The Effects Of Project Lead The Way High School Curriculum

On Science Achievement Gains

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Abstract

This study examined the effects of Project Lead the Way high school curriculum on student achievement gains between eighth and eleventh grade standardized tests in a Missouri suburban school district. Difference in difference estimation was used to determine the outcome of PLTW curriculum on ACT scores while accounting for prior science aptitude by including eighth grade test scores. Students enrolled in at least one PLTW course experienced a 7.68% gain in achievement compared to their non-PLTW peers. Specifically, the students in the biomedical science PLTW program saw only a slight, insignificant increase in gains compared to the engineering PLTW program (0.11%). When the number of PLTW courses completed was examined compared to achievement gains, it was found that, in general, students that completed more PLTW courses saw higher gains, though some gains were not found to be significant (5.6% increase with one course, 6.85% increase with two courses, and 10.28% increase with three courses). These results indicate that the PLTW curriculum is successful in improving skills such as critical thinking and problem solving that are utilized on science standardized tests and should be considered by administrators as a tool to improve STEM education at the high school level.

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Chapter 1

Introduction

As the demands of the modern world continue to evolve, education surrounding the STEM (science, technology, engineering, and math) fields has been gaining momentum with educators, policy makers, and industry professionals. This push for expanded STEM education is based largely on quantitative studies that demonstrate student college readiness scores, STEM career needs, and student retention in STEM fields. For example, in a 2007 review, Baldi & Green found that fifteen-year-old students in the United States score lower on science literacy assessments than peers in 16 of 29 tested jurisdictions. The U.S. scores were below the combined average science literacy scores from all recorded locations. Statistics similar to these continue to drive STEM education in the United States (Baldi & Green, 2007).

In addition to poor science literacy scores, researchers observe a lack of interest and follow-through in STEM-related majors. There has been a steady decline in U.S. students earning STEM-related college degrees over the last several decades (Tai, 2012). While many issues arise regarding retention within STEM majors at the undergraduate level, it has been shown that approximately 90% of chemistry and physics students develop an interest in science before the end of their high school career (Tai, 2012). This demonstrates a requirement for increased science education to help encourage and maintain student STEM participation throughout the college years.

The combination of poor science assessment performance and decreased participation in STEM majors has called for a need in increased and improved STEM education. Project Lead the Way (PLTW) became one of the several programs implemented in the United States in hopes of increasing science literacy. This STEM-focused curriculum, as well as teacher professional development program, is geared towards preparing elementary, middle and high school students for the global economy (Tai, 2012). In addition to the elementary program, Launch, and the middle school, Gateway, programs, PLTW provides three high school pathways: engineering (ENG), computer science (CS), and biomedical sciences (BMS). The high school PLTW curricula are a variety of year-long courses focused around fundamental engineering, computer science, biological and medical concepts as well as critical thinking skills. Specifically, PLTW claims to help students "develop in-demand, transportable skills – such as problem solving, critical and creative thinking, collaboration, and communication – that they will use both in school and for the rest of their lives, on any career path they take" (PLTW, 2020a).

PLTW also strives to provide meaningful and lasting professional development for teachers. Educators receive two weeks of hands-on, immersive training before teaching any of the high school PLTW courses. These trainings introduce the teachers to the core concepts, help build confidence around the problem-based curriculum format, and allow educators to network with other passionate teachers from across the country. Beyond core training, teachers have continued access to a digital community as well as the opportunity to meet for annual summit conferences. These resources ensure continuity in their programs across all 50 states and that best practices are being implemented through teacher-teacher support (PLTW, 2020b).

Many researchers have explored the effects of the PLTW curriculum. The overall perception from administrators, despite the expensive price tag associated with purchasing the curriculum, is positive. On average, the startup cost of a BMS PLTW course is over $20,000 with additional annual fees and teacher training costs. However, administrators perceive a positive effect on motivation and enthusiasm in students, as well as critical thinking and problem solving skills. Principals also noted a seemingly increased level of enthusiasm, motivation and teamwork between PLTW teachers. Students are also more challenged in PLTW courses compared to non-PLTW coursework. Other studies show that PLTW leads to an increase in likelihood of students attending a 2- or 4-year school after completing high school compared to their non-PLTW peers (Rogers, 2007).

