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

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## Abstract

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 non-academic 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 in contrast to students who are not identified with a learning disability.

## Keywords

Course-taking; vocational; career and technology education; elective; math; science; learning disabilities; high school; academic achievement

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## Introduction

The courses a student completes by the end of high school have important implications for postsecondary pursuits, potentially putting students who are identified with a learning disability (LD) at a serious disadvantage. Not only is there a federal impetus to increase the

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### Author Notes

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science, technology, engineering, and mathematics (STEM) achievement of all students (Augustine, 2007; U.S. Department of Education, 2007), but admission into 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; for example, completion of Algebra I is generally required before a student can take Geometry (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 has typically focused on improving pedagogy and curriculum within science and math courses (Marino 2010; Calhoon and Fuchs 2003; Maccini and Gagnon 2000; Bodzin et al. 2007), 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 over 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 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 oft-mentioned 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 of 2002 (ELS), a large national dataset of both regular and special education students who were in the 10<sup>th</sup> 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, 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 8th grade National Assessment of Educational Progress 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 such as: lower levels of self-esteem and self-efficacy, a lack of social skills, and reduced motivation (Barrera, et al., 2006; Calhoun & 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, Forthcoming; Stone, 2004). Students with LD might also experience lower levels of STEM success simply because the education system has yet to find effective responses to their unique learning style. We address the influence of these factors to a certain degree by comparing students identified with LD to students who are not identified, but 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 filled a non-academic role. Non-core courses were initially intended to prepare students for direct entry into the workforce and remain classified within the ten federal categories<sup>1</sup> 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 are also 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 (CTE *and* academic) went on to a two- or four-year college (Gray, 2002). In fact, little to no difference is found between the high school achievement of academic concentrators and integrated concentrators, even though the latter start school with lower 8<sup>th</sup> grade test scores (Gray, 2002; Plank, 2001). Stone and Alfeld (2004) actually find that CTE concentrators take more science and math than their general track peers. Moreover, students with disabilities are specifically mentioned as one of the “special populations” targeted by the changes in the funding for non-core coursework (Apling, 1998). Concurrent with the aforementioned legislative shift in 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, thought to particularly facilitate the academic development of students with LD (Bodzin, Waller, Santoro, & Kale, 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,

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<sup>1</sup>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.

with fewer restraints, smaller classes, and potentially better topical alignment (e.g., Computer Science, Engineering, and Architecture courses).

Lastly, 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, perhaps less aware than core teachers of students' academic histories, may interact with the student as 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 paper 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 do the non-core, science, and math high school course-taking of students identified with a 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?, and 3) Is any effect on STEM preparation experienced by students who are identified comparable to that 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 10<sup>th</sup> graders in 2002 enrolled in approximately 750 high schools. We utilize measures from the student surveys (2002, 2004) and the parent survey (2002), as well as data from the students' high school transcripts. ELS is an ideal dataset for this study for several reasons. There are very few large datasets with measures of both disability and socio-demographic characteristics (Ong-Dean, 2006). In contrast to ELS, the federal datasets focused specifically on special education do not include peers who are not in special education as a base of comparison. ELS continues to conduct surveys with students who have dropped out; because of their higher rates of drop out, students with LD would experience greater rates of attrition from datasets that do not include dropouts.

After excluding students without transcript data, who have a disability other than LD, or who attended a school that did not provide Individualized Education Plan (IEP) reports, we utilize an analytic sample of approximately 9,850<sup>2</sup> students in 540 schools. Descriptive statistics are provided in Table 1. A student-level weight is applied in all analyses to account for survey design. Unless the information was available in a later wave of data, mean and

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<sup>2</sup>Frequencies are rounded per NCES guidelines.

mode imputation were used to account for missing values on all independent variables except for race, gender, and identification with a LD; imputation flags were included in all multivariate models.

**Identified with a Learning Disability**—School administrators were asked to identify which sampled students have 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 focuses on the students identified by their school with a “Specific Learning Disability.”<sup>3</sup> 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 are comparable percentages of students identified as having an IEP, and identified with a 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 enable us to conclude that the schools who reported on *some* (rather than *all* or *none*) of their students simply reported only when a student had an IEP; thus, we consider the students for whom these schools did not provide an IEP report as not identified with a LD.<sup>4</sup> The 4,200 students attending schools that did not provide the IEP status for any of their students are excluded from analyses. Since the differences in the average characteristics of the excluded schools and the schools in the analytic sample are statistically significant, the analytic sample cannot be claimed with absolute confidence to be nationally representative.

**Social Background**—Because there are systematic differences in the backgrounds of students who are and are not identified with LD (Shifrer, et al., Forthcoming), the influence of these differences on academic outcomes is accounted for by including controls for being male, non-white, living with both biological parents, and having low SES. More specifically, SES is captured with indicators of highest level of parental education and family income.

