Combining Academic and Career-Technical Courses To Make College an Option for More Students: Evidence and Challenges

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Overview

This paper is about the promise of and barriers to pathways through high school to college that combine the college-preparatory curriculum with career-related learning. Whether high school vocational and academic coursework should be separated or combined has long been debated in the U.S. Federal legislation in the 1990s encouraged states and localities to "integrate" academic and vocational education. While an integrated curriculum that prepares students for both college and careers is not a new idea, it continues to have logical appeal as part of a strategy that would make college an option for greater numbers of students. This paper will discuss the potential benefits, and the barriers to achieving them, and possible strategies for moving forward.

In the first section of this paper we explain why blending academic coursework with career-technical education (CTE) is one key element in a strategy that would aim to make college an option for greater numbers of high school students. This is one among several possible kinds of pathways that could serve that purpose. In the second section we briefly review the research on combining academic coursework with CTE in high schools. Getting clear-cut research results has been difficult because most studies have not been able to determine whether apparent effects are due to particular programs or to selection of particular kinds of students into those programs.

In California, the high school courses required for admission to public universities are spelled out in a list known as "a through g." In order for a California student to count a course as fulfilling an a-g requirement, that course, in that particular high school, must have been approved by the University of California (UC). The third section of this paper describes the process by which the process by whichUC decides whether to approve courses proposed by high schools. Since 2000, UC has been helping high schools understand how to get CTE courses approved for a-g credit, and we will describe examples of such courses. In the fourth section we will explain some of the obstacles to curricular integration posed by the California Education Code, teacher credentialing, and other regulatory requirements. We will conclude with recommendations for meeting these challenges, in order to create combinations of courses that prepare students for college <u>and</u> careers.

Why try to combine academic and career-technical education in high school?

Everyone knows that college graduates on average earn substantially more money than high school graduates, who in turn make substantially more than high school dropouts. The professional and managerial jobs that require bachelor's or advanced degrees also offer non-monetary benefits including prestige, comfortable working conditions, and greater autonomy. So it is no wonder that the vast majority of high school students say they aspire to complete a bachelor's or advanced degree, and their parents express similar aspirations for them.

Vocational education, on the other hand, has traditionally been defined as a pathway that does not lead to a bachelor's or advanced degree. The original Smith-Hughes Act of 1917, which provided the first federal grants for vocational education, repeatedly stipulated that the "purpose of such education shall be to fit for useful employment; that such education shall be of less than college grade…." Successive reauthorizations of the federal law continued to distinguish vocational education from preparation for college. The 1998 Perkins Act included such a statement in defining vocational and technical education as "a sequence of courses that provides individuals with the academic and technical knowledge and skills the individuals need to prepare for further education and for careers (other than careers requiring a baccalaureate, master's, or doctoral degree)…." The 2006 reauthorization of the Perkins Act finally removed this restriction, opening the possibility for creating more programs that combine CTE with preparation for college.

Since the traditional purpose of vocational education was to prepare students for work and not for college, students aspiring to achieve a bachelor's or advanced degree would logically avoid CTE in high school. Indeed, students who go directly from high school to a four-year college or university tend to take fewer vocational classes in high school (e.g., see DeLuca and others, 2006). As college-going rates increased during the 20th century, vocational course-taking declined. Some have argued that CTE should be allowed to disappear from high schools altogether, leaving community colleges as the main providers of CTE.

But career-technical educators rightly point out that most high school students still do not go on to complete bachelor's or advanced degrees. As of March 2004, the Current Population Survey found only 30.2 percent of 25-34 year olds had completed bachelor's or advanced degrees. An additional 8.8 percent had completed associate degrees, while another 19.3 percent had some college but no degree (Statistical Abstract of the US 2006, Table 216). Given the gradual rate at which the percentage of bachelor's or advanced degree completers has grown over recent decades, it will probably take decades before they become a majority of 25-34 year olds.

In short, there is an enormous gap between college aspirations and actual college completion. While 80 or 90 percent of high school students say they want to get a bachelor's or advanced degree, only about 30 to 35 percent actually get one. How should high schools deal with this?

One policy strategy would aggressively pursue "college for all." A prevalent argument nowadays is that the country "needs" a lot more college graduates, in order to remain competitive in the global economy. The strategy calls for raising academic expectations for all students in high school, so that many more will be prepared to succeed in college and graduate with bachelor's degrees.

Raising academic achievement is indisputably desirable for a number of reasons, not the least of which is preparation of adults who are more capable of participating in civic life and understanding public issues. However, the economic rationale of "college for all" is not compelling. A rapid increase in the number of new college graduates will tend to reduce the earnings advantage associated with a college degree. As a result, college becomes a less attractive investment, and fewer high school students will choose to attend. This happened in the 1970s, after large numbers of college-educated baby boomers flooded the labor market (Freeman 1976, Levy and Murnane 1992). Fortin (2006) found that states in which the supply of college graduates expanded during the 1990s also experienced a reduction in graduates' relative earnings. There is a limit to how many college graduates the market will absorb. The current rate of return to college is high enough to warrant some increase in the number of college graduates. But pushing the bachelor's degree completion rate to 100 percent would not make economic sense. Even 50 percent would be an ambitious 20-year target.

For the next couple of decades at least, it is realistic to expect that no more than half of high school students actually will go on to complete bachelor's or advanced degrees. High schools have to deal with the fact that most students will not complete college, even though the students sincerely aspire to do so.

A second policy strategy is tracking. If college for all is not feasible in the foreseeable future, then high schools can offer one set of courses for students who are academically inclined, and a different curriculum for the non-collegebound. The 1917 Smith-Hughes Act was part of the development of separate curricular tracks in US high schools. By various means, students were assigned to different course sequences, the main ones being vocational, academic, and "general" (Rosenbaum 1976, Oakes 1985/2005).

However, tracking was eventually discredited as unfair and wasteful. It is unfair because, as many studies have shown, students assigned to the non-college tracks tend to be less affluent, less likely to have parents who attended college, and more likely to belong to racial, ethnic, or linguistic minorities who are traditionally under-represented in higher education. Tracking also is wasteful because students in non-college tracks are given less challenging coursework, and therefore do not develop their academic and intellectual capabilities as much as they would if they were challenged and motivated. For these reasons, counselors, administrators, and school boards grew uncomfortable saying they practiced tracking. Explicit forms of tracking became less widespread in the latter decades of the 20th century, though tracking has persisted in less obvious ways (Lucas 1999; Oakes 2005).