Due to the emphasis on critical thinking skills, one measure of PLTW success has been associated with standardized science assessment scores. Since these tests typically rely on very little science content knowledge, the nature of the PLTW curriculum nurtures the skills necessary for high test scores. In particular, the science portion of the ACT assesses “the interpretation, analysis, evaluation, reasoning, and problem-solving skills required in the natural sciences” (ACT, 2020). The aforementioned focuses of the PLTW curriculum theoretically lend themselves to provide students with the skills necessary to perform well on the science portion of the ACT.

Statement of Problem:

A lack of studies directly examine the effects of the PLTW BMS curriculum and science ACT performance. While many administrators do see an overall positive effect on student and staff moral and motivation, the effects on standardized test scores has yet to be fully explored for the PLTW curriculum at the high school level. In particular, the BMS program, in comparison to the well-studied engineering program, has yet to be examined deeply to determine the effects of the curriculum on test scores. The data utilized in this study could help administrators guide their decisions regarding the inclusion of PLTW curriculum at their school.

Purpose of Study:

The researcher's purpose of this study was to determine the effects of the biomedical science (BMS) and engineering (ENG) PLTW curricula on high school students' science achievement gains. High school students' science ACT scores were statistically compared between those who have participated in the PLTW high school curriculum to those who have not been exposed to the PLTW high school curriculum. In order to account for any previous science aptitude prior to PLTW coursework, eighth grade Missouri Assessment Program (MAP) science scores were utilized in statistical analyses. This study sought to identify an increase in science achievement gains between eighth and eleventh grade tests for those students in the PLTW curriculum.

Research Question:

Q1: Do students enrolled in any PLTW curriculum experience greater gains in science standardized test scores between eighth grade MAP testing and eleventh grade ACT testing compared to their non-PLTW peers?

Q2: Do students enrolled in PLTW BMS curriculum experience greater gains in science standardized test scores between eighth grade MAP testing and eleventh grade ACT testing compared to their non-PLTW peers?

Q3: Do students enrolled in PLTW ENG curriculum experience greater gains in science standardized test scores between eighth grade MAP testing and eleventh grade ACT testing compared to their non-PLTW peers?

Q4: Do students enrolled in PLTW BMS curriculum experience greater gains in science standardized test scores between eighth grade MAP testing and eleventh grade ACT testing compared to their PLTW ENG peers?

Q5: Do students enrolled in higher amounts of PLTW courses experience greater gains in science standardized test scores between eighth grade MAP testing and eleventh grade ACT testing compared to students who enrolled in fewer PLTW courses?

Null Hypothesis:

Q1 H_0: There is no significant gain in science standardized test scores of high school students who have been exposed to the PLTW curriculum compared to scores of students from the same schools who have not participated in the PLTW curriculum.

Q2 H_0: There is no significant gain in science standardized test scores of high school students who have been exposed to the PLTW BMS curriculum compared to scores of students from the same schools who have not participated in the PLTW BMS curriculum.

Q3 H_0: There is no significant gain in science standardized test scores of high school students who have been exposed to the PLTW ENG curriculum compared to scores of students from the same schools who have not participated in the PLTW ENG curriculum.

Q4 H_0: There is no significant gain in science standardized test scores of high school students who have been exposed to the PLTW BMS curriculum compared to scores of students from the same schools who have been exposed to the PLTW ENG curriculum.

Q5 H_0: There is no significant gain in science standardized test scores of high school students who have been exposed to a higher number of PLTW courses compared to scores of students from the same school who have been exposed to fewer PLTW courses.

Alternative Hypothesis:

Q1 H_1: There is a significant gain in science standardized test scores of high school students who have been exposed to a higher number of PLTW courses compared to scores of students from the same school who have been exposed to fewer PLTW courses.

Q2 H_1: There is a significant gain in science standardized test scores of high school students who have been exposed to the PLTW BMS curriculum compared to scores of students from the same schools who have not participated in the PLTW BMS curriculum.

