AC 2011-468: A LONGITUDINAL EVALUATION OF PROJECT LEAD THE WAY IN THE STATE OF IOWA

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A Longitudinal Evaluation of *Project Lead The Way* in the State of Iowa

Abstract

The State of Iowa has implemented *Project Lead The Way* (PLTW), a sequence of pre-engineering courses for students in middle and high schools. The intent of PLTW is to increase student interest in STEM careers through a rigorous, project-based curriculum. Despite the popularity and rapid expansion of PLTW program in Iowa, little is known about its efficacy. This is partially due to the lack of studies with robust data, such as comprehensive statewide K-12 and postsecondary databases, or the lack of a control group where pre-existing differences in student demographic characteristics, PLTW course enrollment, academic performance, and standardized tests are considered. This study addressed these two design concerns as we are conducting a statewide, longitudinal evaluation using secondary and postsecondary data maintained by the State of Iowa to evaluate and measure students' socio-demographic characteristics, academic achievement, course taking patterns, and progress from high school to postsecondary education.

The initial findings indicate PLTW participants are more likely to be white, male, enroll in math and science courses, and have higher standardized test scores. The team is currently involved in "propensity score matching" to reduce the effects of self-selection and define the covariates for the differences between PLTW participants and nonparticipants. A key goal of the long-term study is to determine if PLTW courses increase a students' pursuance of STEM postsecondary education. This study has implications for researchers, practitioners, and policy makers regarding the comprehensive evaluation design and the critical role that PLTW can play to increase the participation, both generally and within non-traditional groups, in postsecondary STEM education in the U.S.

Introduction

PLTW's stated goal is to "increase the number of young people who pursue engineering and engineering technology programs requiring a four- or two-year college degree" (PLTW, 2009). The PLTW program offers a sequence of pre-engineering courses for students, including Introduction to Engineering Design, Principles of Engineering, Digital Electronics, Aerospace Engineering, Bio-technical Engineering, Civil Engineering and Architecture, Computer Integrated Manufacturing, and Engineering Design and Development in high school and Gateway to Technology in middle school. PLTW provides students the opportunity to develop skills in scientific inquiry such as data collection and analysis, as well as collaboration and public speaking skills.

PLTW began about 12 years ago in 10 high schools in New York and New Hampshire. Since then it has grown rapidly throughout the country and is now present in all 50 states and in over 2500 high schools. PLTW was introduced in Iowa 4 years ago with 7 high schools and 3 middle schools. Since then we have experienced rapid growth in the state with more than 85 of the 360 high schools in the state now offering PLTW courses.

PLTW has experienced rapid growth due to various factors, including anecdotal evidence that it attracts students who would otherwise be unlikely to participate in a pre-engineering course, and it is a well-organized professional development and curriculum sequence (Adelson & Blais, 1998). Despite the upward trend in PLTW enrollment in Iowa (Schenk, et al., 2009) as well as other states (e.g., Brandt, 2009; Cech, 2008; Spellman, 2007) only one major study has examined student outcomes of PLTW participation. A research brief by the Southern Regional Education Board (SREB) found that PLTW students did significantly better in mathematics and science on the High Schools that Work (HSTW) assessment than career/technical students in comparable fields (Bottoms & Uhn, 2007). Differences between PLTW students and similar career/technical students were also found for subsequent course-taking behavior, with PLTW students more likely to complete the HSTW-recommended curriculum (Bottoms & Uhn, 2007). However, this may not have been an appropriate control group since the PLTW courses can all result in college credit. Thus, there is a need for evaluations to been conducted on a large, state-wide level such as the current research.

Iowa provides a unique opportunity to assess the outcomes of PLTW. The state has only had PLTW for 4 years but as noted, about 25% of the schools participate in the PLTW program. However, Iowa also has a K-12 database that is not available in most states. To help address the current lack of study of PLTW, we have initiated a study using the Iowa K-12 database (maintained by the Iowa Department of Education) combined with data from community colleges to assess the impact of PLTW courses on high school students.

Methodology

Research Questions

The following research questions guided this evaluation at this early stage:

- RQ1: What are the socio-demographic, academic, and cognitive characteristics of PLTW students and what characteristics are associated with PLTW participation?
- RQ 2: Do PLTW students take more math and science courses than non-PLTW students?
- RQ3: Is the cognitive improvement for PLTW students greater than that for non-PLTW students?

