauser, Simmons, & Pager, 2000).

Research on whole-school reform comprises the second conceptual base for this study. By whole- or comprehensive school reform, we refer to efforts to restructure the organization of a school and the priorities of instruction so that a particular, unified vision of an improved school pervades the school. Whole-school reform always requires additional professional development for a school's entire faculty, with a focus on high standards for all students and enhanced cross-disciplinary cooperation. Forty years of research in diverse educational areas (Newmann & Associates, 1996; Nunnery, 1998; Stringfield et al., 1997) have demonstrated that school reforms are much more likely to have long-term impacts on school culture and student achievement if the change effort involves a schoolwide focus, rather than a targeted focus. School personnel are more likely to see results if they engage in a coherent, unified reform than if they introduce isolated, piecemeal reform practices.

A second significant finding from research on whole-school reform has been that locally developed reform efforts tend to begin with a flurry of committees and design work, but rarely progress to classroom implementation (Nunnery, 1998). For this reason, many schools have adopted externally developed reform designs. Schools have also been spurred by federal funding for Comprehensive School Reform Demonstration (CSRD), a program that began in 1997 with the goal of increasing student achievement “by assisting public schools across the country with implementing comprehensive reforms that are grounded in scientifically-based research and effective practices” (U.S. Department of Education, 2003a).

Various organizations have developed, marketed, and delivered comprehensive school reform designs to schools across the country. In 2003, the federal government provided $310 million in CSRD funding to support K–12 schools interested in adopting these externally developed reform designs. Schools can also use CSRD funds to develop their own approaches to revamping their curricula, instruction, and management around a unifying theme. The goal is for school personnel to look at the big picture and decide on a path of coherent reform toward improvement of student outcomes. Most schools adopt externally developed reform designs. However, these designs will necessarily look different in each school, due to schools’ different contexts, histories, and desires or capacities for change. School personnel are said to co-construct, or adapt, reform designs to their context (Datnow, Hubbard, & Mehan, 2002).

The third background frame for this study supports a broader conceptualization of career and technical education (CTE) as an important tool for engaging secondary students. Hopkins (1999) advocated for an expansive view of CTE in which students are exposed to the contemporary workplace through three non-exclusive approaches: education through work, education about work, and education for work. Education through work refers to strategies in which students learn school subjects within a work context, or work-based learning. Education about work describes a curriculum that assumes that knowledge about the world of work is valid school knowledge. All students need to learn about democratic rights in the workplace, career ladders, and labor markets. Finally, education for work refers to job-specific training. Some argue that such training is best concentrated in the postsecondary phase of students’ lives. However, others believe that this is an appropriate role for secondary education (Rosenbaum, 2001). Either way, education for work must be premised upon actual workplace needs, and the curriculum must satisfy the broader educational needs of workers, including general education components and education for participation in a democratic society.

Education through and about work can be infused into academic as well as vocational classes in high school. Teachers can work across subject-matter disciplines to integrate their curricula so that students experience real-world uses for curriculum content, such as mathematical equations. Students can participate in internships that use what they have learned in school. Student engagement often increases when they participate in hands-on, real-world learning, as opposed to learning from traditional textbook and lecture methods (Dewey, 1916; Lave, 1988; National Research Council, 1999). Students see the relevance of what they are learning to contexts outside of school, where many students are oriented and find motivation.

LITERATURE REVIEW

Mathematics Coursetaking and Achievement

Since 1982, high school graduation requirements in academic subjects have been increasing (Campbell, Hombo, & Mazzeo, 2000). The average number of Carnegie units needed to graduate has risen from 22 in 1982 to 25 in 1998 (Hurst & Hudson, 2000). Murnane and Levy (1996) make the argument that the increase in units brings high school graduation requirements only up to high-school-level abilities. In other words, they claim that prior to these increases, students were not necessarily graduating with high-school-level skills. Rosenbaum (2001) argues that today's students are still not graduating with high-school-level skills.

Since 1978, there has been a 14% increase in the number of students taking Algebra (Campbell et al., 2000). Studies have shown that taking more advanced math courses is linked to higher math achievement as measured on tests from the National Education Longitudinal Study of 1988 (NELS:88; Atanda, 1999; Rock & Pollack, 1995), on a subset of tests from the National Assessment of Educational Progress (NAEP; Gamoran, Porter, Smithson, & White, 1997), and on subsequent math course advancement (Smith, 1996). While this might seem obvious, the point that many scholars make is that this speaks to an opportunity to learn. Schools in areas with high concentrations of known risk factors (e.g., high urbanicity) tend to have more limited curricular opportunities (Lee, Burkham, Chow-Hoy, Smerdon, & Geverdt, 1998). Students in schools such as these may find it difficult to achieve in math to the extent now required by federal, state, and local policies.

Large urban schools that serve high numbers of poor, minority, or immigrant students have not offered the same range of high-level mathematics courses and, in fact, have tended to offer more math courses below Algebra than schools serving more affluent, low-minority student populations (Lee et al., 1998). Even within the same school, studies have found that differential tracking widens the achievement gap (Gamoran et al., 1997; Levesque, Lauen, Teitelbaum, Alt, & Librera, 2000), because students tend to be sorted into tracks along the lines of social stratification (i.e., the risk factors of race or ethnicity and socioeconomic status). There is a need to examine the equity of math course offerings and the opportunity to learn in schools and districts across the nation, especially in light of accountability requirements and the goal of leaving no child behind.

The evidence on the impact of increases in graduation requirements on drop out rates is mixed. Hoffer (1997) concluded that there had been no associated increase in drop out rates, which could dispel the idea that many students would simply give up when confronted with more stringent graduation requirements. However, Greene (2002) documented a small decline between 1998 and 2000 to the current estimate of 69%. Barton (2002), taking a longer view, reports that high school completion rates peaked in the late 1960s and have been on a steady decline since then. Neither of these reports links the decline to increases in graduation requirements, but they have occurred during the period of increased requirements in both Carnegie units and mandatory state tests.

Regardless, the increase in academic coursework has not led to an increase in achievement (Clune & White, 1992; Hoffer, 1997). In fact, high school NAEP scores for math, science, and reading have been flat for 30 years (Castellano, Stringfield, & Stone, 2002). Therefore, despite increases in math requirements and changes in how math is taught and assessed, how to increase math achievement among high school students in the United States remains unclear.

CTE Students and Mathematics Achievement

High school students who concentrate their course of study on CTE have certain characteristics in common. Recent studies have supported previous descriptions of CTE students as being economically more disadvantaged and lower academic achievers than their peers who concentrate on other non-CTE curricular options (Agodini, cited in Silverberg, Warner, Goodwin, & Fong, 2002). CTE concentrators (or even those who take three unrelated CTE credits) who graduated high school in 1992 were also more likely than non-concentrators (i.e., academic concentrators or those without a concentration) to have scored in the lower third of students on both math and English achievement tests when they were in eighth grade. Agodini found, contrary to previous studies, that a CTE course of study did not attract a higher percentage of minority students than other courses of study, once other factors such as socioeconomic status had been held constant. Agodini noted that these data were from the graduating class of 1992. More current data from the 1997 National Longitudinal Survey of Youth (NLSY97) suggest that CTE and dual concentrators are more likely to come from minority and low-income families and enter high school with a lower grade point average (Stone & Aliaga, 2002). It is commonly accepted that increased vocational coursetaking is associated with lower academic achievement (McCormick, Tuma, & Houser, 1995). However, since 1982, CTE concentrators have greatly increased their academic coursetaking. In 1982, 51% of CTE concentrators took Algebra 1; by 1994, 65% of CTE concentrators were taking Algebra 1 (Levesque et al., 2000). This percentage still lagged behind students in other courses of study such as college preparatory (71%) and so-called dual concentrators, who complete both an academic and CTE concentration of classes during high school. Dual concentrators had the highest percentage of students taking Algebra 1 (78%). However, when CTE concentrators are compared to general concentrators, Stone and Aliaga (2002) found that CTE concentrators took significantly more math and more high levels of math. They argued that this comparison presented a more realistic picture of changes in math course-taking behavior than previous comparisons, as general concentrators more closely resembled CTE concentrators on early measures of ability and household income.

