Career and Technical Education Transition Programs: Effects of Dual Credit Participation on Postsecondary Readiness, Retention, Graduation, and Time to Degree

Jacob Marszalek, Rongchun Zhu, Jane W. Loeb, Debra Bragg, and Margaret Brooks-Laraviere
University of Illinois at Urbana-Champaign

Abstract

In response to the demand for a highly skilled workforce, national interest in Career and Technical Education (CTE) transition programs is growing. A CTE transition program is a formal CTE partnership between institutions at the postsecondary and secondary level designed to support successful student transition from secondary to postsecondary education and to encourage successful completion of a degree program. This paper presents findings from a mixed-method longitudinal study assessing the effects of participation in CTE transition programs on student outcomes. Specifically, it examines the differences in transition to college and academic achievement between program participants and non-participants.

Over the past two decades, secondary schools have engaged in a host of educational reforms designed to facilitate the transition of more high school graduates into college in preparation for technical and professional careers. Precollege outreach programs have been offered to facilitate student transition into college through various forms of early interventions, student adjustment programs, and college partnerships with K-12 (Tierney & Hagedorn, 2002). Swail and Perna (2002) recognized reform mechanisms that policy makers have used to facilitate student transition to college in the forms of charter schools, voucher programs, and early interventions. School-to-career educational reforms begun during the past decade have been yet another mechanism to encourage a larger proportion of high school students to make the transition to college. This study focused on Career and Technical Education (CTE) transition programs in particular among these school-to-career reforms.

For the purposes of this investigation, CTE transition pathway programs were defined as coordinated secondary and postsecondary educational programs that provide students with the opportunity to begin a course of study at the high school level that continues to the two-year college level—frequently offering opportunities for students to continue study at four-year colleges and universities—and ultimately obtain viable employment. As a part of the curriculum, CTE transition pathway programs enroll students in academic and CTE courses, many of which offer college credit prior to high school graduation. Advanced course-taking has been identified by numerous scholars as integral to successful student transition to college (Adelman, 1999; Peterson, 2003), and the best CTE transition pathway programs have recognized the importance of offering courses consistent with a challenging academic approach. These CTE transition pathway programs have been intended to offer systematic curricular options that reach students with a wide range of backgrounds, educational experiences, and educational and career aspirations, including students who have not typically considered going to college. In the past twenty years, a wide range of transition programs have proliferated, engaging students in various curricular opportunities extending from high school to two- and four-year colleges and universities (see, for example, Clark, 2002; Hershey, Silverberg, Owens, & Hulsey, 1998; Kirst & Venezia, 2004). Among these, partnerships between secondary and postsecondary organizations involving the adoption of formal articulation agreements and implementation of organizational (infrastructure) changes have been integral to implementation of high school-to-college transition programs.

CTE transition pathway programs have been a response to criticisms that tracking at the K-12 level creates separate and unequal paths for secondary students based on the designation of college bound status or immediate workforce status. Recognizing that tracking has done a disservice to students and the larger community as a whole, Berry (2003) and others have argued that the state and its citizenry would be better served by preparing all students for educational advancement beyond high school. Callan and Finney (2003) agreed that all students should be prepared for college, whether they choose to attend or not, contending that the most significant objective of education reform is to ensure that all students are prepared to attend at least two years of postsecondary education and training after high school graduation. They pointed out that present day employees have been expected to have demonstrable critical thinking and management skills, communication and problem-solving skills, and the flexibility and ability to perform a myriad of work-related tasks.

Given the focus of CTE transition pathway programs on serving diverse students who have a range of prior educational experiences, it is not surprising that community colleges have been the primary postsecondary partners for secondary CTE programs. Historically, community colleges have served large numbers of diverse traditional-age students (students between the ages of 18 and 24), and many of these students have been first-generation college attendees who were not fully prepared to enter college and perform at the collegiate level. Indeed, Adelman (2005) and Callan and Finney (2003) reported that freshmen enrolling in community colleges were more likely to be first-generation than were their four-year college counterparts, typically coming from lower socioeconomic strata and attending underachieving high schools in higher proportions. Cabrera and LaNasa (2001) reported that approximately 71% of students in the lowest socioeconomic stratum were not academically prepared for a collegiate course of study. Notwithstanding socioeconomic factors, Haycock (2001) drew upon national data to demonstrate the existence of the "achievement gap" for minority students, showing that a much higher proportion of African American and Latino students reached the 12th-grade reading at the 8th-grade level compared to their white counterparts. Not surprisingly, low income and minority students who have matriculated into the community college have been overrepresented in remedial education, often precluding them from taking college level courses (Perin, 2002).

CTE transition pathway programs have been intended to respond to the calls by experts (e.g., Callan & Finney, 2003; Ewell, Jones, & Kelly, n.d.) for more high school students to make the transition to college, including students with characteristics like those who have typically not attended college in the past. The past two decades have witnessed tremendous growth of CTE transition pathway programs, paralleled by growth of technical education offered by community colleges. Student participation in postsecondary CTE has grown as more students have sought technical degrees in preparation for a workforce that requires higher levels of technical and academic skills (Grubb, 1999a). Recently, approximately 60% of the community college student body has pursued a technical or occupational course of study (Grubb, 1999a). These certificate and degree programs, in which a four-year degree is not necessary for job-related workforce entry, have sometimes been described as subbaccalaureate programs. However, thinking of postsecondary CTE as subbaccalaureate has increasingly become a misnomer, as more and more technical programs have begun to offer students the opportunity to transfer to a bachelor's degree program (Townsend, 2000). Examining postsecondary technical programs offered by community colleges, Grubb (1999b), and more recently Adelman (2005), reported positive economic gains for postsecondary technical education students, and these gains were greatest for those who graduated from technical programs and found jobs related to their fields of study.

The CTE transition pathway programs of today have built on models and approaches that began emerging well over a decade ago, including tech prep (see, for example, Hershey, Silverberg, Hulsey, & Owens, 1998), career academies (see, for example, Kemple & Snipes, 2000), school-to-work or school-to-career programs (see, for example, Pedraza, Pauly, & Kopp, 1997); and dual credit, dual enrollment, or accelerated learning programs (see, for example, Robertson, Chapman, & Gaskin, 2001). While dual enrollment programs have been around for well over 30 years, the rapid growth of programs and courses that award college credit simultaneously with high school credit, known as *dual credit*, has been a fairly recent phenomenon (Bailey, Hughes, & Karp, 2002; Karp, Bailey, Hughes, & Fermin, 2004). In his study to examine the expansion of dual credit and dual enrollment nationally, Clark (2002) documented the existence of high school courses that also award college credit in a wide range of academic as well as CTE subjects. Nomenclature and practices associated with dual credit vary from state to state, and oftentimes, from school system to school system. For the purpose of this study, dual credit was defined as applying to high school students taking a course or courses that provided both high school credit and college credit simultaneously (Kim, Barnett, & Bragg, 2001).

The advantages and disadvantages of dual credit programs have been discussed extensively in the literature. Kim (2005) provided an excellent review and summary. Among benefits, saving time and money in the pursuit of a college degree by accelerating students' earning of college credit was often cited in the literature. An additional positive feature claimed by proponents was the enhancement of the academic rigor of the senior year, a time when some students rest on their laurels and bide time toward college rather than engaging in challenging academic curricula. In addition, if dual credit courses were well articulated between secondary and postsecondary institutions, the result would be less overlap and duplication in the curriculum. Increased opportunities could also result, especially for students in high schools with relatively low resource levels, such as rural and inner city schools. Proponents also believed that dual credit programs could increase students' self-confidence, enhance their interest in college, and better prepare them for college through allowing them to experience college level work.

