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The Impact of Dual and Articulated Credit on College Readiness and Retention in Four Community Colleges

JoHyun Kim
Western Illinois University

Debra D. Bragg
University of Illinois at Urbana-Champaign

Abstract

Using Astin's I-E-O model, relationships among the input (I) variables of gender, high school percentile rank, Tech Prep participation, and high school course-taking; environmental (E) variables of academic, career and technical education (CTE), and total dual credit and articulated credit; and output (O) variables of college readiness and total credit hours were investigated with a sample of 1,141 students drawn from an extant dataset called Community College and Beyond (CC&B). Multiple regression results showed a significant effect for dual credit hours and articulated credit hours earned on total college-level credit hours earned, while controlling for gender and educational background. Logistics regression revealed differences among the four community colleges on students being college ready in reading, writing, and mathematics.

Introduction

Community colleges contribute greatly to expanding students' access to higher education with their geographic proximity and competitive cost (Cohen & Brawer, 2003). The National Center for Education Statistics (NCES) (2006) reported that 4 of 10 undergraduate students in the U.S. enrolled in community colleges in 2003-2004. Almost all community colleges maintain an open door policy to provide greater opportunities for students to enroll in college (Cohen & Brawer, 2003). However, as Rosenbaum (1998) pointed out, the notion of an open door that aligns closely with open access is sometimes linked to lower standards and the enrollment of students who are not prepared academically. Indeed, the lack of academic preparation of students entering community colleges is a troubling national dilemma, with the percentage of students taking at least one remedial reading, writing, or mathematics course ranging from about 40% to over 60% (Adelman, 2006; Lewis, Farris, & Greene, 1996).

Along with remediation, student retention and completion is problematic for community colleges. Only about one-third of beginning full-time students earns associate degrees (Tinto, Russo, & Kadel, 1994). The NCES (1998) reported that

over 40% of students who enrolled originally in a two-year college left during their first year. Reporting similar findings, the Southern Regional Education Board (SREB, 2003) reported only 45% of community college first-time, full-time freshmen graduated in the period from 1998 to 2001, and that 32% of the students who completed their first year failed to return for their second year. These statistics suggested that, although an open door policy provides greater opportunities for students to engage in a collegiate experience, community college attendance is associated strongly with inadequate preparation and lowered student retention and completion.

Over the past two decades, numerous efforts have been made to assist students to transition from the secondary to the postsecondary level. Examples include Tech Prep supported by the Carl D. Perkins Career and Technical Education legislation and school-to-career (STC) or education-to-career (ETC) initiatives supported by the federal School to Work Opportunities legislation. Other educational reform initiatives include High Schools That Work (HSTW), career academies, middle college high schools, and dual and articulated credit programs and courses. Of these, Tech Prep and dual credit have received attention nationwide as potential solutions to the less than optimal transition experiences of high school students, including students who have not participated in a college preparatory curriculum. Through dual credit, students receive both high school and college credit for a college-level class completed successfully (Kim, Barnett, & Bragg, 2003). While Clark (2001), Greenberg (1989), and Puyear (1998) claimed that dual credit promotes better student transition, little is known about the impact of dual credit on student transition from high school to college. Even less is known about the impact of student experiences with respect to dual credit, articulated credit, and Tech Prep on college readiness; adequate levels of preparation to enroll in college-level courses; and college retention and performance. This study addresses this gap in the literature.

Literature Review

Dual credit has received considerable attention nationwide as a potential solution to the less than optimal transition of students (Andrews, 2001; Bailey, Hughes, & Karp, 2003; Pierce, 2001). According to Waits, Setzer, and Lewis (2005), about 71% of all public high schools offer courses that award dual credit, with approximately 1.2 million enrollments in dual credit courses in 2002-03. Kleiner and Lewis (2005) reported that 98% of public two-year institutions had high school students taking courses for college credit in 2002-03.

The literature and research studies are rich in claims of positive outcomes for dual credit (e.g., Andrews, 2001; Bailey, Hughes, & Karp, 2003; Boswell, 2000; Cartron, 2001; Chatman & Smith, 1998; Greenberg, 1989; Hugo, 2001; Karp, Calcagno, Hughes, Jeong, & Bailey, 2007; Pierce, 2001). Realizing the transitional problems students experience between secondary and postsecondary education, these

studies have suggested that dual credit programs have the potential to resolve disconnected curriculum, senioritis, high school dropout, and college remediation and attrition. However, like other educational programs, several issues have emerged as dual credit programs have evolved. Among these are limited access for low income and low achieving students, low academic quality, liability with underage high school students on the college campus, and inconsistent dual credit funding practices (Andrews, 2001; Clark, 2001; Fincher-Ford, 1996; Greenberg, 1989; Hughes, Karp, Fermin, & Bailey, 2005; Krueger, 2006; Oregon Joint Boards of Education, 2000).

Indeed, the dual credit literature abounds with positive and negative claims but is scarce with outcome studies. With a limited research base, it is unreasonable to generalize results on dual credit for several reasons. Most importantly, dual credit opportunities are often restricted to high school students with higher academic abilities and course-taking patterns (e.g., college preparatory). Additionally, higher academic achievers typically are more successful in college than less academically prepared students (e.g., Chatman & Smith, 1998). Without controlling for ability differences between dual credit and nondual credit students, it is not possible to know whether positive outcomes can be attributed to the program or to students' academic abilities. Only a few studies have controlled for students' prior academic performance in examining the influence of dual credit on academic performance. Four studies (Kotamraju, 2005; Nitzke, 2002; Richardson, 1999; Spurling & Gabriner, 2002) reported that dual credit students performed better; whereas, two studies (Chatman & Smith, 1998; Eimers & Mullen, 2003) found no differences in outcomes. Among three studies that controlled for students' academic ability in examining the influence of dual credit on student retention, two (Crook, 1990; Eimers & Mullen, 2003) reported a higher retention rate for dual credit students than all other comparison groups, while one (Nitzke, 2002) revealed that dual credit students earned less college credits than nondual credit students. Most recently, Karp et al. (2007) supported dual credit participation as a way to promote retention in postsecondary education. Given the growing concern for college remediation and claims made by dual credit advocates, it is perplexing that no studies were found that controlled for prior academic performance while investigating the influence of dual credit on college remediation. Given the growing interest in dual credit and the potential for substantial new investments into dual credit programs, empirical studies focusing on student outcomes are needed for further implementation of dual credit programs.

