Technology and Communications Coursework: Facilitating the Progression of Students with Learning Disabilities Through High School Science and Math Coursework

Dara Shifrer and Rebecca Callahan
The University of Texas at Austin

Students identified with learning disabilities experience markedly lower levels of science and mathematics achievement than students who are not identified with a learning disability. Seemingly compounding their disadvantage, students with learning disabilities also complete more credits in non-core coursework—traditionally considered nonacademic coursework—than students who are not identified with a learning disability. The Education Longitudinal Study of 2002, a large national dataset with both regular and special education high school students, is utilized to determine whether credit accumulation in certain types of non-core coursework, such as technology and communications courses, is associated with improved science and math course taking outcomes for students with learning disabilities. Results show that credit accumulation in technology and communications coursework uniquely benefits the science course taking, and comparably benefits the math course taking, of students identified with learning disabilities (LD) in contrast to students who are not identified with learning disabilities.

The courses a student completes by the end of high school have important implications for postsecondary pursuits, potentially putting students who are identified with learning disabilities (LD) at a serious disadvantage. Not only is there a federal impetus to increase the science, technology, engineering, and mathematics (STEM) achievement of all students (Augustine, 2007; U.S. Department of Education, 2007), but admission to college requires completion of certain key science and math courses. High school math and, to some extent, science coursework is comprised of a strand of courses that are sequentially ordered. Completion of Algebra I is generally required before a student can take geometry, for example (Stevenson, Schiller, & Schneider, 1994). Progression along the math course taking pipeline is predictive of general high school performance and college enrollment (Schneider, Swanson, & Riegle-Crumb, 1998). While research on supporting the learning of students identified with LD typically has focused on improving pedagogy and curriculum within science and math courses (Bodzin, Waller, Santoro, & Kale, 2007; Maccini & Gagnon 2000; Marino 2010; Calhoon & Fuchs 2003), we take a wider, more systemic approach to the issue from a course placement perspective.

We theorize that identified students' disproportionate credit accumulation in non-core course taking—traditionally perceived as disadvantageous for students identified with LD—may offer a new source of STEM content. Shifts in the purposes of non-core coursework and the needs of the labor force during the last several decades may have transitioned non-core coursework into a unique educational resource for technological preparation and improvement of practical STEM skills. The 1980s and 1990s embodied a movement toward combining vocational and academic education, in contrast to the previous dichotomy of either college or workforce preparation (Plank, 2001). During the 1990s, federal legislation, such as amendments to The Carl D. Perkins Vocational and Applied Technology Education Acts (Perkins II and III) (1990, 1998) and the School-to-Work Opportunities Act (1994) explicitly tied federal funding to the integration of vocational and academic curricula, and the promotion of work-related experience (Stone, 2004; Stone & Alfeld, 2004). With a federal emphasis on responsiveness to labor force needs and maintenance of America's globally competitive edge (Goldin & Katz, 2008; Stone & Aliaga, 2005), non-core coursework emerged as a natural arena in which these evolving needs could be addressed. In addition to the often mentioned and growing demand for STEM professionals in the U.S. (Augustine, 2007), there is a national labor market shortage of technicians (Gray, 2002; Stone, 2004). Perkins II (1990) specifically authorized the Tech Prep program, which allocated funding to redefine the mission of non-core coursework to include the preparation of students to transition into postsecondary technical education (Apling, 1998; Gray, 2002). In sum, the convergence of these social forces may have forged more explicit links between non-core coursework and STEM curriculum.

We utilize the Education Longitudinal Study (ELS) of 2002, a large national dataset of both regular and special education students who were in the tenth grade during 2002, to determine: (1) the degree to which there is a difference in the non-core, science, and math course taking of students who are and are not identified with LD; (2) which types of non-core coursework are associated with better science and math course taking outcomes; and (3) whether students identified with LD experience an effect of non-core course taking on STEM outcomes, namely end of high school math and science course completion, comparable to that experienced by students not identified with LD.

Background

A marked gap in STEM achievement persists between students who are and are not identified with LD. Wagner, Newman, Cameto, and Levine (2006) use The National Longitudinal Transition Study-2 (NLTS2), a large, nationally representative sample of secondary age youth with disabilities to show that students with LD score below the mean score of students without disabilities on standardized science and math assessments. Additionally, 67% of students with disabilities performed below basic proficiency on the eighth grade National Assessment of Educational Progress (NAEP) math test in contrast to 26% of students without disabilities (Lee, Grigg, & Dion, 2007). To our knowledge, no studies have examined differences in course taking for students with LD in particular. The present study provides a unique contribution to the field in its analysis of differences in science and math course taking between students who are and are not identified with LD.

