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Building the STEM Talent Pipeline: The Impact of Project Lead the Way

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Abstract

Project Lead the Way (PLTW) is an applied STEM Career Technical Education program that has been adopted widely across the country. Using data from Missouri, we investigate the impact of PLTW course expansion on program participation and early post-secondary outcomes overall and by gender. Our identification strategies rely on within-school between-cohort variation in PLTW course availability, which serves as an instrument to identify program participation impacts. We find that greater PLTW course availability is related to higher program participation, college enrollment, and STEM major declaration with greater benefits for students with strong prior STEM preparation. Males are more responsive to Engineering course expansion and females to Biomedical Science expansion. Participation impacts on five-year STEM major declaration are larger for females than males.

Key words: High School Applied STEM Program, Career Technical Education, Post-Secondary Outcomes, Quasi-Experimental Design

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Introduction

Strengthening the education to workforce pipeline in science, technology, engineering, and mathematics (STEM) is an important national policy goal. STEM occupations represent a large and growing share of U.S. employment. In 2021, 37 million workers, or 24 percent of the U.S. workforce were employed in STEM occupations. Between 2011 and 2021 both the number and share of the workforce in STEM fields increased. The U.S. Department of Labor projects that between 2021 and 2031, employment in STEM occupations will increase by 10.8 percent versus 4.9 percent in non-STEM occupations.[1]

To expand K-12 student interest in STEM, applied STEM programs have grown over the last few decades. The aim of these programs is to engage students in meaningful STEM learning by connecting the traditional STEM disciplines to real-world problem solving through project-based learning. Project Lead the Way (PLTW) is one such program. First introduced in a handful of districts in New York more than two decades ago, the program is now offered in more than 12,000 schools in all 50 states (Project Lead the Way 2024).

At the high school level, the PLTW program offers coursework in three of the largest STEM occupational fields—Engineering, Biomedical Sciences, and Computer Science. These courses are offered as electives and/or part of CTE training. In some schools, students can earn college credits by successfully completing PLTW courses and meeting the conditions set by specific colleges. In this regard, PLTW and other STEM-focused curricular programs are doubly important: they not only provide learning experiences that directly affect students' content knowledge, but also develop a pathway to STEM majors in college and thus related occupations.

Using data for public high school students in Missouri, this study investigates how expanding PLTW opportunities impacts students' early college outcomes. There are two ways in which PLTW opportunities become more available to students. The first mechanism – the extensive margin—is to broaden access as more schools adopt the program. In Missouri, the high school program grew from 13 schools in 2005 to 198 schools by 2025 – or 38% of all public high schools.

The second mechanism is through increasing course offerings within the same high school (intensive margin). This includes adding more sections of the same course, new courses, and/or new subject areas.[2] This study focuses on the intensive margin and addresses the following research questions.

1) What is the average impact of increasing PLTW course availability in a given high school on PLTW participation and initial post-secondary outcomes?

2) Does the impact of increasing PLTW course availability differ by gender or STEM skills at high school entry?

3) What is the average impact of PLTW participation on initial post-secondary outcomes for those who participate in the program?

4) Do the participation impacts differ by gender or STEM skills at high school entry?

We find that within-school PLTW course expansion increased initial STEM major declaration. The impact on five-year STEM declaration is particularly large, especially for students in the top quartile of STEM readiness. The impact of PLTW course expansion appears to increase college enrollment for male students, but the impact on female students is less conclusive. Program participation increases college enrollment and STEM major declaration. Participation impacts on five-year STEM major declaration are larger for females than males. In particular, it appears that expansion of the Biomedical Science track draws female participants broadly across a range of STEM readiness.

The remainder of this paper is organized as follows: The next section provides a brief description of PLTW and a literature review on the impact of high school applied STEM coursework on student outcomes. We then discuss our data and methods, followed by statistical analysis. We conclude with a summary of the findings, implications for policy, and future research.

PLTW as an Applied STEM Career Technical Education Program

PLTW first launched the high school Engineering program in the late 1990's with a goal of better preparing students for the 21st-century workforce through a project-based curriculum (Symonds, Schwartz, and Ferguson 2011). It also attempted to raise the rigor of the traditional career and technical education (CTE) curriculum and better align high school training to the changing workforce need of business. Since that beginning, PLTW has grown to include five programs: Launch for Pre-K through 5th grade; Gateway for Grades 6 through 8; and the three high school "pathways," in Engineering as before, but adding Biomedical Sciences, and Computer Science. In Missouri, the Engineering pathway was introduced first in AY 2004-05, followed by Biomedical Sciences in AY 2011-12 and Computer Science in AY 2014-15.

In general, the PLTW curricula provide scaffolded and structured activities with real-world problems, while emphasizing student-centered instruction and collaborative learning. Each pathway follows a sequence of courses. Introductory and foundation-level courses provide an overview of the field, which are intended to develop students' understanding of major ideas of the field and stimulate enthusiasm for further study. In advanced courses, students are expected to deepen their understanding through more specialized content. The program ends with a capstone course which requires students to take their own ideas from design through development of a product or plans to produce one.

PLTW has several characteristics that suggest its potential efficacy for increasing STEM workforce readiness as well as students' interests in pursuing STEM or related fields after high school. First, classroom instruction is consistent with prior research on effective STEM instruction. Specifically, benefits of student-centered hands-on activities, the instructional content relevant to students, co-operative learning, group activities, and organizational support for teachers are reported by several studies (Woolnough 1994; Capraro, Capraro, and Morgan 2013; Kokotsaki, Menzies, and Wiggins 2016; Thibaut et al. 2018; Hanif, Wijaya, and Winarno 2019; Rehmat and Hartley 2020). PLTW is also designed to promote students' transition into postsecondary STEM education and careers in two ways. First, the course sequences are delivered via year-long high school courses and represent intensive learning opportunities with rigorous content. Second, students have the potential to earn college-level credit (i.e., dual credit) for advanced-level courses, potentially facilitating their transition into college and STEM majors (e.g., Edmunds et al. 2023; Hu and Chan 2023).

Literature Review

There is a growing body of studies that examine the impact of student participation in applied STEM courses, including PLTW. Using the national survey data, enrollment in applied STEM courses is related to higher 12th-grade math scores (Gottfried, Bozick, and Srinivasan 2014) and higher rates of STEM major declarations (Gottfried and Bozick 2016). Phelps, Camburn, and Min (2018) also showed enrolling in engineering and engineering technology courses during high school improves STEM enrollment in college.

The results from PLTW studies are generally consistent. Specifically, some studies find that PLTW participants have a higher likelihood of college enrollment (e.g., Rethwisch et al. 2013; Van Overschelde 2013; Camburn et al. 2022), a STEM major declaration (e.g., Pike and Robbins 2019; Starobin et al. 2013; Nomi et al. 2025; Camburn et al. 2022), and second-year retention than non-participants (e.g., Utley et al. 2019). However, in another study, which focused on college students who were enrolled in a pre-Engineering program, high school PTLW participation status did not affect college persistence (Cole, High, and Weinland 2013). Likewise, studies by Cole, High, and Weinland (2013) and Utley et al. (2019) showed no evidence of improvement in STEM degree completion for PLTW students. However, these latter studies had very small sample sizes, and the sample selection (e.g., college engineering students) may be affected by PLTW participation.

Most prior studies rely on observed covariates to remove selection bias. Those using the national surveys include an extensive set of covariates, which are not available in the state or institutional student administrative data. For example, studies on STEM degree completion (e.g., (Federman 2007; Maltese and Tai 2011; Wang 2013) include such variables as earlier STEM interests, attitudes towards and knowledge of math and science, self-efficacy, STEM career expectations as well as math test scores and grades. Even after controlling for these variables, statistically significant associations are found between math and science course enrollment and STEM degree completion.

An earlier study on PLTW (Nomi, DeChane, and Podgursky 2025) used a difference-in-difference (DID) method to examine the effect of school adoption of PLTW (i.e., extensive margin) on early post-secondary outcomes (college enrollment and initial STEM major). It used a subset of Missouri high schools that began offering the program after AY2012 and compared them to schools that never offered the program. The results showed positive effects of PLTW adoption on STEM major declaration for academically well-prepared students. Also, to estimate PLTW participation impacts, the study combined the DiD analysis with the principal stratification weighting method, using a comprehensive set of covariates. The result showed substantively meaningful impacts of PLTW participation on initial STEM major declaration (Nomi et al., 2025).