**Course-Taking**—All course-taking is 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 1 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 99.99<sup>th</sup> percentile); the vast majority of courses are assigned 0.5 or 1.0 Carnegie credits, described as ‘credits’ in the *Results*. The federally designated Classification of Secondary School

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<sup>3</sup>“Specific learning disabilities” is also 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 is used rather than the parent-report of disability, because of the lack of consistency between the two measures, and because it is not clear whether the parent-report is based on a diagnosis by a psychologist nor whether the student has been identified by the school with disability. There are no other measures of having been identified with a learning disability in the database.

<sup>4</sup>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.

Courses (CSSC) codes and high school designated course titles available in the transcript data are employed to further distinguish courses by course type or subject. This study's operationalization of 'core' – math, English, science, and social studies courses – follows the federal definition (Shettle, et al., 2007), however foreign language courses are also included as core coursework in the current study due to the fact that they are usually required for admission to a 4-year college. Conversely, English as a second language (ESL) courses, which do not fulfill admission requirements, are categorized as non-core.

This study focuses 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 12<sup>th</sup> grade and completion of Chemistry by the 12<sup>th</sup> grade, both of which are argued to be highly predictive of college-going (Adelman, 1999)). Slightly modifying the federal SLMP areas (Gray, 2002; Plank, 2001), eight types of non-core coursework are explored in this study: 1) Liberal Arts, 2) Visual and Performing Arts, 3) Technology and Communications, 4) Health Care, 5) Public Policy, 6) Personal and Other Services, 7) Business, Marketing, and Distribution, and 8) Agriculture, Trade, and Industry. Appendix A displays the main CSSC categories that comprise each of the types of non-core coursework. Details on the CSSC sub categories which comprise Technology and Communications coursework are available from the authors upon request. To determine whether students who have been identified with a LD experience different course-taking outcomes than students who are not identified with a LD but have comparable early high school math placement, we include an ordinal measure of each student's 9<sup>th</sup> 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 lay the foundation for the study with bivariate analyses of differences in course-taking between students who are and are not identified with a 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 12<sup>th</sup> 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 experience benefits comparable to those experienced by students who are not identified with LD. Both of these models include controls for sex, race/ethnicity, family income, highest parental education level, family structure, and highest unfailed 9<sup>th</sup> grade math course. We estimate robust standard errors that account for students being clustered within schools. The *Results* section concludes with a graphical presentation (Figure 1) of predicted probabilities of science and math course completion estimated from the coefficients of the logistic regression models.



## Results

In contrast to students who are not identified with a LD, students identified with LD are significantly disadvantaged along every measure of high school course-taking and key STEM outcomes (Table 1). The proportion of students identified with a LD who progressed through Algebra II or higher by the 12<sup>th</sup> grade (22%) is significantly lower than the proportion among students who are not identified (69%). Similarly, whereas 58% of students who are not identified with a LD completed Chemistry by the 12<sup>th</sup> grade, only 16% of identified students did. Students identified with LD complete 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 12<sup>th</sup> grade. Credit accumulation across the various types of non-core coursework is distributed differently for students who are and are not identified with LD. Students with learning disabilities complete significantly more credits than students who are not identified in 1) Agriculture, Trade, and Industry, 2) Business, Marketing, and Distribution, and 3) Personal and Other Services coursework. In contrast, students identified with LD take significantly fewer credits than students who are not identified with LD in 1) Liberal Arts, 2) Visual and Performing Arts, 3) Technology and Communications, and 4) Health Care coursework. These bivariate statistics demonstrate the sizeable gaps in academic core credit accumulation and STEM pipeline progression between students who are and are not identified with LD, as well as variation in the levels of credit accumulation across types of non-core coursework.

Table 2 shows selected coefficients from logistic regression models predicting having completed Chemistry by 12<sup>th</sup> grade and having completed Algebra II or higher by the 12<sup>th</sup> grade. Although the corresponding coefficients are not shown in Table 2, these models account for the influence of differences in students' sex, race/ethnicity, family income, highest parental education level, family structure, and highest 9<sup>th</sup> grade math course. First, these models reaffirm the general STEM course-taking disadvantage for students identified with LD. Net of all controls, the log odds of completing Chemistry or Algebra II or higher by the 12<sup>th</sup> grade are significantly lower for students identified with a LD. These models also establish which types of non-core coursework have positive associations with STEM course-taking. Evident by the coefficients in the upper panel of Table 2, credit accumulation in 1) Technology and Communications, 2) Liberal Arts, and 3) Visual and Performing Arts coursework is significantly and positively associated with progression along both the science and math course-taking pipelines for all students (the exception being that the estimated effect of Technology and Communications coursework on science course-taking is only marginally significant). In contrast, credit accumulation in 1) Business, Marketing, and Distribution or 2) Agriculture, Trade, and Industry coursework has a significant and negative association with STEM course-taking. The other types of non-core coursework are not significantly associated with course completion in science or math.