Students with LD may experience lower levels of STEM achievement because of a variety of cognitive impediments, including difficulties paying attention for sustained periods of time, calculating basic math functions, retaining and retrieving information by memory, using problem-solving strategies, generalizing, and using abstract algebraic reasoning. Co-occurring psychosocial and social factors also exist. They include lower levels of self-esteem and self-efficacy, a lack of social skills, and reduced motivation (Barrera, et al., 2006; Calhoon & Fuchs, 2003; Cass, Cates, Smith, & Jackson, 2003; Maccini & Gagnon, 2006). Other characteristics of students with LD that may negatively impact their likelihood of progression along the STEM course pipeline, and simultaneously increase their likelihood of participating in non-core coursework include poorer academic histories (usually by definition), the propensity to have other social status markers of disadvantage such as low socioeconomic status (SES), being a racial/ethnic and/or language minority, and an increased risk of lower educational expectations (Cooney, Jahoda, Gumley, & Knott, 2006; Gray, 2002; Shifrer, Muller, & Callahan, in press; Stone, 2004). Students with LD also might experience lower levels of STEM success simply because the education system has yet to find effective responses to their unique learning styles. We address the influence of these factors to a certain degree by comparing students identified with LD to students who are not identified but who have similar social backgrounds and initial high school math placement.

Despite the increasing academic emphasis within high schools, non-core coursework continues to account for 20% of all high school course taking (Gray, 2002). Students with disabilities have traditionally been disproportionately represented in non-core coursework, with non-special-needs students taking an average of 3.7 non-core credits and students with disabilities taking an average of 5.6 non-core credits by the end of high school (Gray, 2002). Non-core courses—which include, but are not limited to, career and technical education (CTE), vocational classes, and electives—traditionally have filled a nonacademic role. Non-core courses initially were intended to prepare students for direct entry into the workforce, and they remain classified within the 10 federal categories[1] of Specific Labor Market Preparation (SLMP) (Gray, 2002; Plank, 2001). While non-core coursework may be better suited to the needs of some students, such courses also are thought to contribute to stratification and segregation, restricting certain students' access to the academic curriculum.

Alternatively, there is evidence to suggest that legislative changes have affected shifts in the content and purposes of non-core coursework. In contrast to former notions of the rigidity of high school tracking (academic or vocational), 83% of CTE concentrators (students who take a sequence of three or more courses in one occupational area) in 1998 also completed an academic concentration (Gray, 2002). As evidence that non-core coursework should prepare students for postsecondary education as well as participation in industry (Stone, 2004), more than half of the students who were integrated concentrators (students who took both CTE and academic courses) went on to a two- or four-year college (Gray, 2002). In fact, little to no difference was found between the high school achievement of academic concentrators and integrated concentrators, even though the latter started school with lower eighth grade test scores (Gray, 2002; Plank, 2001). Stone and Alfeld (2004) actually found that CTE concentrators took more science and math than their general track peers. Moreover, students with disabilities were mentioned specifically as one of the special populations targeted by the changes in the funding for non-core coursework (Apling, 1998). Concurrent with the aforementioned shift in legislative priorities for CTE, these findings suggest that some types of non-core coursework may be positively associated with STEM outcomes and may prove beneficial for students with LD in particular.

Technology and communications coursework, with a STEM-oriented topical focus, appears particularly promising as a potential non-core avenue into improved science and math course-taking outcomes. Non-core courses, with an emphasis on providing real-world contexts and hands-on activities, may present a context in which students with LD experience the distinctive instructional practices that better enable their learning (Gray, 2002; Stone, 2004; Stone & Alfeld, 2004). Such strategies are encouraged in academic and non-core courses alike, and are thought to be particularly helpful for students who are disengaged or low achieving (Plank, 2001). Furthermore, the lower levels of standardization and accountability within the curriculum and administration of non-core coursework may actually facilitate the sort of differential pedagogy that is thought to be especially helpful for students with LD. Educators in core academic courses may find it difficult to find the time and/or resources to incorporate real-world experiences into curriculum that already demands coverage of a wide range of topics. Thus, non-core coursework in general, and technology and communications courses in particular, may present students with LD with the opportunity to experience high-level curriculum via the pedagogical practices best suited to their learning differences.

Additionally, non-core coursework may expose students with LD to more technological innovations. Incorporating technology into the lesson is a widely advocated pedagogical strategy for this generation of students, and is thought particularly to facilitate the academic development of students with LD (Bodzin et al., 2007; Cass et al., 2003; Maccini & Gagnon, 2006; Marino, 2010). Not only is increasing the use of technology in non-core courses a specific tenet of Perkins III (Apling, 1998), but non-core educators may be better situated to incorporate technology into their lessons than their core focused peers due to fewer restraints, smaller classes, and potentially better topical alignment (e.g., computer science, engineering, and architecture courses).

Finally, placement in non-core courses may provide students with LD a fresh context for learning. After years of struggling in core courses, they may find it difficult to start a new year of math, science, or English without feeling dread and/or disengagement before the class has even begun (Byers, Davies, Fergusson, & Marvin, 2008). Similarly, non-core course teachers, who perhaps are less aware than core teachers of students' academic histories, may provide students with a clean slate, intentionally or unintentionally communicating hope and higher expectations. Any success or positive adult relationships experienced in non-core courses is likely to reverberate into other arenas of a student's schooling (Stone & Alfeld, 2004). In sum, the novel instructional approach and potential for academic achievement offered by enrollment in non-core courses in general, and technology and communications in particular, may translate into higher attainment in core STEM courses.