Q3 H_1: There is a significant gain in science standardized test scores of high school students who have been exposed to the PLTW ENG curriculum compared to scores of students from the same schools who have not participated in the PLTW ENG curriculum.

Q4 H_1: There is a significant gain in science standardized test scores of high school students who have been exposed to the PLTW BMS curriculum compared to scores of students from the same schools who have been exposed to the PLTW ENG curriculum.

Q5 $H_{1:}$ There is a significant gain in science standardized test scores of high school students who have been exposed to a higher number of PLTW courses compared to scores of students from the same school who have been exposed to fewer PLTW courses.

Chapter 2

Literature Review

Purpose of the Study

The purpose of this quantitative study was to explore the relationship between the PLTW BMS and ENG curriculum and science standardized test scores for high school students in a Missouri school district. Previous science aptitude was accounted for using students' 8th grade MAP science scores. Similar studies have indicated a potential relationship between the PLTW engineering program and science and math ACT scores, as well as middle school PLTW curriculum and 8th grade test scores; however, a lack of research specifically examining the BMS curriculum and science ACT scores prompted this study.

History of STEM Education

Guided largely by the National Science Foundation and the National Council of Teachers of Mathematics, STEM education was familiarly named in 2001 after a change from the original "SMET" in the 1990s after a complaint that the acronym was too similar to the negative word "smut" (Sanders, 2012). After some confusion with stem cell research and general lack of knowledge surrounding the meaning of the field, STEM education has become a widespread topic of discussion and recognition in the current education field.

Much of the discussion around STEM fields and STEM education has been negative as it highlights the lack of student retention, poor representation from minority groups, and the shortage of qualified STEM teachers, particularly at the secondary education level. STEM professionals are also somewhat skeptical of the STEM acronym providing a common field among the four subfields of science, technology, engineering and math. For this reason, integrative STEM programs have popped up across the country in an attempt to truly assimilate the four subfields into one overarching, inclusive field (Sanders, 2012).

In addition to professional and educator issues in the STEM fields, student retention has also been a major concern. Less than half of the three million students who enter U.S. colleges yearly intending to major in a STEM field persist in STEM until graduation (Olson & Riordan, 2012). Additionally, women, racial, and ethnic minorities are underrepresented in STEM majors but collectively make up 68% of college students in the United States. Studies of successful programs regarding STEM student college retention highlight three commonly used interventions (i) early research experiences, (ii) active learning in introductory courses, and (iii) membership in STEM learning communities. These are now the pillars seen in many innovative STEM curricula available today (Graham et al., 2013).

Many initiatives and political attempts have been made to remedy these shortfalls of the STEM field. For example, the No Child Left Behind Act of 2001 increased focus on recruiting and maintaining quality STEM educators (Sanders, 2009). Additionally, Obama’s Every Student Succeeds Act in 2015 contributed to an increase in STEM awareness and prioritization in politics (United States Department of Education, 2020). Unfortunately, many schools that now offer STEM integrated coursework have little to no professional development on best practices in STEM fields and do not confidently implement such programs (Sanders, 2009).

In 2012, a new attempt at integrative STEM education at the elementary and secondary education level arose with the name of Next Generation Science Standards (NGSS). NGSS state a commitment to fully integrating engineering and technology into the structure of science education by raising engineering design to the same level as scientific inquiry. This integrative STEM approach focuses heavily on transferrable skills over memorization of content (Next Generation Science Standards, 2013). Missouri adopted their version of the NGSS, the Missouri Learning Standards, during the 2015-16 school year with full integration across the state in the 2018-2019 school year. A pilot test was utilized for the End of Course (EOC) exam in the Spring of 2018 with the test fully aligning with the Missouri Learning Standards starting in 2019 (Missouri Department of Elementary and Secondary Education, 2020b).