Given the fact that students who pursue a CTE concentration tend to start high school with lower achievement levels and come from lower socioeconomic strata than other students, it is reasonable to assume that many could be at risk of dropping out. However, recent research suggests that CTE can play an important role in keeping CTE students in school. In an analysis of NELS:88 data, Plank (2002) found that the risk of dropping out was lowest near the point at which a student completed three Carnegie units of CTE for every Carnegie unit of academic subject (i.e., approximately 40% of a student's high school courses were CTE-related). While Plank did not find a corresponding increase in academic achievement among CTE concentrators, it is also evident that students stand a much better chance of improving academically if they remain in school than if they drop out.

Rivera-Batiz (2003) studied the impact of school-to-work activities on minority youth, finding that students who participated in such activities as Tech Prep[1] or career majors were more likely to take more advanced courses in math and science than minority students who did not participate in these broadly-defined school-to-work activities. This might be the same phenomenon observed by Plank (2002): The CTE course of study may not directly require students to take more math and science, but CTE might be the reason why students are remaining in school and taking more advanced coursework.

Studies have shown that when schools focus their whole-school reform efforts around CTE themes, students often take more math courses than similar students in other schools without such reforms. In some cases, this increase in math coursetaking has led to improvements in achievement. For instance, low-achieving students in career magnets were found to outperform a control group on the state measure of math achievement (Crain, Heebner, & Si, 1992). Talent Development High Schools (TDHS) with career academies is another CTE-centered whole-school reform design that increases expectations for at-risk students in a personalized, career-themed context (Legters, Balfanz, Jordan, & McPartland, 2002). Studies have shown that TDHS students took more math courses and scored higher in math on state-mandated tests and norm-referenced posttests than students at those schools prior to implementation of TDHS (Philadelphia Education Fund, 2000, 2002). One possible factor, among others, for the positive outcomes reported may be the opportunity to learn provided by the TDHS design.

Academic improvement is not universal among students at schools where CTE themes have been incorporated into reform efforts. For example, low-performing students in career academies showed no improvement on math achievement scores (Kemple & Snipes, 2000), and others have found no consistent positive impact of CTE reforms such as Tech Prep on student math achievement (Bragg, 2001).

It appears clear that simply increasing the number of required math courses is not likely to improve achievement. However, it is also clear that offering advanced math courses is a necessary, if not sufficient, condition for improving the achievement of at-risk students in CTE curricular programs. Once these courses are on the school schedule, school staff must engage youth in a learning endeavor, so they are motivated to take those courses. Students must recognize the benefits if they are to become motivated to take courses that will be challenging. Rivera-Batiz's (2003) research shows that at-risk students do recognize these benefits and will take challenging courses when they perceive that the benefits outweigh the difficulty of taking the courses.

This report seeks to further identify the necessary and sufficient conditions for improving the math achievement of at-risk secondary students. Based on the literature reviewed and previous reviews that describe the promise of CTE-enhanced whole-school reform efforts (Castellano et al., 2003), we hypothesize that students in high schools that have infused their reforms with CTE themes will have better math outcomes than students in high schools that either do not have any

[1] For a description of reform designs mentioned in the discussion but beyond the scope of the present analysis, see Castellano, Stringfield, & Stone, 2003.

reform efforts underway,[2] or have not incorporated career and technical themes into their reform efforts. Specifically, we believe that students in the schools that have blended reforms will take and pass more math courses, take and pass more advanced math courses, go further in the math sequence, and make better progress overall to graduation than students in schools with no reforms, or no blended reforms.

[2] Virtually all schools are perpetually involved in one or more change efforts (Lee & Smith, 2001). However, we sought control schools that were not involved in focused, comprehensive school reform efforts of the type and scope present at the study schools. A description of the sample schools is provided in the following section.

STUDY QUESTIONS

The following questions form the basis for the larger study. The first two questions were addressed in the 2nd-year report (Castellano et al., 2002). The last Questions, 5 and 6, necessarily await the gathering of 4th- through 5th-year data. As with any longitudinal study, the final word on all of these questions will come in the final report. In this 3rd-year report, we provide initial findings on the measures of progress that lead to the indicators of success listed in Questions 3 and 4. The specific questions that form the present analysis are found in the Introduction.

1. How have comprehensive school reform models affected CTE and overall education in middle schools and high schools—especially those that serve large at-risk populations?

2. How do students choose the pathway, shop, or academy concentration they will pursue for their high school years? Are issues of equity (e.g., encouraging nontraditional career choices, preventing CTE from becoming a dumping ground for low-achieving at-risk students) considered in the structuring of this choice?

3. Has student attainment of proficiencies, credentials, or degrees increased?

4. Have student participation and completion rates for CTE programs, postsecondary education, and employment increased?

5. Have the changes to high schools brought about by comprehensive school reforms in turn influenced community-college CTE and postsecondary education overall?

6. How have community colleges adapted their CTE programs in response to changes in the middle schools and high schools where comprehensive school reforms are implemented?

STUDY SAMPLE

The sample for the larger study includes longitudinal, control, and replication sites that were identified and selected through a multi-stage sampling process. Other reports have discussed the sampling process and the replication sites in detail (Castellano et al., 2002).

The schools eventually selected for inclusion in the sample are located in various parts of the country. They are involved in different comprehensive school reform designs and in several CTE reform efforts, and they serve a range of at-risk populations. We deliberately selected high schools that represented four common high school organizational structures that offer career and technical education. Specifically, there is a comprehensive, grades 9–12 high school, which is the most common high school structure, at about 18,000 nationwide (U.S. Department of Education, 2003b). Like many comprehensive high schools, the high school in this study collaborates with a regional vocational or skills center to provide students with half-day focused CTE programs. This skills center is also participating in the study. Because students only spend part of their day at these centers and then return to their home high schools, national data are not collected on these schools. It is therefore unknown how many regional vocational centers there are in the United States, but it is believed that there are approximately 1,100 (Lynch, 2000). There is also a vocational high school participating in the study, of which there are about 300 in the nation (Hoffman, 2003). Finally, this study includes a high school divided into academies. This is a fast-growing structure for U.S. high schools; there were about 1,500 high schools implementing academies in 2000 (Kemple & Snipes, 2000).

Study Sites

Academy High School

Academy High School[3] (AHS) is located in a large urban center in the West. A few of the many products of this large manufacturing center include aircraft, aircraft equipment, aluminum, games and toys, and women's apparel. The city is a hub for trade with Pacific Rim countries. Despite the large manufacturing base, the service sector, retail trade, and government sectors are the leading employers in the county. This city’s population continues to grow, fueled in large part by immigration from Asia and Latin America (see Table 1).

[3] To protect anonymity, school names are pseudonyms, and all sites are disguised without altering the general characteristics of the schools or communities.

Table 1
Population Statistics for Participating Cities

	City served by Academy and Control-A High Schools	City served by Vocational and Control-B High Schools	City served by Pathways High School	City served by Control-C High School
Total city population	> 2 million	150,000–200,000	25,000–50,000	10,000–15,000
Latino (%)	46	27	56	73
African American (%)	11	20	3	<1
Non-Latino White (%)	30	49	37	25
Asian American (%)	10	2	2	<1
American Indian (%)	<1	<1	1	1
Other/Multiracial (%)	3	<1	4	3

Note. All data are derived from the U.S. Census 2000 (U.S. Census Bureau, 2001). Census respondents are allowed to self-identify in multiple ethnic groups. All numbers are deliberately approximate to protect the anonymity of participating cities and students.

AHS is an Urban Learning Center. This reform design includes three main components (Johnson & McDonald, 1996)

1. Teaching and learning—integrating high standards into a thematic, interdisciplinary curriculum, experiential learning, and school-to-work transitions;

2. Governance and management—all staff and school stakeholders are empowered to collaborate in the decision-making process; and

3. Learning supports—health services, social services, and parent education on site.

Urban Learning Centers are K–12 schools housing an elementary school, a middle school, and a high school, all as one integrated facility with one principal. As part of the Urban Learning Centers mandate to create a K–12 learning community campus that includes the teaching and learning elements noted in component 1, AHS 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.

AHS has a strong career and college preparatory focus. Only students who attend the middle school at the same facility as AHS are eligible to apply. Most students self-select to attend AHS, but because the middle school is over 3 times as large as the high school (2,500 vs. 700 students), there is an oversubscription of student applicants. Students are drawn from the pool in a stratified random manner. There are exceptions to the random feature of the draw. The first includes one classroom cohort's worth of students who have participated in a local, university-based academic enrichment program since the sixth grade. For reasons of continuity, this group is allowed to remain at the learning center through high school if they wish. Second, AHS has a very limited athletic program. For this and perhaps other reasons, self-selected male students are underrepresented at the high school, and therefore there is an over-sampling of male students in the draw.