Among disadvantages posited in the literature, Kim (2005) noted problems transferring technical credit, and even when transferable, issues regarding its applicability to the student's chosen degree. However, maintenance of college level quality in courses taught by high school faculty or otherwise serving predominantly high school level students was a major issue to some authors cited by Kim. If students were not selected into the courses based on past records indicating a likelihood of readiness for college work, the issue of quality may have been exacerbated. Yet dual credit courses were often an important component of programs designed to reach a broad range of the high school student body. Finally, questions regarding program effectiveness were persistent for dual credit programs, including questions about whether they increased access to college and resulted in reduced remedial course work (see Barnett, Gardner, & Bragg, 2004; Catron, 2001; Peterson, Anjewierden, & Corser, 2001; Puyear, Thor, and Mills, 2001).

The growing body of knowledge on the impact of CTE transition pathway programs on student outcomes, such as readiness for college and successful transition into postsecondary education, has been an important discourse about reforming education in order to facilitate student transition to postsecondary institutions and career options. Bailey and Karp (2003) observed that no definite conclusions could be drawn from much of the existing literature, because those few studies that examined student outcomes typically exhibited problems with the adequacy of research designs. It appears that research needs to continue to gather credible empirical evidence of characteristics of the programs and the mechanisms through which they have affected student outcomes.

To address the lack of knowledge that exists concerning outcomes of CTE transition pathway programs, the current study examined the relationship between student participation in a CTE transition pathway program with readiness for college, measured in terms of having taken remedial courses and the levels of remedial courses students took, and related readiness for college with later measures of student performance and retention in college. The study took a careful look at student performance at a selected community college that acted as a lead postsecondary institution in a collaborative partnership with multiple K-12 and secondary districts having numerous high schools with substantial dual credit offerings. A primary focus was the extent to which students who successfully participated in dual credit courses while in high school may have differed in readiness for college from those who did not. Additionally, we questioned whether a high degree of engagement in these programs might positively affect the general level of coursework available to students, and thus be beneficial. A second question involved the degree to which remedial need is related to later outcomes, such as college level credit amassed, GPA, degree attainment, and the length of time needed to achieve a degree. A third question deals with differences between participants in dual credit programs and other students in achievement of these later outcomes of college.

The University of Illinois at Urbana-Champaign (UIUC) and the Academy for Educational Development (AED) National Institute for Work and Learning partnered to undertake this study of two selected CTE transition programs that have been recognized as implementing exceptional programs or “best practices.” During the summer and fall of 2003, UIUC and AED team members conducted a nationwide search for research sites that produced a number of viable nominations, ultimately focusing on sites located in states in the Midwest, Southeast, Southwest, and Northwest. Utilizing a careful selection process, two community colleges were selected as primary sites. This paper focuses on the Northwest site, which offers an outstanding Information Technology/Computer Information Science (IT/CIS) transition pathway that extends from participating high schools to four regional community and technical colleges. Study participants included 25 participating high schools, a community college, and an intermediary transition organization, Hawkeye County Careers Connection (HC3), which has fostered partnerships between secondary and postsecondary institutions, and taken the lead in brokering articulation agreements through which CTE dual credit (DC) courses were offered in participating high schools, taught by high school faculty according to agreed-upon course descriptions. Successful completion with a grade of “B” or better guaranteed credit awarded simultaneously at the high school and college. These courses were offered in five CTE pathways and were applicable toward degrees and certificates at the community college. At the same time, high school students at this site have had the opportunity to earn dual credit through the Running Start program, through which they could take college level coursework at the community college. Unlike the CTE dual credit program, the Running Start (RS) program was not limited to

CTE courses, and required the student to pass relevant placement examinations before registering. Using transcript data provided by Hawkeye Community College (HCC), this study addressed the following research questions:

1. What was the level of remedial need at HCC, overall and in mathematics and in communication? Was remedial need the same for participants in CTE DC, participants in RS, and non-participants?
2. Controlling for differences in cohort (age), race-ethnicity, gender, and the proportion of students in the school eligible for free or reduced lunch, were CTE DC participants and non-participants equal in the amount of remediation they needed? Was the degree of the high school's engagement in the CTE dual credit program related to its students' need for remediation?
3. What was the relationship of the need for remediation to longer term outcomes of postsecondary education, namely: retention, performance, degree achievement, and terms to the degree?
4. Did students in CTE dual credit and RS programs who completed associate degrees need less time to do so than students who did not participate in these programs while in high school?
5. Did students in CTE DC and RS programs earn more college level credit and/or earn higher GPAs at HCC than students who did not participate in either program while in high school? Were the effects of the two programs on these outcomes the same?

Method

Sample

The sample consisted of 6450 Hawkeye College students whose last high school attendance was at one of 25 schools selected by several criteria. Selected schools had articulation agreements with Hawkeye College through the HC3 consortium, and were in the community college district. None of the schools was designated as an "alternative" high school. The schools were also selected in order to get a sample representative of various ethnic and socioeconomic groups, and of various levels of school engagement in the CTE dual credit program through the consortium. Table 1 provides figures for each school's enrollments and average socioeconomic status (indexed by the proportion of students eligible for free or reduced-price lunch). It also shows where each school fell on a composite rating of the school's engagement in the CTE dual credit program provided by the former director of HC3.

The students themselves were selected because they attended Hawkeye College anytime from Fall 2000 to Spring 2004, and generally had last attended high school from Fall 1998 through Spring 2003. These time spans were chosen because they were far enough in the past to include many students who participated in the CTE dual credit articulation program run by HC3, which became solidly institutionalized and quite active in 2000, and to include a number of students who had enough time since high school to graduate from Hawkeye College. The Running Start (RS) program, a different type of dual credit program, was begun in 1990, and was used as a comparison group for the CTE dual credit program. Because CTE DC became active more recently than RS, student age was expected to affect the dependent variables in the study, especially credit hours earned and degree attainment, and, therefore, was controlled in regression analyses. In addition, all students in the sample participated in either CTE DC or RS only, or neither program. There were 106 students who participated in both CTE DC and RS programs, but were excluded from the sample.

Students who went to HCC exclusively for high school completion or GED coursework were excluded from the sample. Similarly, students selected for this analysis had enrolled at HCC after high school, excluding from the sample students whose only HCC matriculation was through CTE DC or RS during high school. For the analysis of terms required to the degree, the sample was further limited to those students who earned an associate degree, as all such degrees at HCC require about the same number of credit hours for completion.

Overall, the students were 58.0% female and 42.0% male, and the ethnic breakdown was: American Indian/Alaskan Native, 1.8%; Asian/Pacific Islander, 12.3%; African American, 8.0%; Hispanic, 6.4%; Caucasian, 67.7%; and Other, Unknown, or International Student, 3.8% (see Table 2). The ages of the 6450 students were distributed as follows: 18-19 years, 1.0%; 20 years, 11.6%; 21 years, 16.9%; 22 years, 19.9%; 23 years, 20.1%; 24 years, 16.7%; 25 years, 11.3%; and 26 or more years, 2.5% (see Figure 1 for exact counts).

Variables

For the purposes of this study, a CTE DC student was defined as any student who had credit for at least one course at Hawkeye College awarded through the CTE DC program but who did not participate in RS, and a RS student was defined to be any student who had spent at least one term in the RS program while in high school but did not earn any CTE dual credit. A non-participant was in neither of these programs.

Placement test scores were not available for most students, as HCC by policy keeps them for only one year, necessitating the use of less direct measures of the need for remediation. Remediation was measured in three areas—mathematics, communication (reading and writing), and general (mathematics or communication)—and two ways: whether or not a student attempted at least one remedial course after high school, and the level of the lowest remedial course taken. Remedial level was not computed for the general area because of the inequatability of math level and communication level. Remedial courses were identified by the course catalog and documents from the college (e.g., placement score tables used to assign students to entry level courses).