Conceptual Framework

This study uses Astin's Input-Environment-Outcome (I-E-O) model for its conceptual framework, providing three major components: Input variables, environment variables, and outcome variables (Astin, 1991, 1993). *Inputs* refer to those personal qualities the student brings initially to the educational program.

Environment refers to the student's actual experiences during the educational program. *Outcomes* refer to the gains made as a result of the educational program. Input variables are also called control variables; whereas, environment variables are independent variables, and outcome variables are dependent variables. Astin and Sax (1998) pointed out that in educational research, students may have different characteristics before participating in an educational program; therefore, the outcomes may not reveal the impact of program participation, but may simply represent differences in the characteristics of students. Considering this perspective, the I-E-O model controls for input differences, resulting in a more accurate estimate with respect to how environment variables influence student outcomes. Utilizing Astin's I-E-O model, the impact of dual credit on students' college outcomes was investigated while controlling for gender and educational background characteristics.

Purpose of the Study

The purpose of this study was to investigate how dual credits and articulated college credit hours influence college outcomes, while controlling for student gender and educational background characteristics. Accordingly, the following research question was posited: Are dual credit hours and articulated credit hours earned significant predictors of students' placement in remedial courses and college-level credit hours earned, controlling for student gender, high school percentile rank, Tech Prep participation, and high school course-taking?

Method

This study used a quantitative research design with an existing dataset from the *Community College and Beyond* (CC&B) study. The CC&B study examined secondary academic performance; transition from high school to the community college; community college participation, retention, and completion; and employment. The dataset contains approximately 4,700 student records representing students in local Tech Prep consortium in the states of California, Florida, Illinois, Ohio, Oregon, North Carolina, and Texas, and an anonymous state in the Northeast. A panel of experts selected these eight consortia, which were comprised of high schools with a community college district having one or more campuses. In the eight selected consortia, the student sample was selected based on systematic random sampling to ensure that the Tech Prep participant and nonparticipant groups were similar on high school academic performance. The CC&B study tracked high school graduates over a four-year period, collecting data using surveys and high school and community college transcripts. The study identified participants who earned dual or articulated credit hours in the Tech Prep and nonparticipant groups.

Of the eight original consortia included in the CC&B dataset, the Ohio, Texas, Florida, and Oregon consortia were selected for this study. The other four consortia were excluded because students in these sites did not have adequately detailed

records to ascertain dual or articulated credit course enrollment. The four consortia selected had an original sample size as follows: Ohio (n = 347), Texas (n = 583), Florida (n = 597), and Oregon (n = 483). To qualify as a participant in dual credit and articulated credit courses, individuals who enrolled in a community college must have had both high school and college transcripts showing enrollment in the courses and had to provide adequate evidence for transcript analysis. Thus, the sample was restricted as follows: Ohio (n = 188), Texas (n = 341), Florida (n = 339), and Oregon (n = 273). The sample was similar to the original total sample in terms of gender, educational background characteristics, and college outcomes. All identified students who graduated from high school in 1995, 1996, or 1997 and matriculated into the lead community college.

Further, documents and transcripts collected by the CC&B study provided the raw data essential to create the variables for this study. To identify dual and articulated course-taking and ensure accuracy, course catalogues, student handbooks, and information from high school and college websites were used. In some cases, student handbooks provided the list of dual credit or articulated credit courses. Information from these documents also confirmed the interpretation of dual credit and articulated credit status for the purpose of performing the transcript analysis. Dual and articulated course-taking included the variables of academic, career and technical education (CTE), and total dual and articulated credit hours earned. Students in the Texas consortium had all four types of credit, while the Ohio students had only articulated credit. Students in Florida and Oregon had the dual credit variables, only.

The dual and articulated credit variables served as the independent (environment) variables. The dependent variables were placement in remedial reading, writing, and mathematics serving as the measures of college readiness; and total college-level credit hours earned in which remedial credit hours, exam credit hours, and dual and articulated credit hours were excluded. Each consortium employed different types of placement tests, so the readers were cautioned against making a direct comparison of placement cutoff scores between the four consortia. It is also important to note that, in determining college readiness in mathematics, different cutoff scores were used for students enrolled in the community college, CTE, and transfer programs. In all four consortia, higher cutoff scores were required in mathematics for students in transfer programs. In addition, 10 control (input) variables were used and arranged into 4 categories: (a) gender, (b) high school percentile rank, (c) Tech Prep participation, and (d) high school course-taking, including seven variables associated with the quantity and rigor of mathematics and English courses, and the number of semesters of science and CTE courses.

Statistical analyses were performed separately for each consortium and the results were compared descriptively; therefore, the differences between consortium results were not tested. This approach was selected because the phenomena under investigation, particularly dual and articulated credit, were known to differ from

consortium to consortium. Accordingly, this investigation focused on the examination of group differences within consortia. Descriptive and inferential statistical analyses were used to answer the research question. In conducting multiple and logistic regression analyses, the block variable entry method was used (Pedhauser, 1997). All tests of statistical significance were conducted at an alpha level of .05, which is considered a reasonable level of accuracy for educational research (Glass & Hopkins, 1996).

The findings across the four consortia were presented to address the research question. The findings revealed within consortia were also discussed because of the insights they provided. In interpreting the magnitude of correlation coefficients, the range from 0.10 to 0.29 was considered a weak association, from 0.30 to 0.49 a moderate association, and from 0.50 to 0.69 a strong association (Davis, 1971).

Findings

Student Characteristics and Dual and Articulated Credit Hours

In the Ohio and Oregon consortia, males comprised the majority of the student sample. In the Texas and Florida consortia, females were the majority of the sample. Tech Prep participants comprised approximately 56% of the sample in Texas, 47% in Florida, 52% in Oregon, and 86% in Ohio. The mean High School Percentile Rank (HSPR) of students in the Ohio and Oregon consortia was 55%; whereas, the students in the Texas and Florida consortia had higher HSPRs, averaging about 67%.