This article will explore the effects of placement in non-core courses on students' STEM course taking, taking into account identification with LD and the characteristics associated with identification that might influence course taking. In this study, we utilize ELS to ask:

1. How does the non-core science and math high school course taking of students identified with LD compare to those of students who are not identified with LD?
2. Which types of non-core coursework, if any, are positively associated with higher levels of science and math course taking?
3. Is any effect on STEM preparation experienced by students who are identified with LD comparable to what is experienced by students who are not identified with LD?

Methodology

Data

ELS was conducted by the National Center for Education Statistics (NCES), a division of the U.S. Department of Education. The survey sampled 16,373 spring term tenth graders enrolled in approximately 750 high schools in 2002. We utilized measures from the student surveys (2002, 2004) and the parent survey (2002), as well as data from the students' high school transcripts. The ELS is an ideal dataset for this study for several reasons. There are very few large datasets with measures of both disability and sociodemographic characteristics (Ong-Dean, 2006). In contrast to the ELS, the federal datasets that are focused specifically on special education do not include peers who are not in special education as a base of comparison. The ELS continues to conduct surveys with students who have dropped out. Because of their higher drop out rates, students with LD would experience greater rates of attrition from datasets that do not include dropouts.

After excluding students without transcript data who had a disability other than LD, or who attended a school that did not provide Individualized Education Plan (IEP) reports, we utilized an analytic sample of approximately 9,850[2] students in 540 schools. Descriptive statistics are provided in Table 1. A student-level weight was applied in all analyses to account for survey design. Unless the information was available in a later wave of data, mean and mode imputation were used to account for missing values on all independent variables except for race, gender, and identification with LD; imputation flags were included in all multivariate models.

Identified with a Learning Disability. School administrators were asked to identify which sampled students had an IEP; an IEP indicates that the student has been identified as eligible for special education services. Administrators were next asked to indicate the associated specific federal disability category for students with an IEP; this analysis focused on the students identified by their school with a Specific Learning Disability.[3] Schools did not report on the IEP status of 7,300 of the students in the sample. Knowing that students in ELS are clustered within schools, we determined that 350 of the schools indicated the IEP status of all of the students sampled from their school, 200 schools reported on some of the students sampled, and 200 schools reported on none of the students sampled. By comparing school-level distributions, it was found that, despite differences in reporting, there were comparable percentages of students identified as having an IEP, and identified with LD, in the set of schools that reported on all of their students and the set of schools that reported on some of their students. These school-level statistics enabled us to conclude that the schools who reported on some (rather than all or none) of their students reported only when a student had an IEP; thus, we considered the students for whom these schools did not provide an IEP report as not identified with LD.[4] The 4,200 students attending schools that did not provide the IEP status for any of their students were excluded from analyses. Since the differences in the average characteristics of the excluded schools and the schools in the analytic sample were statistically significant, the analytic sample could not be claimed with absolute confidence to be nationally representative.

Social Background. Because there were systematic differences in the backgrounds of students who were and were not identified with LD (Shifrer et al., in press), the influence of these differences on academic outcomes was accounted for by including controls for being male, non-white, living with both biological parents, and having

Table 1

Weighted Descriptive Statistics by LD Status

	Mean or Proportion (SD)		Difference	
	LD (n=530)	Non-LD (n=9300)	Diff.	Signif.
STEM Course Taking Outcomes				
Completed Algebra II or higher by 12th grade	0.22	0.69	-0.47	$p<0.001$
Completed Chemistry by 12th grade	0.16	0.58	-0.42	$p<0.001$
Academic Core Credits by 12th Grade	12.70 (4.23)	15.82 (4.15)	-3.12	$p<0.001$
Non-core Credits by 12th Grade	10.21 (4.10)	8.54 (3.12)	1.67	$p<0.001$
Non-core Credits by 12th Grade by Topic				
Technology and Communications	0.67 (1.13)	0.81 (1.04)	-0.13	$p<0.01$
Liberal Arts	0.11 (0.54)	0.23 (0.79)	-0.13	$p<0.001$
Visual and Performing Arts	1.47 (1.73)	1.95 (1.89)	-0.48	$p<0.001$
Health Care	0.06 (0.33)	0.11 (0.55)	-0.06	$p<0.05$
Public Policy	0.23 (0.57)	0.27 (0.54)	-0.04	$p<0.10$
Personal and Other Services	4.23 (2.67)	2.82 (1.62)	1.41	$p<0.001$
Business, Marketing, and Distribution	1.73 (2.07)	1.54 (1.63)	0.19	$p<0.05$
Agriculture, Trade, and Industry	1.72 (2.87)	0.79 (1.53)	0.93	$p<0.001$
Social Background				
Male	0.66	0.49	0.17	$p<0.001$
Nonwhite	0.40	0.36	0.05	$p<0.05$
One or both parents have BA or higher	0.26	0.38	-0.12	$p<0.001$
Family income	0.27	9.10	-8.83	$p<0.001$
Student lives with both biological parents	0.49	0.59	-0.11	$p<0.001$
9th Grade Position on the Math Course Sequence	2.30	3.66	-1.357	

Note. Frequencies are rounded per NCES guidelines.

low SES. More specifically, SES was captured with indicators of highest level of parental education and family income.