Remedial level was defined using college course descriptors and associated placement scores. In math, the lowest level of remediation, Level 1, was assigned to courses under the Adult Basic Education rubric, whose content was basic arithmetic, including fractions, decimals, and percents. Levels 2-4 were assigned to courses whose range covered further arithmetic (operations with fractions and decimals) to prealgebra (operations with signed numbers, coordinate graphing, and solving linear equations). Levels 5 and 6 were assigned to courses—including two business courses—that covered topics ranging from solving linear equations to linear graphs and solving quadratic equations (introductory algebra). Level 7 designated enrollment in an intermediate algebra course (systems of linear equations, rational and radical algebraic expressions). Students taking none of these remedial courses were assigned Level 8.

In communication, the lowest level of remediation, Level 1, also was assigned to courses under the Adult Basic Education rubric, whose content ranged from learning phonics and alphabet recognition to reading for comprehension and writing using correct punctuation and grammar. Level 2 referred to courses that emphasized phonics and word analysis, and sentence structure and paragraph development. Level 3 designated courses that concentrated on identifying main ideas and drawing inferences in reading, and classifying and expressing information in the form of sentences in writing. The most advanced remedial level, Level 4, was assigned to courses that focused on reading tactics (comprehension methods and study skills) and writing composition (skills in writing unity, coherence, and control of serious sentence faults). Students taking none of these courses were assigned Level 5.

College level credit hours earned and college level GPAs excluded remedial courses, courses offered through community outreach activities, and courses not typically applicable to toward degrees (e.g., high school completion and GED courses). In mathematics and English, post-high school college level GPAs were also computed by excluding remedial courses, dual credits received for courses taken while in high school and credits for high school completion and GED coursework.

Degrees earned included certificates, technical/professional degrees, and transfer associate degrees. Terms-to-degree was defined to be the number of terms enrolled at Hawkeye College after high school attendance was completed and before attainment of the first associate degree was earned at the college. Students who earned certificates were excluded from this analysis, because HCC certificates typically take about half the time required for an associate degree.

Because the inception of RS was earlier than the CTE DC articulation agreement program, opportunities for students in the sample to participate in these high school educational experiences were restricted by age, and comparisons of DC and RS outcomes could be biased by the differential starting dates. Thus, age was controlled in these analyses.

Procedure

Descriptive statistics, chi-squared tests, and one-way ANOVAs were computed for remedial need and lowest level of remediation taken for the three groups of students—CTE DC, RS, and non-participants—in general and in the areas of mathematics and communication (Research Questions 1). Since these analyses of college readiness are absent necessary control variables, they do not necessarily reflect differences in the effectiveness of dual credit programs from others in preparing students for colleges. In particular, student age, gender, and race-ethnic groups were available and could control expected sources of variation in college readiness. It was expected, for example, that females would not be as college ready as males in mathematics, and that there might be gaps between Caucasian and other students in college readiness. Age of student might well affect readiness, as students who had been out of school longer when they took the placement exams would have forgotten information and lost skills that they had not used. Thus, all three variables were controlled in analyses of level of remediation needed in mathematics and in communication (Research Question 2). The focus here was on the difference between CTE DC students and others. Because RS requires students to pass placement exams, and the coursework involved is all college level and taken at HCC, participation in this program would not be expected to affect college readiness of these already college-ready students. In contrast, passing placement exams is not required for entry into CTE DC courses, and the courses could help ready students for college more effectively than high school courses that are not taught at the college level.

Since students were nested within high schools, hierarchical linear modeling was used for this analysis. To address the question concerning the effect of the degree of the high school's engagement in the CTE dual credit transition program, engagement ratings by the former director of the CTE DC consortium (HC3) were employed as a high school level variable. To control socioeconomic status to some extent, the proportion of students within a school who qualified for free or reduced-price lunch was entered at the second level.

Results

Need for Remediation

Overall, 70% of HCC students apparently needed some remediation, based on course-taking behavior, with the CTE DC group about equal to the non-participant group in remedial need, at about 74% and 73% respectively (see Table 3). However, only about half of RS students, compared to about three-quarters of others, took any remedial course. Given the near equality of the CTE DC and non-participant groups, the significant (at the $\alpha = .0005$ level) chi square of 134.733 ($df = 2$, $p < .0005$) probably resulted from the comparatively low proportion of RS students taking remedial courses.

In mathematics, about two-thirds attempted at least one remedial math course in the total, CTE DC, and non-participant groups. However, only about half of the students participating in RS took one or more mathematics remedial courses. The differences in these proportions was significant overall ($\chi^2 = 88.24$, $df = 2$, $p < .0005$), and given the similarity of remediation rate for CTE DC and non-participants, at 69% and 66%, respectively,, it would appear that the superior college readiness of the RS students was the main reason for the significant difference.

In reading and writing, grouped together as communication, fewer students took remedial courses than they did in mathematics, with just over one-third (37%) doing so. Again, CTE DC students and non-participants were very similar in their need for remediation, at 38% and 41% respectively, but only 9% of RS students took remedial courses in this area. The latter difference undoubtedly accounts for the significant chi square of 337.799 ($df = 2$, $p < .0005$).

The mean level of lowest remedial mathematics course taken was 6.27 overall, and this equates to a course in introductory algebra (see Table 4 for means and standard deviations of all groups). The three groups differed at the .0005 level of significance in level of mathematics remedial course taken ($F = 84.78$; $df = 2, 6447$; $p < .0005$). Tests of differences between specific group means using the Tukey method ($\alpha = .05$) indicated that the RS students had a higher mean than either the CTE DC students or the non-participant group. The latter two groups did not differ in level of first course taken, however.

In communication, where less than half the students needed a remedial course, the mean level of course taken was 4.52 {approximately midway between the highest possible remedial course, and the first college level course). As in mathematics, the three groups differed in remedial level ($F = 149.273$, $df = 2, 6447$, $p < .0005$). Again, Tukey post hoc tests indicated that the RS students were at a higher level of college readiness than were either of the other two groups on average.

Remedial Need of CTE DC and Other Students

As mentioned previously, the first analyses did not control for several potential sources of confounding variability, such as age, sex, ethnicity, or socioeconomic status. These are controlled in the multilevel analyses that compare CTE DC and other students on mathematics and communication remedial levels.

Mathematics Remedial Level

The first step in a multilevel analysis is typically to conduct a one-way ANOVA to determine whether the level 2 intercepts vary randomly. This model estimates the school means on the dependent variable, and allows for the partition of variance into components that are within versus between schools. Results of this "null model" for mathematics are provided in Table 5. Here we see that the schools vary significantly at the $\alpha = .005$ level in mean remedial level of the lowest mathematics course taken ($\chi^2 = 88.53$, $df = 24$, $p < .005$), but most of the variance is at the student level, or within rather than between schools. Multilevel modeling would not even be required with only 1% of the variance between schools, but we proceeded with the analysis as planned in order to demonstrate the results.

We fitted the level 1 model, with gender, age, and dummies for race-ethnicity entered as controls, and CTE DC participation as the independent variable. All control and independent variables were grand mean centered, meaning that the model provided estimates of the adjusted means on the dependent variable, and the results provided an analysis of covariance model. In the presence of all these other controls, gender was still significant, with males taking higher mathematics courses by about a quarter of a level than did females. For race-ethnic category, Caucasian was the omitted category so that the coefficients provide contrasts between each group and white students. In this model both Native American and African American students took lower levels of remediation than did white students. No other controls were significant at the .05 level. More importantly, once these variables were controlled, participation in CTE DC while in high school had no effect on college readiness in mathematics as measured by the level of the lowest mathematics course taken. However, the school means still varied randomly even with these variables accounted for ($\chi^2=79.11$, $df = 24$, $p<.001$).