The current study adds to this earlier work by addressing a different set of questions with a longer panel of outcomes and taking an alternative methodological approach to estimate the impact of PLTW course expansion in the same school (i.e., intensive margin). This study makes a unique contribution in the following ways. First, the earlier study used a subset of schools (N=96 schools) that began offering the program in AY2012 or later (late adopters with pre-adoption student observations). This excludes many high schools (N=129 schools) that began offering the program in earlier years (i.e., schools without pre-adoption student records). These early PLTW adopters tend to be suburban or urban high schools serving a much higher proportion of Black and Hispanic students than the late adopters. In comparison, the current study uses all schools, including these early adopters. This extends the generalizability of the findings.

Second, the treatment schools in the earlier study primarily offered Engineering courses. Biological Sciences, which is much more popular among female students, was largely absent during the study period. Also, PLTW participation rates were relatively low (approximately, 4% of the first cohort and 9% of the second cohort attending schools with PLTW during their high school years), and this did not allow subgroup analysis by gender. This study, by utilizing all available cohorts and all schools, can reveal how male and female students differ in program participation patterns and the PLTW impact on the timing of post-secondary STEM participation.

Lastly, to identify PLTW participation impact (overall and by gender), this study uses arguably exogenous within-school between-cohort variation in PLTW course offerings as an instrument. By contrast, the earlier study relied on observed covariates to remove student selection to PLTW participation. We believe these two approaches together (i.e., both the extensive and intensive margins) bring greater credibility to causal inferences regarding the program impact.

In related work (not on PLTW), several researchers use exogenous variation in high school course offerings to examine post-secondary outcomes (Altonji 1995; Levine and Zimmerman 1995; Rose and Betts 2004; Federman 2007; Darolia et al. 2018). Of these, all but Darolia et al. (2018) use cross-sectional national data where the researchers utilize between-school or between-state variation in course offering. However, as Darolia et al. (2018) note, endogeneity is still a concern in these studies as high school curricular opportunities or state graduation requirements are not random. Also, differences in curricular opportunities may affect students' decisions on which high school to attend, and this is also likely to affect later outcomes.

To address these limitations, Darolia et al. (2018) used multiple cohorts of public college students in Missouri and data on high school course offerings in the traditional STEM subjects. Specifically, to estimate the impact of STEM course offerings on post-secondary outcomes, the authors isolated within-school between-cohort variation in STEM course availability by including cohort and high school fixed effects. They used this variation as an instrument to identify the impact of students' STEM course enrollment on post-secondary outcomes. Their findings indicate that, unlike earlier studies, greater access to traditional STEM courses, or STEM course enrollment, has few effects on STEM major declaration or degree attainment (Darolia, et al., 2018). This finding differs from a study by Federman (2007) who used between-state variation in high school graduation requirements as an instrument for STEM course enrollment, and finds much larger impacts on STEM degree declaration.[3]

We use the identification strategy of Darolia et al. (2018), but also note two important differences in our context. First, Darolia, et.al (2018) find relatively modest within-school year-to-year variation in course availability in the traditional STEM subjects that is only weakly related to students' STEM course enrollment. This limits the ability to identify the impact of STEM course offerings or students' enrollment in STEM courses. As will be shown below, within-school variation in PLTW course availability is large, which yields a strong instrument. Second, their study population consists of Missouri public college enrollees. This is problematic if high school STEM course completion affects the likelihood of enrolling in college. To address this limitation, we use the first-time ninth-grade students as the study population. We note as well that many of these ninth-grade students will ultimately attend a non-public or non-Missouri higher education institution, all of whom we will track in our dataset.

Data and Methods

The current study uses five cohorts of first-time 9th-grade students in Missouri who began public high school between AY2010 and AY2014. Each cohort has approximately 68,000 students attending 501 public high schools in operation throughout the entire study periods.[4] Of the total student population, the racial composition was 76 percent White, 16 percent Black, 4 percent Hispanic, and 4 percent Other. Nearly 53 percent of entering 9th-graders qualified for Free or Reduced Price Lunch (FRL). Descriptive statistics are shown in Table 1.

(Table 1)

We utilize K-12 student data from the Missouri Department of Elementary and Secondary Education (DESE) linked to National Student Clearinghouse data for post-secondary outcomes. The outcome variables are college enrollment within six months after high school graduation, STEM major declaration upon college entry, and STEM major declaration within five years of entering college. The last outcome is not available for the 2014 cohort and the analysis of this outcome uses data from four cohorts. In this study, STEM majors include those defined by the

Department of Homeland Security (DHS) and all health science majors[5]. The student data include demographic variables (race/ethnicity, gender, and FRL status); 8th-grade Missouri Assessment Program (MAP) scores in math, science, and English Language Arts (ELA) that are converted into Z-scores; a relative strength in Math, measured by the ratio of standardized scores in Math to that in ELA; and Algebra enrollment in 8th-grade.

To measure students' STEM readiness upon high school entry, we construct a composite measure, defined as the predicted probability of obtaining a four-year STEM degree within 5 years of entering college given 8th-grade academic covariates in the absence of PLTW. This is analogous to "prognostic scores" in the medical literature. The outcome is predicted by the baseline (2010) cohort in schools that did not introduce the PLTW program for the baseline cohort. This model is applied to other schools and cohorts to obtain their prognostic scores. The predictors include 8th-grade MAP scores in math, science, and ELA and completing Algebra in 8th grade. The coefficients from this model are applied to all students.

High school course offerings data contain all courses and course sections offered each semester by high school. Using these data, and following Darolia et al. (2018), a variable measuring PLTW course availability is constructed for each cohort. This is defined as the total number of PLTW course sections offered by school per 100 students during high school.[6] Pathway specific PLTW course availability is also created. In this case, we combined the Engineering and Computer Science pathways because only a small number of schools adopted the Computer Science pathways during the study period (38 schools), overall participation rates were small (3.4 percent), and student participation behavior is similar between Engineering and Computer Science (male students are much more likely to participate in these two pathways).

A total of 225 schools offered PLTW during the years when students in the current study were in high school (i.e., anytime between AY2010 and AY2017). These schools are considered "treatment" schools.[7] The remaining 276 schools did not offer PLTW during the period under study, and they constitute "control" schools. The control schools are used to remove between-cohort outcome variation (i.e., cohort effects) unrelated to changes in PLTW availability.

School characteristics differ considerably by the school treatment status (see Table 2 for descriptive statistics for the baseline, 2010 cohort). On average, PLTW schools are racially more diverse, are located in larger cities and suburban areas, have lower FRL rates, and have higher 8th-grade test scores than non-PLTW schools. In contrast, non-PLTW schools are much smaller and tend to be located in rural areas with higher FRL rates and attended by predominantly White students. This pattern of results suggests the challenge of offering a resource intensive program with elective courses in small, rural high schools where the organizational capacity is often limited.

(Table 2)

Among the treatment schools, PLTW course availability increased over time. Table 3 shows that, on average, schools offered 1.29 PLTW courses per 100 students for the 2010 cohort and most of the courses were in Engineering. The total number of PLTW courses increased to 3.15 courses for the 2014 cohort and the share of Biomedical Science courses also increased over time.

(Table 3)

Likewise, the overall program participation increased during the study period. The top panel of Table 4 shows that 9.7% of the 2010 cohort in the treatment schools participated in PLTW with most students enrolling in Engineering courses (the other two subjects were not offered in early years). Participation rates increased for each cohort and doubled for the 2014 cohort. Gender specific participation rates, presented in the middle and lower panels, show that female students are less likely to participate in PLTW than male students overall. Across the subjects, female students are much more likely to choose Biomedical Sciences whereas male students favored Engineering.

(Table 4)

Statistical Models

Effects of Course Availability (ITT)

The first analysis estimates the impact of increases in course availability on program participation and post-secondary outcomes for student i, cohort c, and school j. The statistical model is:

$$Y_{icj} = \alpha + \beta(Z_{cj}) + \psi(X_i) + \gamma(W_{cj}) + Coh_c + \varphi_j + \varepsilon_i \qquad (1)$$

where Z_{cj} is PLTW course availability variable for cohort c in school j, Coh_c are cohort fixed effects, X_i is a vector of student covariates (STEM readiness, relative strength in Math, gender, race, and FRL), W_{cj} is a vector of school-by-year covariates (e.g., average 8^{th}-grade test scores of incoming 9^{th}-grade cohort, percent of incoming 9^{th}-grade students who completed Algebra 1 in 8^{th}-grade, FRL rates, and cohort size), φ_j are school fixed effects, and ε_i is the student error term. The cohort fixed effects capture cohort-to-cohort outcome fluctuations unrelated to Z_{cj}, assumed to be common to all schools (the "common trends" assumption), and β is the effect on students' outcomes associated with changes in PLTW availability.