Students in the Ohio consortium showed the highest mean number of semesters of mathematics and Oregon students showed the lowest. Analysis of the mean number of semesters of English revealed that students in the Florida consortium reported the highest mean and Ohio the lowest. In terms of the number of semesters of science, students in Ohio had the highest mean, with Oregon showing the lowest. The mean number of semesters of CTE courses was higher relative to the mean number of semesters of mathematics, English, and science for students in the Ohio, Florida, and Oregon consortia. Similar to mathematics and science, students in the Ohio consortium showed the highest mean number of semesters of CTE courses taken, as indicated by the significant correlation coefficient between Tech Prep participation and number of semesters of CTE courses taken ($r = 0.70$, $p < 0.001$).

With respect to the number of the highest mathematics course taken on a scale of 1 for basic mathematics to 13 for Advanced Placement (AP) Calculus and AP Statistics, students in the Texas consortium revealed the highest average, and students in the Oregon consortium reported the lowest average. A mean of 7.48 is equivalent to being between Honors and Analytic Geometry and Algebra II and 5.85 is approaching 6, which is Geometry. In terms of the mean percentage of AP/Honors mathematics and English courses, Texas students had the highest mean, while Ohio students revealed the lowest mean.

Dual and articulated credit course-taking included academic, CTE, and total dual credit and articulated credit hours earned. Regarding academic dual credit, about 5% of the student sample had academic dual credit in Texas, 38.9% in Florida, and 10.6% in Oregon. Florida students had a higher average on academic dual credit hours earned (M = 3.12, SD = 5.11) than students in Texas (M = 0.21, SD = 0.94) and Oregon (M = 0.77, SD = 2.38). Concerning CTE dual credit, about 1.5% of the Texas student sample had CTE dual credit, 19.8% of the Florida sample, and 23.4% of the Oregon sample. Oregon students had a higher average on the CTE dual credit hours earned (M = 0.98, SD = 2.03) than Texas (M = 0.06, SD = 0.51) and Florida (M = 0.75, SD = 1.70) students. In terms of total dual credit, only about 6% of the student sample had either academic or CTE dual credit hours in Texas, 42% in Florida, and 32% in Oregon. Students in the Florida consortium had a higher average number of total dual credit hours earned (M = 3.87, SD = 5.77) then students in Oregon (M = 1.75, SD = 3.03) and Texas (M = 0.26, SD = 1.09). Approximately 25% of the student sample had articulated credit in Texas. In the Ohio consortium, approximately 52% of the student sample had articulated credit. Ohio students also had a higher average number of articulated credit hours earned (M = 2.77, SD = 5.42) than the Texas students (M = 1.67, SD = 3.32).

With respect to the relationships between student characteristics and dual and articulated credit hours, the findings revealed a statistically significant mean difference in the Oregon consortium by gender, only with total dual credit hours earned. Higher average total dual credit hours were found for females compared to males, supporting the findings of Cesta (2003) and Windham (1996). In terms of the relationship between dual credit hours earned and Tech Prep participation, the Florida non-Tech Prep participants had a higher average number of academic dual credits than Tech Prep participants (M = 3.86, SD = 2.28 for non-Tech Prep participants; M = 2.28, SD = 4.76 for Tech Prep participants), and the difference was significant (t = -2.88, p = 0.004). In order to take academic dual credit courses, a minimum 3.0 unweighted grade point average (GPA) was required in Florida; non-Tech Prep participants had higher academic performance than Tech Prep participants based on cumulative GPA. Such contextual background needs to be considered when interpreting the data.

Oregon Tech Prep participants showed a higher average of CTE dual credit than non-Tech Prep participants (M = 1.63, SD = 0.27 for Tech Prep participants; M = 0.27, SD = 1.11 for non-Tech Prep participants), and the difference was significant (t = 5.84, $p \leq 0.001$). Considering that college credits associated with Tech Prep are CTE-oriented and students enrolled in a 2 + 2 Tech Prep sequence could earn dual credit in Oregon, these results are not surprising. In Texas, Tech Prep participants had more articulated credits than non-Tech Prep participants. In this consortium, course level articulation agreements form the basis for Tech Prep programs, giving Tech Prep participants more opportunity to take articulated credit courses than nonparticipants.

Table 1 summarizes the Pearson product-moment correlation coefficients between HSPR and high school course-taking and dual credit and articulated credit hours in the four consortia. In terms of HSPR, significant positive relationships were found between HSPR and the academic dual credit hours earned in Texas ($r = 0.23$), Florida ($r = 0.22$), and Oregon ($r = 0.31$). Although not strong, a significant positive correlation was found for HSPR and CTE dual credit hours earned in Texas ($r = 0.16$) and Florida ($r = 0.13$). In the Florida consortium, this finding is likely related to requirements that students who enroll in dual credit courses must have a 3.0 unweighted GPA. In the Texas consortium, students had to demonstrate a certain level of academic competency in high school such as passing one or more sections of the Texas Academic Skills Program (TASP) tests. Similar to Florida, the statistically significant relationships between dual credit and HSPR represent a logical consequence of dual credit students demonstrating higher academic performance.

The course-taking variables displayed interesting relationships with academic dual credit and CTE dual credit across the four consortia. With respect to results for the three consortia in Texas, Florida, and Oregon, statistically significant relationships were found between semesters of science and academic dual credit ($r = 0.25$ for Texas, $r = 0.13$ for Florida, and $r = 0.29$ for Oregon), highest mathematics level taken and academic dual credit ($r = 0.14$ for Texas, $r = 0.31$ for Florida, and $r = 0.32$ for Oregon), and Advanced Placement (AP) or Honors English and academic dual credit ($r = 0.18$ for Texas, $r = 0.20$ for Florida, and $r = 0.51$ for Oregon).

In regard to the relationship between HSPR and articulated credit, a significant but weak correlation was found among students in consortia in Texas ($r = 0.17$) and Ohio ($r = 0.17$). The number of semesters of mathematics revealed a significant but weak relationship with articulated credit in both of these consortia ($r = 0.12$ for Texas and $r = 0.15$ for Ohio). The number of semesters of CTE courses also showed a significant but weak relationship with articulated credit in both consortia ($r = 0.20$ for Texas and $r = 0.21$ for Ohio). Considering that all articulated credit courses offered in both consortia were CTE-oriented, this result is not surprising.