Next, we tested whether degree of school engagement in the CTE DC program affected the school average remedial level (adjusted for controls) or the effect of CTE DC at that school by modeling the school intercepts and their CTE DC slopes. Before attempting to model slopes, the dual credit participation slopes were tested to see if they varied by schools. The results (not shown) indicated that they do vary at the .05 level of significance, with a chi square value for the dual credit slope variance component of 36.39 ($df = 21$, $p < .05$). Similarly, in comparison to the deviance for the previous model, the deviance in this one suggested significantly better fit, with chi square of 5.94 ($df = 2$, $p < .05$).

In the next model, both school level variables, proportion of students with free or reduced-price lunch, and degree of engagement in the transition program, were applied to both slopes and intercepts. Table 5 indicates that neither CTE DC participation nor level of school engagement in the program had a significant effect, either on the adjusted school means or on the slopes of the dependent variable on participation. Thus, there is no evidence from this analysis that CTE DC participation had an effect on mathematics readiness. Similarly, engagement of the school did not affect the mean readiness for the school or the effectiveness of DC participation in terms of mathematics readiness.

Communication Remedial Level

As with mathematics, the communication null model indicated significant variation in the population of school means ($\chi^2 = 154.06$, $df = 24$, $p < .001$), but very little variation at the school level (about 3%; see Table 6). The level 1 model, fitted next, employed the same variables as the mathematics level 1 model, with similar results in terms of the effect of CTE DC participation. CTE DC participation had no effect on communication college readiness at the .05 level of significance. The effects of the covariates were somewhat different, with three race-ethnic groups less ready in this area than were white students: Asian and Pacific Islanders were about one-quarter level behind Caucasian students, African Americans were about one-third level behind, and Hispanic students were about one-fifth level behind whites. On the other hand, in the area of communication, there was no gender difference evident in this analysis. Even with these variables accounted for, the school means still varied randomly.

The next step was to model CTE DC slopes and school intercepts by controlling for free and reduced-price lunch and testing for an effect of level of school engagement. Before attempting this, the CTE DC participation slopes were tested to see if they varied by schools. The results suggest they did not at the .05 level of significance, with a chi square value for the CTE DC slope variance component of 25.61 ($df = 21$, $p > .20$). Similarly, in comparison to the deviance for the previous model, the deviance in this one suggested no significantly better fit, with chi square of 0.44 ($df = 2$, $p > .50$). Since there was no variance to be modeled or accounted for, the level of school engagement was not used as a predictor of school slopes. However, the slope of communication remedial level on CTE DC participation was nonetheless controlled for free and reduced-price lunch in order to see whether the slope was significant when this characteristic of the schools was controlled. Even with free lunch controlled, CTE DC participation did not have a significant effect on the level of communication remediation needed. Schools with relatively high levels of students with reduced or free lunch eligibility did indeed have lower average starting levels in communication coursework, however, even after student race-ethnic group and other student level variables were controlled and free lunch was controlled at the school level. With these factors controlled, variation in the level of school engagement in the CTE DC transition program was negatively related to average starting levels in communication courses, not the expected direction.

Relationship of Remedial Need to Other PSE Outcomes

Having established that CTE dual credit participation does not affect remedial need in mathematics or communication, but level of school engagement in the program has a negative relationship with level of college readiness in communication (Research Question 2), the next question addressed was the extent to which the need for remediation was related to later outcomes of postsecondary education (Research Question 3). Retention, progress, and performance were measured by college level credits earned, term count before the associate degree was achieved, cumulative college level GPA, GPAs in post-high school mathematics and communication courses achieved, and whether or not the student earned a degree or certificate during the time period of the study. All correlations were controlled for age, race-ethnicity, gender, and participation in CTE DC or RS. The controls for dual credit participation were introduced because of the group differences in remedial need observed earlier between RS participants and others. Table 7 indicates that with the exception of terms to the associate degree, all partial correlations between the variables indicating remedial need and these longer term outcomes were small, although given sample size most of them were significant and most are in the expected direction. Thus, taking at least one remedial course of any sort, taking one in mathematics, and taking one in communication were each positively and moderately correlated with the number of terms to a degree. Generally, students who take remedial courses of either sort are slowed down in their degree progress. At the same time, getting a degree or certificate had a small negative correlation with taking remediation in communication. All three GPA measures were negatively correlated with all three measures of remedial course-taking. Students taking one or more remedial courses had somewhat lower GPAs overall, and also in post-high school college level courses in mathematics and English. The one surprise was the positive correlations of taking one or more remedial courses in anything or in math with college level credits earned.

The levels of remediation needed correlated positively with college level credits earned, earning a certificate or degree, and all of the GPAs. Thus, students with the most severe remedial need tended to accrue fewer college level credits, were less likely to earn certificates or degrees, and tended to earn lower GPAs than did students with lesser degrees of remedial need. With negative correlations between remedial levels and terms-to-degree, students needing much remediation tended to take longer to earn their certificates or degrees as expected. Unlike the small correlations with the other variables, remedial levels were moderately associated with terms to the degree.

Comparison of CTE DC, RS, and Other Students on Outcomes

Finally, CTE DC and RS participants' performances on these later PSE outcomes were investigated, controlling for age, gender, race-ethnicity, and the level of remedial need. Level of remedial need served as a control for prior academic achievement, missing in the earlier analyses. Indeed, the latter control was quite specifically needed because RS students were less likely to need remediation in mathematics or communication than were CTE DC students. Table 8 indicates that with these other factors controlled, RS students need fewer terms to their degrees than do those not participating in any dual credit program, but CTE DC students take about the same amount of time as these others. When the coefficients for RS and CTE DC participation are compared, the RS coefficient, -2.122, is significantly larger in the negative direction ($p < .000005$) than the CTE coefficient, -.022, indicating that RS students took less time to earn their degress as measured in terms enrolled.

The above regression function can explain about 45% of total variance in the term-to-degree variable. Among controls, younger students used fewer terms to obtain a degree, and the fewer math or communication remedial courses students took, the fewer quarters they needed to spend for graduation with an associate degree. Specifically, each additional level of remediation needed in mathematics predicted about half (45%) an additional term, while each additional level of communication remediation suggested almost a whole additional term (89%) would be needed. Oddly, Asian-American students needed more quarters for the degree than did Caucasian students of the same age, gender, and levels of remedial need.

Both RS and CTE DC students earned more credit hours at the college level than did students who did not participate in either of these dual credit opportunities while in high school, as indicated by the significance of both (see Table 9). RS students earned more credit than did CTE DC students, on the average, as indicated by the significant ($p < .000005$) difference between their regression coefficients of 32.526 and 15.638, respectively. These effects were about one quarter's worth of credit for CTE DC students, and about two quarters for RS participants, at 15 credit hours per quarter. Among controls, males earned a bit less credit than females, and both American Indian and African American students earned about seven credits less than Caucasian students, on the average. Older students earned more credit than younger students. Finally, unlike time to degree, the remedial levels were not significant predictors of credit hours earned, after other factors were accounted for.

Both CTE DC and RS students earned higher GPAs than did other students, on the average, as indicated by the significance of their regression coefficients (see Table 10).The CTE students' GPAs were higher than the RS students' , as indicated by the significant ($p < .000005$) difference between their regression coefficients of .801 and .341, respectively. As with credit hours earned, males earned lower GPAs than females, an American Indian and African American students earned lower GPAs than did Caucasian students, on the average. Older students earned slightly higher GPAs, and the closer to college level the student's remedial level, the higher the college level GPA, on the average.