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 are equally evident among students identified with LD. While the 'main effects' of credit accumulation previously discussed applied to all students in the analytic sample, the coefficients for the interactions between

credit accumulation and identification with an LD at the bottom of Table 2 express whether the positive associations diverge for students identified with a 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 12<sup>th</sup> grade is significantly *greater* for students identified with LD than it is for students who are not identified. There is 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 a 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 the analyst to compare students with LD to other students of similar social background who completed the same level of math during the 9<sup>th</sup> grade.

Figure 1 also demonstrates the degree to which there is a positive association between Technology and Communications coursework and STEM coursework for students who are and are not identified with a LD. Among students who complete no credits of Technology and Communications coursework, the predicted probability of completing Algebra II or higher by the 12<sup>th</sup> grade is 0.74 for students who are not identified and 0.27 for students identified with a LD. Among students who complete 3 credits of Technology and Communications coursework, the predicted probability of completing Algebra II or higher increases to 0.84 for students who are not identified and to 0.64 for students who are identified with a LD. The *similar steepness* of each of these lines is representative of the *comparable benefit* experienced by both students who are and are 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 not identified with LD. Simply put, the predicted probability of completing Chemistry is 0.22 for a student identified with LD who completed 0 credits of Technology and Communications coursework, whereas the predicted probability of completion is 0.41 for an otherwise similar student who completed 3 credits of Technology and Communications coursework..

## Discussion

At the baseline, these analyses establish that students identified with LD have markedly lower STEM course attainment than students who are not identified. They also take 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 are and are not identified with LD, regardless of Technology and Communications credit accumulation, demonstrates the relevance of work 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 identified students to at least a *comparable* extent as students who are not identified with a LD is a notable and worthwhile finding.

Simple decisions about non-core course placement in fact have very real implications for students with LD. The probability of completing Algebra II or higher by the 12<sup>th</sup> grade increases by 6% on average with every additional credit completed in Technology and Communications coursework for students identified with LD, in contrast to the 3% gain experienced by students not identified with LD. Every additional credit in Technology and Communications coursework increases the probability of completing Chemistry by the 12<sup>th</sup> grade by 6-7% for students who are identified with LD and 1% for students who are not identified. Importantly, these estimates derive from multivariate models that account for differences in social background and 9<sup>th</sup> grade math course placement, and as a result 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 are and are not identified with LD evidenced in Table 1. Although students identified with LD take more credits in non-core courses overall, they accumulate fewer credits on average in the types of non-core coursework that are positively associated with STEM outcomes than students who are 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 on 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 precludes 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's possible that the topics covered in Technology and Communications coursework are more applied or 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 non-traditional pedagogy, or Technology and Communications curricular 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 which produce this important benefit.

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## Appendix A: Types of Non-Core Coursework

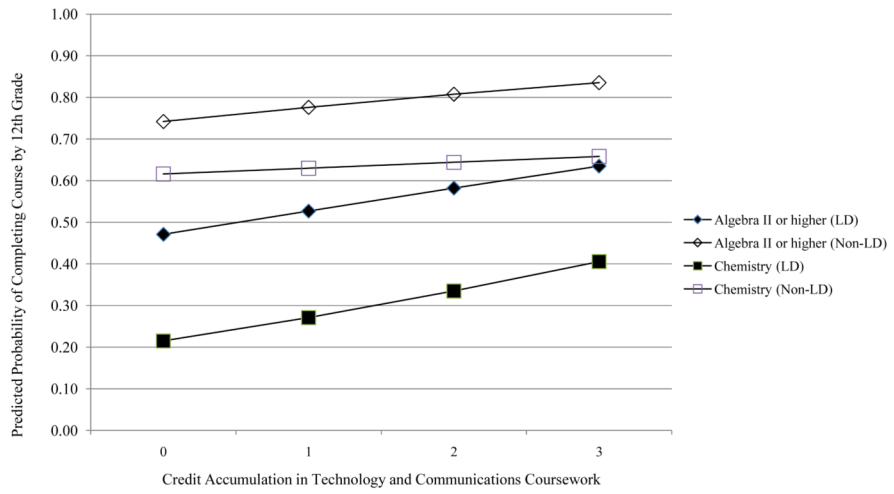
| Type of Non-Core Coursework | CSSC Main Category | CSSC Title                 |
|-----------------------------|--------------------|----------------------------|
| Liberal Arts                | 24                 | Liberal/General Studies    |
|                             | 38                 | Philosophy and Religion    |
|                             | 39                 | Theology                   |
| Visual and Performing Arts  | 50                 | Visual and Performing Arts |

| Type of Non-Core Coursework                                   | CSSC Main Category | CSSC Title                                       |
|---|--------------------|--|
| Technology and Communications (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               |