Dual and Articulated Credit Hours and College Readiness and Total College-Level Credit Hours Earned

Students in all four consortia showed a fairly high level of college readiness in reading (about 88.5% in Texas, 72.3% in Florida, 88.4% in Oregon, and 83.6% in Ohio) and writing (about 90.1% in Texas, 70.8% in Florida, 86.2% applying career standard and 40.9% applying transfer standard in Oregon, and 83.6% in Ohio). In all four consortia, readiness in mathematics was lower than reading and writing applying the career standard (about 81.1% in Texas, 67.1% in Florida, 76.4% in Oregon, and 61.0% in Ohio) and even lower applying transfer standard (about 51.4% in Texas, 17.3% in Florida, 10.4% in Oregon, and 33.9% in Ohio).

Table 1
Correlations between HSPR and High School Course-Taking and Dual Credit and Articulated Credit Hours

Characteristics	Academic DC	CTE DC	Total DC	Articulated Credit
	Texas			
HSPR	0.23**	0.16**	0.27**	0.17**
Semesters of mathematics	0.04	0.04	0.06	0.12*
Semesters of English	0.07	-0.07	0.02	0.04
Semesters of science	0.25**	0.08	0.25**	0.13*
Semesters of CTE	-0.04	-0.11*	-0.08	0.20**
Highest mathematics level	0.14*	0.11*	0.17**	0.14*
% AP/Honors mathematics	0.22**	0.21**	0.29**	0.12*
% AP/Honors English	0.18**	0.18**	0.24**	0.12*
	Florida			
HSPR	0.22**	0.13*	0.23**	-
Semesters of mathematics	0.27**	0.03	0.25**	-
Semesters of English	0.42**	0.06	0.39**	-
Semesters of science	0.13*	-0.09	0.09	-
Semesters of CTE	-0.18**	-0.17**	-0.21**	-
Highest mathematics level	0.31**	0.10	0.31**	-
% AP/Honors mathematics	0.09	0.07	0.10	-
% AP/Honors English	0.20**	0.06	0.20**	-
	Oregon			
HSPR	0.31**	0.004	0.24**	-
Semesters of mathematics	0.23**	-0.13*	0.10	-
Semesters of English	-0.03	-0.05	-0.06	-
Semesters of science	0.29**	-0.02	0.22**	-
Semesters of CTE	-0.14*	0.40**	0.15*	-
Highest mathematics level	0.32**	-0.07	0.20**	-
% AP/Honors mathematics	0.22**	-0.02	0.16**	-
% AP/Honors English	0.51**	-0.06	0.36**	-

Table 1 *(continued)*
Correlations between HSPR and High School Course-Taking and Dual Credit and Articulated Credit Hours

Characteristics	Academic DC	CTE DC	Total DC	Articulated Credit
		Ohio		
HSPR	-	-	-	0.17*
Semesters of mathematics	-	-	-	0.15*
Semesters of English	-	-	-	0.15*
Semesters of science	-	-	-	0.01
Semesters of CTE	-	-	-	0.21**
Highest mathematics level	-	-	-	0.11
% AP/Honors mathematics	-	-	-	-0.07
% AP/Honors English	-	-	-	-0.04

* $p < 0.05$. ** $p < 0.01$.

The range of the average of total credit hours earned was between 21.5 and 46.4 (about 29.1 in Texas, 20.5 in Florida, 32.4 in Oregon, and 46.4 in Ohio). It should be noted that the Ohio and Oregon community colleges use the quarter system; whereas, the community colleges in the Texas and Florida consortia use the semester system. Therefore, under the same conditions, students in Ohio and Oregon would receive more credit hours than those in the other two consortia. In general, full-time students take about 15 credit hours per quarter in quarter systems and 12 credit hours per semester in semester systems. Five credits are usually converted as 3.3 credit hours when students transfer from quarter to semester systems. Since this study did not test the differences between consortium results, no attempt was made to convert total credit hours earned into the same credit system to make them comparable. Given the different credit systems, it was important to note that Texas surpassed Florida and Ohio surpassed Oregon.

Dual credit and articulated credit hours and college readiness. Overall, dual credit hours earned and articulated credit hours earned had significant relationships with college readiness. Articulated credit hours earned had a significant positive relationship with being college ready in reading and writing; whereas, academic dual credit hours earned had a significant positive relationship with college readiness in mathematics. Table 2 summarizes the results.

When the transfer major criterion was applied, academic dual credit hours earned yielded a significant positive relationship with college readiness in mathematics in Texas ($r = 0.15$) and Oregon ($r = 0.19$), and the strongest relationship in Florida ($r = 0.34$). When the career major criterion was applied, a significant but

Table 2
Correlations between College Readiness and Dual Credit and Articulated Credit Hours

College Readiness	Academic DC	CTE DC	Total DC	Articulated Credit
		Texas		
Reading	0.07	0.01	0.06	0.12*
Writing	0.06	0.00	0.06	0.17**
Mathematics (Transfer)	0.15**	0.09	0.18**	0.07
Mathematics (Career)	0.10*	0.03	0.10	0.18**
		Florida		
Reading	0.12	0.12	0.14*	-
Writing	0.08	0.12	0.11	-
Mathematics (Transfer)	0.34**	0.02	0.30**	-
Mathematics (Career)	0.23**	0.13*	0.24**	-
		Oregon		
Reading	0.09	0.04	0.09	-
Writing (Transfer)	0.20**	-0.07	0.09	-
Writing (Career)	0.09	0.05	0.10	-
Mathematics (Transfer)	0.19**	-0.03	0.11	-
Mathematics (Career)	0.06	-0.02	0.03	-
		Ohio		
Reading	-	-	-	0.17*
Writing	-	-	-	0.16*
Mathematics (Transfer)	-	-	-	0.01
Mathematics (Career)	-	-	-	0.14

* $p < 0.05$. ** $p < 0.01$.

weak positive relationship was found with total dual credit hours earned and being college ready in mathematics in Texas ($r = 0.10$) and Florida ($r = 0.23$). A possible explanation is that, in Florida, according to course catalogs, to be eligible for admission to a dual credit course, Florida students must be placed at the college-level on the SAT, ACT, or the Florida Placement Test. In Texas, students were required to satisfy college admission requirements and pass the college Texas Academic Skills

Program (TASP) test or TASP equivalent test. These admission requirements helped explain why a statistically significant relationship was found between dual credit hours earned and college readiness in mathematics. With respect to the relationship between articulated credit hours earned and college readiness, significant but weak positive relationships were found between college readiness in reading and writing in Texas (r = 0.12 for reading and r = 0.17 for writing) and Ohio (r = 0.17 for reading and r = 0.16 for writing).