Discussion

A large percentage of HCC students took at least one remedial course in either mathematics or communication. However, at 70%, this number falls squarely in the middle of recent estimates of remediation rates of new community college students as high as 60% to 80% (Adelman, 2004; Grubb, 1999c). The need was greater in math than in communication, with the average student being two remedial levels short of college ready in mathematics but only half a level in arrears in communication. These data underscore the heavy burden placed on community colleges to prepare students for college level work. However, as long a open door admission remains the rule, offering higher education to all who would seek it, remediation will continue to be a significant responsibility at these institutions. At the college under study here, high school graduation is not a requirement for matriculation, and placement tests are the only examinations required. That two-thirds of students take some remedial work should not necessarily be viewed with sock or alarm under these circumstances.

Running Start students, who take their dual credit courses on the college campus and must pass relevant placement tests before doing so, were in substantially less need of remediation than were CTE dual credit students. The CTE DC program offers select, articulated technical courses for dual credit in the high school. Students with an A or B receive dual credit, but no placement testing is required. While it might be expected that achievement of an A or B would indicate readiness to manage college level work, it seems quite possible that some of these courses would not involve much use of college level mathematics or writing. Nonetheless, the fact that three quarters of CTE DC students took some remediation does not seem to support the argument that dual credit courses serve to ready students for college. Of course, this overall remediation rate is absent controls for variables such as race-ethnic group, SES, and prior academic achievement so it is possible that the makeup of the group is such that even more of these CTE students would have needed remediation had they not taken dual credit in high school.

A better test of the extent to which dual credit programs prepare high school students for college level work compared the math and communication remedial levels of the CTE DC students with all others. Even though controls were in effect for age, gender, race-ethnic group, and proportion of students in the school that were eligible for free or reduced-price lunch, no effect of CTE dual credit participation was evidenced for either remedial level. The absence of control for prior academic achievement weakens this result, however, as it is conceivable that CTE DC participants are generally very weak students compared to non-participants. In this case, the absence of a difference between the groups could actually be a positive result. High school transcript analysis will be possible for a small sample of these students for whom transcripts are available, and will hopefully clarify this issue when completed.

While there was no effect of level of engagement of the high school in the CTE DC program on mathematics, for communication level of remediation the more engaged high schools tended to enroll students at HCC who took lower levels of communication courses than did students from less engaged high schools. We can only speculate that this puzzling result could have to do with level of school resources and prior academic achievement of the students, neither of which we were able to control. We picture that the more engaged schools may also have relatively strong resource bases and may be strongly engaged in multiple programs, such as providing strong college counseling. If so, their higher achieving students may be more likely to go to four-year schools than would high achieving students in schools that have fewer resources for programs such as these. Another possibility may be that schools that devote more resources to CTE DC programs may have fewer to devote to their own remedial courses, or to curricula designed to help students disinclined to pursue academics (perhaps the very students most likely to choose community college over four-year institutions, or to be attracted to CTE).

A final note on this analysis pertains to race-ethnic and gender effects. Race-ethnic gaps were found for math between both American Indian and African American students and white students. For communication there was no American Indian gap, but Asian and Pacific Island (AOI) students and also Hispanic students as well as African Americans took lower level remedial communication courses than did white students. While the API and Hispanic gaps could easily have to do with some students with languages other than English as their first language, English as a second language (ESL) courses were not included in our definition of remedial communication courses. Thus, the differences pertain to the non-ESL remedial reading and writing courses in which these students tend to start at a lower level than do Caucasian students.

Among the later outcomes studied, only terms to the associate degree had moderate relationships with the various indices of remedial need. These data indicate that needing and taking remediation slows down degree completion among those who complete associate's degrees. The other relationships were weak, however, suggesting that readiness for college is not itself a strong predictor of ultimate success. If remedial programs work well, and if students continue beyond then, this would be the desired result.

Performance, measured by GPA, was negatively correlated with remedial need in math, communication, or both. Students with a higher remedial need tend to have lower GPAs, which makes sense: if remedial level is considered a measure of prior academic achievement it would be expected to predict future college performance. One measure that combines retention and performance, the number of college level credits earned, was positively correlated with remedial taking at least one remedial math course. This is unexpected (remedial courses at Hawkeye College do not provide college level credit), because there would seem to be less of an opportunity for a student to earn college level credits if the student has to spend time in one or more remedial courses, especially in an intensive subject like math. One explanation is that math is a sequential subject, and no further classes in the student's chosen pipeline may be taken until requisite math skills are acquired. Because many students wish to take more than one class in a given term, extra electives may be taken along with the remedial math course. However, when remedial need is measured by lowest level of remedial course taken, the relationships are in the expected directions. Students with the most severe remedial need tend to have fewer college level credits, are less likely to earn certificates or degrees, and tend to have lower GPAs. They also tend to take longer to graduate, enrolling in more terms before earning their degrees.

This latter result brings us to the fourth research question, do CTE DC students and RS students need less time to earn associate's degrees than non-participants in these programs? In these analyses, prior academic achievement was controlled by use of remedial course levels in math and communication, and all other controls were retained. In short, the RS students need an average of two less quarters to complete their degrees than CTE DC students or non-participants, and the CTE DC students do not differ significantly from the non-participants themselves. Perhaps the simplest explanation for this result is the versatility of the dual credit courses taken. In the RS program, students can earn dual credit for core academic courses that may be applied to a much wider variety of degree programs than the typically much more specialized courses offered in CTE. Thus, if a student decides to change major, s(he) is much less likely to lose time if the dual credit is in core courses than if it is in a specialized technical field. Support for this view lies within a related result: RS students have more college level credit on average than CTE DC students, and both groups have more credit than non-participants. Although the CTE DC students have more credit, they did not differ from non-participants in the number of terms to degree, indicating that the additional credit may have not been applicable to the chosen major. However, RS students have much more credit than either group, but still took less time to graduate, indicating that not only was the credit applicable, but most likely a significant portion was earned in high school (recall that only post-high school terms to degree were counted). Alternatively, however, it is quite possible that CTE DC and RS students differ in credits taken per term, as they might if one group was more involved in jobs than the other. This could account for the difference in terms-to-degree, and we will investigate the possibility in later analyses.

Interestingly, the results show that the CTE DC students have higher GPAs than RS students, and both groups have higher GPAs than non-participants. At least a partial explanation for this is simple: CTE DC students only get college level credit for their dual credit courses if they earn grades of "B" or better. On the other hand, RS students receive credit for any grade but "F." This naturally, biases the results in favor of the CTE DC students, but not for the RS students. It also biases the results for credits earned against the CTE DC students. So, whereas the results regarding the RS versus non-participant groups on these two variables can still be justifiably retained, the results regarding comparison to the CTE DC group must be qualified.

What have we learned from these data with regard to dual credit programs? While not fully controlled, the data provide no support for the belief that dual credit courses in high school can help prepare students for college—there is no evidence here that CTE DC participants are more college ready than non-participants. Further, it seems that even with prior academic achievement controlled, in the form of lowest levels of remedial courses taken, RS speeds degree completion but CTE DC does not do so. Dual credit participation does favorably affect total college level credits earned by students who subsequently enroll at the community college, however, even when remedial need, age, gender, and race-ethnicity are controlled. RS students earn even more credit than do TE DC students, though the trade-off is that in this program in which only Bs and As are recorded for CTE DC courses, students with such credit go into college with a GPA boost that seems to last. Cumulative GPAs in college level courses favored CTE DC students over RS and non-participating students. We conclude that DC programs of both types can be beneficial, even though they may not affect remedial need or time to degree.

References

Adelman, C. (1999). *Answers in the tool box: Academic intensity, attendance patterns and bachelor's degree attainment*. Washington, DC: U.S. Department of Education.

Adelman, C. (2004). *Principal indicators of student academic histories in postsecondary education, 1972-2000.* Washington, DC: U.S. Department of Education.

Adelman, C. (2005). *Moving into town—and moving on: The community college in the lives of traditional-age students.* Washington D.C: U.S. Department of Education, Office of Vocational and Adult Education.