In the 1980s, influential representatives of the nation's employers began to point out the inefficiency of tracking. They complained that graduates from high school vocational programs lacked the academic knowledge and thinking skills to participate in the newly emerging economy where incessant change requires continual learning and problem solving (National Academy of Science 1984; Committee for Economic Development 1985; Kearns and Doyle 1988). Employers had been the most politically important backers of vocational education since its inception, so these statements had a decisive effect on the debate in Congress when the federal law authorizing support for vocational education came up for its periodic renewal.

The 1990 amendments to the Carl Perkins Act turned vocational education 90 degrees, requiring that the basic federal grant to the states for vocational education be spent only on programs that "integrate academic and vocational education." This idea was subsequently reinforced and elaborated by the 1994 School-to-Work Opportunities Act, though that law expired in 1999 and was not renewed. The 1998 amendments to the Carl Perkins Act again mandated "integration of academics with vocational and technical education programs through a coherent sequence of courses to ensure learning in the core academic, and vocational and technical subjects" (section 135(b)(1)).

A third strategy thus presents itself: college as an option for all –– or at least for greater numbers of students. While recognizing that most high school students will not complete bachelor's degrees, this strategy aims to avoid both the waste and the unfairness of tracking. Like college-for-all, this third strategy aims for all students to complete a set of academic courses that prepares them to succeed in a four-year college or university. At the same time, high schools would offer a variety of pathways designed to accommodate students' diverse interests and preferred methods of learning. Among these multiple pathways, some would offer a set of challenging CTE courses combined with college-preparatory academic coursework.

A policy aimed at making college an option for all students enables students to pursue various sequences of schooling and work. Students who are prepared with high school CTE coursework could go directly to a bachelor's degree program and earn more money "on the side" to support their college participation. Others would enter two-year colleges, postsecondary vocational training, or full-time work –– but they all would have completed the academic prerequisites to enter a bachelor's degree program later on, if they so choose. Choices might be responses to developing aspirations, career opportunities, long-term economic and job market shifts, and more. Meanwhile, those who entered bachelor's programs immediately after high school, but who do not complete their degrees, could turn to alternative options if they gained work-related knowledge and skill in their high school CTE. This strategy therefore allows for the various ways of combining college and work, or alternating between them, that characterize the American system.

Is there evidence that combining academic and career-technical learning in high school can improve preparation for college?

To make college an option for larger numbers of students, some new pathways would blend academic and career-technical learning. Traditional vocational education that prepares students for work but does not advance their preparation for college would be part of a tracking strategy, not part of a strategy that aims to make a bachelor's degree an option for all. But blending CTE with college preparation should mean that students would pursue both at the same time, rather than forcing students to choose between them at a time in their lives when they are not well prepared to make seemingly irrevocable decisions. A curriculum that shows how academic knowledge and skills are used in the world of work may motivate more students to persevere in the academic courses that prepare them for college. Overlapping the content of academic and CTE courses has the pedagogical advantage of enabling students to see applications of academic subject matter outside of school, which may increase students' motivation, understanding, and retention of concepts. This has been part of the rationale for integrating academic and career-technical coursework (e.g., see Grubb 1995).

Unfortunately, there is not yet conclusive evidence that blending CTE with academic coursework actually increases college-going and degree completion. A number of correlational studies have produced findings that are consistent with a positive answer, but these findings also have other likely explanations, as we will explain. Two studies have randomly assigned students to programs that combined academic learning with CTE: the answer from one of these is positive but limited, and the other is ambiguous.

Correlational studies. Several studies have looked at outcomes for high school students who take a sequence of CTE courses along with a college-preparatory academic curriculum. Kang and Bishop (1989) were the first to examine the effects of combining academic and vocational coursework. They discovered a positive interaction between the number of academic courses and the number of vocational courses in predicting post-high school earnings for males who did not attend college. Kang and Bishop did not study effects on college attendance, however. Arum and Shavit (1995) identified students who had taken a set of advanced academic courses, a sequence of vocational courses, or both. Four years after senior year, individuals who had completed both an advanced academic and a vocational sequence in high school had the greatest likelihood of being employed in professional, managerial, or skilled jobs –– and also the greatest likelihood of being enrolled in postsecondary education. Outcomes for this group were better, or at least as good, as for students who had taken advanced academic courses but not a CTE sequence.

Levesque and associates (2000) analyzed achievement test results and found that students who combined a college-preparatory academic curriculum with a specific vocational sequence had gains in math, reading, and science test scores during high school that were similar to the gains of students who took only the college-prep curriculum –– and both of these groups gained substantially more than other students. Plank (2001) used the same data (NELS) and found similar results as Levesque and associates. However, using multiple regression instead of simple means to compare changes in test scores, Plank found that "dual concentrators" gained significantly less than the academic-only group. The dual concentrators also started at a lower level in grade 8, so they fell further behind the academic-only group during high school.

Importantly, Plank (2001) studied whether course-taking patterns were associated with dropping out of high school –– which has an obvious influence on the chances of going to college. Plank computed the ratio of CTE credits to academic credits earned by each student, and found that a higher ratio was associated with a smaller chance of dropping out. Extrapolating this result to its logical conclusion would imply that replacing all academic courses with CTE courses would minimize the dropout rate. To preclude this inference, Plank added the square of the CTE/academic ratio to the analysis, to allow a curvilinear relationship. The results then imply that a ratio of three CTE courses for every four academic courses would minimize the likelihood of dropping out, other things equal.

Plank's finding that dropouts tend to take relatively fewer CTE classes could result, in part, from the fact that more CTE course-taking generally occurs in grades 11 and 12 than in grades 9 and 10. Dropouts simply are not in high school long enough to take as many vocational classes as students who stay.

On the other hand, Bishop and Mane (2004) point out that students who do not like academic subjects are presumably more likely to drop out of high school, and are also more likely to take CTE classes. If the available data do not include good measures of students' inherent interest or disinterest in academic subjects, then measuring the correlation between the amount of CTE coursework and dropping out would give a misleading result.

These considerations illustrate the difficulty of using correlational data to draw conclusions about cause and effect. Similar issues arise in interpreting the finding that students who combine a strong academic curriculum with an occupational sequence perform better both at school and at work. These students may start high school already possessing more ambition, energy, drive, self-discipline, or awareness of what it takes to do well in the world –– qualities which cause them to take a doubly demanding curriculum in high school and also to excel in their post-high school pursuits. Their built-in get-up-and-go might enable them to succeed just as well without the extra coursework. Since the available data do not include good measures of these qualities, the results of correlational studies may be misleading.