Course Taking. All course taking was measured through credits earned rather than credits attempted. NCES standardizes the school reports of credits with Carnegie credits, which are standard units of measurement that represent the completion of a secondary-level course that meets one period per day for one year (Ingels, Pratt, Rogers, Siegel, & Stutts, 2004, p. 180). For example, 0.5 would generally be an indication of a semester-long course that met one period every day. Carnegie credit values for a single course are truncated to 4.0 (the 99.99th percentile); the vast majority of courses are assigned 0.5 or 1.0 Carnegie credits, described as credits in the results section. The federally designated Classification of Secondary School Courses (CSSC) codes and high school designated course titles available in the transcript data were employed to further distinguish courses by course type or subject. This study's operationalization of core—math, English, science, and social studies—courses followed the federal definition (Shettle et al., 2007), however foreign language courses also were included as core coursework in the current study due to the fact that they are usually required for admission to a four-year college. Conversely, English as a second language (ESL) courses, which do not fulfill admission requirements, were categorized as non-core.

This study focused on the association between credit accumulation in various types of non-core courses and progression along the math and science course pipelines (completion of Algebra II or higher by the twelfth grade and completion of chemistry by the twelfth grade, both of which are argued to be highly predictive of college attendance (Adelman, 1999)). Slightly modifying the federal SLMP areas (Gray, 2002; Plank, 2001), eight types of non-core coursework were explored: Liberal Arts (CSSC course codes 24, 38, & 39); Visual and Performing Arts (CSSC course code 50); Technology and Communications (CSSC course codes 04, 09, 10, 11, 14, 15, 25); Health Care (CSSC course codes 17, 18); Public Policy (CSSC course codes 22, 33, 44); Personal and Other Services (CSSC course codes 12, 32, 34–37); Business, Marketing, and Distribution (CSSC course codes 06–08, 13, 19, 20, 28, 29, 31, 43); and Agriculture, Trade, and Industry (CSSC course codes 01–03, 21, 46–49). Appendix A displays the main CSSC categories that comprise each of the types of non-core coursework. A detailed overview and description of the CSSC codes/representative courses can be obtained at **http://nces.ed.gov/surveys/hst/courses.asp**, including descriptions of the subcategories that comprise technology and communications coursework.

To determine whether students who have been identified with LD experience different course-taking outcomes than students who are not identified with LD but have comparable early high school math placement, we included an ordinal measure of each student's ninth grade position on the math course-taking sequence (0=no math, 1=basic/remedial, 2=general/applied, 3=pre-algebra, 4=Algebra I, 5=geometry, 6=Algebra II, 7=advanced math, 8=pre-calculus, and 9=calculus).

Analytic Plan

The weighted descriptive statistics presented in Table 1 provide the foundation for the study with bivariate analyses of differences in course taking between students who were and were not identified with LD. With selected coefficients from two logistic regression models, Table 2 explores the association between credit accumulation in various types of non-core coursework and the odds of completing Algebra II or higher and chemistry by the twelfth grade. By including interactions between identification with LD and credit accumulation in the types of non-core coursework that were positively associated with our outcomes, these models also show whether students identified with LD experienced benefits comparable to those experienced by students who were not identified with LD. Both of these models included controls for sex, race/ethnicity, family income, highest parental education level, family structure, and highest unfailed ninth grade math course. We estimated robust standard errors that accounted for students being clustered within schools. The Results section concludes with a graphical presentation of predicted probabilities of science and math course completion estimated from the coefficients of the logistic regression models (see Figure 1).

Results

In contrast to students who were not identified with LD, students identified with LD were significantly disadvantaged along every measure of high school course taking and key STEM outcomes (Table 1). The proportion of students identified with LD who progressed through Algebra II or higher by the twelfth grade (22%) was significantly lower than the proportion among students who were not identified (69%). Similarly, whereas 58% of students who were not identified with LD completed chemistry by the twelfth grade, only 16% of students who were identified with LD did. Students identified with LD earned significantly fewer credits (12.70 vs. 15.82) in academic core courses (math, science, social studies, English, and foreign language), and significantly more credits in non-core courses overall (10.21 vs. 8.54) by the twelfth grade.

Credit accumulation across the various types of non-core coursework was distributed differently for students who were and were not identified with LD. Students with learning disabilities completed significantly more credits than students who were not identified in agriculture, trade, and industry; business, marketing, and distribution; and personal and other services coursework. In contrast, students identified with LD took significantly fewer credits than students who were not identified with LD in liberal arts, visual and performing arts, technology and communications, and health care coursework. These bivariate statistics demonstrate the sizeable gaps in academic core credit accumulation and

STEM pipeline progression between students who were and were not identified with LD, as well as variations in the levels of credit accumulation across types of non-core coursework.

Table 2 shows selected coefficients from logistic regression models predicting completion of chemistry by twelfth grade and completion of Algebra II or higher by the twelfth grade. Although the corresponding coefficients are not shown in Table 2, these models accounted for the influence of differences in students' sex, race/ethnicity, family income, highest parental education level, family structure, and highest ninth grade math course. First, these models reaffirmed the general STEM course-taking disadvantage for students identified with LD. The net of all controls, the log odds of completing chemistry or Algebra II or higher by the twelfth grade were significantly lower for students identified with LD. These models also established which types of non-core coursework had positive associations with STEM course taking. Evident by the coefficients in the upper panel of Table 2, credit accumulation in technology and communications, liberal arts, and visual and performing arts coursework was significantly and positively associated with progression along both the science and math course-taking pipelines for all students. (The exception was that the estimated effect of technology and communications coursework on science course taking was only marginally significant.) In contrast, credit accumulation in business, marketing, and distribution or agriculture, trade, and industry coursework had a significant and negative association with STEM course taking. The other types of non-core coursework were not significantly associated with course completion in science or math.