Bailey, T. & Karp, M. (2003). *A review of credit-based transition programs.* Washington D.C.: U.S. Department of Education, Office of Vocational and Adult Education.

Bailey, T R., Hughes, K. L., & Karp M. M. (2003). *Dual enrollment programs: Easing transitions from high school to college. CCRC Brief 17*. New York: Columbia University, Teachers' College, Community College Research Center.

Barnett, E., Gardner, D., & Bragg, D. (2004, March). *Dual credit in Illinois: Making it work.* Champaign: Office of Community College Research and Leadership, University of Illinois at Urbana-Champaign.

Berry, L. (2003). Bridging the gap: A community college and area high schools collaborate to improve student access in college. *Community College Journal of Research and Practice, 27*, 393-407.

Cabrera, A. F., & LaNasa, S. M. (2001). On the path to college: Three critical tasks facing America's disadvantaged. *Research in Higher Education*, *42*(2)*,* 119-149.

Callan, P. M., & Finney, J. E. (2003, June) *Multiple pathways and state policy: Toward education and training beyond high school*. Retrieved February 9, 2005 from The National Center for Public Policy and Higher Education Web site: http://www.highereducation.org/reports/multipath/Multipathstate.pdf

Catron, R. K. (2001). Dual enrollment in Virginia. In P. F. Robertson, B. G. Chapman, & F. Gaskin (Eds.). Systems for offering concurrent enrollment at high schools and community colleges (pp. 51-58). *New Directions for Community Colleges,* No. 113. San Francisco: Jossey-Bass.

Clark, R. W. (2001). *Dual credit: A report of programs and policies that offer high school students college credits.* Seattle, WA: Institute for Educational Inquiry.

Ewell, P. T., Jones, D. P., & Kelly, P. J. (n.d.). *Conceptualizing and researching the educational pipeline: National Center for Higher Education Management Systems*. The National Information Center for Higher Education and Policymaking and Analysis. Retrieved November 15, 2004 from http://www.higheredinfo.org/suppinfo/Pipeline%20Article.pdf

Grubb, W. N. (1999a). *Edging toward effectiveness: Examining postsecondary occupational education.* Independent Advisory Panel Meeting. National Assessment of Vocational Education. May 6-7. Retrieved February 25, 2005 from http://www.tc.columbia.edu/ccrc/PAPERS/nave02.pdf

Grubb, W. N. (1999b). *The economic benefits of sub baccalaureate education: Results of national studies.* Brief No. 2. New York: Community College Research Center, Teachers College, Columbia University.

Grubb, W. N. (1999c). *Honored but invisible*. Metro: Routledge.

Haycock, K., & Huang, S. (2001). Youth at the crossroads: Facing high school and beyond. [Electronic version] *The Education Trust, 5,* 1-24.

Hershey, A., Silverberg, M., Owens, T., & Hulsey, L. (1998). *Focus for the future: The final report of the national tech-prep evaluation.* Princeton, NJ: Mathematica Policy Research.

Karp, M. M, Bailey, T., Hughes, K., & Fermin, B. (2004, September). *State dual enrollment policies: Addressing access and quality*. Washington D.C.: U.S. Department of Education, Office of Vocational and Adult Education.

Kemple, J. J., & Snipes, J. C. (2000). *Career academies: Impacts on students' engagement and performance in high school.* New York: Manpower Demonstration Research Corporation.

Kim, J. (2005). *The impact of dual and articulated credit on college readiness and total credit hours in four selected community colleges.* Unpublished doctoral dissertation, University of Illinois at Urbana-Champaign.

Kim, J., Bragg, D., & Barnett, E. (2001). *Illinois' Tech Prep on-site review and improvement process for 2000-2001: Cross-consortium results and implications for practice.* Champaign: Office of Community College Research and Leadership, University of Illinois at Urbana-Champaign.

Kirst, M., & Venezia, A. (2001). Bridging the great divide between secondary schools and postsecondary education. *Phi Delta Kappan, 83*(1), 92-97.

Kist, M. W., & Venezia, A. (2004). *From high school to college: Improving opportunities for success in postsecondary education.* San Francisco: Jossey-Bass.

Pedraza, R. A,, Pauly, E., & Kopp, H. (1997). *Home grown progress*. New York: MDRC.

Perin, D. (2002). The location of developmental education in community colleges: A discussion of the merits of mainstreaming vs. centralization. *Community College Review, 30*(1), 27-44.

Peterson, K (2003). *Overcoming senior slump: The community college role.* (ERIC Digest No. EDO-JC-03-01). Los Angeles: ERIC Clearinghouse for Community Colleges. Retrieved March 2, 2005 from http://www.ericdigests.org/2004-1/slump.htm

Peterson, M. K., Anjewierden, J., & Corser, C. (2001). Designing an effective concurrent enrollment program: A focus on quality of instruction and student outcomes. In P.F. Robertson, B.G. Chapman, & F. Gaskin (Eds.) Systems for offering concurrent enrollment at high schools and community colleges (pp. 23-32). *New Directions for Community Colleges, No.* 113. San Francisco: Jossey-Bass.

Puyear, D. E., Thor, L. M., & Mills. K. L. (2001). Concurrent enrollment in Arizona: Encouraging success in high school. In P.F. Robertson, B.G. Chapman, and F. Gaskin (Eds.), Systems for offering concurrent enrollment at high schools and community colleges (pp. 33-42). *New Directions for Community Colleges, No.* 113. San Francisco: Jossey-Bass.

Robertson, P. F., Chapman, B. G., & Gaskin, F. (Eds.) (2001). Systems for offering concurrent enrollment at high schools and community colleges. *New Directions for Community Colleges*, No. 113. San Francisco: Jossey-Bass.

Swail, W., & Perna, L. (2002). Pre-college outreach programs: A national perspective. In L. S. Hagedorn & W. G. Tierney (Eds.), *Increasing access to college: Extending possibilities for all students* (pp. 15-34). Albany, NY: State University of New York.

Tierney, W. G., & Hagedorn, L. S. (Eds.). (2002). *Increasing access to college: Extending possibilities for all students.* Albany: State University of New York Press.

Townsend, B. (2000). Blurring the lines: Transforming terminal education. In D. Bragg (Ed.), The new vocationalism in community colleges (pp. 63-72). *New Directions for Community Colleges*, No. 115. San Francisco: Jossey-Bass.

Author Note

Jacob Marszalek, Department of Educational Psychology, University of Illinois at Urbana-Champaign.

Rongchun Zhu, Department of Educational Psychology, University of Illinois at Urbana-Champaign.

Jane W.Loeb, Department of Educational Psychology, University of Illinois at Urbana-Champaign.

Debra Bragg, Department of Educational Organization and Leadership, University of Illinois at Urbana-Champaign.

Margaret Brooks-Laraviere, School of Social Work, University of Illinois at Urbana-Champaign.

The work reported was supported by the National Research Center for Career and Technical Education at the University of Minnesota, and the National Dissemination Center for Career and Technical Education at The Ohio State University, through contracts with the Office of Vocation and Adult Education of the United States Department of Education. However, the contents do not necessarily represent the positions or policies of any of these institutions.