Social scientists have tried hard to finesse these problems. One of the most sophisticated attempts is Altonji's (1995) analysis, which he describes as "the first systematic study of the effects of secondary school curriculum on postsecondary education and on success in the labor market" (p. 410). However, Altonji found a strange result: foreign language courses stand out as the best predictor of both post-high school wages and college attendance (Tables 2 and 3). No other academic or vocational subject had a consistently significant association with wages, although both "industrial" and "commercial" course-taking were negatively associated with college attendance. Altonji does not accept these results at face value (though the Modern Languages Association might be pleased if he did!). Unfortunately, despite the attempt to rid the data of bias due to unmeasured differences among students, Altonji's findings and discussion do not inspire much confidence in the possibility of reaching clear conclusions about cause and effect from correlational studies.

Program evaluations without random assignment of students.[1] Correlational studies provide information about naturally occurring variation in the types of courses students take. Another source of evidence about the effects of combining academic and vocational coursework in high schools comes from evaluations of programs that include a planned mix of academic coursework and CTE. In particular, programs known as career academies lend themselves to this kind of evaluation, because they are relatively well-defined and examples have existed now for more than three decades.[2]

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[1] Parts of this section draw from Stern, D., Wu, C., Dayton, C., and Maul, A., forthcoming.

[2] The idea of combining vocational and academic coursework is also central to *High Schools That Work*, a network launched in 1987 to raise academic achievement by blending a rigorous academic curriculum with modern vocational studies (Bottoms and Presson 1995). The network had grown to more than 1,200 high schools in 2006 (www.sreb.org/Programs/hstw/hstwindex.asp). Since its inception, *HSTW* has used standardized tests based on NAEP to monitor the achievement of CTE completers, and has shown positive trends based on comparisons of successive cohorts of students. However, these data cannot be used to measure growth of a

The term "career academy" was coined by Stern, Raby, and Dayton (1992) to describe the kind of high school configuration that originated in Philadelphia, then spread to New York City, to California, and eventually nationwide. Common themes for career academies are health, business and finance, arts and communications, computers, engineering, law and government. There is no authoritative, uniform definition of a career academy, and as the term has become popular the variation among programs that call themselves career academies has increased.[3] In 1993 MDRC began the first random-assignment evaluation of career academies (Kemple and Rock 1996). MDRC abstracted three main features to define a career academy:

(1) School-within-a-school organization in which academy students at each grade level take a set of classes together, and stay with the same small group of teachers for at least two years.

(2) Curriculum that includes academic courses meeting college entrance requirements, along with CTE classes, all related to the academy theme.

(3) Employer partnerships to provide internships and other experiences outside the classroom, related to the academy theme.

Six different researchers or research teams, using longitudinal data from different sets of academies between 1985 and 2000, compared performance of academy and non-academy students from the same high schools. These studies are described and summarized by Stern (2003). None of these studies assigned students at random to the academy or non-academy groups. Most researchers

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given group of students over time, or to compare progress of students in *HSTW* with non-*HSTW* students.

[3] The state of California provides grants to school districts for "partnership academies" which are defined by statute, but this definition does not apply to the hundreds of academies in California that do not receive state funding. A few other states also have funded such academies. The federal School-to-Work Opportunities Act in 1994 included career academies on a list of seven "promising practices," but did not not define them. Building on the MDRC definition, the Career Academy Support Network (http://casn.berkeley.edu) helped negotiate a common definition among several networks currently promoting career academies.

used statistical regression techniques to control for some observed differences between academy and non-academy students. In some studies the researchers and teachers chose each comparison student individually to match one of the academy students.

All of these studies reported academy students performing significantly better than comparison students while in high school. Salient findings on students' performance during high school are as follows:

- Reller (1984, 1985) studied the first two career academies in California. Academy students earned significantly more course credits than a matched comparison group from the same high schools. One-year attrition rates ranged from 2 to 6 percent in academies, 10 to 21 percent in the comparison group.
- Stern et al. (1988, 1989) studied 10 state-funded academies in California. Academy students tended to perform significantly better than matched comparison groups from the same high schools in attendance, credits earned, average grades, and likelihood of staying in school. The three-year attrition rate for the cohort entering in 1985 was 7.3 percent from academies, 14.6 percent from the comparison group.
- Hayward and Talmadge (1995) evaluated 10 different programs that used some form of vocational education to promote success in high school. Two of the sites were career academies. These showed generally better results than other programs, improving students' attendance, credits, grades, and likelihood of completing high school.
- McPartland et al. (1996, 1998) reported on the reorganization of Patterson High School in Baltimore in 1995, which included creation of career academies for all students in grades 10–12. Attendance in the first implementation year rose from 71 to 77 percent, contrasting with districtwide decline from 73 to 70 percent in grades 9–12. A survey of teachers found great improvement in reported school climate.

• Maxwell and Rubin (1997, 2000) analyzed 1991–95 school records for three cohorts of students in grades 10–12 in an urban district, including nine career academies. Controlling for other characteristics of students, academy students received significantly better grades than non-academy students, in both academy and non-academy classes. 92 percent of the academy students graduated from high school within the study period, compared to 82 percent of non-academy students.

• Elliott, Hanser, and Gilroy (2000) compared 1994–96 data from three Junior Reserve Officers Training Corps (JROTC) career academies in large cities with student data from other career academies or magnets in the same or similar schools, and data on JROTC students not in academies and on students not in any academy or magnet program. Propensity-weighted regression was used in an attempt to offset possible selection bias. Students in JROTC career academies and in other career academies or magnets generally received higher grades, had better attendance, completed more credits, and were less likely to drop out than statistically similar students not in academies.

Three of these studies also gathered data on post-high school outcomes. Salient findings were:

• Reller (1987) surveyed students 15 months after graduation. She found 62 percent of academy graduates were enrolled in postsecondary education, compared with 47 percent of the comparison group. Expecting to complete a bachelor's degree or more were 55 percent of academy graduates, 22 percent of the comparison group. Another survey, 27 months after graduation, found no significant differences between academy and comparison students in employment status, wages, or hours worked.