PLTW History and Background

As a result of the increased awareness and emphasis on STEM education, programs such as PLTW have also appeared as an attempt to remedy some of the aforementioned issues in the world of STEM education. PLTW is the most well-known STEM education program in the United States and is currently taught in over 4,000 schools in all 50 states. They began offering the engineering program in 1997 to a limited number of New York schools and have expanded ever since (PLTW, 2020a). One elementary school, one middle school and three high school pathways exist within the PLTW curriculum. The elementary program, Launch, is aligned with kindergarten through 5th grade standards. The middle school curriculum, Gateway, consists of ten units ranging from robotics to flight and space to medical detectives. At the high school level, computer science (CS), engineering (ENG) and biomedical science (BMS) pathways allow for increased specialization while still maintaining an integrative STEM approach. The PLTW curriculum highlights themes such as integrative STEM skills, collaboration, presentation, leadership, and hands-on problem/project based learning (PLTW, 2020b).

The PLTW BMS program is a series of four classes with a capstone experience. The first course is called Principles of Biomedical Sciences and examines the death of a fictional woman over the course of the year, exploring topics such as forensic science, diseases including diabetes, sickle cell, heart disease, and infections while covering essential biological science concepts through a real-world, hands-on approach. The following courses, Human Body Systems and Medical Interventions, focus on human anatomy/physiology and the prevention, diagnosis, and treatment of diseases, respectively. The capstone course, Biomedical Innovations, incorporates the previous three years of knowledge and skills to explore some of the most pressing heath challenges in the world today. Topics such as public health and biomedical engineering are exercised through independent design projects with a mentor at a local university, research institute, or medical facility (PLTW, 2020b).

The PLTW engineering program offers a wider range of courses compared to the BMS pathway; however, students still work towards a capstone course in which they identify a problem, research and design a solution, and then present their solution to a panel of professionals. Students often start with the Introduction to Engineering Design or Principles of Engineering courses, which focuses on the engineering design process and implementing problem solving, research, and teamwork skills to solve relevant problems. Other courses available in the PLTW ENG program include Aerospace Engineering, Environmental Sustainability, and Civil Engineering and Architecture, to name a few. These specialized courses allow students to dive deeper into the varied engineering fields and develop a more personalized plan for future education. In addition, there is one crossover course, Computer Science Principles, which crosses over between the engineering and computer science programs. This course focuses on introductory programming skills to help students explore app development, cybersecurity, and more (PLTW, 2020b). The CS program will not be explored individually in this study and will not be discussed further.

Current PLTW Research

Several previous studies have explored the effects of PLTW curriculum on student performance. In particular, the engineering program is the most well researched program in the PLTW curriculum. Tran & Nathan (2010), expanding on their previous research, studied a variety of urban school districts in a Midwestern city to test their hypothesis that, after controlling for prior achievement, teacher experience, and student characteristics, students taking one or more engineering courses are expected to score higher on science and math standardized tests than students with no engineering coursework. Statewide tests in math and science were given to students in 8th and 10th grades. The authors show that there is an increase in math scores (correlation with $r=0.14$, $p=0.057$); however, no increase in science scores is present ($r=0.08$, $p=0.270$). Rethwisch et al. (2012) also explored the effects of engineering PLTW curriculum on students from Iowa's statewide longitudinal data system and followed multiple cohorts of engineering PLTW participants from eighth grade into secondary education. The authors control for pre-existing achievement in science by using middle school score comparisons (Iowa Test of Basic Skills) as well as eleventh grade scores (Iowa Test of Educational

Development). The authors found that there was a moderate and small effect on math and science scores, respectively (5-point increase with 0.15 effect size in mathematics and 0.05 effect size in science).

In addition to the engineering program, the middle school Gateway program has also been studied. Gabriel & Quinlin, (2016) used data from mid-range socioeconomic middle and elementary schools from two Missouri districts. The authors test their hypothesis that there is an increase in Missouri Assessment Plan (MAP) test scores of students in grades five and eight that have been exposed to middle-school level PLTW curriculum compared to scores of students who have not been exposed. T-testing shows a significant difference between achievement scores of those in PLTW compared to their peers (0.236 points higher, $p = 0.000$). Bellinger (2019), however, studied PLTW Gateway's effect on MAP scores and showed no difference in math MAP scores for students who enrolled in the curriculum compared to their non-PLTW peers ($p=0.22$).