Effects of Course Participation (ToT)

We then use 2-stage least squares (2SLS) to identify the impact of PLTW participation on participants in schools that ever offered PLTW. The first stage model estimates program participation with Z as an instrument, using the following model:

$$T_{icj} = \alpha + \gamma(Z_{cj}) + \psi(X_i) + \gamma(W_{cj}) + Coh_c + \varphi_j + \varepsilon_i, \quad (2)$$

where the outcome *T* indicates program participation during high school (1=yes and 0=no) and the coefficient γ represents the impact of an increase in PLTW course offerings by one section per 100 students on program participation. To estimate the impact of PLTW participation on the outcomes, we estimate the following second stage model using the predicted probability of program participation from Equation 2 as a predictor:

$$Y_{icj} = \alpha + \delta(\hat{T}_{icj}) + \psi(X_i) + \gamma(W_{cj}) + Coh_c + \varphi_j + \varepsilon_i. \quad (3)$$

The parameter of interest is δ, representing the effect of PLTW participation, instrumented by PLTW expansion, on the outcome among students who are induced to participate in the program due to PLTW course expansion.

We use two sets of instruments for Z. Our first analysis uses overall PLTW course availability per 100 students as a measure of Z_{cj}. The second analysis uses pathway specific course availability entered as two measures of Z_{cj}. All statistical models are analyzed for the overall student population, separately for male and female students, and by the quartiles of STEM readiness, and by the STEM readiness quartiles by gender.

Key identification assumptions for the IV analysis are the exogeneity of the instruments (within-school PLTW expansion), given covariates and the exclusion restriction assumption. For the former, we include pre-treatment student-level covariates and school-by-year covariates (e.g., prior achievement, demographic characteristics, and cohort size of the rising 9^{th}-grade students) as additional controls. This assumption is violated if more able (conditional on covariates) students increasingly choose PLTW high schools as the latter expanded their course offerings. We investigated this possibility (results shown after the Results section below) and found no such evidence. The second assumption is that the PLTW course expansion within high school only affects student outcomes through program participation. This is violated if PLTW course offer/expansion had spillover effects. This could happen, for example, if PLTW course offer/expansion improved teaching skills of PLTW teachers who may teach non-PLTW courses and benefit non-PLTW participants taking these courses.[8] Also, if PLTW course offer/expansion improved the outcomes of program participants, these positive impacts may affect their peers who did not participate in the program. An earlier study by Nomi et al. (2025) investigated spill-over effects of PLTW program adoption on the outcomes of non-participants who are observationally similar to PLTW participants in the same school and finds no such evidence.[9]

Results

Impact of PLTW Course Availability on Program Participation (ITT)

The top panel of Table 5 presents results for all students and by gender and STEM achievement quartiles. Comparing students across cohorts in the same school, we find that PLTW participation rose when schools increased course availability. Specifically, for the overall student population, an increase in PLTW course availability by one section per 100 students leads to an increase in program participation by 3.2 percentage points ($p<0.001$). From descriptive statistics in Table 4, the average increase in PLTW course sections from the 2010 to 2014 cohorts is about two courses per 100 students. Based on our statistical model, this would lead to an increase of 6.2 percentage points in PLTW participation over five cohorts. The magnitude of impact is similar by gender with an estimated increase of 3.0 percentage points ($p<0.001$) for male students and 3.4 percentage points ($p<0.001$) for female students. The analysis by the quartiles of STEM readiness shows that the impact is larger for students in the higher quartiles. An increase in one course section per 100 students is associated with a nearly 5 percentage point increase in program participation for students in the top quartile ($p<0.001$) as compared to 1.7 percentage points for students in the bottom quartile ($p<0.001$). The pattern of result by STEM quartiles is similar for male and female students.

(Table 5)

The results of pathway specific analysis (bottom panel, Table 5) show that the Engineering pathway is most likely to draw participants from students with high STEM readiness. The analysis, using all students, showed an estimated impact of 5.9 percentage points ($p<0.001$) for students in the top quartile. Also, male students are more likely to respond to increases in Engineering course offerings. Adding one Engineering course section per 100 students is associated with an increase in male program participation by 7.5 percentage points for the top quartile ($p<0.001$) and 5.8 points for the third quartile as compared to an increase of 4.1 and 2.5 percentage points for their female counterparts ($p<0.001$). By comparison, female students are much more likely to respond to Biomedical Science course availability with an overall participation increase of 4.6 percentage points as compared to 1.1 percentage points for males ($p<0.001$). Increases in Biomedical Science course offerings appear to affect female program participation relatively evenly across STEM readiness quartiles with an estimated increase ranging from 2.8 percentage points for the bottom quartile to 5.4 percentage points for the top quartile ($p<0.001$). For female students, Engineering course offerings also affect their PLTW participation, particularly among the top performing students (4.1 percentage points in the top quartile, $p<0.001$), while the impact is smaller for female students in lower quartiles.

The Effect of PLTW Course Availability on Students' Outcomes (ITT)

The next analysis examines the impact of PLTW course expansion on students' post-secondary outcomes (Table 6). In general, increasing PLTW course availability is associated with improvements in the outcomes examined (top panel). Across the overall population, adding one PLTW course section per 100 students is associated with an average increase of 0.3 percentage points for college enrollment ($p<0.01$); 0.2 percentage points for STEM major declaration within six months of college enrollment ($p<0.01$); and 0.3 percentage points for STEM major declaration within five years ($p<0.01$). These estimates appear small. However, considering that the average impact of PLTW course expansion on PLTW participation is 3.2 percentage points, the impacts of PLTW participation on the outcomes of participants are likely to be substantial. We estimate these ToT impacts in the next section.

(Table 6)

The analysis by gender shows that the impact of PLTW course expansion on college enrollment is greater for male students (0.5 percentage points, $p<0.01$) than female students (0.3 percentage points, n.s.). The impact on initial STEM major declaration is similar for males and females (0.3 and 0.2 percentage points, respectively), but only the coefficient for males is statistically significant at five percent. In contrast, five-year STEM major declaration increased by 0.8 percentage points for females ($p<0.001$), and this is slightly larger than the impact for male students (0.5 percentage points, $p<0.01$).

For the pathway specific analysis (bottom panel), we find statistically significant impact of Engineering course expansion on college enrollment for male students (0.7 percentage points, $p<0.01$). This suggests that, for male students, the impact of PLTW expansion on college enrollment found earlier (0.5 percentage point, $p<0.01$) is primarily driven by Engineering course expansion. For the initial STEM major declaration, the pattern of pathway-specific results is similar to that of our earlier results based on the combined pathways with the estimated impacts of 0.2 or 0.3 percentage points (n.s. for both estimates).

The most notable finding is observed for five-year STEM major declaration. For the overall population, we find a statistically significant impact of Engineering expansion (0.4 percentage points, $p<0.01$), but not for Biomedical science expansion (0.1 percentage points, n.s.). However, further analysis shows clear gender differences. For male students, offering an additional Engineering course section (per 100 students) is associated with an increase in five-year STEM declaration by 0.7 percentage points ($p<0.05$), but the expansion in Biomedical Science does not appear to affect this outcome (0.1 percentage points, n.s.). This is consistent with the program participation patterns observed earlier where male PLTW participation is much more likely to be affected by Engineering course expansion than Biomedical Science (see Table 5, bottom panel). For female students, the expansion of Biomedical Science by one course section (per 100 students) is likely to increase five-year STEM major declaration by 1.1 percentage points ($p<0.01$), and an increase of 0.5 percentage points is expected if schools add one Engineering course section (n.s.). While the latter result is not statistically significant, we note that the analysis of this outcome does not include the 2014 cohort which has the highest number of course offerings and the highest participation rates (see Table 3 and Table 4).

Table 7 reports results by the quartiles of STEM readiness. Here we find that the estimated impacts of PLTW course expansion on college enrollment are positive for Quartiles 2 through 4, ranging from 0.2 (n.s.) to 0.6 percentage points ($p<0.05$), and this appears to be driven by the male population. For STEM major outcomes, the impact of PLTW course expansion is only found for students in the top quartile. Specifically, adding one PLTW course per 100 students is likely to increase initial STEM major by 0.5 percentage points for the overall population in the top quartile. Although this was not statistically significant, the initial increase in STEM major was also likely to be due to male students with the estimated impact of 0.5 percentage points ($p<0.05$), while no significant impact was found for female students. However, five-year STEM major declaration increased for both male and female students in the top quartile with the estimated impact of approximately 1 percentage point ($p<0.05$). The average impact across all students in the top quartile was 1.3 percentage points ($p<0.001$).