Middle school student applicants must have passed Algebra 1 in the eighth grade in order to be eligible to apply to the high school. 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. Therefore, over and above the academic enrichment program with its explicit university attendance goal, there is an ethic of doing college-preparatory-level work at this school. Indeed, students in the enrichment program are not the only ones who are accepted to various colleges and universities: 98% of the 1999 graduating class of AHS was admitted to a postsecondary institution, two thirds of them to 4-year colleges and universities.

Vocational High School

Vocational High School (VHS) is located in a small city in the northeastern United States. This city has a history as a manufacturing center for textiles and metal. As with many industrial cities in the region, the 1980s brought recession and the offshore flight of its industry and manufacturing. Today, the city is revitalizing, although manufacturing employment remains low. Most jobs in the city are in the service sector, in wholesale and retail trade, and in government. Table 1 provides general population statistics by race and ethnicity for this city, based on the U.S. Census 2000.

Before embarking on its reform agenda, VHS was in danger of losing its accreditation. Adult authority had broken down, gang members openly sold drugs on the school premises, and teachers reported fearing for their safety. New leadership arrived in 1994 and succeeded in making the school 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. The VHS staff added higher-level academic courses and also targeted students who were coming to high school below grade level for extra support. Given the history of VHS as the recommended high school in the district for students with neither particular academic ambitions nor strong prior academic achievement, helping students reach grade level in math or English became a major focus of the ninth grade. A variety of learning styles are accommodated through the VHS ninth-grade Prep School, which helps most students progress to grade level during their freshman year. Even the lowest achievers progress several grade levels in math and reading ability through the Prep School.

VHS, as a vocational high school, did not traditionally offer a college preparatory curriculum or any Advanced Placement courses. In the past, students in this district who were interested in a college preparatory curriculum had a choice of three comprehensive high schools. Now, however, VHS students must meet the same state-mandated academic standards as all comprehensive high schools in the state.

Pathways High School

Pathways High School (PHS) is located in an agricultural area in the northwestern United States, where primary crops are potatoes and wheat. As such, many local jobs involve production agriculture, food processing, and agribusiness. There are also some industry and manufacturing interests that developed to support nearby federal facilities. Highly electricity-dependent metals manufacturing, such as aluminum and titanium, is also present. Due to its location at the intersection of major rivers and highways, the city is a transportation hub for the region, with links to the world through air, rail, truck, and barge. Table 1 provides 2000 U.S. Census data on the city's population statistics by race and ethnicity.

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 and Industrial Technology provides 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 broad career pathways at the end of their ninth-grade year, after they complete 2-week units on each pathway in their regular academic classes. Starting in the sophomore year, student experience with pathways is manifest in their elective classes, which should be aligned with their pathways. Examples include drama, journalism, metal fabrication, or 3-D digital animation. In contrast, students' academic classes are not specific to career pathways. That is, students from several pathways may be enrolled in a given math or English course. Academic teachers do attempt to incorporate pathways where possible, and encourage student assignments and projects to be based on each student's pathway. It is best to think of career pathways at PHS as a way of providing a focus to the otherwise often diffuse high school experience.

Career pathways form the context for curriculum reform and integrated activities such as senior projects and other interdisciplinary activities. Schools implementing a pathways model need to have strong connections with business and industry and with postsecondary education, in order to provide students with 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.

All of the high schools in this study serve a majority of students from contexts traditionally regarded as placing students who are at risk of educational failure. Table 2 provides demographic information on the three study high schools.[4] While all three high schools have student populations that are predominantly Latino, these populations are quite different. For example, at PHS, students are predominantly Mexican. Some of these students are members of migrant families and are away for almost one half of the school year. The Latino population at VHS is primarily Puerto Rican. Although the city's population is just over one quarter Latino, this high school population is 53.4% Latino—a disproportionate number in relation to the city's

[4] All data presented are rounded approximations to further protect the anonymity of the sites.

population. Such an imbalance is not the case at the high schools in the other two cities in the study, where the Latino populations are near or over one half of the entire city's population. At AHS, the Latino population is varied, although chiefly Mexican and Central American. No students at either AHS or VHS are from migrating agricultural families, since the schools are located in urban areas.

Table 2
Descriptive Data for Study Schools

	Academy High School	Vocational High School	Pathways High School
Number of students	600–800	1200–1500	2000–2500
Free/Reduced price lunch (%)	94	57[b]	50
Latino (%)	71	53	54
African American (%)	28	28	4
Non-Latino White (%)	<1	17	38
Other ethnicity (%)	<1	2	4
Limited English proficient (%)	27	10	10
Special education (%)	3	35	11

Note. Data derived from public school records. Unless otherwise noted, all data are from the 1999–2000 school year. Data for Academy High School are reported for K–12, but are representative of the high school. All numbers are deliberately approximate to protect the anonymity of participating cities and students.
[b]2000–2001 data.

The districts to which these schools belong represent the broad range of school district contexts in United States education. PHS is the only high school in its small-town district. The region has a vocational center that provides specialized CTE instruction; it serves and is funded by 13 area districts. This vocational center is also participating in the study, where we are focusing only on PHS students. VHS is one of four high schools in a medium-sized city with one district. Students are offered open enrollment to their choice of high schools. Three of the high schools are specifically college preparatory in nature, and VHS is the district's vocational technical high school. AHS is in a large urban district with over 60 high schools. The small number of high school students listed in Table 2 conceals the fact that it is a K–12 facility serving approximately 3,400 students.

Control Sites

Working with the local school districts of the study schools or with neighboring districts, the research team identified matched control schools for each high school. AHS and Control-A High School (HS) are located in the same very high-poverty urban community. Control-A HS draws students from the same neighborhood as AHS. In fact, Control-A HS receives many of the students who attended middle school at the same Urban Learning Center facility where AHS is located. Data collection is underway to identify two subsets of Control-A HS students: those who attended middle school at the Urban Learning Center, and those who applied for admission to AHS but were not accepted. Future analyses will compare outcomes using these groups of students. Control-A HS has a citywide magnet program on its campus that draws students from the entire city. Magnet students were excluded from the analyses because of the potential change in student demographics that these students introduced.

Two control schools were necessary for VHS: another vocational high school (necessarily in another district) and a comprehensive high school located in the same city and district. Middle school students in this same district have their choice of high schools. Students with a vocational interest tend to choose VHS, while the others choose from among three comprehensive high schools. One of these, Control-B HS, recently began an International Baccalaureate (IB) program, although this does not substantially affect the high school experience of the Classes of 2004 or 2002.[5] The second control school is located in a different city, but with similar demographics. The comparisons between VHS and the control vocational high school are currently being analyzed and are not included in this report.

PHS and Control-C HS are located in the same agricultural valley, but in different cities and districts. Like PHS, Control-C HS has a sizable migrant student population. At all control schools, the research team is gathering the same systems-level data that are being collected at the study schools.

[5] The Control-B HS 11th-grade cohort missed the IB opportunity completely. Students from the ninth-grade cohort who are interested in IB can apply after their sophomore year, so data are from pre-IB years. However, ninth-grade students were made aware of the program, and if they thought they might be interested, they were advised to take as many honors academic courses as they could in the first 2 years of high school.

METHOD

The larger 5-year study examines diverse processes and outcomes through a combination of qualitative and quantitative methods (Tashakkori & Teddlie, 1998; 2002). The longitudinal component of the study involves following the broader progress of three cohorts of students as they proceed through the schools at the longitudinal sites. Cohorts chosen for the study included students who were in 7th, 9th, and 11th grades during the 2000–2001 school year, in both study and control schools. The choice of these grade cohorts allows for examination of the effects of the individual schools on students' progress, as well as an examination of the effects and effectiveness of three critical transitions among schools and community colleges in diverse feeder patterns. Specifically, these cohorts allow the study to shed light on the transition from middle school to high school (grades 7–10), the high school experience, including choosing a CTE concentration (grades 9–12), and the transition from high school to postsecondary education or work (grades 11–14). Although students in these cohorts may be held back a year, they remain in the study cohorts for analysis purposes. For ease of reference, these cohorts will be called the Class of 2006, the Class of 2004, and the Class of 2002, respectively, although we recognize that not all students are on target to graduate in those years with their cohort peers.