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**Figure 1.**  
attached in separate file as per JSET guidelines



**Table 1**

## Weighted Descriptive Statistics by LD Status

|   | LD                 | Non-LD          | Difference |     |
|---|--------------------|-----------------|------------|-----|
|   | Mean or Proportion | (SD)            |            |     |
| <b>STEM Course-taking Outcomes</b>                |                    |                 |            |     |
| Completed Algebra II or higher by 12th grade      | 0.22               | 0.69            | -0.47      | *** |
| Completed Chemistry by 12th grade                 | 0.16               | 0.58            | -0.42      | *** |
| <b>Academic core credits by 12th grade</b>        | 12.70<br>(4.23)    | 15.82<br>(4.15) | -3.12      | *** |
| <b>Non-core credits by 12th grade</b>             | 10.21<br>(4.10)    | 8.54<br>(3.12)  | 1.67       | *** |
| <b>Non-core credits by topic</b>                  |                    |                 |            |     |
| Technology and Communications                     | 0.67<br>(1.13)     | 0.81<br>(1.04)  | -0.13      | **  |
| Liberal Arts                                      | 0.11<br>(0.54)     | 0.23<br>(0.79)  | -0.13      | *** |
| Visual and Performing Arts                        | 1.47<br>(1.73)     | 1.95<br>(1.89)  | -0.48      | *** |
| Health Care                                       | 0.06<br>(0.33)     | 0.11<br>(0.55)  | -0.06      | *   |
| Public Policy                                     | 0.23<br>(0.57)     | 0.27<br>(0.54)  | -0.04      | +   |
| Personal and Other Services                       | 4.23<br>(2.67)     | 2.82<br>(1.62)  | 1.41       | *** |
| Business, Marketing, and Distribution             | 1.73<br>(2.07)     | 1.54<br>(1.63)  | 0.19       | *   |
| Agriculture, Trade, and Industry                  | 1.72<br>(2.87)     | 0.79<br>(1.53)  | 0.93       | *** |
| <b>Social background</b>                          |                    |                 |            |     |
| Male  | 0.66               | 0.49            | 0.17       | *** |
| Non-white   | 0.40               | 0.36            | 0.05       | *   |
| One or both parents have BA or higher             | 0.26               | 0.36            | -0.10      | *** |
| Family income                                     | 0.27               | 9.10            | -8.83      | *** |
| Student lives with both biological parents        | 0.49               | 0.59            | -0.11      | *** |
| <b>9th grade position on the math course seq.</b> | 2.30               | 3.66            | -1.357     |     |
| <b>Total Students</b>                             | 530                | 9300            |            |     |

Note: Frequencies are rounded per NCES guidelines.

\*  
p < 0.05,

\*\*  
p < 0.01,

\*\*\*  
p < 0.001,

+  
p < 0.10

**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)   |     | B  | (SE)   |     |
| <b>LD per IEP</b>                                      | -1.76                                 | (0.25) | *** | -1.17  | (0.21) | *** |
| <b>Credit accumulation in non-core courses:</b>        |                                       |        |     |  |        |     |
| Technology and Communications                          | 0.06                                  | (0.03) | +   | 0.19   | (0.04) | *** |
| Liberal Arts   | 0.30                                  | (0.06) | *** | 0.39   | (0.06) | *** |
| Visual and Performing Arts                             | 0.07                                  | (0.02) | **  | 0.10   | (0.02) | **  |
| 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) | **  | -0.07  | (0.02) | *** |
| Agriculture, Trade, and Industry                       | -0.14                                 | (0.02) | *** | -0.13  | (0.02) | *** |
| <b>Credit accumulation interacted with LD per IEP:</b> |                                       |        |     |  |        |     |
| Technology and Communications                          | 0.24                                  | (0.10) | *   | 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) | +   |
| McFadden's Adjusted R2                                 | 0.26                                  |        |     | 0.17   |        |     |

Note: Controls for sex, race/ethnicity, family income, highest parental education level, family structure, and highest unfailed 9th grade math course are included in both models.

Note: These analyses were conducted with data on approximately 9850 students in 540 schools.

\*  
p < 0.05,

\*\*  
p < 0.01,

\*\*\*  
p < 0.001,

+  
p < 0.10