• Stern, Raby, and Dayton (1992) conducted follow-up surveys 10 and 22 months after graduation. They found no consistent differences between academy and comparison graduates in postsecondary attendance or degree aspirations. Academy graduates on average were working 3 more hours per week, but there was no consistent difference in hourly earnings.

- Maxwell and Rubin (1997, 2000) found no significant differences in wages or hours worked between former academy and non-academy students, though former academy students more often said their high school program had prepared them well for further education and work. However, participation in postsecondary education was higher among former academy students: 52 percent were attending four-year colleges, compared to 36 percent of the non-academy students. In a subsequent study of students at a public university campus, Maxwell (2001) found that academy graduates were less likely to need remedial coursework, and were more likely to complete bachelor's degrees, compared to statistically similar graduates from the same district.

In sum, different researchers studying different sets of career academies have consistently found that academy students are outperforming their non-academy schoolmates on various measures of academic success while in high school. Post-high school differences in further education and employment have been less consistent, but where significant differences have been found they have favored the academy students.

Although these studies statistically controlled for measured differences between academy and non-academy students, the possibility remains that unobserved differences account for the results. For example, the academy students may have been more motivated or better organized to begin with, and that may explain why they did better. Indeed, there might be a systematic tendency for career academies to attract more motivated or better-organized students.[4]

Program evaluations using random assignment of students. The classic method for eliminating bias due to selection or self-selection is for researchers to

[4] Innovative educational programs also may attract more motivated teachers and administrators.

use a random procedure to assign some subjects to the "treatment," and the others to the control group. This procedure ensures that the average difference between the two groups –– on both observed and unobserved variables –– will be negligible, given a large enough sample. Despite this great advantage, there are well-known drawbacks and limitations to using random assignment in educational field studies. Denying a beneficial treatment to a control group may raise ethical questions. Some important educational variables –– e.g., completing high school –– cannot be experimentally manipulated. Even when random assignment is feasible and ethical, absence of a placebo means that Hawthorne effects and other biases may influence the result. Nevertheless, a well-designed random-assignment study can eliminate the problem of selection bias that plagues much educational research. (For a fuller discussion, see Stern and Wing 2004.)

In 1993 MDRC began its random-assignment evaluation of career academies, initially with 10 sites, but one academy ceased operating. All nine remaining academies are in high schools with large proportions of low-income and minority students. Each was the only career academy in its high school.

At the start of the MDRC evaluation, the academies recruited more applicants than they could accommodate. Applicants knew they might not be admitted. MDRC randomly assigned about two-thirds of the applicants to the academy; the others became the control group. For more than 10 years since the evaluation began, MDRC has collected student records, surveyed students during each of their high school years, and conducted follow-up surveys one year and four years after high school.

During the high school years, the career academies studied by MDRC produced several positive impacts on students' experience and achievement. Compared to the control group, academy students reported receiving more support from teachers and from other students (Kemple 1997). They were more likely to combine academic and technical courses, engage in career development activities, and work in jobs connected to school (Kemple, Poglinco, and Snipes 1999). As of spring of senior year, academies retained a larger fraction of the students whose initial characteristics made them more likely to drop out (Kemple and Snipes 2000). Among students at less risk of dropping out, academies increased participation in CTE courses and career development activities without reducing academic course credits (Kemple and Snipes 2000).

The first follow-up survey, one year after scheduled graduation, found no significant impacts on students' high school completion, GED acquisition, or participation in postsecondary schooling. It also showed no significant impact on employment or earnings, though students who had been assigned to career academies were working and earning somewhat more than the control group (Kemple 2001).

MDRC's most recent follow-up, about four years after scheduled graduation from high school, found large and significant impacts on employment and earnings, and no difference in educational attainment (Kemple and Scott-Clayton 2004). In the full sample, students assigned to career academies earned higher hourly wages, worked more hours per week, had more months of employment, and earned about 10 percent more per month than the control group. All these differences occurred for both males and females, but they were not statistically significant for females. Impacts on high school completion or postsecondary education were not significantly positive or negative for the sample as a whole or for any subgroup, but Kemple and Scott-Clayton (2004) note that both the academy and control groups had high rates of high school completion and postsecondary enrollment compared to national (NELS) data on urban high school students.

In sum, the most recent results from MDRC indicate that students who *applied* to the career academies had high college-going rates, whether or not they actually *participated* in the academies. There was no statistically significant difference in college-going between academy participants and the control group.

However, graduates from the career academies did earn significantly more money than the control group. In other words, the benefit from career academies occurred in the labor market, not in further education, but the labor market gains also did not come at the expense of academy students' further educational attainment.

A recent study by Stone and others (2005) also used random assignment to test the effects of combining academic instruction with CTE. This was a more limited intervention than the career academies, which represent a multi-year pathway involving much of a student's high school curriculum. The Stone study focused on individual CTE classes as settings in which to improve students' performance in one academic subject, namely, mathematics. A total of 134 CTE teachers took part in the study: 60 were randomly assigned to the experimental group, and the remaining 74 were the control group. Each CTE teacher in the experiment partnered with a math teacher from the same high school. The treatment consisted of bringing together the CTE teachers in each of five disciplines –– agriculture, auto technology, business/marketing, health, and information technology –– along with their math teacher partners, to identify mathematical content embedded in the CTE discipline, and develop lesson plans to teach the math within the occupational context. All students in the experimental and control classrooms were given pre- and post-tests in math. After one year, students in the experimental classrooms scored significantly higher on TerraNova and Accuplacer math tests, though there was no significant difference in performance on the math portion of WorkKeys, which is less advanced. These findings demonstrate that it is possible to provide professional development for teachers that leads to improved math achievement by students in CTE classrooms. Such professional development could be part of a strategy to make college an option for more students by combining academic and career-technical instruction.

Increasing college-going in California by combining academic and technical course content: getting courses approved by the University of California

In California, the 1960 Master Plan for Higher Education directed the University of California (UC) to draw from the top 12.5 percent of high school graduates, while the California State University (CSU) system draws from the top one-third. To qualify for admissions at either UC or CSU, a student must complete a specific sequence of courses, known as the "a through g" requirements, each with a grade of C or better.[5] The UC faculty established the "a-f" (now "a-g") subject area requirements in the 1930s as a method for UC faculty to clearly articulate to high school educators and students the sequence of courses they believe is essential for high school students to take in order to be well prepared for the rigors of a University education. Beginning in 2003, CSU and UC became aligned, requiring the same sequence of 15 courses for eligibility for admission to both systems.