Dual and articulated credit hours and college-level credit hours earned. Significant weak correlation coefficients were found between total college-level credit hours earned and different types of dual credit hours earned. Academic dual credit hours earned had a significant, weak, and negative relationship with total college-level credit hours earned in Texas (r = -0.17) and Florida (r = -0.13). The CTE dual credit hours earned had a significant, weak, and negative relationship with total college credit hours earned in Oregon (r = -0.14). These findings concurred with findings of Nitzke (2002) who revealed that dual credit students earned fewer college credits than nondual credit students, but contradict the findings of Guruel (1996) who found students taking more dual credit hours earned more college credits than nondual credit students. The findings from this study may reflect that students who took academic dual credit while in high school were oriented towards attending four-year institutions; they transferred to four-year colleges after a short time in the community college, resulting in their earning fewer total college credits on the community college transcript. A similar situation was found in Oregon for students who took CTE dual credit courses; they tended to obtain less college-level credit hours. This finding was attributed to many CTE dual credit courses being core requirements in Oregon for two certificate programs: the secretarial certificate and the office software application specialist certificate. Because it takes students only one year to complete these certificate programs, students with higher CTE dual credits would be expected to enroll in fewer total college credit hours.

Unlike dual credit hours earned, articulated credit hours earned had a significant positive relationship with total college-level credit hours earned in the Ohio (r = 0.41) and Texas (r = 0.15) consortia where articulated credit was offered. In these consortia, articulated credit courses were provided as part of a career pathway, a sequence of courses connecting high school and community college curricula and leading to a postsecondary degree and employment. A career pathway was a four-year program spanning the junior year in high school through two years of the community college. For example, in the Ohio consortium, if students chose an allied health career pathway program, they could earn up to 18 articulated credits during the junior and senior years in high school and obtain the remaining required credit hours during the two years in the community college. Therefore, participation in this type of program could have contributed to this significant positive relationship.

Students' Gender and Educational Background and College-Level Credit Hours Earned and College Readiness

Overall, high school course-taking variables had significant positive relationships with college readiness. The variables related to mathematics course-taking, including number of semesters of mathematics, highest mathematics level, and percentage of AP or Honors mathematics, revealed significant positive relationships with college readiness in mathematics at the $\alpha = 0.01$ level across the consortia. This suggested that the more semesters of mathematics and advanced mathematics courses taken, students were more likely to pass the college placement test in mathematics. These findings supported the results of Berry (2003) who reported that 73% of the students who took rigorous high school mathematics, were beyond Algebra 2, and placed into college-level mathematics, compared to 29% of these students whose highest mathematics course taken was Algebra 2 and placed into college-level mathematics. The highest high school mathematics course level also had significant positive relationships with college readiness in reading and writing in all four consortia except Ohio, where the highest mathematics level was related to college readiness in reading, only. The percentage of AP or Honors mathematics had significant positive relationships with college readiness in reading in Texas ($r = 0.20$) and Florida ($r = 0.18$) and with college readiness in writing in Texas ($r = 0.21$), Florida ($r = 0.15$), and Oregon ($r = 0.29$) as well. These results supported the importance of high school mathematics preparation for college-level education.

The percentage of AP or Honors English had significant positive relationships with college readiness in reading and writing in Texas ($r = 0.21$ for reading and $r = 0.23$ for writing) and Florida ($r = 0.26$ for reading and $r = 0.29$ for writing). This result was consistent with findings of Holton (1998) that showed students who completed rigorous courses in high school English such as AP English increased their probability of passing placement tests in reading and writing, while controlling for student characteristics such as race/ethnicity, gender, and high school GPA. In addition, the number of semesters of high school science had a significant but weak positive relationship with mathematics readiness in all consortia except Ohio in both applying transfer criteria ($r = 0.28$ in Texas, $r = 0.15$ in Florida, $r = 0.36$ in Oregon) and career criteria ($r = 0.30$ in Texas, $r = 0.26$ in Florida, $r = 0.15$ in Oregon). The number of semesters of science courses taken also had a significant positive relationship with reading in all consortia except Florida ($r = 0.23$ in Texas, $r = 0.16$ in Ohio, and $r = 0.20$ in Oregon) and writing readiness in all consortia except Florida, ($r = 0.22$ in Texas, $r = 0.17$ in Ohio, and $r = 0.24$ applying transfer criteria and $r = 0.15$ applying career criteria in Oregon). These results indicated that the more semesters of science taken, the more likely students were ready for a college education. They supported the findings from ACT (2004) that taking science courses such as biology, chemistry, and physics increased greatly the likelihood of college readiness of students, regardless of their academic achievement levels. In terms of

the total college-level credit hours earned, no significant relationships were found for any consortia.

Total College-Level Credit Hours Earned and College Readiness

The findings from the multiple regression and logistics regression analysis are presented in Tables 3, 4, and 5. Model 1 included only the gender variable. Model 2 included HSPR and the gender variable. Model 3 included the Tech Prep participation variable and the variables included in Models 1 and 2. Model 4 included seven high school course-taking variables, added to the variables in Models 1-3. High school course-taking included the total numbers of mathematics (HSMTHSEM), English (HSENGSEM), science (HSSCISEM), and CTE (CTETOT) courses taken, level of highest mathematics course taken (MATHHI), percentage of all mathematics courses taken that were Advanced Placement or Honors mathematics courses (PCTMTHAP), and percentage of all English courses taken that were Advanced Placement or Honors English courses (PCTENGAP). Finally, Model 5 included the dual and articulated credit hours variables as well as the gender and educational background characteristics variables specified for Models 1-4. The block entry method allowed for the examination regarding how much each block of variables such as gender, HSPR, Tech Prep participation, high school course-taking, and the independent variables of dual and articulated credit hours added power in predicting college retention and readiness.