Quantitative data regarding inputs, processes, and outcomes are being combined with qualitative, longitudinal case studies of each site. The input variables include a combination of district information on students' ethnic background, language status, poverty status (free or reduced-price lunch program participation), attendance rates, prior achievement, special education status (as defined by the local districts), migrant student status, and CTE programs participation. Process variables include a combination of results of low-inference classroom observations and more descriptive multiyear observations of students, classrooms, schools, and districts. Previous reports have discussed the qualitative methods in more detail (Castellano et al., 2002).

The research team is conducting baseline and yearly data collection to observe trends. This report provides preliminary findings from a comparison of the math course-taking patterns and the progress to graduation for the selected cohorts at the study and control high schools. As such, it provides preliminary evidence of the progress of student cohorts toward these transition and outcome measures.

Participants in Present Analysis

Participants included students from both the study and control high schools who were in the 9th or 11th grade during the 2000–2001 school year (the Class of 2004 and the Class of 2002), and who were not participating in Special Education.[6] Table 3 describes the sample by school and grade cohort in terms of gender, ethnicity, and free or reduced-price lunch program participation. Cohort data in Table 3 match the corresponding school data from Table 2, with slight discrepancies attributable to the different years in which the data in each table were

[6] We note that students in Special Education are typically overrepresented among at-risk populations. Due to the variations from the standard math sequence that many students in Special Education experience, we are conducting separate analyses of these data to be included in the final report.

collected, and to the fact that Table 3 only contains two of four grade-level cohorts of student data. The largest discrepancy is among the VHS numbers for participation in the free and reduced-price lunch program. School officials there had already reported that students are hesitant to sign up for the program despite the need, because of the stigma they perceive in program participation.

Table 3
Sample Description by Gender, Ethnicity, and Free Lunch Program

	N	Gender		Ethnicity				Free/ Reduced price lunch (%)
		Male (%)	Female (%)	African American (%)	Latino (%)	White (%)	Other (%)	
Academy HS, Class of 2004	202	37	63	21	78	0	1	90
Control-A HS, Class of 2004	*1045*	*54*	*46*	*22*	*78*	*0*	*0*	*89*
Academy HS, Class of 2002	115	35	65	21	78	0	1	88
Control-A HS, Class of 2002	*615*	*49*	*51*	*21*	*79*	*0*	*0*	*84*
Vocational HS, Class of 2004	245	50	50	21	67	11	1	67
Control-B HS, Class of 2004	*349*	*44*	*56*	*38*	*44*	*17*	*2*	*5*
Vocational HS, Class of 2002	186	48	52	32	47	17	4	28
Control-B HS, Class of 2002	*236*	*34*	*66*	*46*	*34*	*17*	*3*	*11*
Pathways HS, Class of 2004	450	49	51	3	58	37	2	55
Control-C HS, Class of 2004	*374*	*47*	*53*	*0*	*69*	*30*	*1*	*64*
Pathways HS, Class of 2002	326	48	52	3	41	53	3	38
Control-C HS, Class of 2002	*244*	*50*	*50*	*0*	*65*	*32*	*2*	*42*

Note. Total sample size for Class of 2004 represents the number of students in 9th grade at start of 2000–2001 school year. Total sample size for Class of 2002 represents the number of students in 11th grade at start of 2000–2001 school year. To help with readability, statistics for control schools are italicized.

The following year (i.e., the 2001–2002 school year), data were collected again for students from the two grade cohorts who had remained in their same schools. Table 4 describes the percentage of students with successful follow-ups by school and grade cohort. The range of students successfully followed up over the 2 years of this analysis ranged from 76% to 97%, with an average follow-up rate across all schools of 87%. In each pairing of grade-level cohorts between study and control schools, the study school's percentage of students who were followed up is the same or larger than that of the control school. Note that the two prevalent reasons for inability to follow a student were (a) dropping out and (b) transferring to a different school—both of which beyond the control of the research team. The overall high rate of follow-up has allowed the research team to monitor the progress of many students through the high school requirements.

Table 4
Number of Participants In School During the 2001–2002 School Year

	N	In school 2001–2002 (*n*)	In school (%)
Academy High School, Class of 2004	202	192	95
Control-A High School, Class of 2004	*1045*	*834*	*80*
Academy High School, Class of 2002	115	106	92
Control-A High School, Class of 2002	*615*	*466*	*76*
Vocational High School, Class of 2004	245	190	78
Control-B High School, Class of 2004	*349*	*274*	*79*
Vocational High School, Class of 2002	186	161	87
Control-B High School, Class of 2002	*236*	*198*	*84*
Pathways High School, Class of 2004	450	429	95
Control-C High School, Class of 2004	*374*	*341*	*91*
Pathways High School, Class of 2002	326	315	97
Control-C High School, Class of 2002	*244*	*226*	*93*

Note. Total sample size for Class of 2004 represents the number of students in 9th grade at start of 2000–2001 school year. Total sample size for Class of 2002 represents the number of students in 11th grade at start of 2000–2001 school year. "In school" represents students from the initial 2000–2001 sample who attended the same school in 2001–2002. To help with readability, statistics for control schools are italicized.

Measures

The present report focuses on progress to graduation and mathematics course-taking patterns. Specific measures include whether the student was on track to graduate, mathematics course participation, mathematics course completion, level of mathematics course difficulty, and progression through the school's mathematics sequence.

Math course participation was evaluated by analysis of a student's high school course-taking history. Based on transcript information, students were divided into two groups: those who took a math course both years of data collection, and those who did not take a math course in at least 1 year. For the Class of 2004, data were available for the freshman and sophomore years (the 2000–2001 and 2001–2002 school years). For the Class of 2002, data were available for the students' junior and senior years (the 2000–2001, and 2001–2002 school years).

Math course completion was evaluated by observing the student's overall math grade for a particular school year. Students were considered to have completed a math course if they attained a grade of D or above.

To help with data interpretation, math courses taken during a particular year were grouped into levels of low, medium, or high difficulty. This structure was developed using the Secondary Schools Taxonomy (SST; Nelson, 1999) as a guide, and augmenting this taxonomy with information provided by school personnel. The SST is not intended to be so specific as to include every math course offered by every school, so it was necessary to interview math personnel at each school to provide empirical support. The resulting classification is similar to, but more detailed than, the SST. Courses grouped in a "low" level of difficulty included any course less difficult than Algebra 1. Examples of such courses are remedial math courses, basic math courses, and pre-Algebra courses. Courses grouped in the "medium" level of difficulty were not basic or general math courses, but they were less difficult than Trigonometry. Examples of medium courses include Algebra 1, Geometry, and Algebra 2. Courses grouped in the "high" level of difficulty are courses at the Trigonometry level and higher, such as Math Analysis, Pre-Calculus, and Calculus. Students could also fall in the category "no math course" if they did not take a math course in a particular year. This variable was constructed separately for the 2000–2001 school year and for the 2001–2002 school year.

Progression through the math sequence was evaluated by observing each student's math course in 2000–2001, the math course for each respective student in 2001–2002, and comparing these courses with the math sequence provided by the student's school. After taking a math course in 2000–2001, 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.

Finally, progress to graduation was measured as advancing to the next grade the following school year. In assessing progress to graduation, students' status as of the 2001–2002 school year was observed, with three possible outcomes: repeating a grade, advancing to the next grade, or leaving school. Students in the Class of 2004 who were in 10th grade in the 2001–2002 school year were considered on track to graduate, as were students in the Class of 2002 who were in 12th grade in 2001–2002. Students who repeated a grade were considered not on track to graduate. Students who were not available for data collection during the 2001–2002 school year were considered “not in school.” These were students for whom the district had no record of attendance the following year. These students may have transferred to another district, participated in home-schooling, or dropped out of school.

RESULTS

Study schools were chosen as exemplars of differing models of CTE-driven whole-school reform. While some cross-site interpretation is included in this report, results from the three contexts/reform types are analyzed separately. For each measure, a percentage difference between the study and control schools was computed, along with 95% confidence intervals for this difference[7].

In this report, we present analyses of mathematics participation and coursetaking for the two high school cohorts. The younger cohort (Class of 2004) was beginning the 9th grade when the study began, and the second (Class of 2002) began the study in the 11th grade. We examine progress at each study and control location, through the first 2 years of data gathering. Data from 2 additional years and three additional subject areas (English, science, and CTE) will be presented in the subsequent years' reports.

Analyses will be presented in the following order. First, we will examine schools' "holding power" (e.g., the percentages of students who remained in the same school through the first 2 years of the study), and then the students' progress to high school graduation. The remainder of the analyses will focus on mathematics coursetaking through the initial 2 years of the study. We will examine mathematics course participation, mathematics course completion, levels of mathematics courses difficulty, and progression through a mathematics sequence.