Currently about 30 percent of California high school graduates satisfy the a-g course requirements. Making higher education an option for significantly larger numbers of students in California (where CSU and UC account for most of the four-year college enrollment) means enabling more students to meet these course requirements, which are similar to those of other four-year institutions of higher education in California and other states.

If the strategy to increase college-going involves combining college-prep academic classes with a CTE sequence, it becomes advantageous to maximize the overlap between the academic and CTE coursework, for at least two reasons. One is pedagogical: a blended program might motivate more students to study academic subjects, and might improve their understanding through application

[5] Eligibility for UC and CSU also requires a minimum GPA and test scores. The CSU Eligibility Index is accessible at http://www.csumentor.edu/planning/high_school/cal_residents.asp. The UC Eligibility Index is accessible at http://www.universityofcalifornia.edu/admissions/undergrad_adm/paths_to_adm/freshman/scholarship_reqs.html.

to practical contexts. A second reason is logistical: students' time is limited. On a typical high school schedule, taking six courses a year for four years, a student would complete 24 year-long courses. The minimum course requirements for UC and CSU amount to 15 of those 24. The "recommended" sequence for UC includes an additional year of math, science, and language other than English, bringing the total to 18 year-long courses. A CTE sequence of one or two courses a year might add up to another six. That should be possible to accomplish in theory, but in practice the complexities of high school scheduling, and other requirements like physical education and health, can make this difficult or impossible. However, if one or more of the CTE courses could satisfy a university requirement (or vice versa), the scheduling problem becomes easier.

How UC approves high school courses. Procedurally, getting a particular CTE course to count for UC and CSU admission means obtaining approval by the UC Office of the President (UCOP). Unlike other state university systems, UC actively reviews individual course descriptions from each public and private high school in the state to determine whether a course meets faculty guidelines and thus satisfies one of the a-g requirements. The UC faculty, represented by the Board on Admissions and Relations with Schools (BOARS), establishes and regularly clarifies criteria for course approval in each of the subject areas: (a) history/social science; (b) English; (c) mathematics; (d) laboratory science; (e) language other than English; (f) visual and performing arts; and (g) college preparatory electives. BOARS provides guidelines[6] to UCOP staff who review course descriptions. When UCOP articulation staff, individually and jointly, is unsure whether a course meets criteria, they consult the faculty.

Every WASC-accredited (or WASC-affiliated) public and private high school in California maintains a list of UC-approved courses on the "Doorways"

[6] Accessible at www.ucop.edu/doorways/guide

web site.[7] Anyone can view the Doorways list of approved courses for each high school, but making changes to the list requires a password. The list is used in counseling prospective students and in admissions reviews of applicants to UC. Each high school is asked to update its Doorways list annually, by electronic submission. A flow chart in the attached appendix shows the timeline for updating a-g course lists.

CTE courses can be approved to satisfy a-g requirements. The fundamental purpose of the a-g requirements is to ensure that potential University students are prepared for university level coursework. Recognizing that UC is primarily an academic institution, the guidelines for course approval reflect that mission and focus on preparation in academic subject areas, rather than career-technical areas. However, UC also recognizes that some high schools have reformed their curricular paths and integrated higher level academics into their career-technical courses in order to simultaneously prepare students for college and careers. In the past few years UC has accepted an increasing number and broader range of applied academic courses in subject areas including agriculture, business and finance, engineering, media and entertainment, health and bioscience, and others. According to an October 2006 report by the California Department of Education (CDE)[8], more than 4,700 career-technical courses had been approved for a-g credit.

UC approval of larger numbers of CTE courses has been the result, in part, of UC's own "a-g Guide Project" [9] which was launched in 2000 to accomplish three goals:

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[7] Viewable at www.ucop.edu/doorways/list

[8] Accessible at http://www.ucop.edu/a-gGuide/ag/content/CDE-UCApprovedCTECourses2006-07_002.doc

[9] The project was funded initially by the California School-to-Career Interagency Partners (CDE, Economic Development Department, California Community Colleges), and subsequently by CDE.

(1) To provide to high school educators with more and better information about the UC a-g subject area requirements and the course approval process;

(2) To offer a broad range of tools, resources, and professional development to assist schools in designing courses that meet the a-g criteria; and

(3) To clarify UC policy and streamline UC procedures for approving courses that meet the requirements.

The project has produced several significant accomplishments. Specifically, the a-g Guide web site[10] provides information, resources, and tools to help high design and submitcourses for UC approval. Some of these materials pertain specifically to career-technical educators seeking to receive a-g approval for their courses. Over 100 workshops and presentations conducted by project staff have communicated UC faculty expectations for course approval and offered customized advice to CTE teachers and administrators on how to approach course design and presentation in order to increase chances of UC approval. A "cadre of experts," 300 strong, made up of UC admissions and outreach staff and high school educators, have been trained to support and advise high school colleagues around the state. Recently, mini-grants have been offered to teams of academic and career-technical teachers to modify academic courses by introducing career skills via a lab, field study, or practicum component, in order to make those courses more relevant to the world outside school and strengthen students' grasp of academic concepts.

As a result of this project and other initiatives, high school educators increasingly have integrated academic and CTE content to create courses that are both academically deep and personally relevant to students. Those integrated courses that satisfy the a-g requirements span the full range of subject areas, but most cluster in just three –– visual and performing arts (2,476), college prep elective (1,427), and laboratory science (752). This clustering can be explained by two realities. First, most of the a-g areas are very narrowly defined by UC

[10] Accessible at www.ucop.edu/doorways/guide

faculty. For example, in the "a" (history/social science) area UC only accepts courses in U.S. history, world history, and American government –– specific academic disciplines into which very few technical courses fall. Other social science courses –– e.g., child development, business economics, or law –– can be more easily blended with CTE but would be approved in the "g" elective area. The three areas in which blended academic-CTE courses are more readily approved are more broadly defined by UC faculty, allowing for a greater variation in course approvals.

Second, the sciences and arts serve as foundations for the majority of industry sectors. Scientific knowledge and skills support agriculture and natural resources, energy and utilities, engineering, biomedical and health services, manufacturing and product development, and transportation.   The arts support media and entertainment, textiles and fashion, and architecture and interior design.