Data

These three research questions were investigated using merged datasets, which are maintained by the Iowa Department of Education. This merged PLTW dataset currently includes two data sources. These are:

1) Project EASIER, which includes PK-12 data, including PLTW status, standardized test scores (Iowa Test of Basic Skills, ITBS and Iowa Test of Educational Development, ITED), high school courses, and demographic data.
2) The Community College Management Information System (MIS), which includes courses taken, program of study, student degrees and demographic information for Iowa community colleges.

Merging these datasets provided the research team the capability to follow students longitudinally. Project EASIER contains K-12 data, including courses taken and individual student scores on Iowa's standardized achievement test, the Iowa Test of Basic Skills (8^{th} grade) and the Iowa Test of Educational Development (11^{th} grade). The Community College MIS includes data from all of Iowa's 15 community colleges.

The quality of the data in the Project EASIER and Community College MIS is satisfactory, based on the current evaluation study. Out of 88,000 students, only 6.44% had incomplete data for the mandatory Iowa Test of Educational Development (ITED, grade 11), and 8.84% for the mandatory Iowa Test of Basic Skills (ITBS, grade 8). We are currently using covariates to deal with missing data in the propensity score analysis (D'Agostino & Rubin, 2000). The ITBS and the ITED are norm-referenced tests currently administered to students in Iowa. Normative data for the tests are gathered every seven years and are representative of the U.S. population. The ITBS has KR20 reliability coefficients ranging from 0.85 to 0.92. The ITED has KR20 reliability coefficients above 0.98. The ITED is a good predictor of the ACT composite score, with correlations between 0.85 and 0.89.

Currently, our team is working on adding information from the Iowa Regents institutions (courses, GPA) and the National Student Clearinghouse, a nationally recognized repository of enrollment information for over 3,000 technical colleges, community colleges, and universities. It has been used as the basis of a number of transfer studies (Bers, 2001; Laanan, Starobin, Compton, Eggleston, Duree, 2007; Porter, 2002) and will be used to track students who attend postsecondary education outside of Iowa.

The PLTW database is constructed so that students enrolled in a PLTW course were identified and denoted as PLTW participants. A control cohort was chosen from students who were enrolled in schools which offered PLTW, but were not actually enrolled in any PLTW courses (non-participants). The PLTW database currently contains nearly 88,000 total students, with nearly 5,000 students in the PLTW group (2009-2010). There are currently 73 Iowa PLTW school districts and over 85 PLTW school buildings.

Students are tracked and analyzed by graduation cohorts, based on expected year of high school graduation. Thus, each cohort has similar ages, equivalent opportunity to participate in PLTW, and experiences the same school environment. Four cohorts have been identified for the current evaluation study—the class of 2008, 2009, 2010, and 2011.

Analysis

We are currently conducting propensity score analysis to account for the initial differences between PLTW and non-PLTW participants, thereby reducing the bias from self-selection (Titus, 2007; Rosenbaum & Rubin, 1983; Amemiya, 1985). This type of analysis represents a statistical response to one potential threat to internal validity—selection bias, or a systematic difference between students who choose to participate in PLTW and students who decide not to participate. When that systematic difference is also related to the outcome of interest, there is the potential for results to be biased. However, if participants and non-participant had been equated on characteristics that might also be related to the outcome of interest, we could be more confident that any observed changes are the result of PLTW participation rather than pre-existing differences in students (Shadish, Cook, & Campbell, 2002).

Results

As mentioned in the introduction, PLTW in Iowa has experienced rapid growth since 2005, when there were just over 200 students who participated in PLTW. In 2008, 1,737 students were enrolled, a 66 percent increase since the prior year. The results provide some evidence that PLTW will continue to grow in Iowa for the upcoming years. The Iowa PLTW class of 2008 had 352 students while the class of 2011—who were freshmen in this study—has already enrolled 542 students.

In addition to the larger size, there are demographic differences between the treatment and control cohorts. PLTW participants were disproportionally white compared to students in the

control. Ninety percent of Iowa PLTW participants were white, compared to 79 percent of the control group. In addition, 15.5 percent of all participants were female, compared to 50.4 percent of nonparticipants (Figure 2). Overall, PLTW is dominated by males, which comprise 84 percent of enrollment. However, female participation was greater in PLTW for the younger cohorts. For the class of 2008 and 2009, female participation was 11.6 and 15 percent, respectively. Meanwhile, 16.8 and 17.5 percent of PLTW enrollment was female for the classes of 2010 and 2011.