Overall, there is a lack of research exploring the BMS PLTW curriculum and its effects on standardized test scores at the high school level. Further research completed on the BMS program would help provide a more well-rounded picture of the PLTW curriculum as a whole. The elementary Launch program also lacks proper studies to show its effects on student achievement and further research on this program could help researchers understand perceptions of STEM education from an early age.

ACT Research

The ACT Assessment is an objective measure of student academic achievement and college readiness. Besides the science portion, which was a focus of this study, English, mathematics, and reading, are also assessed. As a whole, this assessment is meant to demonstrate whether a student is ready for post-secondary education or highlight weaknesses in a student's academic repertoire before college level coursework. For example, research demonstrate that a student with a benchmark ACT Science score of 24 has an 80% chance of earning a C or higher in Biology at the typical college (Allen & Sconing, 2005).

Difficulty with ACT test preparation nationally stems from several underlying educational issues. Students' improvements are higher the more that their teachers' instructional practices reflect "best practices" in their subject aligned with the ACT. Unfortunately, using limited class time specifically for test practice reduces the amount of time spent in class dedicated to learning the essential skills and content needed for many standardized tests. The strongest predictor of improvements from one test to another is the grade they earn in the associated content class (Allen, 2015). This highlights the need for quality STEM education and professional development for improvements in educational test scores.

Missouri ACT/PLTW Specifics

The PLTW data for this project were obtained from a suburban school district in the Saint Louis, Missouri area. The school district utilized in the study began offering the first PLTW BMS class in 2014, and as a state, Missouri will offer over 918 programs across the state during the 2020-2021 school year (Missouri University Science & Technology, 2020). The district utilized in this study offers all four BMS courses as well as the following ENG courses: Introduction to Engineering Design, Principles of

Engineering, Civil Engineering and Architecture, and Computer Science Principles. There are no additional computer science-specific courses so that PLTW pathway will not be isolated on its own group or discussed further in this project.

Missouri offered the ACT free of charge for all junior students from 2015 to 2017. After budget cuts at the government level, the study's school district began covering the cost for juniors in 2018. These years provide valuable data utilized in this project. Additionally, each regular education student in Missouri at the 8th grade level takes the science MAP assessment. The combination of PLTW data, ACT data, and MAP data provided the resources necessary to complete this project.

Chapter Summary

Although the STEM field has become more prevalent and studied in the last three decades, STEM professions and STEM education still have a lot of improving to do. Programs such as PLTW are attempting to bridge the gap between students interested in STEM fields and professionals currently participating in the STEM world. The inclusion of PLTW engineering courses at the high school level have been shown to improve high school standardized test scores (Tran & Nathan, 2010, Rethwisch et al., 2012); however, the effects of the PLTW BMS program on student achievement have not yet been studied. This study aimed to illustrate any relationship between the two.

Chapter 3

Methods

Problem and Purpose Overview

The purpose of this study was to investigate the effects of Project Lead the Way Curriculum on student science achievement gains between eighth grade and eleventh grade. To accommodate for prior science aptitude, eighth grade science MAP score were incorporated into the analyses. Difference in difference (DID) estimation tests were used to examine the relative gains in science achievement between students who took at least one PLTW course and their peers who did not elect to take any PLTW courses. Data were collected by the school district and provided to the researcher directly through district office personnel. All students in the sample were part of the classes of 2017-2019. The results from this study would help administrators make better informed decisions when implementing PLTW curriculum at the high school level, and beyond. A significant difference in student achievement gains between PLTW and non-PLTW students suggests that the PLTW curriculum better prepares students with skills needed for the science ACT, such as critical thinking, problem solving, and creativity compared to traditional curriculum.

Research Design/Data

The researcher completed the college’s required institutional review board (IRB) process and the project was approved as exempt due to the lack of identifying participant information and the fact that the data were collected previously through the host school district. This study utilizes data from a school district containing four mid-range socioeconomic high schools in a St. Louis suburban area. This district has over 18,000 students enrolled at a total of 25 schools. The free and reduced lunch percentages range from 11-21% at the four district high schools (Missouri Department of Elementary and Secondary Education, 2020a). The data were provided by the district from the classes of 2017-2019 with a total of 4,047 students. Student demographic data including gender and race were included in the data set but identifying information, such as names, were removed. Student enrollment data were provided to allow for grouping of PLTW and non-PLTW students. The researcher removed students from the sample if they were missing gender, race, eighth grade MAP science scores, or eleventh grade science ACT scores. Table 1 shows the percentage of student data that was missing. The final population included 3,308 total students.