Courses that integrate CTE are approved only if they make teaching of the academic concepts central to technical understanding. For example, UC has accepted courses in the area of sports medicine that require biology as a prerequisite, focus substantially on anatomy and physiology, revolve around the understanding of body systems, and use science texts to drive acquisition of scientific knowledge. Similarly titled courses have not been approved if they prioritize first aid and injury prevention and treatment, are organized around body parts (rather than systems), and use technical manuals with limited scientific teaching.

In the era of popular TV shows like *CSI*, forensic science has become a popular high school course for career pathways in biomedical sciences and/or law and government. UC has accepted some of these courses but, again, only if they highlight the scientific underpinnings of crime scene investigation –– biology and chemistry. Acceptable forensics courses typically expect biology and chemistry as prerequisites, teach advanced science topics, use college level texts, and require complex scientific inquiry and experimentation. Unacceptable courses focus almost exclusively on laboratory methods and procedures without requiring students to master the scientific concepts that underlie the analysis of crime scene investigation.

In the visual arts, UC has accepted many design courses (e.g., graphic, architectural, fashion, furniture) as well as some courses in video/film production, digital media, and animation. An acceptable architectural design course, for example, would emphasize the artistry in the design of buildings, that is, the art in architecture. The course would emphasize knowledge of architectural styles across cultures and historical periods. A student's work products would grow from understanding the elements of art and principles of design and enable students to replicate ancient and modern structures and express creatively their own ideas through architectural sketches, designs and models perhaps using a variety of media. Students also would be expected to critique architectural designs using appropriate vocabulary. In contrast, courses that focus primarily on the technical aspects of architecture, such as building codes, materials, and costs would not be approved.

Other barriers to curricular integration, and how to overcome them.

Getting UC to approve CTE courses for a-g credit is not the only obstacle to a strategy that would make college an option for greater numbers of students in California. In the 20th century, educators, legislators, and public perceptions sharply distinguished academic from vocational education, or college preparation from career preparation. We have postulated that preparing larger numbers of students for college will require multiple pathways, including some that blend academic and career-technical coursework. Such a change faces systemic and programmatic challenges. . This section will discuss some of these challenges and suggest some steps to overcome them.

Systemic challenges. The separation between academic and career-technical education is written into existing law. The California Education Code and the regulations of various educational agencies fund these programs from different sources, maintain distinct facilities (regional occupational centers apart from comprehensive high schools), follow different sets of curricular standards, and require different kinds of credentialling procedures for academic and CTE teachers. Until California's Education Code is changed, the state will continue to incur the social and economic consequences of operating dual –– and dueling –– systems of education.

Let us start with an example. Suppose a high school wanted to combine a physics course with auto mechanics, so that students taking physics would see how theories and formulas are applied in the world outside school, and students taking auto mechanics would understand the underlying physics of automotive technology. An immediate challenge would be finding teachers who possess the knowledge and skills to offer this kind of integrated course. The typical physics teacher has gone from high school to college and back to high school again, learning physics and then teaching it in a primarily abstract and theoretical way without experience in its practical applications. The auto shop teacher typically comes out of private industry with substantial experience under the hood, but little theoretical knowledge of physics.

The teacher credentialing requirements for teachers of core academic subjects differ significantly from those for the majority of career-technical teachers.[11] These differing requirements tend to produce teachers who have expertise to teach either the theoretical underpinnings of a core academic subject

[11] To receive a single subject teaching credential in an academic subject, a candidate must earn a baccalaureate degree, complete a graduate level teacher preparation program approved by the California Commission on Teacher Credentialing, pass the California Basic Education Skills Test (CBEST), and fulfill other requirements (see www.ctc.ca.gov/credentials/leaflets/cl560c.html). In contrast, to receive a vocational education designated subjects teaching credential, a candidate must demonstrate evidence of five years of work experience (or equivalent) directly related to the vocational subject to be named on the credential, hold a high school diploma (or equivalent), along with other requirements (see www.ctc.ca.gov/credentials/leaflets/cl698a.html).

(e.g., physics) or the practical applications of it (e.g., auto mechanics), but rarely both.

Instead of collaborating, teachers may feel they have to battle one another in order to preserve their programs, retain their funding, gain prestige, or protect their educational beliefs and philosophies. They may not realize that both their favored disciplines' and their students' success may lie in discarding the existing paradigm and embracing a new way to educate youth that may be more effective. Yet, teachers' reactions are natural, given the structure of the educational system in which they work.

Current accountability policies, based on tests in academic subjects, put pressure on CTE teachers to beef up the academic content of their courses. This may be an incentive to collaborate with their academic colleagues –– but there is no corresponding pressure on teachers of academic subjects to link their courses with CTE. The main priority for high schools now is to address state content standards, meet state targets measured by Academic Performance Index (API) and federal targets defined by Adequate Yearly Progress (AYP), and get students to pass the California High School Exit Exam (CAHSEE). CTE teachers are being asked, often demanded, to incorporate in a more significant way the academic content standards into their CTE courses. And in other cases, their courses are dropped altogether so that students can spend more time learning basic skills needed to pass high-stakes tests.

In 2002 the legislature passed a law (AB 1412) mandating the California Department of Education (CDE) to develop distinct CTE standards, which the State Board of Education approved in 2005. These standards are intended to clarify and legitimate what is taught in CTE courses. They give CTE teachers something to stand on. But since they are not included in the state and federal accountability measures that currently drive high schools, the CTE standards are irrelevant from the standpoint of academic teachers. Separate sets of academic and CTE standards reinforce the dual and dueling systems of education.

The systemic separation of academic and CTE is embodied in procedures for collecting basic data about course offerings. The California Basic Education Data System (CBEDS) requires every public school to submit, each October, a broad range of data items, including the number of students enrolled in career-technical education, excluding Regional Occupational Centers/Programs.[12] CBEDS does not define CTE, but the presumption is that CTE courses are distinct from courses in academic subjects. Courses such as agricultural biology, engineering, journalism, architectural design or photography may successfully combine academic and CTE content –– and may even be approved by UC for a-g credit –– but there is no way to designate such courses as integrated curriculum in CBEDS.