Table 2

Selected Log Odds from Logistic Regression Models Predicting Science and Math Course Taking

	Completed Chemistry by the 12th Grade			Completed Algebra II or Higher by the 12th Grade		
	B	SE	Signif.	B	SE	Signif.
LD per IEP	-1.76	0.25	$p<0.001$	-1.17	0.21	$p<0.001$
Credit Accumulation in Non-core Courses						
Technology and Communications	0.06	0.03	$p<0.10$	0.19	0.04	$p<0.001$
Liberal Arts	0.30	0.06	$p<0.001$	0.39	0.06	$p<0.001$
Visual and Performing Arts	0.07	0.02	$p<0.01$	0.10	0.02	$p<0.001$
Health Care	0.06	0.06		0.05	0.06	
Public Policy	0.02	0.08		0.03	0.07	
Personal and Other Services	-0.02	0.02		-0.01	0.02	
Business, Marketing, and Distribution	-0.06	0.02	$p<0.01$	-0.07	0.02	$p<0.001$
Agriculture, Trade, and Industry	-0.14	0.02	$p<0.001$	-0.13	0.02	$p<0.001$
Credit Accumulation Interacted with LD per IEP						
Technology and Communications	0.24	0.10	$p<0.05$	0.03	0.11	
Liberal Arts	-0.13	0.15		-0.17	0.12	
Visual and Performing Arts	0.11	0.08		-0.15	0.08	$p<0.10$
McFadden's Adjusted R^2	0.26			0.17		

Note. Controls for sex, race/ethnicity, family income, highest parental education level, family structure, and highest ninth grade math course completed are included in both models. These analyses were conducted with data on approximately 9,850 students in 540 schools.

The lower panel of the models in Table 2 shows whether the estimated effects of each type of non-core coursework on STEM course taking were equally evident among students identified with LD. While the main effects of credit accumulation discussed previously applied to all students in the analytic sample, the coefficients for the interactions between credit accumulation and identification with LD at the bottom of Table 2 show whether the positive associations diverge for students identified with LD. In fact, the interactions show that, net of all controls, the positive estimated effect of credit accumulation in technology and communications coursework on completing chemistry by the twelfth grade was significantly greater for students identified with LD than it was for students who were not identified. There was no significant difference in any of the other positive associations for students identified with LD.

To truly understand the real world associations between non-core course taking and STEM course taking for students identified with LD, the reader must simultaneously consider (1) the main effect of being identified with LD, (2) the main effect of the non-core course taking cluster of interest, and (3) the interaction effect for that type of non-core coursework and identification with LD. This is best accomplished through a graphical representation of the models. Figure 1 displays predicted probabilities of completing math and science coursework estimated from the models in Table 2. The reader will note that the controls included in the models allow comparison of students with LD to other students of similar social background who completed the same level of math during the ninth grade.

Figure 1 also demonstrates the degree to which there was a positive association between technology and communications coursework and STEM coursework for students who were and were not identified with LD. Among students who completed no credits of technology and communications coursework, the predicted probability of completing Algebra II or higher by the twelfth grade was 0.74 for students who were not identified with LD and 0.27 for students who were identified with LD. Among students who completed three credits of technology and communications coursework, the predicted probability of completing Algebra II or higher increased to 0.84 for students who were not identified and 0.64 for students who were identified with LD. The similar steepness of each of these lines is representative of the comparable benefit experienced by students who were and were not identified with LD. In contrast, the line predicting chemistry completion for students identified with LD is much steeper than the line for students not identified with LD. The steeper slope here represents the additive benefit of credit accumulation in technology and communications coursework for science course taking experienced by students identified with LD compared to their peers who were not identified with LD. Simply put, the predicted probability of completing chemistry was 0.22 for a student identified with LD who completed no credits of technology and communications coursework, compared with a predicted probability of completion of 0.41 for an otherwise similar student who completed three credits of technology and communications coursework.