The multiple regression analysis results revealed a significant effect for dual and articulated credit hours earned on total college-level credit hours earned, controlling for gender and educational background characteristics. The block of dual and articulated credit hours earned variables accounted for a significant portion of the variance of college-level credit hours earned and significantly improved the fit of the model. Academic dual credit hours earned had a significant negative effect on the college credit hours earned over and above what other variables accounted for in Texas and Florida. The CTE dual credit hours earned revealed a significant negative effect on total college-level credit hours earned in Oregon. In contrast, articulated credit hours earned had a significant positive effect on total college credit hours earned in both Ohio and Texas. These results were consistent with the correlation analysis findings that examined relationships between the independent and dependent variables. The results further confirm the direct effect of dual and articulated credit on retention at the college-level while controlling for the influence of gender and educational background characteristics (see Table 3).

The logistics regression analysis results differed for students being college ready in reading, writing, and mathematics for the four consortia. Ohio was the only consortium that articulated credit hours earned accounted for a significant portion of the variance of college readiness in reading and writing. Table 4 summarizes the results for Ohio, starting with the fourth block. Academic and CTE dual credit hours earned variables accounted for a significant portion of the variance of college

Table 3

Multiple Regression Analysis of Total College-Level Credit Hours Earned for the Texas, Florida, Oregon, and Ohio Consortium

Variable	*B*	*SE B*	*t*
	Texas (Model 5)[a]		
Female	3.56	2.91	1.23
HSPR	0.30	0.10	2.87**
TP	0.36	2.86	0.13
HSMTHSEM	0.87	1.08	0.81
HSENGSEM	-0.89	1.10	-0.82
HSSCISEM	-2.06	0.96	-2.15*
CTETOT	0.31	0.35	0.87
MATHHI	1.68	1.04	1.61
PCTMTHAP	-0.11	0.08	-1.50
PCTENGAP	0.01	0.06	0.23
Academic dual credit	-5.24	1.52	-3.44**
CTE dual credit	-2.87	2.76	-1.04
Articulated credit	1.05	0.45	2.35*
	Florida (Model 5)[b]		
Female	4.15	3.00	1.39
HSPR	0.08	0.11	0.70
TP	-4.05	3.30	-1.23
HSMTHSEM	0.12	1.31	0.09
HSENGSEM	0.60	0.92	0.66
HSSCISEM	-0.27	1.15	-0.24
CTETOT	0.37	0.30	1.24
MATHHI	1.80	0.95	1.91
PCTMTHAP	0.00	0.07	-0.04
PCTENGAP	-0.04	0.05	-0.72
Academic dual credit	-1.05	0.35	-3.04**
CTE dual credit	0.39	0.89	0.44
	Oregon (Model 5)[c]		
Female	-9.64	5.28	-1.83
HSPR	0.36	0.14	2.51*
TP	-14.00	6.41	-2.18*
HSMTHSEM	3.11	2.18	1.43
HSENGSEM	-0.32	3.05	-0.10
HSSCISEM	1.44	1.79	0.80
CTETOT	0.92	0.69	1.33
MATHHI	-3.15	1.61	-1.95
PCTMTHAP	-0.18	0.15	-1.24

Table 3 *(continued)*
Multiple Regression Analysis of Total College-Level Credit Hours Earned for the Texas, Florida, Oregon, and Ohio Consortium

Variable	*B*	*SE B*	*t*
Oregon (Model 5)[c] *(continued)*			
PCTENGAP	-0.32	0.15	-2.20*
Academic dual credit	0.18	1.22	0.14
CTE dual credit	-2.81	1.34	-2.09*
Ohio (Model 5)[d]			
Female	1.76	6.83	0.26
HSPR	0.48	0.14	3.51**
TP	10.99	13.59	0.81
HSMTHSEM	4.04	2.75	1.47
HSENGSEM	-1.44	2.80	-0.51
HSSCISEM	-0.07	2.03	-0.04
CTETOT	-0.36	1.31	-0.27
MATHHI	-0.79	1.95	-0.41
PCTMTHAP	-0.02	0.41	-0.05
PCTENGAP	-0.04	0.23	-0.16
Articulated credit	2.85	0.57	4.98**

[a] $R^2 = 0.147$, F (Model) = 4.232**, F (ΔR^2) = 5.95 ($p < 0.001$). [b] $R^2 = 0.050$, F (Model) = 1.43, F (ΔR^2) = 4.64 ($p < 0.05$). [c] $R^2 = 0.121$, F (Model) = 2.43**, F (ΔR^2) = 2.21 ($p < 0.11$). [d] $R^2 = 0.259$, F (Model) = 5.38**, F (ΔR^2) = 24.75 ($p < 0.001$).
* $p < 0.05$. ** $p < 0.01$.

readiness in mathematics in only one consortium, Florida, and then only when applying the transfer major criterion. Table 5 summarizes the results for Florida, starting with the third block. The academic dual credit hours earned was especially meaningful in explaining mathematics readiness over and above what other variables explained. Several correlations were not found to be significant when controlling for the influence of gender and educational background characteristics.

In terms of the effect of other blocks of variables, HSPR and high school course-taking were significant predictors of college readiness in writing and mathematics. The block of HSPR significantly improved the fit of the model for placement in college-level writing in three consortia (Texas, Ohio, and Oregon) and in college-level mathematics applying the transfer criteria in three consortia (Texas, Ohio, and Florida), after accounting for gender. The block of high school course-taking variables contributed to the prediction of being college ready in writing in three consortia (Texas, Florida, and Oregon), while controlling for gender, HSPR, and Tech Prep participation. It also added to the prediction of the odds of being college ready in mathematics applying the transfer major criterion in all four

consortia and applying the career major criterion in three consortia (Texas, Florida, and Oregon).