Additional differences emerged between PLTW and control cohorts on an indicator socioeconomic status. Participants were less likely to be eligible for free and reduced lunch than their peers. As displayed in Table 1, 22% of participants were eligible for free and reduced lunch, while 41.4% of nonparticipants were eligible for the same program. Married couples with two children are eligible for free meals if they earn less than $18,200 a year and eligible for reduced price meals if they earn less than $25,900 (Iowa Department of Education, 2009).

PLTW participants were also more likely to be enrolled in gifted and talented programs, as 30% of PLTW participants met those requirements in 2008, compared to 12.6% of nonparticipants. Gifted and talented students have either demonstrated achievement or potential ability or require educational services to meet their abilities that are beyond the regular school program.

In addition to the demographic characteristics of the PLTW and the control cohorts, students' achievement scores were analyzed. The State of Iowa requires at least two summative tests, which measure comprehensive knowledge in four subject areas: English, mathematics, science, and social studies. Students are required to take the Iowa Test of Basic Skills (ITBS) in 8^{th} grade, and then the Iowa Test of Education Development (ITED) in 11^{th} grade. Since Iowa students do not participate in PLTW until high school, the ITBS scores indicate a student's cognitive ability *before* PLTW.

PLTW students performed better on the mathematics and science subtests on the ITBS as well as on the ITED. Sixty-one percent of eventual PLTW students were above the 80^{th} percentile for ITBS mathematics subtest, compared to just 28% of nonparticipants. Likewise, 55% of PLTW participants were above the 80^{th} percentile on the science ITBS, compared to 28 percent of nonparticipants. See Table 1 for a summary of percentile ranks for the ITBS and ITED mathematics and science subtests, sorted by PLTW participation.

PLTW students also performed comparatively better on the ITED mathematics and science subtests. Sixty-four percent of participants were over the 80^{th} percentile in mathematics and 61% were over the 80^{th} percentile in science. Only 34 and 36% of nonparticipants were above the 80^{th} percentile in mathematics and science, respectively.

Finally, we examined the course-taking patterns for PLTW and control students. Table 2 and Figure 1 displays the proportion of courses enrolled in by participants and nonparticipants for all cohorts since 2006, which is the inception of course data to Project EASIER. Courses are

Table 1. *Summary of percentile ranks for ITBS and ITED mathematics and science subtests, by PLTW participation*

	Mathematics				Science			
	Mean	Median	Std. Dev.	Count	Mean	Median	Std. Dev.	Count
ITBS								
Participants	79.53	86	19.02	1,321	78.76	84	18.53	1,321
Nonparticipants	57.98	61	27.94	25,683	61.18	64	25.42	25,683
ITED								
Participants	80.46	88	21.16	748	79.25	87	21.58	748
Nonparticipants	61.32	66	28.50	16,684	64.88	70	26.89	16,684

Table 2. *Percentage of Course by Course Area and PLTW Participation*

	Frequency		Percentage	
Courses	**Control**	**PLTW**	**Control**	**PLTW**
Business	19,486	912	33.7%	34.0%
Computer and Information Systems	10,873	670	18.8%	25.0%
Construction Trades	3,536	211	6.1%	7.9%
Consumer and Homemaking Education	9,543	240	16.5%	9.0%
Drafting	1,422	981	2.5%	36.6%
Elective Activities	4,554	179	7.9%	6.7%
English Language and Literature	85,852	4,150	148.5%	154.9%
Fine and Performing Arts	26,167	1,150	45.3%	42.9%
Foreign Language and Literature	41,943	2,426	72.6%	90.5%
Health and Safety Education	11,033	547	19.1%	20.4%
Industrial/Technology Education	459	390	0.8%	14.6%
Life and Physical Sciences	54,004	3,085	93.4%	115.1%
Mathematics	41,050	2,819	71.0%	105.2%
Military Science	51,779	2,582	89.6%	96.3%
Social Sciences and History	57,807	2,680	100.0%	100.0%

aggregated upon two-digit NCES course codes, a broad description of a variety of classes (Oregon Department of Education, 2009). PLTW students were more likely to enroll in mathematics, life and physical sciences, industrial and technology, foreign language, and drafting courses than nonparticipants. Nonparticipants disproportionally enrolled in business, consumer and homemaking education, English language and literature, military science, social sciences and history courses at a higher rate.

Iowa's community colleges offer joint enrollment—sometimes known as concurrent or dual enrollment—options. PLTW participants were more likely to jointly enroll at a community college. Seventeen percent of PLTW students were jointly enrolled compared to 12% for nonparticipants.