We found differences in course content at some of the school pairs. For instance, while both Academy HS (AHS) and Control-A HS offer essentially the same math sequence, AHS does not accept students who did not pass Algebra 1 in middle school. Hence, more AHS students start high school higher in the math sequence. In the next pairing, Vocational HS (VHS) recently phased out an applied math sequence in favor of an upgraded sequence with added opportunities to take higher-level math courses, including at the Advanced Placement level. Control-B HS had a relatively traditional math sequence. The course titles at both schools became the same, although in practice, VHS still included more applied material relevant to vocational programs. Another difference in course content is found in the Algebra 1 course. All incoming freshmen in this district are expected to take Algebra 1. Many VHS students start high school performing below ninth-grade level in math. These students take a class called "1 Algebra 1," which satisfies the requirement that all freshmen take algebra, although it includes mostly pre-algebra content. Finally, Pathways HS (PHS) and Control-C HS are both comprehensive high schools in the same state with explicit learning standards, so both schools have a similar math sequence.

[7] Confidence intervals give upper and lower bounds such that we are 95% sure that the true population value falls between these values. Confidence intervals offer information about the magnitude of difference between study and control schools; readers may find it useful to think of these bounds as "believable values" for the percentage difference.

Progress to Graduation

Tables 4 and 5 are concerned with general progress to graduation. Data in Table 4 relate to whether students remained at the same school from the Fall of the 1st year of the longitudinal study (September 2000) through the Spring of the 2nd year (June 2002). Obviously, a student who does not stay in school can neither take additional mathematics courses, nor graduate. In these and all subsequent analyses, data will be presented by matched pairs of schools, always in the following order: Academy High School (AHS) and Control-A HS, Vocational High School (VHS) and Control-B HS, Pathways High School (PHS) and Control-C HS.

Academy High School

In the upper one third of Table 4, a stark difference can be seen between AHS and Control-A HS. Fully 95% of the AHS initial 9th-grade cohort (members of the Class of 2004 who began high school at AHS in the Fall of 2000) were still in school at the end of the 2nd year of the study. This contrasts with 80% of the 9th grade cohort at Control-A HS. The original 11th-grade cohort reveals a similar story. Fully 92% of the AHS original 11th-grade cohort (the Class of 2002) were still at AHS 20 months later (Spring of 2002), as contrasted with 76% of the original 11th graders of Control A HS. So, in both the grade 9–10 and grade 11–12 transitions, AHS was able to hold substantially larger percentages of its students.

Vocational High School

Data on VHS and Control-B HS can be seen in the middle section of Table 4. The data indicate no clear difference in rates of student persistence at the two schools.

Pathways High School

PHS and Control-C HS data are presented in the bottom one third of Table 4. Both the younger and older PHS cohorts have modestly (4%) greater persistence rates than Control-C HS over 2 years. The PHS persistence rate of 97% for its original 11th-grade cohort was the highest 2-year rate in the study, and its 9th-grade cohort's 95% rate tied AHS for second-highest. Across three schools and two initial grade-cohorts, the study schools averaged approximately 8% higher persistence rates in the 2 years that data have been collected.

The data in Table 5 go a step further in our analyses of progress to graduation. Each year, students are assigned to a grade level based on their having met local or state criteria toward graduation. Typically, these criteria involve not simply remaining on the rolls, but passing a certain number of courses. Table 5 goes beyond persistence, and shows the progress to graduation for the two high school cohorts at each site.

Table 5
Progress to Graduation, 2001–2002 Status

	N	Valid *n*	On target (%)	One year behind (%)	Not in school (%)
Academy High School, Class of 2004	202	192	71	24	5
Control-A High School, Class of 2004	*1045*	*834*	*77*	*3*	*20*
Percentage difference			**-6**	**21***	**-15***
95% CI for difference			(-13, 1)	(15, 27)	(-19,-11)
Academy High School, Class of 2002	115	106	90	3	8
Control-A High School, Class of 2002	*615*	*466*	*75*	*1*	*24*
Percentage difference			**15***	**2**	**-16***
95% CI for difference			(8, 22)	(-1, 5)	(-22, -10)
Vocational High School, Class of 2004	245	190	55	22	22
Control-B High School, Class of 2004	*349*	*274*	*53*	*23*	*22*
Percentage difference			**2**	**-1**	**0**
95% CI for difference			(-7, 11)	(-9, 7)	(-8, 8)
Vocational High School, Class of 2002	186	161	83	3	13
Control-B High School, Class of 2002	*236*	*198*	*80*	*4*	*16*
Percentage difference			**3**	**-1**	**-3**
95% CI for difference			(-5, 11)	(-5, 3)	(-10, 4)
Pathways High School, Class of 2004	450	429	66	30	5
Control-C High School, Class of 2004	*374*	*341*	*83*	*8*	*9*
Percentage difference			**-17***	**22***	**-4***
95% CI for difference			(-23, -11)	(17, 27)	(-8, 0)
Pathways High School, Class of 2002	326	315	86	11	3
Control-C High School, Class of 2002	*244*	*226*	*87*	*6*	*7*
Percentage difference			**-1**	**5***	**-4**
95% CI for difference			(-7, 5)	(0, 10)	(-8, 0)

Note. Valid *n* represents students in school during both years of the study. "On target" represents percentage of students who were satisfactorily progressing toward graduation as of 2001-2002. "One year behind" represents percentage of students who were not satisfactorily progressing toward graduation as of 2001–2002. "Not in school" represents percentage of study participants from the initial 2000–2001 sample who were not in school during 2001–2002. 95% CI is the 95% confidence interval around the respective percentage difference between study and control schools. Significant differences at the .05 level between study and control schools are noted by *.

Academy High School

By one definition, students who were in 9th grade in September of 2000 (the Class of 2004) at both AHS and Control-A HS, advanced at similar rates (71% vs. 77% were in 10th grade during the 2001–2002 school year, and hence “on target” to graduate). However, a substantial difference can be seen among the “not-on-target” students. While 29% of the AHS initial 9th graders were not on target to graduate the next year, over three quarters of those students were still in school (24% vs. 5%). By contrast, of the 23% of the Control-A HS initial 9th-grade students who were not on target a year later, less than one seventh (3% vs. 20%) were still in school. Whereas many of the AHS freshman–sophomore students had fallen behind, most had not dropped out. Twenty percent of the Control A HS students simply were no longer in school, making the eventual obtaining of a high school diploma more difficult.

The group of AHS and Control-A HS students who began the study in the 11th grade shows a similar but even more dramatic story. Fully 90% of the AHS 11th-grade students from the Fall of 2000 (the Class of 2002) were on target to graduate in the Spring of 2002. Three of the 11% not on target were still at AHS. In striking contrast, only 75% of the Control-A HS original 11th graders were on target to graduate two Springs later. The overwhelming majority (24% vs. 1%) of those not on target had left Control-A HS altogether.

Vocational High School

Table 5 indicates that VHS and Control-B HS were very similar in terms of promotion and school leaving.

Pathways High School

Control-C HS had many more students in the Class of 2004 on track to graduate at the end of the 2001–2002 school year than did Pathways HS (83% and 66%, respectively); however, a larger percentage of the not-on-target 9th graders at PHS were, in fact, repeating (30%, vs. 5% no longer in school) than was the case at Control-C HS, where 8% were repeating 9th grade, but 9% were no longer in school.

The original 11th-grade cohorts at the two schools had almost identical percentages on target to graduate in 2002 (86% vs. 87%). But again, among the students not on target to graduate, the substantial majority of PHS students were still in school (11%, vs. 3% not in school), whereas at Control-C HS, a slight majority had actually left school (7% not in school, vs. 6% one year behind).

In summary, the data in Table 4 indicate that, in general, the three CTE-enhanced whole-school reform schools tended to have larger percentages of students still in school after 2 years of data collection. Table 5 indicates that the percentages of students making progress to graduation are similar between study and control schools, but that the majority of students not making adequate progress at the CTE-enhanced high schools are staying in school and trying to get back on target. The remaining tables focus specifically on progress in mathematics.

Table 6
Math Course Participation: Students Taking Math in Both 2000–2001 and 2001–2002.