Table 4
Logistic Regression Analysis of College Readiness in Reading and Writing for Ohio

Variable	*B*	*SE B*	Wald	Exp (*B*)
		Reading (Model 4)[a]		
Female	-1.36	0.54	6.37*	0.26
HSPR	0.04	0.01	9.52*	1.04
TP	2.18	1.13	3.74	8.86
HSMTHSEM	0.11	0.20	0.32	1.12
HSENGSEM	-0.26	0.21	1.55	0.77
HSSCISEM	0.05	0.15	0.10	1.05
CTETOT	-0.08	0.10	0.63	0.93
MATHHI	0.00	0.13	0.00	1.00
PCTMTHAP	0.02	0.02	0.76	1.02
PCTENGAP	0.04	0.02	2.42	1.04
		Reading (Model 5)[b]		
Female	-1.46	0.57	6.71**	0.23
HSPR	0.03	0.01	7.42**	1.03
TP	1.96	1.13	2.98	7.07
HSMTHSEM	0.11	0.20	0.30	1.12
HSENGSEM	-0.30	0.21	2.09	0.74
HSSCISEM	0.09	0.15	0.34	1.09
CTETOT	-0.10	0.10	1.02	0.90
MATHHI	-0.04	0.14	0.08	0.96
PCTMTHAP	0.02	0.02	0.66	1.02
PCTENGAP	0.04	0.02	2.31	1.04
Articulated credit	0.17	0.13	1.73	1.19
		Writing (Model 4)[c]		
Female	-0.38	0.48	0.62	0.68
HSPR	0.03	0.01	9.67**	1.03
TP	0.33	1.00	0.11	1.40
HSMTHSEM	-0.01	0.17	0.00	0.99
HSENGSEM	-0.16	0.18	0.80	0.85
HSSCISEM	0.14	0.13	1.12	1.15
CTETOT	-0.02	0.09	0.08	0.98

Table 4 *(continued)*
Logistic Regression Analysis of College Readiness in Reading and Writing for Ohio

Variables	*B*	*SE B*	Wald	Exp (*B*)
		Writing (Model 4)[c]		
MATHHI	0.07	0.12	0.38	1.08
PCTMTHAP	0.01	0.01	0.89	1.01
PCTENGAP	0.00	0.02	0.06	1.00
		Writing (Model 5)[d]		
Female	-0.43	0.50	0.74	0.65
HSPR	0.03	0.01	7.34**	1.03
TP	0.08	1.01	0.01	1.09
HSMTHSEM	-0.02	0.18	0.01	0.98
HSENGSEM	-0.20	0.18	1.29	0.82
HSSCISEM	0.19	0.14	1.76	1.20
CTETOT	-0.04	0.09	0.18	0.96
MATHHI	0.05	0.12	0.14	1.05
PCTMTHAP	0.01	0.01	0.99	1.01
PCTENGAP	0.00	0.02	0.06	1.00
Articulated credit	0.14	0.09	2.27	1.15

Note. [a]-2 LL = 121.828, χ^2 (Model) = 33.49**, χ^2 (- 2LLΔ) = 7.96 (p = 0.34). [b]-2 LL = 117.477, χ^2 (Model) = 37.84**, χ^2 (- 2LLΔ) = 4.35 (p = 0.04). [c]-2 LL = 151.545, χ^2 (Model) = 21.33**, χ^2 (- 2LLΔ) = 4.96 (p = 0.66). [d]-2 LL = 147.031, χ^2 (Model) = 25.84**, χ^2 (- 2LLΔ) = 4.51 (p = 0.03). * $p < 0.05$. ** $p < 0.01$.

Conclusions and Implications

The findings of this study supported prior studies that suggested dual credit positively impacts college readiness (Crook, 1990; Monroe Community College, 2003); however, the findings for Monroe community college are not entirely comparable because the differences associated with student characteristics were not controlled. Correlation analysis revealed that academic dual credit was related significantly to being college ready in mathematics in all three consortia (Texas, Florida, and Oregon) that offered academic dual credit, while articulated credit was related significantly to reading and writing in the two consortia (Ohio and Texas) offering articulated credit. This finding is confounded by significant correlation coefficients between academic dual credit hours earned and articulated credit hours earned and HSPR in all four consortia; students with higher grades were more likely to be enrolled in academic dual credit courses and articulated credit courses. These significant correlation coefficients explained why different results were revealed from the regression analysis while controlling for gender, HSPR, and high school

Table 5
Logistic Regression Analysis of College Readiness in Mathematics for Florida Based on Transfer Major Criteria

Variable	*B*	*SE B*	Wald	Exp (*B*)
		Model 3[a]		
Female	-0.68	0.36	3.58	0.51
HSPR	0.03	0.01	5.82*	1.03
TP	-0.84	0.38	4.92*	0.43
		Model 4[b]		
Female	-0.59	0.40	2.18	0.55
HSPR	0.00	0.01	0.03	1.00
TP	-0.41	0.46	0.81	0.66
HSMTHSEM	0.12	0.17	0.48	1.12
HSENGSEM	0.03	0.12	0.08	1.03
HSSCISEM	-0.07	0.14	0.21	0.94
CTETOT	0.04	0.04	0.92	1.04
MATHHI	0.53	0.16	11.19**	1.70
PCTMTHAP	0.01	0.01	1.58	1.01
PCTENGAP	0.00	0.01	0.43	1.00
		Model 5[c]		
Female	-0.69	0.42	2.62	0.50
HSPR	-0.01	0.02	0.97	0.99
TP	-0.31	0.49	0.41	0.73
HSMTHSEM	0.04	0.17	0.05	1.04
HSENGSEM	-0.27	0.16	2.83	0.76
HSSCISEM	-0.07	0.16	0.20	0.93
CTETOT	0.06	0.05	1.78	1.06
MATHHI	0.44	0.16	7.12**	1.55
PCTMTHAP	0.02	0.01	3.50	1.02
PCTENGAP	0.00	0.01	0.20	1.00
Academic dual credit	0.17	0.05	11.18**	1.19
CTE dual credit	-0.12	0.15	0.65	0.89

Note. [a]-2 LL = 205.947, χ^2 (Model) = 12.00**, χ^2 (- 2LLΔ) = 5.23 (p = 0.02). [b]-2 LL = 170.944, χ^2 (Model) = 47.00**, χ^2 (- 2LLΔ) = 35.00 ($p < 0.001$). [c]-2 LL = 157.676, χ^2 (Model) = 60.27**, χ^2 (- 2LLΔ) = 13.27 ($p < 0.01$).
* $p < 0.05$. ** $p < 0.01$.

course-taking. That is, academic dual credit hours earned had a direct effect on college readiness in mathematics after controlling for gender, HSPR, and high school course-taking; however, this finding was found in Florida, only.