Larger ITT impacts on five-year STEM major declaration than on initial STEM major declaration can be explained by the fact that students tend not to declare a major immediately upon college entry. Also, Missouri offers a scholarship for free community college to students who meet specific (modest) academic standards. Thus, higher-achieving students who first enroll in community college may not declare a STEM/health science major until they have transferred to a four-year college (community colleges offer an Associate of Science or Arts for students who intend to transfer).

(Table 7)

Next, we conducted the pathway specific analysis by the quartile of STEM readiness. Here we only report the results based on all students as the gender specific analysis appears to lose statistical power and it is difficult to draw conclusions (the results are available in the Appendix. See Tables A1 and A2). In general, the result of this analysis (Table 8) follows the pattern of results observed earlier. We find that Engineering course expansion is associated with increases in college enrollment for students in the top quartile, with an estimated impact of 0.8 percentage points ($p<0.05$). The estimated impacts on the initial STEM declaration among students in the top quartile are 0.2 and 0.5 percentage points for a one course section increase in, respectively, Engineering and Biomedical Science, although neither is statistically significant.

For both subjects, the impact on five-year STEM major declaration is much larger for students in the top achievement quartile. One additional course section in Engineering and Biomedical Science per 100 students raises the five-year STEM major rate by 1.3 ($p<0.05$) and 1.1 percentage points (n.s.), respectively. The Biomedical Science course offering effect is similar for students in the second STEM readiness quartile (1 percentage point, $p<0.05$).

(Table 8)

The Effect of PLTW Participation on Students' Outcomes (ToT)

To identify PLTW participation impacts, we conducted two sets of analyses: one using PLTW expansion as an instrument (IV1) and the other using pathway specific expansions as instruments (IV2). The OLS results are presented for comparison. The two IV results are similar and we report the IV1 results here for conciseness. Overall, we find statistically significant and large positive impacts of PLTW participation on all three post-secondary outcomes. Specifically, the IV1 results for all students showed that participating in PLTW increases college enrollment, on average, by 11.7 percentage points ($p<0.01$); STEM major declaration within six months by 7.8 percentage points ($p<0.01$); and STEM major declaration within five years by 22.2 percentage points ($p<0.001$). Gender specific analysis finds that the PLTW participation impact on college enrollment is larger for males (15.8 percentage points, $p<0.01$) than females (9.4 percentage points, n.s.). The gender specific impacts on initial STEM major declaration are relatively similar with the estimated impacts of 8.3 percentage points for males and 7.4 points for females ($p<0.05$ for both estimates). In contrast, the impact on five-year STEM major declaration is larger for females (25.3 percentage points, $p<0.001$) than for males (19.8 percentage points, $p<0.01$).

(Table 9)

The next analysis estimates participation impacts by the quartile of STEM readiness overall and by gender. We first present OLS results (Table 10), which find statistically significant impacts on all outcomes for all quartiles and both gender groups. These tend to be overestimates particularly for students in lower quartiles. For comparison, the instrumental variable (IV) results, using PLTW expansion as an instrument, are shown in Table 11 (The results using pathway specific expansion are similar and found in Table A2 in Appendix). Overall, the pattern of IV results follows earlier results regarding the ITT impact of PLTW course expansion. For college enrollment, PLTW participation impacts are statistically significant for students in the second and fourth quartiles (22.2 percentage points, $p<0.01$ and 9.9 percentage points, $p<0.05$, respectively). Also, the impacts appear to be larger for males than for females. Gender specific analysis appears to lose statistical power, and none of the estimates for females are statistically significant even though the magnitude is fairly large for some quartiles.

For STEM major outcomes, PLTW participation raises initial STEM major declaration for male students in the top quartile. The estimated impact for the overall population in Quartile 4 is 8 percentage points (n.s.) and 12.2 percentage points for male students ($p<0.05$). For female students, we find a similar magnitude of participation impact in Quartile 2 (11.5 percentage points) although this was not statistically significant. By contrast, the participation impacts on the five-year STEM declaration are much larger than those on initial STEM major declaration for the overall population and both gender groups in the top STEM readiness quartile. Specifically, among program participants in the top quartile, we estimate an increase in five-year STEM major declaration by 27.9 percentage points ($p<0.001$) for the overall population, 23.3 percentage points for male participants ($p<0.01$) and 24.4 percentage points for female participants ($p<0.01$). We also note that for female participants in the second and third quartiles, the magnitude of the impact is quite large (20 and 19.8 percentage points for Quartiles 2 and 3, respectively) although they are not statistically significant. As noted earlier, the analysis of five-year STEM does not include the 2014 cohort. In future work we plan to investigate this outcome as well as degree attainment outcomes using all the cohorts.

(Tables 10 and 11)

Test of Common Cohort Trends Assumption

A key identification assumption required for our ITT analysis is that the cohort effects (i.e., between-cohort outcome difference in the absence of PLTW, that is, Z=0) are constant for the treatment schools (schools that offered/expanded PLTW course sections) and the control schools (schools that never introduced PLTW). Specifically, the impact of PLTW expansion (Z) would be biased if the treatment schools had different outcome trajectories than the control schools in the absence of PLTW.

While the common trends assumption is not directly testable, we investigate the plausibility of this assumption by conducting a DiD analysis, using pre PLTW adaptation data. This analysis uses the control schools and a subset of treatment high schools that did not offer PLTW for the 2010 and 2011 cohorts, but expanded PLTW sections for later cohorts (the 2012 cohort or later). We expect the equality of the cohort effects between the treatment and control schools during the periods when the treatment schools had not yet introduced PLTW to their students. This analysis uses four cohorts (the 2010 through 2013 cohort). The 2014 cohort is not included since almost all treatment schools offered PLTW by then.

The total number of schools used for this analysis is 56 treatment schools (28,321 students) and 274 control schools (72,667 students). The statistical model includes cohort fixed effects with the 2010 cohort as the reference group, the interactions between cohort fixed effects and the school treatment status, as well as student and school-by-cohort covariates that are used in the main analysis, and school fixed effects. The parameter of interest is represented by the coefficients on the interaction terms, indicating the average within-school between-cohort outcome differences between the treatment and control schools during years in which the treatment school had not yet introduced PLTW to their students.

The results are provided in Appendix Table A3 (available online). We find little evidence of differential trends between the treatment and control schools prior to PLTW offer/expansion overall or by gender and achievement quartiles. The only statistically significant result is found for initial STEM major declaration for the 2011 cohort. The analysis based on all students and male students show slightly greater increases (by 1.4 percentage points, $p<0.05$) for the 2011 cohort in the treatment schools than those in the control schools. However, none of the other estimates are statistically significant.

Addressing Validity Threat due to Students' Sorting to Schools due to PLTW Expansion

This study assumes that within-school between-cohort variability in PLTW course offerings is exogenous, conditioning on covariates. This assumption is violated if, for example, more motivated students are increasingly choosing high schools that are expanding PLTW opportunities and motivation is not captured by the covariates. This study controlled for key time-varying confounders for incoming 9th-grade cohorts (average 8^{th}-grade math and science test scores, 8^{th}-grade Algebra completion rates, FRL rates, racial composition, and cohort size) as well as students' own demographic and academic characteristics.

Additionally, we assess the possibility of selection bias due to students' sorting to high schools associated with PLTW expansion, given covariates. Specifically, we examine the relationship between our instrument (PLTW availability for cohort c) and the likelihood of incoming 9th-grade students attending a high school that differs from the assigned high school based on their middle school in the prior year. The outcome takes a value of one if students deviated from the feeder patterns (this includes students from charter middle schools without feeder high schools and from non-Missouri public middle schools) and zero otherwise. If PLTW course expansion affects high school choice, we would expect a positive association between PLTW expansion and this outcome in a given high school.

The first model only includes year fixed effects and our instrument without any control variables. The results for all students (Appendix Table A4, first column) show a positive and statistically significant association, that is, PLTW expansion by one section per 100 students is associated with a 2.9 percentage point increase in students from non-feeder middle schools ($p<0.01$). The pathway specific analysis also shows the coefficients of similar magnitude (2.9 percentage points for Engineering/Computer Science and 2.3 percentage points for Biomedical Science) although they are not statistically significant. Once student and cohort covariates and school fixed effects are controlled for, these relationships are eliminated (the coefficient of -0.003, n.s.). The pattern of results is similar when the same analysis is conducted for each gender group. These results together suggest that the observed covariates sufficiently remove time-varying confounders of PLTW impacts that are operated through students' sorting to high school.