	Valid *n*	% taking math both years
Academy High School, Class of 2004	192	98
Control-A High School, Class of 2004	*834*	*95*
Percentage difference		**3***
95% CI for difference		(1, 5)
Academy High School, Class of 2002	106	70
Control-A High School, Class of 2002	*466*	*41*
Percentage difference		**29***
95% CI for difference		(19, 39)
Vocational High School, Class of 2004	190	88
Control-B High School, Class of 2004	*274*	*99*
Percentage difference		**-11***
95% CI for difference		(-16, -6)
Vocational High School, Class of 2002	161	83
Control-B High School, Class of 2002	*198*	*71*
Percentage difference		**12***
95% CI for difference		(3, 21)
Pathways High School, Class of 2004	429	87
Control-C High School, Class of 2004	*341*	*85*
Percentage difference		**2**
95% CI for difference		(-3, 6)
Pathways High School, Class of 2002	315	51
Control-C High School, Class of 2002	*226*	*33*
Percentage difference		**18***
95% CI for difference		(10, 26)

Note. Valid *n* represents the number of students in school during both years of the study. Percentage taking math represents percentage of students taking a math class both years of the study. 95% CI is the 95% confidence interval around the percentage difference between study and control schools. Significant differences at the .05 level between study and control schools are noted by *.

Mathematics Course Participation

High school students do not necessarily take a mathematics course every year. The first analysis partitions the sample into students who took a mathematics course during each of the first 2 years of this study, and those who took math in 1 or no year.

Academy High School

Table 6 shows that 98% of the AHS Class of 2004 who remained at AHS for the 2 years took a mathematics course during each of their first 2 years in high school, and that 95% of the Control-A HS remaining cohort did the same, for a 3% difference. In the Class of 2002, this discrepancy is much wider, with 29% more AHS students taking math every year.

Vocational High School

At VHS, 88% of the Class of 2004 took math during each of the first 2 years of the study, versus 99% for Control-B HS. Hence, there were 11% fewer students in the Class of 2004 who took a math class both years, while 12% more students in the Class of 2002 took math every year than their Control-B HS counterparts. The VHS class of 2002 had an 83% rate of math taking during the last 2 years—the highest Class of 2002 participation rate found at any study or control school for the older cohort.

Pathways High School

Similar rates of 2-year math coursetaking were found among students in the Class of 2004 at PHS and Control-C HS. Among students in the Class of 2002, however, there were considerable differences, with 18% more PHS students than Control-C HS students having taken math every year (51% v. 33%).

Mathematics Course Completion

The next logical analysis is concerned with mathematics course completion. While course participation reflects both a school's and a student's continued commitment to opportunity to learn, course completion reflects at least one outcome of that opportunity.

Academy High School

Generally, AHS showed more students passing their math courses than students at Control-A HS (see Table 7). During the 2000–2001 school year, 10% more students in both cohorts at AHS passed their math courses than at the control school. That difference declined to 1% in the 2001–2002 school year for the Class of 2004. However, the 10% differential remained constant for the Class of 2002 in the 2001–2002 school year.

Vocational High School

At VHS, 7% more students in the Class of 2004 passed their 2000–2001 math class than did their peers at Control-B HS (see Table 7). However, the following year, 10% fewer students in the Class of 2004 passed their math class at VHS than at Control-B HS. In the Class of 2002, 13% fewer VHS students passed their 2000–2001 math classes, but the passing rates were similar for both groups the following year, with a 3% difference favoring Control-B HS.

Table 7
Math Course Completion: Students Passing Math in 2000–2001 and 2001–2002

	Valid *n*	% passing math in 2000–2001	% passing math in 2001–2002
Academy High School, Class of 2004	192	61	68
Control-A High School, Class of 2004	*834*	*51*	*67*
Percentage difference		**10***	**1**
95% CI for difference		(2, 18)	(-6, 8)
Academy High School, Class of 2002	106	81	95
Control-A High School, Class of 2002	*466*	*71*	*83*
Percentage difference		**10***	**12***
95% CI for difference		(1, 19)	(7, 17)
Vocational High School, Class of 2004	190	61	54
Control-B High School, Class of 2004	*274*	*54*	*64*
Percentage difference		**7**	**-10***
95% CI for difference		(-2, 16)	(-19, -1)
Vocational High School, Class of 2002	161	71	84
Control-B High School, Class of 2002	*198*	*84*	*87*
Percentage difference		**-13***	**-3**
95% CI for difference		(-22, -4)	(-10, 4)
Pathways High School, Class of 2004	429	81	79
Control-C High School, Class of 2004	*341*	*64*	*79*
Percentage difference		**17***	**0**
95% CI for difference		(11, 23)	(-6, 6)
Pathways High School, Class of 2002	315	87	82
Control-C High School, Class of 2002	*226*	*68*	*85*
Percentage difference		**19***	**-3**
95% CI for difference		(12, 26)	(-9, 3)

Note. Valid *n* represents the number of students in school during both years of the study. Percentage passing math represents percentage of students passing a math class in the respective study year. 95% CI is the 95% confidence interval around the respective percentage difference between study and control schools. Significant differences at the .05 level between study and control schools are noted by *.

Pathways High School

At PHS, significantly higher numbers of students in both grade cohorts passed their math courses in 2000–2001 than did students at Control-C HS. In each case, however, during the 2nd year of the longitudinal study (2001–2002), the two cohorts at Control-C HS were passing courses at statistically similar rates to the students at PHS.

Across the three study schools and their three matched controls, the overall picture that emerged after 2 years was a modest trend toward the study schools having greater percentages of students passing math classes. The data presented above understate that advantage somewhat, in that the percentages are based on students who remained in school. Recall from Table 4 that somewhat higher percentages of students in the control schools were no longer in their schools.

Levels of Mathematics Difficulty

The next question concerns the level of difficulty presented in the various mathematics courses taken. It would be of little practical value to a student to pass a long series of introductory level, pre-algebraic mathematics courses, when a substantial amount of research indicates the importance of passing Algebra (and higher) courses for success beyond high school (National Research Council, 1989; U.S. Department of Education, 1997). Tables 8 and 9 display math courses aggregated according to difficulty into low, medium, and high classifications for the 2000–2001 and 2001–2002 school years data, respectively.

Academy High School

Students at AHS generally took higher-level math courses than did students at Control-A HS. From the Class of 2004, AHS students took higher-level math courses than Control-A HS students in the 9th grade, and continued to take higher-level courses the following year (see Table 9).

Large differences were also found in both school years between AHS students and Control-A HS students in the Class of 2002. AHS students opted out of the math sequence less often than did students at Control-A HS. By the 2001–2002 school year (see Table 9), 64% of AHS students in the Class of 2002 took a high-level math course. By contrast, 56% of the same cohort of Control-A HS students took no math course at all.

Vocational High School

Students from Control-B HS generally were more advanced than VHS in their math course-taking patterns, although the difference was not as distinct as with the AHS comparisons. To illustrate, our course transcript analyses indicate that 10% of students in the VHS Class of 2004 took no math course in 2000–2001, compared to less than 1% of students in the Class of 2004 at Control-B HS (see Table 8). Forty-five percent of students of the Control-B HS Class of 2002 took a high-level math course during the 2001–2002 school year, compared to 23% of the VHS Class of 2002 (see Table 9).

Table 8
Math Coursetaking: Percentage of Students in Math Course Levels, 2000–2001

	Valid *n*	No math course (%)	Low (%)	Medium (%)	High (%)
Academy High School, Class of 2004	192	0	0	99	1
Control-A High School, Class of 2004	*834*	*6*	*11*	*83*	*0*
Percentage difference		**-6***	**-11***	**16***	**1**
95% CI for difference		(-7, -4)	(-13, -9)	(13, 19)	(0, 2)
Academy High School, Class of 2002	106	3	0	24	74
Control-A High School, Class of 2002	*466*	*14*	*2*	*79*	*5*
Percentage difference		**-11***	**-2***	**-55***	**69***
95% CI for difference		(-15, -7)	(-3, -1)	(-64, -47)	(60, 77)
Vocational High School, Class of 2004	190	10	0	90	0
Control-B High School, Class of 2004	*274*	*0*	*0*	*100*	*0*
Percentage difference		**10***	**0**	**-10***	**0**
95% CI for difference		(5, 14)	(0, 0)	(-14, -6)	(0, 0)
Vocational High School, Class of 2002	161	4	0	94	2
Control-B High School, Class of 2002	*198*	*2*	*0*	*87*	*11*
Percentage difference		**2**	**0**	**7***	**-9***
95% CI for difference		(-2, 6)	(0, 0)	(1, 13)	(-14, -4)
Pathways High School, Class of 2004	429	3	16	81	0
Control-C High School, Class of 2004	*341*	*6*	*50*	*43*	*2*
Percentage difference		**-3***	**-34***	**38***	**-2**
95% CI for difference		(-6, 0)	(-40, -28)	(32, 44)	(-3, 0)
Pathways High School, Class of 2002	315	8	0	38	53
Control-C High School, Class of 2002	*226*	*22*	*13*	*47*	*19*
Percentage difference		**-14***	**-13***	**-9***	**34***
95% CI for difference		(-20, -8)	(-17, -9)	(-17, -1)	(26, 42)

Note. Valid *n* represents the number of students in school during both years of the study. Low, Medium, and High levels of math courses are derived from the taxonomy described in the text. 95% CI is the 95% confidence interval around the respective percentage difference between study and control schools. Significant differences at the .05 level between study and control schools are noted by *.