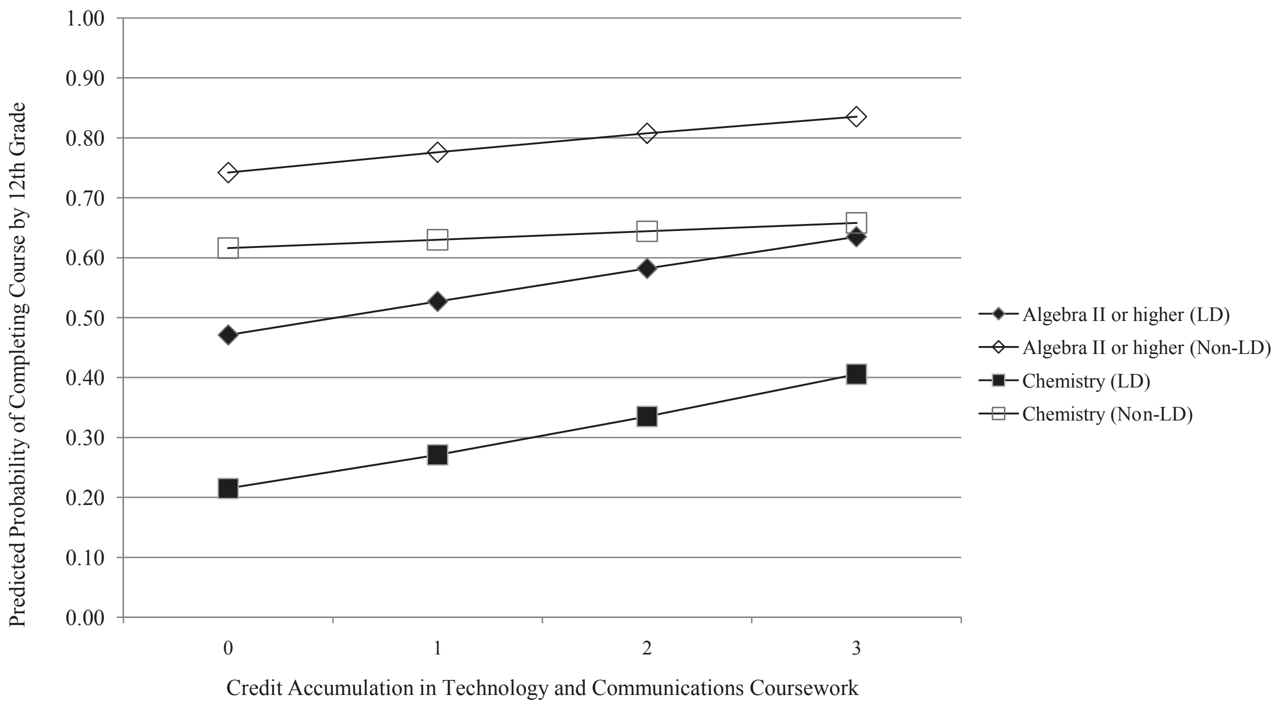
Discussion

At the baseline, these analyses established that students identified with LD had markedly lower STEM course attainment than students who were not identified. They also took relatively more credits in non-core coursework and fewer credits in the types of non-core coursework positively associated with STEM outcomes. Findings from the present study suggest that educators and schools can begin to address these inequities in very real ways through course placement. The persistent and sizeable gaps in STEM attainment between students who were and were not identified with LD, regardless of technology and communications credit accumulation, demonstrate the relevance of exploring students' course-taking patterns. Students with LD are often identified when they fail to respond like other students to standard curriculum and pedagogy. As a result, locating coursework that benefits students who are identified with LD to at least a comparable extent as students who are not identified with LD is a notable and worthwhile endeavor.

Simple decisions about non-core course placement have very real implications for students with LD. The probability of completing Algebra II or higher by the twelfth grade appears to increase by 6% on average with every additional credit completed in technology and communications coursework for students identified with LD, in contrast to a 3% gain that appears to be experienced by students not identified with LD. Every additional credit in technology and communications coursework appears to increase the probability of completing chemistry by

Figure 1

Association between T&C and STEM Coursework



the twelfth grade by 6–7% for students who were identified with LD and 1% for students who were not identified. These estimates derive from multivariate models that accounted for differences in social background and ninth grade math course placement; thus, these findings are not an artifact of students identified with LD having lower SES, for example, or starting high school in lower level math classes.

Now that we understand how the different types of non-core coursework are associated with STEM course taking for all students and for students with LD in particular, we reflect briefly on the implications of the present disparities in non-core credit accumulation between students who were and were not identified with LD as evidenced in Table 1. Although students identified with LD took more credits in non-core courses overall, they accumulated fewer credits on average in the types of non-core coursework that are positively associated with STEM outcomes than students who were not identified with LD.

Educators and counselors who work closely with students with LD will want to carefully consider the implications of placement of these students in non-core, non-STEM-associated coursework. Policies regarding placement of students with LD in non-core coursework should highlight the benefits of technology and communications placement. Given the choice between placement of a student with LD in either a non-core agriculture course or a non-core technology and communications course, an informed high school counselor or educator would choose the latter.

Implications for Policy, Practice, and Future Research

The central finding of this study, that accumulating credits in technology and communications coursework uniquely benefits the science course taking, and comparably benefits the math course taking of students with LD in contrast to students who are not identified with LD, has considerable implications for policy and practice. Educating teachers, parents, and counselors about the potential for improving STEM achievement within technically focused non-core coursework would enable them to encourage students with LD to consider technology and communications courses rather than less academically associated non-core coursework. Equally important, issues of equitable access and opportunity arise if technology and communications coursework is not offered at all schools. Appropriate policy implications depend in part upon location of the underlying sources of these STEM benefits.