Conclusion

High school is a critical period for the development of STEM knowledge and skills as well as STEM career interests and identity through coursework and learning experiences (e.g., Bottia et al. 2015; Corin, Sonnert, and Sadler 2020). Most students with STEM degrees enter the pipeline in high school and continue in college (Tai et al. 2006; Maltese and Tai 2011). Project

Lead the Way is an applied STEM program, first introduced in a handful of high schools during the 1990's and expanded rapidly to thousands of high schools since then. PLTW offers curricula that are focused on hands-on, problem-based learning and real-world applications with a goal of strengthening the STEM workforce training and broadening student participation in meaningful STEM learning experiences.

This study, using the data on all public high school students in Missouri, examines how program participation increased following the expansion of PLTW course offerings, and how this, in turn, affected college enrollment and the choice of STEM or health science as a college major. Our evidence suggests that offering this type of applied STEM program during high school has the potential to increase student STEM participation in college. We also find notable differences by gender and prior STEM skill levels. The main findings are summarized as follows:

1) Overall student participation increased as schools expanded PLTW course offerings. Males, particularly those with strong STEM readiness, were responsive to Engineering course expansion. Female participation was driven more by Biological Science expansion, and this was observed relatively evenly across levels of STEM readiness.

2) College enrollment increased with PLTW course expansion for males. The program participation impact on college enrollment was not statistically significant for females.

3) STEM/Health Science major declaration rose for students in the top quartile of STEM readiness as schools increased PLTW course offerings, and for females, increases were only observed for five-year major declaration.

4) PLTW participation had statistically significant and substantial impacts on STEM major declaration, on average, with larger impacts for five-year than initial declaration for both

genders. Participation impacts on five-year STEM major declaration were larger for females than males.

This study highlights the importance of STEM academic readiness in improving post-secondary STEM outcomes as the positive impacts of PLTW course expansion were found primarily among students in the top quartile of STEM readiness. PLTW participation grew for students with all skill levels as schools expanded PLTW course offerings, with the largest increase for students in the top preparation quartile. For students in the bottom three preparation quartiles, even though their program participation did increase, we did not find statistically significant impacts of PLTW course expansion or program participation on STEM major declaration (initial or five-year).

We also note that not all students who declare a STEM/Health Science major do so upon college entry. Thus, to capture a fuller scope of post-secondary impacts, it is important to consider major declaration beyond the first year of college. Particularly for female students, the impact of course expansion on initial major declaration was not statistically significant although the direction of impact was positive. PLTW participation impacts on five-year declaration were larger than those on initial declaration for both gender groups.

Lastly, for female students, the expansion of Biomedical Science appears to draw participants broadly across the range of STEM readiness, and participation impacts on five-year major declaration were relatively similar across the top three achievement quartiles although the result is only statistically significant for the highest quartile. These findings are promising. The five-year outcomes were not available for all cohorts at the time of this study. However, as more data becomes available, it will be possible to examine in a systematic way whether the increase in STEM majors induced by PLTW translates into more completed STEM degrees.

Endnotes

[1] See https://ncses.nsf.gov/pubs/nsb20245/u-s-stem-workforce-size-growth-and-employment and https://blog.dol.gov/2022/11/04/stem-day-explore-growing careers#:~:text=At%20the%20Bureau%20of%20Labor,grow%20much%20faster%20than%20average

[2]In Missouri, PLTW began with 60 Engineering sections in 2005 and increased to 411 sections by the first year o this study (AY 2009–10). Biomedical Science was first introduced in AY 2011–12 with 186 sections, alongside Engineering sections. Computer Science began in AY 2014–15 with 11 sections, joining 864 Engineering and 42 Biomedical sections. By the final study year (AY 2016–17), total offerings had grown to 2,125 sections: 1,121 in Engineering, 754 in Biomedical Science, and 250 in Computer Science. PLTW sections continued to increase in number until after AY 2020-21 (2,871 sections), when schools were most impacted by COVID and distance learning.

[3] Studies by Altonji (1995), Levine and Zimmerman (1995), and Rose and Betts (2004) examined labor market outcomes associated with high school STEM course taking. These studies find that taking more rigorous courses only a small effect on wage (Altonji 1995); taking more math and science courses increases wages and the likelihood of entering STEM fields only for females (Levine and Zimmerman 1995); enrolling in more advanced courses has positive impacts on earnings ten years after high school graduation (Rose and Betts 2004).

[4] 37 schools were closed or opened during the study period and not included in the study.

[5] While the DHS does not consider health science majors as STEM majors, we consider health science as part of STEM. This is relevant for those who participate in the Biomedical Science PLTW pathway.

[6] We also constructed a variable measuring the total number of unique PLTW courses offered during high school capture course variety. However, once course availability measure is included in the model, adding this variable not improve the overall model and the results remained the same, so we removed this variable from our analysis.

[7] Some treatment schools (88 schools) also have access to Career Centers which offer various CTE courses, including PLTW courses. Course availability through career centers is also used as additional predictor in the statistical model. However, an addition of this variable did not change the results.

[8] All teachers who teach PLTW are required to complete a two-week (80 hour) summer institute which is deliver by colleges and universities that are PLTW network affiliates, and they are provided with ongoing professional development training.

[9] To investigate this question, Nomi, DeChane, and Podgursky (2025) used principal score weighting methods to equate PLTW participants and non-participants attending the same school. Their outcome difference is compared that of similar students (non-participants) attending schools that never offered PLTW.

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Tables

Table 1. Descriptive Statistics

	Mean	SD
C2010	.199	.400
C2011	.194	.395
C2012	.193	.395
C2013	.208	.406
C2014	.206	.405
Female	.486	.500
White	.761	.426
Black	.155	.362
Hispanic	.042	.201
Asian	.017	.130
Other	.024	.152
FRL	.533	.499
MAP ELA	.000	1.000
MAP Math	.000	1.000
MAP Science	.000	1.000
8^{th} Grade Alg.	.185	.389
AI G8	.171	.168
STEM AI G8	.029	.052
N students	333,507	
N schools	501	

Table 2. Descriptive Statistics on PLTW High Schools and Non-PLTW High Schools in AY2010 (School-level)

	Non-PLTW schools		PLTW schools	
	Mean	SD	Mean	SD
% Female	.475	.096	.478	.053
% White	.867	.439	.720	.289
% Black	.094	.236	.201	.287
% Hispanic	.023	.062	.043	.055
% Other	.016	.028	.036	.032
% Free/Reduced Lunch	.599	.279	.381	.235
Ave. ELA scores	-.152	.978	-.016	.987
Ave. Math scores	-.190	.960	-.048	.984
Ave Science scores	-.165	.963	-.065	.992
% Completed Algebra in Grade 8	.108	.131	.177	.116
Mean GPA in Grade 9	2.636	.962	2.663	.993
District Locale				
-City	8.87	6.8	19.99	16.0
-Suburban	2.86	2.8	45.93	24.8
-Town	17.97	14.7	18.52	15.1
-Rural	56.07	2.9	15.56	13.1
Average School Enrollment	291.060	311.847	1117.252	603.497
School N	276		225	

Table 3. PLTW Course Sections Per 100 Students (Adjusted Course Sections) in Treatment Schools (N=225) by Cohort.