Table 9
Math Coursetaking: Percentage of Students in Math Course Levels, 2001–2002

	Valid *n*	No math course (%)	Low (%)	Medium (%)	High (%)
Academy High School, Class of 2004	192	2	1	90	8
Control-A High School, Class of 2004	*834*	*2*	*2*	*95*	*1*
Percentage difference		**0**	**-1**	**-5***	**7***
95% CI for difference		(-2, 2)	(-3, 1)	(-9, -1)	(3, 11)
Academy High School, Class of 2002	106	30	0	6	64
Control-A High School, Class of 2002	*466*	*56*	*0*	*37*	*7*
Percentage difference		**-26***	**0**	**-31***	**57***
95% CI for difference		(-36, -16)	(0, 0)	(-37, -25)	(48, 66)
Vocational High School, Class of 2004	190	3	0	97	1
Control-B High School, Class of 2004	*274*	*2*	*0*	*98*	*0*
Percentage difference		**1**	**0**	**-1**	**1**
95% CI for difference		(-2, 4)	(0, 0)	(-4, 2)	(-1, 1)
Vocational High School, Class of 2002	161	14	0	63	23
Control-B High School, Class of 2002	*198*	*28*	*0*	*27*	*45*
Percentage difference		**-14***	**0**	**36***	**-22***
95% CI for difference		(-22, -6)	(0, 0)	(26, 46)	(-32, -12)
Pathways High School, Class of 2004	429	12	8	58	22
Control-C High School, Class of 2004	*341*	*11*	*3*	*82*	*4*
Percentage difference		**1**	**5***	**-24***	**18***
95% CI for difference		(-4, 6)	(1, 9)	(-32, -16)	(12, 24)
Pathways High School, Class of 2002	315	49	0	10	41
Control-C High School, Class of 2002	*226*	*62*	*0*	*28*	*10*
Percentage difference		**-13***	**0**	**-18***	**31***
95% CI for difference		(-21, -5)	(0, 0)	(-25, -11)	(24, 38)

Note. Valid *n* represents the number of students in school during both years of the study. Low, Medium, and High levels of math courses are derived from the taxonomy described in the text. 95% CI is the 95% confidence interval around the respective percentage difference between study and control schools. Significant differences at the .05 level between study and control schools are noted by *.

Pathways High School

Students from PHS generally took math at higher levels than did students at Control-C HS, in both cohorts and for both years. In the Class of 2004, differences were largest for medium level math in 2000–2001; this difference led to a significant difference in high-level coursetaking in 2001–2002. For the Class of 2002, differences were greatest in high-level math courses for both years, with students at PHS also significantly less likely to opt out of the math sequence.

Progression Through a Mathematics Sequence

Our final analyses of the first 2 years of mathematics course-taking data are concerned with students' progression through a mathematics sequence. The issue here is whether a student who took a mathematics course during the 1st year of the study took no mathematics course in the following year, repeated the previous course, or advanced to a higher course. Because of the volume of data involved in presenting all math courses taken, Table 10 generalizes math course progression into course repeating and course advancement.

Academy High School

Math course advancement in the Class of 2004 was almost identical for AHS and Control-A HS. However, in the Class of 2002, students from AHS fared significantly better. These students were more likely to take a math class the following year than were students at Control-A HS, and no AHS students repeated a math class the following year.

Vocational High School

Students in both VHS classes appeared slightly more successful than their peers at Control-B HS in math progression. No significant differences were found, but slightly more VHS students in both classes advanced to a higher course, and slightly fewer Class of 2004 students repeated a course than did their Control-B HS counterparts.

Pathways High School

The pattern of student progression through the mathematics sequence for the Class of 2004 is similar at both PHS and Control-C HS. Among students in the older cohort (the Class of 2002) a significantly higher percentage of PHS students advanced to a higher course, with significantly lower percentages of PHS students repeating a course or opting out of math than did their Control-C HS counterparts.

Table 10
Progression Through Math Sequence from 2000–2001 to 2001–2002

	Valid *n*	Took no math course (%)	Repeated previous course (%)	Advanced to higher course (%)
Academy High School, Class of 2004	192	2	24	73
Control-A High School, Class of 2004	*784*	*2*	*24*	*74*
Percentage difference		**0**	**0**	**-1**
95% CI for difference		(-2, 2)	(-7, 7)	(-8, 6)
Academy High School, Class of 2002	103	34	0	66
Control-A High School, Class of 2002	*401*	*61*	*8*	*31*
Percentage difference		**-27***	**-8***	**35***
95% CI for difference		(-37, -17)	(-11, -5)	(25, 45)
Vocational High School, Class of 2004	171	3	26	71
Control-B High School, Class of 2004	*274*	*1*	*32*	*66*
Percentage difference		**2**	**-6**	**5**
95% CI for difference		(-1, 5)	(-15, 3)	(-4, 14)
Vocational High School, Class of 2002	155	21	12	67
Control-B High School, Class of 2002	*194*	*28*	*12*	*60*
Percentage difference		**-7**	**0**	**7**
95% CI for difference		(-16, 2)	(-7, -7)	(-3, 17)
Pathways High School, Class of 2004	416	12	12	76
Control-C High School, Class of 2004	*321*	*11*	*12*	*78*
Percentage difference		**1**	**0**	**-2**
95% CI for difference		(-4, 6)	(-5, 5)	(-8, 4)
Pathways High School, Class of 2002	290	52	5	42
Control-C High School, Class of 2002	*176*	*65*	*15*	*20*
Percentage difference		**-13***	**-10***	**22***
95% CI for difference		(-22, -4)	(-16, -4)	(14, 30)

Note. Valid *n* represents number of students in who took a math course in 2000–2001. “Took no math course” represents percentage of students who did not take math in 2001–2002. “Repeated previous course” represents percentage of students who took the same math course in both 2000–2001 and 2001–2002. “Advanced to higher course” represents percentage of students who took a higher level course in 2001–2002 than in 2000–2001. 95% CI is the 95% confidence interval around the respective percentage difference between study and control schools. Significant differences at the .05 level between study and control schools are noted by *.

DISCUSSION

Analyses of quantitative data have only begun, and will be continuing as 2 additional years of student data are collected. Results presented in this report are necessarily preliminary. We must, therefore, severely limit the interpretation of these initial results, since future analyses might provide different conclusions. Within this caution, then, the findings to date appear promising for improving students' mathematics achievement within schools implementing CTE-centered whole-school reform.

Summary of Results by School

Academy HS (AHS) stands out in these findings as having a particularly strong effect on student outcomes in mathematics coursetaking and overall progress to graduation. While we cannot assign causality to the results, it is certainly plausible that the academic and personal supports of the Urban Learning Centers design and the strong academic focus helped students succeed at AHS. The strong career themes at AHS may also be contributing. Rivera-Batiz (2003) suggested that some at-risk students become motivated to take more math and science courses as a result of a career-focused curriculum and related opportunities to work or participate in internships. This may be occurring at AHS, where career academies allow students to participate in work-related activities while in high school. Students with definite career ambitions in technology, health, or finance may find the academies interesting and motivating, and a reason to continue through an academically challenging curriculum in order to achieve their career goals. Future analyses on these and other data will continue to test this theory.