Table 1

Proportion with Free/Reduced Lunch and Level of Engagement in CTE Dual Credit for Sample High Schools

School	Enrollment	Sample Size	Free/Reduced Lunch	CTE DC Engagement
1	1871	513	0.266	Moderate
2	730	18	0.201	Low
3	1478	349	0.409	Low
4	1379	296	0.183	Moderate
5	680	154	0.287	Low
6	1409	225	0.141	High
7	777	102	0.222	Moderate
8	1936	253	0.471	Moderate
9	1159	281	0.380	Low
10	1743	73	0.066	Low
11	1564	833	0.144	High
12	1521	434	0.193	Low
13	1745	126	0.639	Moderate
14	524	124	0.200	Moderate
15	1527	52	0.213	Low
16	1559	701	0.166	High
17	1765	512	0.300	Moderate
18	1705	107	0.271	Low
19	675	239	0.095	Moderate
20	1702	356	0.184	Low
21	237	49	0.354	Low
22	965	244	0.396	Low
23	1250	141	0.221[a]	Moderate
24	1726	175	0.292	Moderate
25	1447	93	0.313	Moderate

Note. Data obtained from the Washington State Office of Superintendent of Public Instruction website (http://reportcard.ospi.k12.wa.us/) on May 8, 2005, from 2003-04 school report cards.
[a]No data were available on the school report card, so 2002-03 data (2003-04 data were unavailable) gathered from the National Center for Education Statistics website (http://nces.ed.gov/globallocator/) on May 8, 2005, were used instead.

Table 2

Ethnicity and Gender Composition of Sample

	Ethnicity													
	American Indian/ Alaskan Native		Asian/ Pacific Islander		African American		Hispanic		Caucasian		Other, Unknown, or International Student		Total	
Gender	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Column %
Female	79	2.1	430	11.6	267	7.2	257	6.9	2527	68.1	153	4.2	3713	57.6
Male	35	1.3	364	13.3	252	9.2	158	5.8	1839	67.2	89	3.2	2737	42.4
Total	114	1.8	794	12.3	519	8.0	415	6.4	4366	67.7	242	3.8	6450	100.0

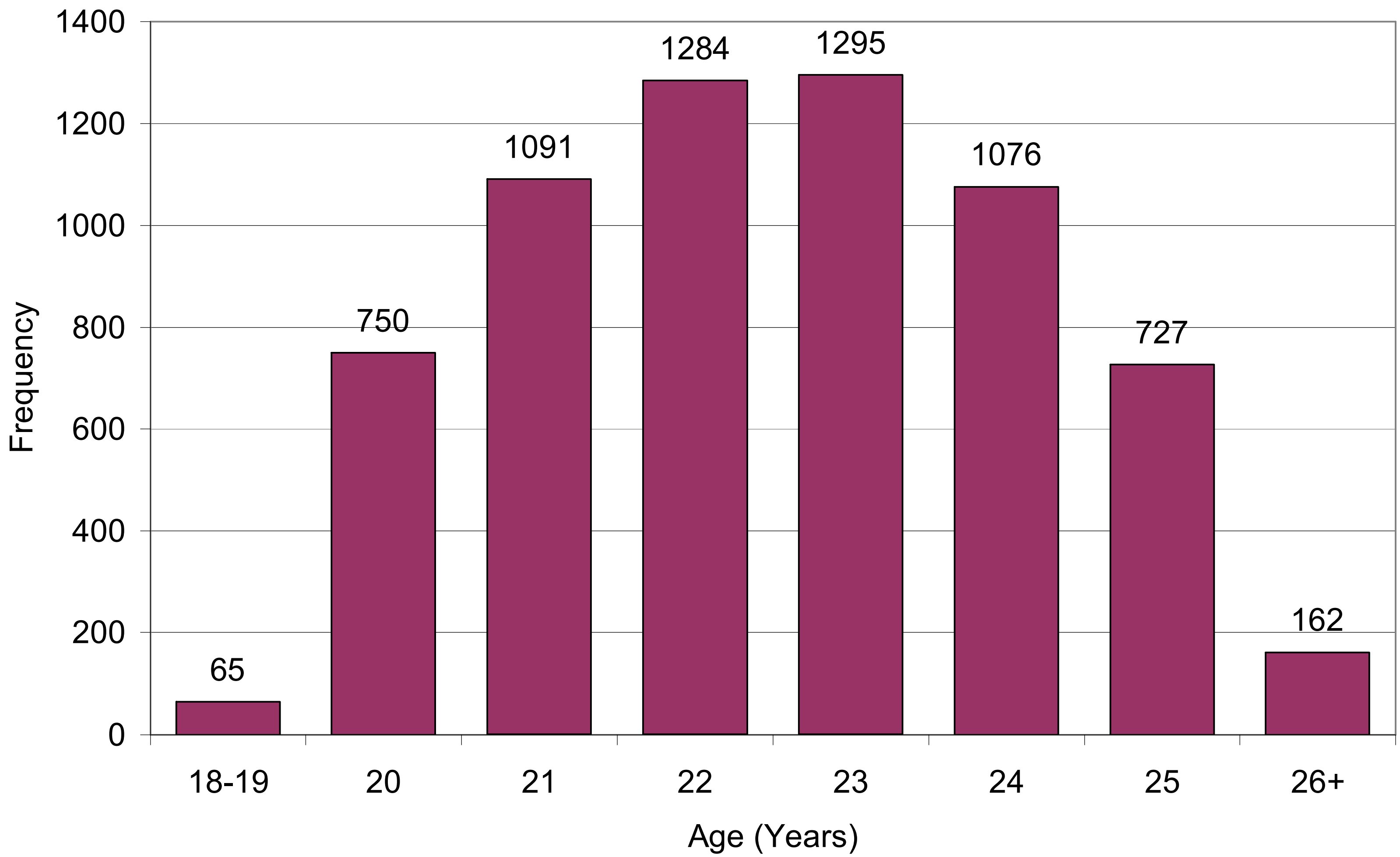

Figure 1. Frequency of ages of Hawkeye College students (N = 6450).

Table 3

Frequencies and Percents of CTE DC, Running Start and Others Taking at Least One Remedial Course (Math and Communication)

		Taking at least one remedial course		Taking at least one math remedial course		Taking at least one communication remedial course	
Participation	N	Count	%	Count	%	Count	%
CTE Dual credit	271	201	74.2	187	69.0	104	38.4
Running Start	863	459	53.2	430	49.8	74	8.6
Non-participant	5316	3856	72.5	3513	66.1	2182	41.0
Total	6450	4516	70.0	4130	64.0	2360	36.6

Note. For general remedial need, Pearson's chi-square was 134.733 (2 *df, p* < .0005).
For math remedial need, Pearson's chi-square was 88.241 (2 *d*f, *p* < .0005).
For communication remedial need, Pearson's chi-square was 337.799 (2 *df*, *p* < .0005).

Table 4

Level of Remediation Taken by CTE Dual Credit, Running Start, and Other Students

		Mathematics		Communication	
Groups	N	Mean	SD	Mean	SD
CTE DC	271	6.36	1.71	4.49	0.72
RS	863	7.02	1.35	4.91	0.31
Non-participants	5316	6.14	1.92	4.45	0.76
Total	6450	6.27	1.87	4.52	0.73

Note. For mathematics: $F = 84.70$, ($df = 2, 6647$; $p < .0005$). In post hoc Tukey test, only the differences of two pairs are significant: RS versus DC, and RS versus non-participants.
For communication: $F = 149.27$ ($df = 2, 6647$; $p < .0005$). In post hoc Tukey test, only the differences of two pairs are significant: RS versus DC, and RS versus non-participants.