	2010	2011	2012	2013	2014
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
All PLTW courses	1.290 (1.477)	1.596 (1.866)	2.062 (2.315)	2.639 (2.667)	3.154 (2.549)
Engineering courses	1.195 (1.361)	1.393 (1.668)	1.672 (1.856)	2.008 (2.065)	2.208 (1.852)
Biomed courses	.164 (.426)	.354 (1.013)	.522 (1.135)	.684 (1.294)	.951 (1.482)
CS courses	.000 (.000)	.007 (.036)	.031 (.093)	.120 (.264)	.246 (.442)

Table 4. Average PLTW Participation Rates by Cohort (Treatment Schools)

	All				
	2010	2011	2012	2013	2014
PLTW	.097	.112	.129	.146	.181
	(.295)	(.315)	(.335)	(.353)	(.385)
Engineering	.077	.083	.092	.099	.116
	(.266)	(.276)	(.289)	(.299)	(.320)
Biomedical	.022	.031	.040	.047	.062
	(.146)	(.173)	(.196)	(.211)	(.241)
CS	.000	.001	.003	.009	.018
	(.000)	(.022)	(.050)	(.094)	.133)
N	48,825	47,654	47,848	51,424	51,410

	Female				
	2010	2011	2012	2013	2014
PLTW overall	.055	.072	.089	.101	.132
	(.228)	(.259)	(.285)	(.302)	(.338)
Engineering	.024	.029	.033	.035	.043
	(.154)	(.168)	(.179)	(.183)	(.202)
Biomedical	.032	.045	.059	.068	.091
	(.176)	(.207)	(.235)	(.252)	(.288)
CS	.000	.000	.001	.002	.005
	(.000)	(.009)	(.023)	(.049)	(.073)
N	23,748	23,174	23,271	25,015	25,005

	Male				
	2010	2011	2012	2013	2014
PLTW overall	.135	.149	.166	.187	.228
	(.342)	(.356)	(.372)	(.390)	(.420)
Engineering	.126	.134	.148	.161	.185
	(.332)	(.341)	(.355)	(.367)	(.389)
Biomedical	.012	.018	.022	.026	.034
	(.109)	(.131)	(.147)	(.160)	(.182)
CS	.000	.001	.004	.015	.030
	(.000)	(.029)	(.066)	(.122)	(.171)
N	25,077	24,480	24,577	26,409	26,405

Note: Standard deviations are in parentheses.

Table 5. The Effect of Adjusted Course Sections on PLTW Participation

All students	Overall	Q1	Q2	Q3	Q4
Intercept	.057***	.016***	.035***	.037***	.062***
	(.003)	(.003)	(.005)	(.006)	(.007)
PLTW	.032***	.017***	.027***	.036***	.047***
	(.001)	(.001)	(.001)	(.001)	(.002)
Male students					
Intercept	.048***	.011*	.022**	.029***	.046***
	(.004)	(.005)	(.007)	(.008)	(.010)
PLTW	.030***	.015***	.024***	.037***	.047***
	(.001)	(.002)	(.002)	(.002)	(.002)
Female students					
Intercept	.005	-.005	.002	-.011	-.017*
	(.003)	(.004)	(.005)	(.006)	(.008)
PLTW	.034***	.017***	.031***	.036***	.048***
	(.001)	(.001)	(.002)	(.002)	(.002)
	Pathway Specific Analysis				
All Students	Overall	Q1	Q2	Q3	Q4
Intercept	.044***	.016***	.035***	.036***	.059***
	(.002)	(.003)	(.005)	(.006)	(.007)
Eng/CS	.035***	.018***	.028***	.040***	.059***
	(.001)	(.002)	(.002)	(.002)	(.003)
Biomed	.028***	.014***	.025***	.030***	.033***
	(.001)	(.002)	(.003)	(.003)	(.003)
Male students					
Intercept	.047***	.011*	.020**	.025**	.039***
	(.004)	(.005)	(.007)	(.008)	(.010)
Eng/CS	.044***	.024***	.033***	.058***	.075***
	(.002)	(.003)	(.003)	(.004)	(.004)
Biomed	.011***	.001	.010*	.009	.014**
	(.002)	(.003)	(.004)	(.004)	(.005)
Female students					
Intercept	.006	-.004	.004	-.009	-.014
	(.003)	(.005)	(.005)	(.007)	(.008)
Eng/CS	.024***	.010***	.023***	.025***	.041***
	(.001)	(.002)	(.003)	(.003)	(.004)
Biomed	.046***	.028***	.041***	.049***	.054***
	(.002)	(.003)	(.003)	(.003)	(.004)
	Sample Size				
All	333,507	83,371	83,382	83,376	83,378
Male	171,296	44,651	41,257	41,689	43,699
Female	162,211	38,720	42,125	41,687	39,679

Note: Q4 is highest level of preparation. The model includes cohort fixed effects, students' covariates, and high school fixed effects. Standard errors are in parentheses. *<.05. **<.01. ***<.001

Table 6. The Effect of PLTW Adjusted Course Sections on Student Outcomes

	College Enrollment			STEM/Health Science Major upon College Entry			STEM/Health Science Major within Five Years After Entering College		
	All	Male	Female	All	Male	Female	All	Male	Female
Intercept	.436***	.440***	.579***	.107***	.105***	.155***	.193***	.198***	.267***
	(.005)	(.006)	(.007)	(.003)	(.004)	(.005)	(.004)	(.006)	(.007)
PLTW	.003**	.005**	.003	.002**	.003*	.002	.003**	.005**	.008***
	(.001)	(.002)	(.002)	(.001)	(.001)	(.001)	(.001)	(.002)	(.002)

Pathway Specific Analysis

	College Enrollment			STEM/Health Science Major upon College Entry			STEM/Health Science Major within Five Years After Entering College		
	All	Male	Female	All	Male	Female	All	Male	Female
Intercept	.436***	.440***	.578***	.107***	.105***	.156***	.193***	.198***	.269***
	(.005)	(.006)	(.007)	(.003)	(.004)	(.005)	(.004)	(.006)	(.007)
Eng/CS	.003	.007**	.002	.002	.002	.002	.004**	.007*	.005
	(.002)	(.003)	(.003)	(.001)	(.002)	(.002)	(.002)	(.003)	(.003)
Biomed	.003	.002	.004	.003	.003	.002	.001	.001	.011**
	(.002)	(.003)	(.003)	(.002)	(.002)	(.002)	(.002)	(.003)	(.004)
N	333,507	171,296	162,211	333,507	171,296	162,211	264,655	136,052	128,603

Note: The model includes cohort fixed effects, students' covariates, and high school fixed effects. The analysis of the first two outcomes (college enrollment and STEM/Health Science major upon college entry) uses five cohorts of students, while that of STEM/Health Science major within five years after entering college is based on four cohorts. Standard errors are in parentheses. *<.05. **<.01. ***<.001

Table 7. The Effect of PLTW Adjusted Course Sections on Student Outcomes by Quartiles of STEM Readiness

	College Enrollment											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.142***	.290***	.446***	.610***	.131***	.292***	.446***	.593***	.255***	.441***	.601***	.71***
	(.007)	(.009)	(.010)	(.009)	(.008)	(.012)	(.013)	(.012)	(.01)	(.012)	(.013)	(.012)
PLTW	0	.006*	.002	.005*	.001	.008*	.004	.006*	0	.005	.001	.003
	(.002)	(.002)	(.002)	(.002)	(.002)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
	STEM/Health Science Major upon College Entry											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.016***	.033***	.082***	.173***	.015***	.033***	.077***	.169***	.034***	.08***	.143***	.21***
	(.003)	(.006)	(.008)	(.010)	(.003)	(.005)	(.008)	(.011)	(.004)	(.007)	(.01)	(.012)
PLTW	0	.002	0	.005	-.001	0	0	.005*	.001	.003	-.001	.001
	(.001)	(.001)	(.002)	(.003)	(.001)	(.001)	(.002)	(.003)	(.001)	(.002)	(.003)	(.003)
N	83,371	83,382	83,376	83,378	44,651	41,257	41,689	43,699	38,720	42,125	41,687	39,679
	STEM/Health Science Major within Five Years After Entering College											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.039***	.086***	.157***	.338***	.037***	.08***	.157***	.34***	.078***	.175***	.244***	.369***
	(.004)	(.008)	(.010)	(.012)	(.005)	(.008)	(.011)	(.014)	(.007)	(.011)	(.013)	(.015)
PLTW	.001	.004	.004	.013***	.001	.002	.001	.01*	0	.005	.006	.011*
	(.002)	(.002)	(.003)	(.003)	(.002)	(.003)	(.004)	(.004)	(.003)	(.004)	(.004)	(.005)
N	66,173	66,154	66,533	65,795	35,253	32,809	33,365	34,625	30,920	33,345	33,168	31,170

Note: Q4 is highest level of preparation. The model includes cohort fixed effects, students' covariates, and high school fixed effects. The analysis of the first two outcomes (college enrollment and STEM/Health Science major upon college entry) uses five cohorts of students, while that of STEM/Health Science major within five years after entering college is based on four cohorts. Standard errors are in parentheses. *<.05. **<.01. ***<.001

Table 8. The Effect of PLTW Pathway Specific Course Sections on Students' Outcomes by Quartiles of STEM Readiness: All students