The story at Vocational HS (VHS) appears to be one of parity with a college preparatory high school in the areas of progress through the math sequence and progress to graduation. While the results favor Control-B HS in some measures, VHS appears to be strong at keeping its junior students who pass medium-level math in the math sequence for their senior year. The success of the school's shift toward higher-level math is illustrated by the fact that nearly a quarter of the students in the VHS Class of 2002 were taking trigonometry or higher in 2001–2002—a significant increase according to teachers. While this growth in higher math courses at VHS is important, the control-school cohort did take significantly more higher-level math courses. However, the percentage of students taking higher-level math courses at VHS is unlikely to exceed that of a college-preparatory comprehensive high school. These outcomes are positive for a vocational high school with high numbers of initially-low-achieving incoming freshmen, and where the faculty has struggled to increase the academic achievement of its students.

Pathways HS (PHS) appears to have a good math pipeline in effect. A larger percentage of students in the Class of 2004 started high school at a higher level of math and they moved further through the sequence in the 2 years of data collection. In the Class of 2002, fewer students opted out of math and more students were taking high-level classes. With respect to progress to graduation, more students were staying in school at PHS than at Control-C HS, even if they were a year behind in credits earned. It is plausible that the greater persistence at PHS can be attributed to the career pathways structure, which encourages students not only to plan but also to work toward their futures. Interviews with students at PHS revealed that they were very knowledgeable about the amount of postsecondary education or training needed to pursue the careers of their choice. PHS students appear to have realized that if they want to attend college, they would need to continue to take math classes throughout high school. Even if students' goals did not include college, they appeared to see the value of finishing high school, as evidenced by PHS having the lowest "not in school" rate among all the high schools in the study.

Cross-Site Analysis

The first of our research questions inquired into general progress to graduation at the study schools compared to the controls. All three Class of 2004 cohorts at the study high schools were either on par with the control schools, or fewer students were on target to graduate on time. However, when we combined the number of students who were 1 year behind but still attending school with those on target to graduate, the CTE-enhanced schools had many more students in this positive category than the control schools (or there was no difference, as was the case with the VHS comparison). We must regard students who were 1 year behind but still attending school as a positive outcome, because they were persisting.

Turning to the Class of 2002, again the comparison to note is the percentage of students "not in school" at the study schools compared to the control schools. In each case, the CTE-enhanced schools had more students remaining in school than their respective control schools, and that difference was especially significant in the case of Academy HS. If we look only at the "on target" measure, again AHS shows a significant difference from its control school, while VHS and PHS are statistically equivalent to their control schools.

The research questions around mathematics outcomes inquired whether students at the study schools, which are involved in CTE-enhanced whole-school reforms, have better mathematics outcomes than students at the control high schools. These better math outcomes were operationalized into higher participation in math courses, higher levels of math course completion, higher rates of students taking higher-level math courses, and further progression through a mathematics sequence. Results are discussed in that order.

With respect to overall student outcomes in mathematics, we are cautiously optimistic that students at the CTE-enhanced high schools fared better on measures of mathematics coursework than their counterparts at the control schools. Most of the positive outcomes occurred in the Class of 2002, which was in its junior and senior years in the school years 2000–2001 and 2001–2002, respectively. This is to be expected under our hypothesis that a CTE-enhanced curriculum increases math outcomes, since students do not normally experience these CTE-enhanced curricula until after their freshman year. In addition, it is in the last 2 years of high school that many students choose to opt out of math, having taken their required number of courses. That we see strong mathematics outcomes in those 2 years adds to the strength of the hypothesis. More data in future years will further confirm this hypothesis, as we expect that the more homogeneous comparisons currently seen in the Class of 2004 will turn into advantages at the CTE-enhanced high schools by the time this class reaches its senior year.

We can conclude that math course participation is generally better at the CTE-enhanced high schools than at the control schools. This is true of both cohorts at AHS, but only for the class of 2002 at both VHS and PHS. Therefore, fewer students in the Class of 2002 opted out of math during their senior year at all three study sites than was the case at their control schools.

In terms of math course completion, significantly more students in every cohort at the study schools, with the exception of the Class of 2002 at VHS, passed more courses than their control-school counterparts in 2000–2001. These advantages tended to flatten out in the 2001–2002 school year, especially at VHS and PHS. AHS retained its strong advantage in terms of math course completion compared to Control-A HS.

Generally, it appears as if the students in the CTE-enhanced schools are taking higher-level math courses than their control-school peers. This is certainly the case for both grade cohorts at AHS and PHS. In the VHS comparison, there are differences in the two grade cohorts. The Class of 2002 saw significantly more students taking higher-level math at Control-B HS than at VHS. This is understandable, given the very different goals of the two schools, where Control-B HS is a college preparatory high school and VHS prepares students for careers—some of which require postsecondary education and others of which do not. However, VHS has been upgrading its academic curriculum in response to state accountability requirements, and the data from the Class of 2004 suggest that the improvements to the math curriculum might have the intended effect of preparing higher numbers of students to enroll in higher levels of mathematics.

The major finding with respect to student progression through a math sequence is that students at the CTE-enhanced schools are staying in their schools' math sequences longer. This advantage is not reflected in the results for the Classes of 2004, but again these data are from those cohorts' freshman and sophomore years, during which time the effects of attending a CTE-enhanced high school may have not become evident. However, the better progression through the math sequence is especially apparent for the Class of 2002 at all three study schools. These cohorts were far enough into their high school experiences during the 2 years of data collection to have experienced the CTE-enhanced reforms. Students in these cohorts were also far along enough in the high school experience that many were probably able to opt out of math if they desired. However, despite mathematics being optional for many seniors, we found that at the study high schools, students continued to make better progress through the sequence than at the control schools. This is reflected in the strong effect sizes for these cohorts in the "took no math course" column of Table 9.

LIMITATIONS OF THE ANALYSIS

This is an analysis of mathematics course-taking patterns, but mathematics teaching and learning may occur in classes other than those that make up the mathematics sequence. Perhaps especially at CTE-enhanced high schools, other courses such as CTE courses might have math concepts and tasks integrated into them, and this can affect the outcomes reported. One current limitation of this report is that it does not take other math teaching and learning opportunities into account. However, we have low-inference qualitative data from many classroom observations that include CTE and academic subjects. For the final report, we will have analyzed these observations and can better determine the extent of math instruction in non-math classes.

Another limitation of the study is that when students at each school pairing are said to be taking "the same course," we cannot yet say the extent to which the contents of these two courses are in fact the same. We have inquired into this, and definitive answers will come. To date, we can say that in two of the three pairings of schools, the schools are located in the same district, and in all cases the paired schools are located in the same state. This means that math courses at each pair of schools adhere to the same state or local curriculum frameworks and standards. Anecdotal evidence confirms this perception, with some differences mentioned earlier. In general, course content for math classes tends to be more specified than for any other academic subject (Lee et al., 1998). We remain confident that further examination will confirm that, say, Algebra 2 equals Algebra 2 at each pairing.

We continue to receive and recode quantitative data on the first 2 years of the longitudinal study. The data presented in this report represent early levels of analysis. In the future, we will add demographic and prior achievement covariates. The current findings provide a description of the sites and their control groups, but do not yet take into account several factors that may affect the results. We plan to conduct parallel analyses of data on English and science coursetaking, as well as analyses of coursework from certain subpopulations such as Special Education students and CTE concentrators. Obviously, 2 additional years of data will be added to the final analyses.

NEXT PHASE OF THE STUDY

The story at each of the sites is one of either parity with strong control schools, or clear advantage over demographically comparable control schools. At AHS and PHS, the schools' records of not losing students to dropping out or other problems is extremely good, regardless of whether students are on grade level or not. We feel some initial confidence that students from the study schools that have blended CTE into their whole-school reform efforts are exhibiting stronger persistence in high school, progress to graduation at similar or better rates than students from their respective control schools, and increased math achievement.

One of the major advantages of longitudinal studies is the ability to follow up on emerging themes. We continue to monitor student progress to graduation and will include post-high-school endeavors in future reports. We will add 2 years of data to the mathematics course-taking analyses, and we will report on English and science coursetaking, as well. Finally, we also will pursue themes from earlier reports. In that vein, we will continue to report on issues of the sustainability of broad education reform in a policy context that defines success and achievement narrowly; on how changes in leadership can affect the reforms in place at a high school; on the diverse mechanisms that facilitate student transitions through secondary education and beyond; and finally, about how high school reforms function to narrow the academic achievement gap between disadvantaged and advantaged students.

Final analysis of outcome data will necessarily be conducted during the 5th year, although interim analyses will continue to be reported. As the analyses progress, we will be refining our understandings of the relationships among whole-school reform, career and technical education, and desired long-term student achievement for disadvantaged students.

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