Students' articulated credit course-taking enhanced their college retention in the two consortia that offered articulated credit. A significant positive relationship was found between articulated credit hours earned and total college-level credit hours earned in both Ohio and Texas. The same results were obtained while controlling for gender and educational background, confirming a significant direct effect of articulated credit course-taking on college retention. This finding might suggest that students who took more articulated credit hours while in high school were more motivated to obtain an advanced CTE degree than those without such experiences, resulting in a longer stay in the community college. Furthermore, the Texas consortium's requirement for students to receive articulated credit by completing three credit hours of additional college-level course work at the lead community college may have contributed to more college-level credit hours earned.

Students' academic and CTE dual credits also impacted their college retention, but requires careful interpretation. A significant negative relationship between academic dual credit hours earned and total college credit hours earned was found in the Texas and Florida consortia. While controlling for gender and educational background, academic dual credit hours earned was a significant negative predictor of college retention in both consortia. Based on these results, students' academic dual credit course-taking was likely to shorten their stay in the community college. A possible explanation for this finding is that students receiving academic dual credit could have been oriented more towards the four-year degree, resulting in shorter stays in community college and transfers to four-year institutions. In terms of CTE dual credit, only Oregon reported a significant negative relationship for retention; CTE dual credit was a significant negative predictor of retention while controlling for gender and educational background characteristics.

Both articulated credit courses and CTE dual credit courses (were CTE-oriented) and articulated credit hours earned had a significant positive impact on retention in Ohio and Texas. However, the CTE dual credit hours earned showed a significant negative impact on retention in Oregon. In both Ohio and Texas, articulated credit courses were offered as part of career pathways leading to two-year Associate in Applied Sciences (AAS) degree programs at the lead community college, possibly influencing retention. The finding of a significant negative relationship between CTE dual credit and total college-level credit hours earned may have reflected the circumstances in Oregon, where most of the CTE dual credit courses were requirements for two one-year certificate programs. These results suggest the length and credential offered by the program awarding the dual credit courses and articulated credit courses may be more influential to retention – students' obtainment of college-level credit hours subsequent to their entering the community college – than the type of college credit.

Further inquiry was conducted to determine how the type of dual credit was related to students' college readiness and retention. According to the results of this study, academic dual credit hours earned were more likely to enhance college mathematics readiness than CTE dual credit hours earned. Nonetheless, this finding did not point to the greater advantage of academic dual credit compared to CTE dual credit relative to being ready for college-level mathematics. In Florida, where academic dual credit hours earned predicted college mathematics readiness, about 18% of total academic dual credit courses taken were college-level mathematics courses and more than two-thirds of them were completed with A or B grades (about 34% of grade A and 33% of grade B). Therefore, students who took academic dual credit courses in high school were already academically well prepared, successfully completing college-level courses while in high school. This is a logical result since well prepared students would be expected to demonstrate a higher level of college mathematics readiness than students less prepared academically. Another possible explanation was found in the relationship between HSPR and academic and CTE dual credit hours earned. That is, the strength of the relationship between academic dual credit and HSPR was stronger than that of CTE dual credit and HSPR, suggesting students who took academic dual credit had higher grades and were academically better prepared than students who took CTE dual credit, leading to better readiness for college-level education. In terms of college retention, a negative relationship was found in two consortia (Texas, Florida) between academic dual credit hours earned and college-level credit hours earned; a negative relationship was found with CTE dual credit in one consortium (Oregon). These mixed results make it difficult to generalize about the effectiveness of one college credit type over another.

Along with dual and articulated credit hours earned, students' high school course-taking played an important role in preparation for postsecondary education, supporting the findings by Adelman (1999), Cabrera, La Nasa, & Burkum (2001), Eimers and Mullen (2003), Horn, Kojaku, and Carroll (2001), and Roth, Crans, Carter, Ariet, & Resnick (1999). In particular, the quantity and rigor of high school mathematics course-taking were influential variables for college readiness. Students who took more semesters and more advanced mathematics courses showed better college readiness in mathematics in all four consortia. The level number of the highest mathematics course taken had significant relationships with college readiness in mathematics, reading, and writing. Moreover, students who took more science courses (in high school) in Ohio, Texas, and Florida, and more mathematics in Texas, Florida, and Oregon showed higher college readiness in reading and writing. These findings concurred with the results of ACT (2004) that showed taking rigorous mathematics beyond Algebra II and science such as biology, chemistry, and physics had a significant effect on college readiness, while controlling for students' academic achievement. Students' AP or Honors English course-taking was also related positively to their college readiness in reading, writing, and mathematics in two consortia (Texas, Florida). This finding supported Roth et al. (1999) who reported that English academic resources were related positively to college readiness in

English after controlling for race/ethnicity, gender, and high school GPA. Consequently, to increase students' college readiness, the rigor and quantity of high school curriculum should be ensured. Additionally, careful guidance and counseling in course selection is essential.

High school course-taking was a significant predictor of college readiness in mathematics, too. In all four consortia, the seven variables of high school course-taking: semesters of mathematics taken, highest mathematics course, percentage of AP or Honors mathematics, semesters of English taken, percentage of AP or Honors English, semester of science taken, and semesters of CTE courses taken accounted for a significant portion of variance on college mathematics readiness. It appears that as the rigor and quantity of course-taking increase, the probability of being college ready in reading, writing, and mathematics increases significantly.

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The Authors

JoHyun Kim is an Associate Director of Planning, Budget, and Institutional Research at the Western Illinois University. Contact by E-mail: j-kim13@wiu.edu or Phone: 309.298.3241

Debra D. Bragg is a Professor in the Department of Educational Organization and Leadership at the University of Illinois at Urbana-Champaign. Contact by E-mail: dbragg@uiuc.edu or Phone: 217.244.8974