Table 5

Two-Level Analysis of Student and School Differences in Effect of CTE DC Participation on Level of Mathematics Remediation Needed (Fully Unconditional Model, Only Level-1 Variable Model, and Full Model)

	Model a: fully unconditional model			Model b: only leve-1 variables			Model c: full model with level-1 and level-2 variables		
Fixed Effect	Coefficient			Coefficient		*t*	Coefficient		*t*
Mean	6.237			6.249			6.367		
Prop. Free/Reduced Lunch							-0.008		-1.992
Engagement with HC3							0.028		0.448
Age				-0.027		-1.858	-0.025		-1.767
Gender (1=male; 0=female)				0.242		5.183***	0.238		5.101***
American Indian				-0.435		-2.475*	-0.436		-2.481*
Asian/Pacific Island				0.090		1.212	0.103		1.374
African American				-0.810		-9.058***	-0.791		-8.770***
Hispanic				-0.194		-2.026	-0.185		-1.931
Other, Unknown, Foreign				0.094		0.770	0.089		0.731
DC Participation, Base				0.042		0.355	0.657		0.508
Prop. Free/Reduced Lunch							-0.008		-0.339
Engagement with HC3							-0.123		-0.426
Random Effect	Variance components	*df*	χ^2	Variance comp.	*df*	χ^2	Variance comp.	*df*	χ^2
Student (Level 1	3.452			3.392			3.382		
School (Level 2)	0.044	24	88.53***	0.034	24	79.11***	0.033	19	64.07***
Dual Credit Participation							0.349	19	36.22**
Deviance	26332.39	2	parameters	26248.48	2	parameters	26264.92	4	parameters

Note. *$p < .05$, **$p < .01$, ***$p < .001$.
In fully unconditional model, student level explains 98.7% of total variance, and school level explains 1.3%.

Table 6

Two-Level Analysis of Student and School Differences inEffect of CTE DC Participation on Level of Communication Remediation Needed (Fully Unconditional Model, Only Level-1 Variable Model, and Full Model)

	Model d: fully unconditional model			Model e: only leve-1 variables			Model f: full model with level-1 and level-2 variables		
Fixed Effect	Coefficient			Coefficient		*t*	Coefficient		*t*
Mean	4.509			4.512			4.782		
Prop. Free/Reduced Lunch							-0.006		-6.708***
Engagement with HC3							-0.039		-3.229**
Age				-0.008		-1.475	-0.008		-1.530
Gender (1=male; 0=female)				-0.013		-0.726	-0.015		-0.813
American Indian				-0.115		-1.674	-0.116		-1.696
Asian/Pacific Island				-0.264		-9.109***	-0.253		-8.878***
African American				-0.355		-10.154***	-0.337		-9.816***
Hispanic				-0.203		-5.440***	-0.197		-5.306***
Other, Unknown, Foreign				-0.005		0.100	0.001		0.030
DC Participation, Base				-0.074		-1.615	0.027		0.225
Prop. Free/Reduced Lunch							-0.004		-0.900
Random Effect	Variance components	*df*	χ^2	Variance comp.	*df*	χ^2	Variance comp.	*df*	χ^2
Student (Level 1	.528			.517			.517		
School (Level 2)	.015	24	154.06***	.006	24	75.246***	.000	22	26.90
Deviance	14242.79	2	parameters	14134.78	2	parameters	14140.75	2	parameters

Note. *p < .05, **p < .01, ***p < .001.
In fully unconditional model, student level explains 97.2% of total variance, and school level explains 2.8%.

Table 7

Partial Correlations of Remedial Course Need with PSE Outcomes, Controlled for Age, Gender, Race-Ethnicity and Proportion Free Lunch in the High School

	General remedial need	Math remedial need (1 = yes)	Communication remedial need (1=yes)	Math remedial level (1=worst)	Communication remedial level (1=worst)
Term to first degree in associate degree sample (N=1156)	.409**	.392**	.377**	-.400**	-.393**
College level credits earned (N=6438)	.118**	.136**	.015	.026*	.032*
College level GPA (N=6438)	-.091**	-.047**	-.120**	.136**	.150**
Earning a degree (1=yes; N=6438)	.004	.018	-.040**	.080**	.063**
GPA of post-high school college level math courses (N=2161)	-.110**	-.097**	-.157**	.074**	.165**
GPA of post-high school college level English courses (N=3741)	-.111**	-.090**	-.113**	.137**	.108**

Note. *p < .05, **p < .01, ***p < .001.
Because some variables are used for controlling, sample sizes drop.

Table 8

Comparison of CTE DC, RS, and Others on Terms to Associate Degree, Controlling for Remedial Levels,Summary of Regression Analysis for Variables of Remedial Course Levels, CTE DC and RS Participation, Age, Gender, and Race-Ethnicity Predicting Terms to Associate Degree (N=1166)

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	*t*	*p*
(Constant)	11.957	.556		21.491	<.0005
Math remedial course level (1=ABE)	-.445	.043	-.249	-10.426	<.0005
Communication remedial course level (1=ABE)	-.890	.113	-.191	-7.868	<.0005
CTE DC participation	-.022	.312	-.002	-.070	.944
RS participation	-2.122	.143	-.353	-14.810	<.0005
Academic age cohorts	.448	.044	.241	10.299	<.0005
Gender (1=male)	-.106	.119	-.020	-.888	.375
American Indian	-.147	.563	-.006	-.260	.795
Asian and Pacific Islander	.429	.183	.052	2.342	.019
African American	.107	.280	.008	.382	.703
Hispanic	.090	.246	.008	.365	.715
Blank or unknown ethnicity	.343	.313	.024	1.098	.272

Note. Adjusted $R^2 = 0.449$ and the regression function is significant, $F = 87.29$ ($df = 11, 1154$; $p < .0005$).
For ethnic groups, here Caucasian group is used as an anchor, and any other groups are compared to it one by one.

Table 9

Comparison of Summary of Regression Analysis for variables of Remedial Course Levels, CTE DC and, RS Participationand Others on College Level Credits Earned, Controlling for Remedial Levels,, Age, Gender, and Race-Ethnicity Predicting College Level Credits Earned (N=6450)

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	*t*	*p*
(Constant)	7.585	3.141		2.415	.016
Math remedial course level (1=ABE)	.313	.252	.016	1.242	.214
Communication remedial course level (1=ABE)	1.262	.652	.025	1.937	.053
CTE DC participation	15.638	2.188	.084	7.146	<.0005
RS participation	32.516	1.305	.298	24.912	<.0005
Academic age cohorts	5.120	.265	.227	19.285	<.0005
Gender (1=male)	-3.580	.875	-.048	-4.093	<.0005
American Indian	-7.364	3.275	-.026	-2.248	.025
Asian and Pacific Islander	-0.556	1.346	-.005	-.413	.680
African American	-7.019	1.623	-.051	-4.324	<.0005
Hispanic	-3.473	1.776	-.023	-1.955	.051
Blank or unknown ethnicity	-1.227	2.279	-.006	-.539	.590

Note. Adjusted $R^2 = 0.141$, and the regression function is significant $F = 97.52$ ($df = 11, 6438$; $p < .0005$).
For ethnic groups, Caucasian group is used as an anchor, and any other groups are compared to it one at a time.

Table 10

Summary of Regression Analysis for variables of Remedial Course Levels,Comparison of CTE DC, and RS Participation, and Others on College Level GPA, Controlling for Remedial Levels, Age, Gender, and Race-Ethnicity Predicting College Level GPA (N=6450)

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	*t*	*p*
(Constant)	.934	.101		9.260	<.0005
Math remedial course level (1=ABE)	.058	.008	.093	7.184	<.0005
Communication remedial course level (1=ABE)	.186	.021	.117	8.890	<.0005
CTE DC participation	.801	.070	.138	11.399	<.0005
RS participation	.341	.042	.100	8.124	<.0005
Academic age cohorts	.073	.009	.103	8.554	<.0005
Gender (1=male)	-.221	.028	-.094	-7.875	<.0005
American Indian	-.381	.105	-.043	-3.625	<.0005
Asian and Pacific Islander	-.032	.043	-.009	-0.740	.459
African American	-.366	.052	-.085	-7.011	<.0005
Hispanic	-.172	.057	-.036	-3.021	.003
Blank or unknown ethnicity	.057	.073	.009	.776	.438

Note. Adjusted R^2 = 0.094 and the regression function is significant F = 62.10 (df = 11, 6438; p < .0005).
For ethnic groups, here Caucasian group is used as an anchor, and any other groups are compared to it one at a time.