Although the data utilized in this study preclude identification of the classroom-level mechanisms whereby these positive associations between technology and communications and STEM coursework emerge, exciting possibilities exist for future research and data collection. It is possible that the topics covered in technology and communications coursework are more applied or more real-world versions of similar topics covered in core math and science courses. Presentation of traditional STEM concepts through technology and communications curriculum may be especially suited to the needs of students identified with LD. The smaller class sizes and fewer curricular constraints of non-core courses may enable educators to utilize nontraditional pedagogy, or technology and communications curriculum content may lend itself to the incorporation of technology within the classroom, an instructional strategy lauded as beneficial for students with LD (Bottge & Hasselbring, 1993; Howell, Sidorenko, & Jurica, 1987; Maccini & Gagnon, 2000; Marino, 2010).

The importance of adult mentoring and/or student self-confidence may prove an implicit finding within future research in this area. Future research and data collection, encompassing both qualitative classroom-based inquiry and quantitative survey analyses, should endeavor to locate the mechanisms behind the positive association between technology and communications coursework and progression along the STEM course pipeline for students with LD. Findings from the present study establish the foundation for an exciting new branch of research on the STEM progression of all students, and especially students with LD. Technology and communications coursework appears to present a novel educational resource for improving STEM attainment for all students, and particularly for students identified with LD. Future research is necessary to explore the mechanisms that produce this important benefit.

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, Office of Educational Research and Improvement.

Apling, R. N. (1998). *Vocational education: Legislation to reauthorize the Carl D. Perkins vocational and applied technology education act*. Washington, DC: Education and Public Welfare Division, Congressional Research Service, The Library of Congress.

Augustine, N. R. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: Committee on Science, Engineering, and Public Policy, National Academy of Engineering, and Institute of Medicine, National Academies of Science.

Barrera, M., Liu, K., Thurlow, M., Shyyan, V., Yan, M., & Chamberlain, S. (2006). *Math strategy instruction for students with disabilities who are learning English. ELLs with disabilities report 16*. Minneapolis, MN: National Center on Educational Outcomes, University of Minnesota.

Bodzin, A. M., Waller, P. L., Santoro, L. E., & Kale, D. (2007). Investigating the use of inquiry and web-based activities with inclusive biology learners. *American Biology Teacher, 69*, 273–279.

Bottge, B. A., & Hasselbring, T. S. (1993). A comparison of two approaches for teaching complex authentic mathematics problems to adolescents in remedial math classes. *Exceptional Children, 59*, 556–567.

Byers, R., Davies, J., Fergusson, A., & Marvin, C. (2008). *What about us? Promoting emotional well-being and inclusion by working with young people with learning difficulties in schools and colleges*. London, England: Foundation for People with Learning Disabilities.

Calhoon, M. B., & Fuchs, L. S. (2003). The effects of peer-assisted learning strategies and curriculum-based measurement on the mathematics performance of secondary students with disabilities. *Remedial and Special Education, 24*, 235–245.

The Carl D. Perkins Vocational and Applied Technology Education Act Amendments of 1990 (Perkins II), Pub. L. No. 101–392 (1990).

The Carl D. Perkins Vocational and Applied Technology Education Act Amendments of 1998 (Perkins III), Pub. L. No. 105–332, H.R.1853 (1998).

Cass, M., Cates, D., Smith, M., & Jackson, C. (2003). Effects of manipulative instruction on solving area and perimeter problems by students with learning disabilities. *Learning Disability Research & Practice, 18*(2), 112–120.

Cooney, G., Jahoda, A., Gumley, A., & Knott, F. (2006). Young people with intellectual disabilities attending mainstream and segregated schooling: Perceived stigma, social comparison and future aspirations. *Journal of Intellectual Disability Research, 50*, 432–444.

Goldin, C., & Katz, L. F. (2008). *The race between education and technology*. Cambridge, MA: The Belknap Press of Harvard University Press.

Gray, K. (2002). *The role of career and technical education in the American high school: A student centered analysis*. Washington, DC: Office of Vocational and Adult Education, U.S. Department of Education.

Howell, R., Sidorenko, E., & Jurica, J. (1987). The effects of computer use on the acquisition of multiplication facts by a student with learning disabilities. *Journal of Learning Disabilities, 20*, 336–340.

Ingels, S. J., Pratt, D. J., Rogers, J. E., Siegel, P. H., & Stutts, E. S. (2004). *Education Longitudinal Study of 2002: Base year data file user's manual* (Vol. NCES 2004.405). Washington, DC: National Center for Education Statistics, U.S. Department of Education.

Lee, J., Grigg, W. S., & Dion, G. S. (2007). *The nation's report card: Mathematics 2007.* (NCES 2007–494). Washington, D.C.: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Maccini, P., & Gagnon, J. C. (2000). Best practices for teaching mathematics to secondary students with special needs. *Focus on Exceptional Children, 32*(5), 1–22.

Maccini, P., & Gagnon, J. C. (2006). Mathematics instructional practices and assessment accommodations by secondary special and general educators. *Exceptional Children, 72*, 217–234.

Marino, M. T. (2010). Defining a technology research agenda for elementary and secondary students with learning and other high-incidence disabilities in inclusive science classrooms. *Journal of Special Education Technology, 25*(1), 1–27.

Ong-Dean, C. (2006). High roads and low roads: Learning disabilities in California, 1976–1998. *Sociological Perspectives, 49*(1), 91–113.

Plank, S. (2001). A question of balance: CTE, academic courses, high school persistence, and student achievement. *Journal of Vocational Education Research, 26*, 279–327.