Figure 1 – Percent of Course Enrollment by NCES Course Area in High School

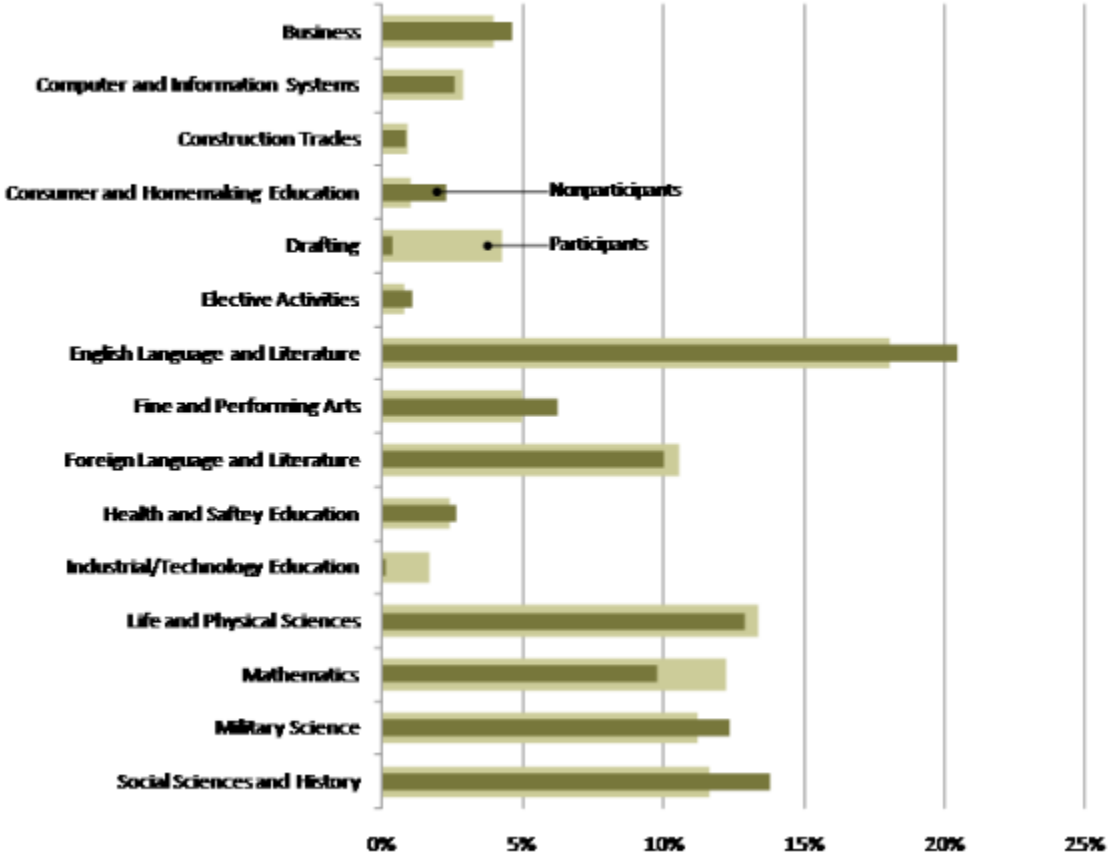

Table 3. *All PLTW participants and nonparticipants, school year 2008*

	Control Group		PLTW Students		Total	
	Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Gender						
Male	17,758	49.4%	1,466	84.4%	19,224	51.0%
Female	18,123	50.4%	270	15.5%	18,393	48.8%
Unknown	98	0.3%	1	0.1%	99	0.3%
Ethnicity						
American Indian/Alaskan Native	330	0.9%	6	0.3%	336	0.9%
Asian/Pacific Islander	902	2.5%	41	2.4%	943	2.5%
Black	3,499	9.7%	41	2.4%	3,540	9.4%
Hispanic	2,433	6.8%	58	3.3%	2,491	6.6%
White	28,294	78.6%	1,577	90.8%	29,871	79.2%
Unknown	521	1.4%	14	0.8%	535	1.4%
Free/Reduced Lunch						
No	21,082	58.6%	1,348	77.6%	22,430	59.5%
Yes	14,897	41.4%	389	22.4%	15,286	40.5%
Section 504						
No	35,511	98.7%	1,718	98.9%	37,229	98.7%
Yes	468	1.3%	19	1.1%	487	1.3%
Gifted/Talented						
No	31,462	87.4%	1,222	70.4%	32,684	86.7%
Yes	4,517	12.6%	515	29.6%	5,032	13.3%
ELL/Immigrant						
No	34,682	96.4%	1,706	98.2%	36,388	96.5%
Yes	1,297	3.6%	31	1.8%	1,328	3.5%
Joint Enrollment						
No	31,616	87.9%	1,443	83.1%	33,059	87.7%
Yes	4,363	12.1%	294	16.9%	4,657	12.3%
Total	**35,979**	**95.4%**	**1,737**	**4.6%**	**37,716**	**100.0%**