	College Enrollment				STEM/Health Science Major upon College Entry				STEM/Health Science Major within Five Years After Entering College			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	$.141^{***}$	$.290^{***}$	$.446^{***}$	$.610^{***}$	$.017^{***}$	$.033^{***}$	$.082^{***}$	$.178^{***}$	$.038^{***}$	$.087^{***}$	$.156^{***}$	$.340^{***}$
	(.007)	(.009)	(.010)	(.009)	(.003)	(.005)	(.007)	(.009)	(.004)	(.008)	(.010)	(.012)
Eng/CS	.002	.007	.002	$.008^{*}$	0	.001	.001	.002	.002	-.002	.007	$.013^{*}$
	(.003)	(.004)	(.004)	(.004)	(.001)	(.002)	(.003)	(.004)	(.003)	(.004)	(.005)	(.006)
Biomed	-.002	.004	.002	.002	.001	.003	-.001	.005	.001	$.01^{*}$	-.001	.011
	(.004)	(.005)	(.005)	(.004)	(.002)	(.003)	(.003)	(.004)	(.003)	(.005)	(.006)	(.006)
N	83,371	83,382	83,376	83,378	83,371	83,382	83,376	83,378	66,173	66,154	66,533	65,795

Note: Q4 equals highest level of preparation. The model includes cohort fixed effects, students' covariates, and high school fixed effects. The analysis of the first two outcomes (college enrollment and STEM/Health Science major upon college entry) uses five cohorts of students, while that of STEM/Health Science major within five years after entering college is based on four cohorts. Standard errors are in parentheses. *<.05. **<.01. ***<.001

Table 9. The Effect of PLTW Participation on Student Outcomes

	College Enrollment								
	All			Male			Female		
	OLS	IV1	IV2	OLS	IV1	IV2	OLS	IV1	IV2
Intercept	.382***	.426***	.427***	.433***	.430***	.429***	.574***	.575***	.575***
	(.005)	(.005)	(.005)	(.006)	(.007)	(.007)	(.006)	(.006)	(.006)
TOT	.158***	.117**	.107**	.101***	.158**	.165***	.124***	.094	.099*
	(.003)	(.036)	(.036)	(.003)	(.052)	(.049)	(.005)	(.049)	(.048)
	STEM/Health Science Major upon College Entry								
	All			Male			Female		
	OLS	IV1	IV2	OLS	IV1	IV2	OLS	IV1	IV2
Intercept	.084***	.102***	.102***	.101***	.101***	.102***	.153***	.154***	.154***
	(.003)	(.003)	(.003)	(.004)	(.004)	(.004)	(.005)	(.005)	(.005)
TOT	.116***	.078**	.072**	.068***	.083*	.065*	.128***	.074*	.076*
	(.002)	(.024)	(.024)	(.002)	(.033)	(.031)	(.003)	(.035)	(.034)
N		333,507			171,296			162,211	
	STEM/Health Science Major within Five Years After Entering College								
	All			Male			Female		
	OLS	IV1	IV2	OLS	IV1	IV2	OLS	IV1	IV2
Intercept	.159***	.183***	.184***	.193***	.189***	.189***	.266***	.265***	.265***
	(.004)	(.005)	(.005)	(.005)	(.006)	(.006)	(.007)	(.007)	(.007)
TOT	.184***	.222***	.212***	.119***	.198**	.194**	.188***	.253***	.254***
	(.003)	(.049)	(.049)	(.003)	(.071)	(.065)	(.005)	(.066)	(.064)
N		264,655			136,052			128,603	

Note: IV1 uses PLTW course sections per 100 students as an instrument. IV2 uses pathway specific course sections per 100 students as instruments. The models include cohort fixed effects, students' covariates, and high school fixed effects. The analysis of the first two outcomes (college enrollment and STEM/Health Science major upon college entry) uses five cohorts of students, while that for STEM/Health Science major within five years after entering college is based on four cohorts. Standard errors are in parentheses. *<.05. **<.01. ***<.001

Table 10. The Effect of PLTW Participation on Student Outcomes by Quartiles of STEM Readiness: OLS estimates

	College Enrollment											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.138***	.286***	.438***	.604***	.127***	.292***	.441***	.589***	.255***	.438***	.597***	.71***
	(.006)	(.009)	(.01)	(.009)	(.007)	(.011)	(.013)	(.012)	(.009)	(.012)	(.013)	(.012)
TOT	.121***	.109***	.108***	.09***	.105***	.1***	.093***	.09***	.159***	.121***	.129***	.082***
	(.007)	(.006)	(.006)	(.004)	(.008)	(.008)	(.008)	(.006)	(.013)	(.011)	(.01)	(.007)
	STEM/Health Science Major upon College Entry											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.015***	.03***	.075***	.169***	.014***	.031***	.074***	.166***	.033***	.08***	.139***	.209***
	(.003)	(.005)	(.007)	(.009)	(.003)	(.005)	(.008)	(.011)	(.004)	(.007)	(.01)	(.012)
TOT	.033***	.055***	.096***	.119***	.023***	.035***	.066***	.107***	.056***	.089***	.15***	.146***
	(.003)	(.003)	(.004)	(.004)	(.003)	(.004)	(.005)	(.005)	(.006)	(.007)	(.007)	(.007)
N	83,371	83,382	83,376	83,378	44,651	41,257	41,689	43,699	38,720	42,125	41,687	39,679
	STEM/Health Science Major within Five Years After Entering College											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.038***	.083***	.149***	.325***	.036***	.079***	.15***	.329***	.078***	.174***	.245***	.368***
	(.004)	(.007)	(.01)	(.011)	(.004)	(.008)	(.011)	(.013)	(.007)	(.01)	(.013)	(.014)
TOT	.054***	.092***	.147***	.192***	.049***	.062***	.113***	.186***	.069***	.145***	.213***	.215***
	(.005)	(.006)	(.006)	(.006)	(.005)	(.006)	(.007)	(.007)	(.01)	(.01)	(.011)	(.01)
N	66,173	66,154	66,533	65,795	35,253	32,809	33,365	34,625	30,920	33,345	33,168	31,170

Note: Q4 equals highest level of preparation. The models include cohort fixed effects, students' covariates, and high school fixed effects. The analysis of the first two outcomes (college enrollment and STEM/Health Science major upon college entry) uses five cohorts of students, while that of STEM/Health Science major within five years after entering college is based on four cohorts. Standard errors are in parentheses. *<.05. **<.01. ***<.001

Table 11. The Effect of PLTW Participation on Student Outcomes by Quartiles of STEM Readiness: IV estimates with PLTW expansion (IV1) as Instrument

	College Enrollment											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.140***	.281***	.44***	.603***	.127***	.284***	.439***	.587***	.255***	.438***	.598***	.71***
	(.007)	(.01)	(.011)	(.01)	(.008)	(.012)	(.014)	(.013)	(.009)	(.012)	(.013)	(.012)
TOT	.017	.222**	.067	.099*	.057	.34*	.124	.125	-.003	.169	.039	.075
	(.122)	(.086)	(.067)	(.046)	(.161)	(.136)	(.093)	(.065)	(.184)	(.108)	(.092)	(.062)
	STEM/Health Science Major upon College Entry											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.015***	.03***	.079***	.172***	.015***	.032***	.077***	.165***	.033***	.079***	.14***	.21***
	(.003)	(.005)	(.007)	(.01)	(.003)	(.006)	(.008)	(.011)	(.004)	(.007)	(.01)	(.012)
TOT	.024	.061	.013	.08	-.048	.007	.006	.122*	.082	.115	-.015	.017
	(.05)	(.047)	(.047)	(.044)	(.059)	(.063)	(.057)	(.058)	(.081)	(.064)	(.071)	(.064)
N	83,371	83,382	83,376	83,378	44,651	41,257	41,689	43,699	38,720	42,125	41,687	39,679
	STEM/Health Science Major within Five Years After Entering College											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.038***	.081***	.149***	.317***	.036***	.078***	.154***	.325***	.078***	.174***	.245***	.367***
	(.005)	(.008)	(.011)	(.013)	(.005)	(.009)	(.013)	(.016)	(.007)	(.011)	(.013)	(.015)
TOT	.08	.168	.143	.279***	.031	.096	.036	.233*	.029	.200	.193	.244*
	(.109)	(.11)	(.101)	(.073)	(.123)	(.165)	(.125)	(.101)	(.186)	(.132)	(.135)	(.102)
N	66,173	66,154	66,533	65,795	35,253	32,809	33,365	34,625	30,920	33,345	33,168	31,170