Despite the continuing systemic separation of academic and CTE curriculum, there is some promise of combining them. The new CTE standards include academic foundations (i.e., state content standards), suggesting that schools should intentionally overlap academic and CTE curricula. As cited earlier, a 2006 CDE report lists 4,705 CTE courses approved to satisfy one of the a-g subject requirements.[13] The same report shows a dramatic increase of the a-g approved CTE courses, up from 4,021 in 2005, 3,336 in 2004, and 1,984 in 2003. Through the a-g Guide Project, UC continues to promote curricular integration. Another positive sign is the work of ConnectEd: The California Center for College and Career[14], backed by the James Irvine Foundation.[15] ConnectEd is a statewide center that promotes the development of comprehensive programs of academic and technical study. Finally, the large and growing number of career academies in California high schools continues to provide settings in which to offer a planned mix of academic and CTE coursework.

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[12] CBEDS School Information Form, Item 30

[13] In this report, a course is classified as CTE if it "could be" taught by a credentialed CTE teacher, whether or not it actually is. For instance, the report lists more than 800 photography courses, of which 26 are actually taught by credentialed CTE teachers.

[14] Accessible at www.ConnectEdCalifornia.org

[15] The James Irvine Foundation also sponsored the writing of this paper.

Programmatic challenges. Overcoming the systemic separation between academic and CTE curriculum ultimately will require changes in both policy and practice. Sometimes practices change first, and prompt the re-examination of policy.

If more high schools are to offer combined academic and career-technical courses that prepare students for both college and careers, several programmatic challenges may exist. We discuss two here.

One is the traditional high school bell schedule. Most high school elective courses compete with one another for student enrollment. Once a student enrolls in the required courses in mathematics, English, history, science, physical education, etc., few class periods remain for elective courses, whether foreign language, art, music, drama, dance, leadership, computer applications, computer programming, or the whole range of CTE options, from auto mechanics and engineering to floral design and video production. If a school limits students to the traditional six-period day, it is difficult to find time for a course sequence that meets college requirements and also includes a CTE sequence.

Some schools have tried to solve this problem by shifting to more creative and flexible schedules (e.g., 4x4 block schedule) that allow students to take up to eight courses per year, significantly increasing the number of total courses they complete prior to graduation. If more California high schools used these scheduling options, a greater number of students would be able to prepare simultaneously for college and career.

A second barrier to blending academic-CTE course sequences in practice is the long-standing tradition of departmentalization. When high school teachers and courses are departmentalized (e.g., English, business, technology, science), often the curriculum of each course stands alone. Some courses are quite theoretical and abstract; others are more applied and practical. Too often, students are left to their own devices to see any connection between lessons learned in their English and business classes, or physics class and auto shop.

Students may have the chance to take both academic and CTE courses, but rarely do teachers of these subjects coordinate the curriculum in a way that promotes connections between theory and practice.

Career academies and other programs attempt to overcome this barrier by grouping a cohort of students and a team of teachers around a particular industry sector and attempting to demonstrate the connections among the career-technical and academic courses taught as a coordinated program. Through common planning time for teachers and projects for which students may receive credit in more than one class, these programs promote academic connectivity across departmental boundaries. However, creating and sustaining a team of teachers, providing shared planning time, and scheduling groups of students to take a set of classes together all require substantial commitment on the part of school administrators, counselors, and faculty.

A less demanding practice is to integrate academic and CTE content one course at a time. As we have noted, CTE teachers have a greater incentive to do this than their academic counterparts do. The growing number of CTE classes that have been approved by UC for a-g credit is evidence that this practice can succeed.

Team teaching offers another solution. Starting with the CTE course and trying to enhance the academic content may appear to be the most natural approach, given the predominance of academic criteria in current accountability standards. For example, Stone and others (2005) showed that students in CTE courses can learn more math if the CTE teacher works with a math teacher to make the mathematical content more explicit. An alternative approach, which may be equally promising, would begin with an academic course and seek to build in related career-technical skills through a laboratory, practicum or field study component. For example:

- A physics course could use the auto shop as the lab environment for investigating and experimenting with concepts like force, motion, friction, heat and thermodynamics, and magnetic fields.

- A geometry course could use carpentry as a practical activity for students to gain a deeper understanding of geometric principles by solving real problems related to perpendicular and parallel lines and planes, right triangles, perimeter, circumference, area, volume, angles, and trigonometric functions.

- A visual arts course could use a graphic design studio to teach students the art elements of line, value, shape, color, form, texture, and space, as well as the design principles of balance, unity, emphasis, contrast, movement, rhythm, and pattern/repetition.

- A psychology course could use a day care center to examine how development theories related to cognition, language acquisition, learning, morality, and psychosocial and personality development play out among children at different stages of development.

Although this strategy is more likely to yield an academically rigorous course that satisfies an a-g subject area requirement, it may compromise a portion of the more specialized job related skills that are customary in CTE.

Concluding thoughts

Blending high school academic and career-technical coursework in a coherent curriculum that prepares students for both college and careers is not a new idea (e.g., Grubb 1995), and all of the specific programmatic options we have described here have been tried before. Yet the idea continues to have logical appeal as one of the multiple pathways that would make college an option for greater numbers of students, while recognizing that most students still do not complete bachelor's degrees. Several studies have found that students who combine academic coursework with CTE perform better in high school, but there is not yet much evidence about whether this kind of blended curriculum in high school improves the chances of college enrollment or completion. In sum, there are good reasons to try to expand the availability of integrated academic and career-technical curricula in high school, while recognizing the systemic and programmatic barriers –– and making serious efforts to evaluate whether these options are producing the desired results.

References

Altonji, J.G., 1995. The effects of high school curriculum on education and labor market outcomes. Journal of Human Resources 30(3):409-439.

Arum, R. and Shavit, Y., 1995. Secondary vocational education and the transition from school to work. Sociology of Education 68: 187-204.

Bishop, J.H. and Mane, F., 2004. The impacts of career-technical education on high school labor market outcomes. Economics of Education Review 23(4):381-402.

Bottoms, G. and Presson, A. (1995). Improving high schools for career-bound youth, in Grubb, W.N. (ed.): Education through Occupations (Vol. 2). New York, NY: Teachers College Press. 35-54.

California Department of Education, 2005. California High School Career-Technical Education Courses Meeting University of California A-G Admission Requirements for 2005-2006. Sacramento, CA: California Department of Education.

Committee for Economic Development, 1985. Investing in Our Children. New York: Committee for Economic Development.

DeLuca, S., Plank, S., & Estacion, A., 2006. Does Career and Technical Education Affect College Enrollment? St. Paul, MN: National Research Center for Career and Technical Education. (Available from National Dissemination

Center for Career and Technical Education, The Ohio State University, 1900 Kenny Road, Columbus, OH 43210-1016; http://www.nccte.org)

Elliott, M. N., Hanser, L. M., and Gilroy, C. L., 2000. Evidence of positive student outcomes in JROTC career academies. Santa Monica, CA: RAND Corporation.