Table 4. *PLTW Students and Nonparticipants, 2008 Cohort*

	Control Group		PLTW Students		Total	
	Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Gender						
Male	4,366	50.2%	311	88.4%	4,677	51.7%
Female	4,313	49.6%	41	11.6%	4,354	48.1%
Unknown	18	0.2%	-	-	18	0.2%
Ethnicity						
Am. Indian/Alaskan Native	74	0.9%	-	-	74	0.8%
Asian/Pacific Islander	227	2.6%	10	2.8%	237	2.6%
Black	698	8.0%	5	1.4%	703	7.8%
Hispanic	514	5.9%	17	4.8%	531	5.9%
White	7,087	81.5%	317	90.1%	7,404	81.8%
Unknown	106	1.2%	3	0.9%	109	1.2%
Free/Reduced Lunch						
No	5,629	64.7%	280	79.5%	5,909	65.3%
Yes	3,068	35.3%	72	20.5%	3,140	34.7%
Section 504						
No	8,591	98.8%	348	98.9%	8,939	98.8%
Yes	106	1.2%	4	1.1%	110	1.2%
Gifted/Talented						
No	7,808	89.8%	276	78.4%	8,084	89.3%
Yes	889	10.2%	76	21.6%	965	10.7%
ELL/Immigrant						
No	8,455	97.2%	341	96.9%	8,796	97.2%
Yes	242	2.8%	11	3.1%	253	2.8%
Joint Enrollment						
No	6,346	73.0%	216	61.4%	6,562	72.5%
Yes	2,351	27.0%	136	38.6%	2,487	27.5%
Total	**8,697**	**96.1%**	**352**	**3.9%**	**9,049**	**100.0%**

Table 5. *PLTW participants and nonparticipants, 2009 cohort*

	Control Group		PLTW Students		Total	
	Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Gender						
Male	4,095	48.4%	363	85.0%	4,458	50.2%
Female	4,341	51.3%	64	15.0%	4,405	49.6%
Unknown	19	0.2%	-	-	19	0.2%
Ethnicity						
American Indian/Alaskan Native	74	0.9%	391	0.0%	465	5.2%
Asian/Pacific Islander	192	2.3%	7	1.6%	199	2.2%
Black	689	8.1%	11	2.6%	700	7.9%
Hispanic	544	6.4%	15	3.5%	559	6.3%
White	6,826	80.7%	3	91.6%	6,829	76.9%
Unknown	130	1.5%	-	0.7%	130	1.5%
Free/Reduced Lunch						
No	5,240	62.0%	332	77.8%	5,572	62.7%
Yes	3,215	38.0%	95	22.2%	3,310	37.3%
Section 504						
No	8,330	98.5%	424	99.3%	8,754	98.6%
Yes	125	1.5%	3	0.7%	128	1.4%
Gifted/Talented						
No	7,410	87.6%	317	74.2%	7,727	87.0%
Yes	1,045	12.4%	110	25.8%	1,155	13.0%
ELL/Immigrant						
No	8,165	96.6%	421	98.6%	8,586	96.7%
Yes	290	3.4%	6	1.4%	296	3.3%
Joint Enrollment						
No	6,922	81.9%	317	74.2%	7,239	81.5%
Yes	1,533	18.1%	110	25.8%	1,643	18.5%
Total	**8,455**	**95.2%**	**427**	**4.8%**	**8,882**	**100.0%**