Note: Q4 equals highest level of preparation. The models include cohort fixed effects, students' covariates, and high school fixed effects The analysis of the first two outcomes (college enrollment and STEM/Health Science major upon college entry) uses five cohorts of students, while that of STEM/Health Science major within five years after entering college is based on four cohorts. Standard errors are in parentheses. <.05. **<.01. ***<.001

Appendix Tables

Table A1. The Effect of PLTW Pathway Specific Course Sections on Students' Outcomes by Quartiles of STEM Readiness and Gender

	College Enrollment							
	Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.13***	.291***	.445***	.593***	.254***	.441***	.6***	.709***
	(.008)	(.012)	(.013)	(.012)	(.01)	(.012)	(.013)	(.012)
Eng/CS	.007	.013*	.005	.008	-.002	.005	.001	.007
	(.004)	(.005)	(.006)	(.005)	(.005)	(.006)	(.006)	(.005)
Biomed	-.007	.001	.003	.004	.003	.005	.002	-.002
	(.005)	(.007)	(.007)	(.006)	(.007)	(.007)	(.007)	(.006)

	STEM/Health Science Major upon College Entry							
	Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.015***	.033***	.077***	.169***	.035***	.081***	.144***	.212***
	(.003)	(.005)	(.008)	(.012)	(.004)	(.007)	(.01)	(.012)
Eng/CS	0	-.001	.001	.004	-.002	.004	-.004	.001
	(.001)	(.002)	(.004)	(.006)	(.002)	(.003)	(.004)	(.005)
Biomed	-.002	.002	-.002	.007	.005	.003	.003	-.001
	(.002)	(.003)	(.004)	(.007)	(.003)	(.004)	(.005)	(.006)
N	44,651	41,257	41,689	43,699	38,720	42,125	41,687	39,679

	STEM/Health Science Major within Five Years After Entering College							
	Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.037***	.081***	.156***	.342***	.078***	.178***	.144***	.37***
	(.005)	(.009)	(.012)	(.014)	(.007)	(.011)	(.01)	(.015)
Eng/CS	.005	0	.01	.006	-.002	-.003	-.004	.014
	(.003)	(.005)	(.006)	(.008)	(.004)	(.006)	(.004)	(.008)
Biomed	-.006	.005	-.013	.014	.004	.015*	.003	.006
	(.004)	(.006)	(.008)	(.009)	(.006)	(.008)	(.005)	(.01)
N	35,253	32,809	33,365	34,625	30,920	33,345	33,168	31,170

Note: The model includes cohort fixed effects, students' covariates, and high school fixed effects.
The analysis of the first two outcomes (college enrollment and STEM/Health Science major upon college entry) uses five cohorts of students, while that of STEM/Health Science major within five years after entering college is based on four cohorts. Standard errors are in parentheses. *<.05. **<.01. ***<.001

Table A2. The Effect of PLTW Participation on Students' Outcomes by Quartiles of STEM Readiness: IV estimates using Pathway Specific Course Sections as Instruments

	College Enrollment											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.14***	.28***	.44***	.602***	.126***	.284***	.44***	.587***	.255***	.437***	.598***	.71***
	(.007)	(.01)	(.011)	(.01)	(.008)	(.012)	(.013)	(.012)	(.009)	(.012)	(.013)	(.012)
TOT	.023	.24**	.068	.108*	.162	.363**	.106	.121*	.025	.189	.044	.07
	(.122)	(.087)	(.067)	(.045)	(.147)	(.131)	(.086)	(.061)	(.175)	(.108)	(.09)	(.062)
	STEM/Health Science Major upon College Entry											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.015***	.03***	.079***	.173***	.014***	.032***	.076***	.168***	.033***	.079***	.14***	.21***
	(.003)	(.005)	(.007)	(.01)	(.003)	(.006)	(.008)	(.011)	(.004)	(.007)	(.01)	(.012)
TOT	.026	.066	.016	.07	-.011	.002	.01	.074	.111	.119	0	.02
	(.05)	(.047)	(.047)	(.044)	(.053)	(.061)	(.053)	(.055)	(.077)	(.064)	(.07)	(.064)
N	83,371	83,382	83,376	83,378	44,651	41,257	41,689	43,699	38,720	42,125	41,687	39,679
	STEM/Health Science Major within Five Years After Entering College											
	All				Male				Female			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Intercept	.038***	.08***	.148***	.319***	.035***	.078***	.149***	.332***	.078***	.173***	.245***	.367***
	(.004)	(.008)	(.011)	(.013)	(.005)	(.009)	(.012)	(.016)	(.007)	(.011)	(.013)	(.015)
TOT	.086	.183	.154	.261***	.146	.082	.131	.158	.042	.236	.218	.227*
	(.102)	(.11)	(.101)	(.072)	(.098)	(.163)	(.11)	(.092)	(.184)	(.129)	(.13)	(.102)
N	66,173	66,154	66,533	65,795	35,253	32,809	33,365	34,625	30,920	33,345	33,168	31,170

Note: The model includes cohort fixed effects, students' covariates, and high school fixed effects. The analysis of the first two outcomes (college enrollment and STEM/Health Science major upon college entry) uses five cohorts of students, while that of STEM/Health Science major within five years after entering college is based on four cohorts. Standard errors are in parentheses.

*<.05. **<.01. ***<.001

Table A3. The Difference in Cohort Effects for Treatment Schools Prior To PLTW Offer/Expansion (DiD Estimates)

	All	Male	Female	Q1	Q2	Q3	Q4
	College Enrollment						
C2011*PLTW	.003	.012	-.009	-.001	.005	-.008	.001
	(.008)	(.011)	(.012)	(.014)	(.017)	(.017)	(.017)
C2012*PLTW	.003	-.008	.012	0	.02	.008	-.018
	(.009)	(.013)	(.014)	(.015)	(.019)	(.02)	(.02)
C2013*PLTW	-.01	.009	-.032	-.01	-.012	-.01	-.006
	(.011)	(.015)	(.016)	(.017)	(.022)	(.024)	(.024)
	STEM/Health Science Major upon College Entry						
C2011*PLTW	.014*	.014*	.014	.002	.011	.015	.022
	(.006)	(.007)	(.009)	(.006)	(.009)	(.012)	(.016)
C2012*PLTW	.009	.007	.01	.002	.013	-.005	.027
	(.006)	(.008)	(.01)	(.007)	(.011)	(.014)	(.018)
C2013*PLTW	.001	.001	.001	-.003	.005	-.002	.008
	(.007)	(.009)	(.012)	(.007)	(.012)	(.017)	(.023)
	STEM/Health Science Major within Five Years After Entering College						
C2011*PLTW	.01	.014	.006	-.003	.008	.001	.027
	(.007)	(.009)	(.011)	(.009)	(.012)	(.015)	(.018)
C2012*PLTW	.002	0	.003	0	.012	-.024	.022
	(.008)	(.01)	(.012)	(.009)	(.014)	(.017)	(.021)
C2013*PLTW	-.006	.005	-.018	-.01	-.007	-.02	.023
	(.009)	(.012)	(.014)	(.011)	(.017)	(.021)	(.026)
N	100,988	51,977	49,011	24,718	26,879	26,794	22,513

Note: The model includes cohort fixed effects, students' covariates, and high school fixed effects.
*<.05. **<.01. ***<.001

Table A4. The Effect of PLTW Course Expansion on Student Sorting to High School

	PLTW Course Expansion					
	All		Male		Female	
	M1	M2	M1	M2	M1	M2
Intercept	.252***	.148***	.248***	.156***	.257***	.148***
	(.026)	(.033)	(.025)	(.034)	(.026)	(.032)
PLTW	.029**	-.003	.028**	-.003	.029**	-.002
	(.011)	(.002)	(.011)	(.003)	(.011)	(.002)
	Pathway Specific Analysis					
	All		Male		Female	
	M1	M2	M1	M2	M1	M2
Intercept	.253***	.148***	.248***	.151***	.259***	.155***
	(.027)	(.04)	(.027)	(.041)	(.027)	(.039)
Eng/CS	.029	-.003	.03	-.002	.028	-.004
	(.017)	(.005)	(.017)	(.006)	(.018)	(.005)
Biomed	.023	-.003	.02	-.005	.026	0
	(.03)	(.005)	(.03)	(.005)	(.03)	(.005)
N	333,507		171,296		162,211	

Note: Dependent variable equals one if student attends non-feeder high school, zero otherwise. M1 includes the PLTW course availability variable(s) only. M2 includes cohort fixed effects, students' covariates, and high school fixed effects. *<.05. **<.01. ***<.001