Fortin, N.M., 2006. Higher-education policies and the college wage premium: Cross-state evidence from the 1990s. American Economic Review 96(4):959-987.

Freeman, R.B., 1976. The Overeducated American. New York: Academic Press.

Grubb, W.N., 1995. The cunning hand, the cultured mind. In Grubb, W.N. (ed.): Education through Occupations (Vol. 1). New York, NY: Teachers College Press.

Hayward, B., and Talmadge, G., 1995. Strategies for Keeping Kids in School. Washington, DC: U.S. Department of Education.

Kang, S. and Bishop, J., 1989. Vocational and academic education in high school: Complements or substitutes? Economics of Education Review 8(2): 133-148.

Kearns, D. T. and D. P. Doyle, 1988. Winning the Brain Race: A Bold Plan to Make Our Schools Competitive. San Francisco, CA: Institute for Contemporary Studies, ICS Press.

Kemple, J. J., 1997. Career academies: Communities of Support for Students and Teachers. Emerging Findings from a 10-site Evaluation. New York: MDRC.

Kemple, J. J., 2001. Career academies: Impacts on Students' Initial Transitions to Post-Secondary Education and Employment. New York: MDRC.

Kemple, J. J., Poglinco, S.M., and Snipes, J. C., 1999. Career academies: Building career awareness and work-based learning activities through employer partnerships. New York: MDRC.

Kemple, J. J., and Rock, J. L., 1996. Career Academies: Early Implementation Lessons from a 10-Site Evaluation. New York: MDRC.

Kemple, J. J., with Scott-Clayton, J., 2004. Career Academies: Impacts on Labor Market Outcomes and Educational Attainment. New York: MDRC.

Kemple, J. J., and Snipes, J. C., 2000. Career Academies: Impacts on Students' Engagement and Performance in High School. New York: MDRC.

Levesque, K., Lauen, D., Teitelbaum, P., Alt, M., and Librera, S., 2000. Vocational Education in the United States: Toward the Year 2000. Washington, D.C.: U.S. Department of Education, National Center for Education Statistics.

Levy, F. and R. J. Murnane, 1992. U.S. earnings levels and earnings inequality: A review of the recent trends and proposed explanations," Journal of Economic Literature 30, 1333-1381.

Lucas, S.R., 1999. Tracking Inequality: Stratification and Mobility in American High Schools. New York: Teachers College Press.

Maxwell, N. L., 2001. Step to college: Moving from the high school career academy through the four-year university. Evaluation Review 25(6):619-654.

Maxwell, N. L., and Rubin, V., 1997. The relative impact of a career academy on post-secondary work and education skills in urban, public high schools. Hayward, CA: California State University, Hayward, School of Business and Economics, The Human Investment Research and Education Center.

Maxwell, N. L., and Rubin, V., 2000. High School Career Academies: A Pathway to Educational Reform in Urban Schools? Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

McPartland, J. M., Balfanz, R., Jordan, W., and Legters, N., 1998. Improving climate and achievement in a troubled urban high school through the Talent Development Model. Journal of Education for Students Placed at Risk *3*:337–361.

McPartland, J. M., Legters, N., Jordan, W., and McDill, E. L., 1996. The Talent Development High School: Early evidence of impact on school climate, attendance, and student promotion. Baltimore: Johns Hopkins University and Howard University, Center for Research on the Education of Students Placed at Risk.

National Academy of Sciences, Panel on Secondary School Education and the Changing Workplace, 1984. High Schools and the Changing Workplace, the Employers' View. Washington, D.C.: National Academy Press.

Oakes, J., 1985/2005. Keeping Track: How Schools Structure Inequality. New Haven: Yale University Press.

Plank, S.B., 2001. A question of balance: CTE, academic courses, high school persistence, and student achievement. Journal of Vocational Education Research 26(3).

Reller, D., 1984. The Peninsula Academies: Final Technical Evaluation Report. Palo Alto, CA: The American Institutes for Research.

Reller, D. J., 1985. The Peninsula Academies, Interim Evaluation Report, 1984–85 School Year. Palo Alto, CA: American Institutes for Research

Reller, D. J., 1987. A Longitudinal Study of the Graduates of the Peninsula Academies, Final Report. Palo Alto, CA: American Institutes for Research in the Behavioral Sciences.

Rosenbaum, J.E., 1976. Making Inequality: The Hidden Curriculum of High School Tracking. New York: Wiley.

Stern, D., 2003. Career academies and high school reform before, during, and after the school-to-work movement. In Stull, W. J., and Sanders, N. M. (Eds.): The School-to-Work Movement, Origins and Destinations. Westport, CT: Praeger, pp. 239-262.

Stern, D., Dayton, C., Paik, I., Weisberg, A., & Evans, J., 1988. Combining academic and vocational courses in an integrated program to reduce high school dropout rates: Second-year results from replications of the California Peninsula Academies. Educational Evaluation and Policy Analysis 10:161–170.

Stern, D., Dayton, C., Paik, I., & Weisberg, A., 1989. Benefits and costs of dropout prevention in a high school program combining academic and vocational education: Third-year results from replications of the California Partnership Academies. Educational Evaluation and Policy Analysis 11:405–416.

Stern, D., Raby, M., and Dayton, C., 1992. Career Academies: Partnerships for Reconstructing American High Schools. San Francisco: Jossey-Bass/Wiley.

Stern, D. and Wing, J.Y., 2004. Is there solid evidence of positive effects for high school students? In High School Reform: Using Evidence to Improve Policy and Practice. New York: MDRC. http://www.mdrc.org/publications/391/conf_report.pdf

Stern, D., Wu, C., Dayton, C., and Maul, A., forthcoming. Learning by doing career academies. In Neumark, D. (Ed.): Improving School-to-Work Transition. New York: Russell Sage.

Stone, J. R., III, Alfeld, C., Pearson, D., Lewis, M. V., and Jensen, S. (2005). Building academic skills in context: Testing the value of enhanced math learning in CTE (Final study). St. Paul, MN: National Research Center for Career and Technical Education. (Available from National Dissemination Center for Career and Technical Education, The Ohio State University, 1900 Kenny Road, Columbus, OH 43210-1016; http://www.nccte.org)