Table 6. *PLTW Students and Nonparticipants, 2010 Cohort*

	Control Group		PLTW Students		Total	
	Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Gender						
Male	4,468	48.8%	345	82.9%	4,813	50.3%
Female	4,664	50.9%	70	16.8%	4,734	49.4%
Unknown	30	0.3%	1	0.2%	31	0.3%
Ethnicity						
American Indian/Alaskan Native	87	0.9%	2	0.5%	89	0.9%
Asian/Pacific Islander	235	2.6%	13	3.1%	248	2.6%
Black	961	10.5%	11	2.6%	972	10.1%
Hispanic	644	7.0%	11	2.6%	655	6.8%
White	7,107	77.6%	376	90.4%	7,483	78.1%
Unknown	134	1.5%	3	0.7%	137	1.4%
Free/Reduced Lunch						
No	5,147	56.2%	317	76.2%	5,464	57.0%
Yes	4,015	43.8%	99	23.8%	4,114	43.0%
Section 504						
No	9,045	98.7%	410	98.6%	9,455	98.7%
Yes	117	1.3%	6	1.4%	123	1.3%
Gifted/Talented						
No	7,943	86.7%	287	69.0%	8,230	85.9%
Yes	1,219	13.3%	129	31.0%	1,348	14.1%
ELL/Immigrant						
No	8,783	95.9%	410	98.6%	9,193	96.0%
Yes	379	4.1%	6	1.4%	385	4.0%
Joint Enrollment						
No	8,784	95.9%	386	92.8%	9,170	95.7%
Yes	378	4.1%	30	7.2%	408	4.3%
Total	**9,162**	**95.7%**	**416**	**4.3%**	**9,578**	**100.0%**

Table 7. *PLTW Students and Nonparticipants, 2011 Cohort*

	Control Group		PLTW Students		Total	
	Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Gender						
Male	4,829	50.0%	447	82.5%	5,276	51.7%
Female	4,805	49.7%	95	17.5%	4,900	48.0%
Unknown	31	0.3%	-	-	31	0.3%
Ethnicity						
American Indian/Alaskan Native	95	1.0%	4	0.7%	99	1.0%
Asian/Pacific Islander	248	2.6%	11	2.0%	259	2.5%
Black	1,151	11.9%	14	2.6%	1,165	11.4%
Hispanic	731	7.6%	15	2.8%	746	7.3%
White	7,289	75.4%	493	91.0%	7,782	76.2%
Unknown	151	1.6%	5	0.9%	156	1.5%
Free/Reduced Lunch						
No	5,066	52.4%	419	77.3%	5,485	53.7%
Yes	4,599	47.6%	123	22.7%	4,722	46.3%
Section 504						
No	9,545	98.8%	536	98.9%	10,081	98.8%
Yes	120	1.2%	6	1.1%	126	1.2%
Gifted/Talented						
No	8,301	85.9%	342	63.1%	8,643	84.7%
Yes	1,364	14.1%	200	36.9%	1,564	15.3%
ELL/Immigrant						
No	9,279	96.0%	534	98.5%	9,813	96.1%
Yes	386	4.0%	8	1.5%	394	3.9%
Joint Enrollment						
No	9,564	99.0%	524	96.7%	10,088	98.8%
Yes	101	1.0%	18	3.3%	119	1.2%
Total	**9,665**	**94.7%**	**542**	**5.3%**	**10,207**	**100.0%**

Implications and Future Directions

This study summarized socio-demographic characteristics, testing data, and course-taking patterns for PLTW students and nonparticipants from 2005 to 2008. The researchers found:

RQ1: The data indicates PLTW students are more likely to be white, male, and strong in the area of math and sciences. Whites were overrepresented compared to their peers. Males were also overrepresented in PLTW compared to their peers, but female participation was higher in the younger cohorts.

A majority of participants are white in all cohorts while whites were overrepresented compared to their peers. Similarly, eventual PLTW students performed remarkably higher than their peers in math and science *before* enrolling in the program.

RQ2: The preliminary analysis indicates that PLTW students were more likely to enroll in math and science courses. However, we are cautious about the interpretation until further analysis is completed.

RQ3: PLTW students perform better in summative tests than nonparticipants before enrolling in the program and during high school. The gap between PLTW students and their peers narrow between the 8th grade and junior year, but the analysis is not definitive.

Scholarly Significance of the Study

This study provides several scholarly contributions to the existing literature on the outcomes of PLTW (Adelson & Blais, 1998; Bottoms & Anthony, 2005; Rogers, 2006; Taylor, et al, 2006; Walcerz, 2007). First, this study introduces a comprehensive evaluation design for PLTW programs in Iowa by using multiple, merged statewide longitudinal data sets.

Second, this study applied a theoretical framework that can measure the causal effects of factors on differences in outcomes among the PLTW participants and nonparticipants. Although this study exhibits the results from the first phase of our three-year evaluation research project, the descriptive statistics indicate that quasi-experimental (e.g., propensity score matching) is a necessary component of an evaluation of PLTW.

Finally, this study also provides policy implications for practitioners and policy makers about the critical role that PLTW can play to increase the number of participation in postsecondary STEM education in the U.S.

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