The School-to-Work Opportunities Act of 1994, Pub. L. No. 103–239, 108 Stat. 568 (1994).

Schneider, B., Swanson, C. B., & Riegle-Crumb, C. (1998). Opportunities for learning: Course sequences and positional advantages. *Social Psychology of Education, 2*(1), 25–53.

Shettle, C., Roey, S., Mordica, J., Perkins, R., Nord, C., Teodorovic, J., … Katsberg, D. (2007). *The nation's report card: America's high school graduates*. Washington, DC: National Center for Education Statistics, U.S. Department of Education.

Shifrer, D., Muller, C., & Callahan, R. (in press). Disproportionality and learning disabilities: Parsing apart race, socioeconomic status, and language. *Journal of Learning Disabilities*.

Stevenson, D. L., Schiller, K. S., & Schneider, B. (1994). Sequences of opportunities for learning. *Sociology of Education, 67*(3), 184–198.

Stone, J. R. III. (2004). Math course taking for CTE concentrators: Evidence from three studies of the impact of a decade of education reform. *Journal of Career and Technical Education, 21*(1), 51–71.

Stone, J. R. III, & Alfeld, C. (2004). Keeping kids in school: The power of CTE. *Techniques: Connecting Education & Careers,* April 2004.

Stone, J. R. III, & Aliaga, O. A. (2005). Career & technical education and school-to-work at the end of the 20th century: Participation and outcomes. *Career and Technical Education Research, 30*, 125–144.

U.S. Department of Education. (2007). Strategic plan for fiscal years 2007–12. Washington, DC: Author.

Wagner, M., Newman, L., Cameto, R., & Levine, P. (2006). *The academic achievement and functional performance of youth with disabilities: A report from the National Longitudinal Transition Study-2).* (NCSER 2006-3000). Menlo Park, CA: SRI International.

Footnotes

[1] SLMP categories include agriculture and renewable resources; business, marketing, and distribution; health care; public and protective services; trade and industry; technology and communications; personal and other services; food service and hospitality; childcare; and work study programs.

[2] Frequencies have been rounded per NCES guidelines.

[3] Specific Learning Disability was an optional response to a question on the base year parent survey: "In your opinion, which of these disabilities does your tenth grader have?" The school report was used rather than the parent report of disability because of the lack of consistency between the two measures, and because it was not clear whether the parent report was based on a diagnosis by a psychologist or whether the student had been identified by the school with disability. There are no other measures of having been identified with a learning disability in the database.

[4] Among the schools that reported the IEP status of all of their sampled students, 6.08% (n=360) of the students were identified with a learning disability, compared to 7.5% (n=329) of the students sampled from schools that reported the IEP status of only some of their students.

Author Notes

Dara Shifrer is a graduate student in the Department of Sociology and a trainee in the Population Research Center, and Rebecca Callahan is an assistant professor in the Department of Curriculum & Instruction and an affiliate of the Population Research Center, both at The University of Texas at Austin.

Correspondence should be addressed to Dara Shifrer, Population Research Center, The University of Texas at Austin, 1 University Station, G1800, Austin TX 78712. Email dshifrer@prc.utexas.edu

This research was supported by grants from the National Science Foundation (HRD-0834177, Chandra Muller, PI, and HRD-0965444, Rebecca Callahan, PI). This research also was supported by grant, 5 R24 HD042849, Population Research Center, awarded to the Population Research Center at The University of Texas at Austin by the Eunice Kennedy Shriver National Institute of Health and Child Development. This research also has received support from the grant, 5 T32 HD007081, Training Program in Population Studies, awarded to the Population Research Center at The University of Texas at Austin by the Eunice Kennedy Shriver National Institute of Health and Child Development. Opinions reflect those of the authors and do not necessarily reflect those of the granting agencies.

Appendix A

Types of Non-core Coursework, Categories and Titles

Type of Non-core Coursework	CSSC Main Category	CSSC Title
Liberal Arts	24	Liberal/General Studies
	38	Philosophy and Religion
	39	Theology
Visual and Arts	50	Visual and Performing Arts
Technology and Communications	09	Communications
	10	Communication Technologies
	11	Computer and Information Sciences
	15	Engineering and Engineering-related Technologies
	25	Library and Archival Sciences
	14	Engineering
	04	Architecture and Environmental Design
Health Care	17	Allied Health
	18	Health Sciences
Public Policy	33	Citizenship/Civic Activities
	22	Law
	44	Public Affairs
Personal and Other Services	12	Consumer, Personal, and Miscellaneous Services
	35	Interpersonal Skills
	36	Leisure and Recreational Activities
	37	Personal Awareness
	32	Basic Skills
	34	Health-related Activities
Business, Marketing, and Distribution	06	Business and Management
	07	Business and Office
	08	Marketing and Distribution
	28	Military Sciences
	29	Military Technologies
	43	Protective Services
	31	Parks and Recreation
	20	Vocational Home Economics
	19	Home Economics
	13	Education
Agriculture, Trade, and Industry	01	Agribusiness and Agricultural Production
	02	Agricultural Sciences
	03	Renewable Natural Resources
	21	Industrial Arts
	46	Construction Trades
	47	Mechanics and Repairers
	48	Precision Production
	49	Transportation and Material Moving