Table 1
Number of Students Missing Data for Each Descriptive Category

	Race	Gender	MAP	ACT
Number of individuals with missing values	563	558	550	177

All PLTW students from the BMS and ENG were placed into one large experimental group. A random sample of the remaining, non-PLTW students was created to match the sample size of the combined PLTW students. This group is considered the large control group. For additional tests, any student who took at least one biomedical PLTW course was considered to be part of their own experimental group. Students who took at least one an engineering PLTW course were placed in a second individual experimental group. A second, small control group was created from the original large control group to provide a better comparison for the smaller experimental groups. Group descriptions are found in Table 2. Students enrolled in the BMS program were more likely to be female while students in the ENG program were primarily male. The final grouping of students includes breaking up PLTW students by the number of PLTW courses that were completed, ranging from one to six courses.

Table 2
Descriptive Statistics for Each Sample

	Control - large	Control - small	PLTW combined	PLTW BMS	PLTW ENG
Sample size	604	302	604	300	304
Male	292	137	329	69	260
Female	312	165	275	231	44
Asian	18	7	34	26	8
Hawaii/Pacific Islander	0	0	3	3	0
Black	40	22	16	13	3
Hispanic	20	14	10	7	3
White	506	247	526	241	285
Multi-racial	20	12	15	10	5

Data Analysis

Statistical analyses were performed using Version 26 of the IBM SPSS Statistics program as well as Microsoft Excel Software and tables were created using Microsoft Excel Software. The difference-in-difference (DID) technique was utilized to examine the effects of PLTW enrollment on test scores. The DID method uses longitudinal data to estimate the effects of a specific treatment, in this case the enrollment in PLTW courses. This method allows the researcher to account for previous science aptitude by looking at the relative change in test scores of the two groups rather than simply comparing means of eleventh grade ACT scores. The following equation was used to calculate the relative difference in science achievement gains.

$$DID = (Y_1^T - Y_0^T) - (Y_1^C - Y_0^C)$$

Y represents an outcome which in this study is the test scores. 1 represents the “after treatment” scores which are the mean eleventh grade ACT scores while the 0 represents the “before treatment” scores which are the mean eighth grade MAP scores. T indicates the treatment group (PLTW students) and C indicates the control group (non-PLTW students). Means were calculated in SPSS and the final DID estimate was calculated in Excel. Since the before and after treatment tests utilize a different points scale, all test scores were first converted into a percentage before applying them to the aforementioned formula. This allowed the researcher to determine the relative percentage of achievement gains, rather than an arbitrary effect number. Analysis was performed to compare the combined PLTW sample against the large random sample from the control group, individual PLTW programs each against the small random sample from the control group, and students broken up by the number of PLTW courses against the small random sample from the control group.

Chapter 4

Results

Mean MAP and ACT scores, listed as both the calculated test percentage as well as raw scores, are found in Table 3 along with standard deviation calculations. All mean MAP and ACT scores were higher for PLTW groups compared to control groups. A graphical representation of the values (Figure 1) illustrates the trends seen in test scores for combined PLTW students and the large control group. The graph also includes a dashed line to represent what the predicted ACT scores would be for the PLTW students if they had followed the same trend as the control group. The vertical dashed line represents the observed difference in difference between the two groups. The differences between MAP scores and ACT scores for each group can be found in Table 4. Calculated DID estimate values can be found in Table 5. There was a 7.68% percent difference in science achievement gains between the combined PLTW group and the large control group. When broken down into BMS and ENG groups specifically, the BMS students were found to have a 7.78% difference in science achievement gains compared to their non-PLTW peers while the ENG students were found to have a 7.66% difference in science achievement gains compared to their non-PLTW peers. The researcher found a non-significant difference of 0.11% between the BMS and ENG pathways. p-values for all tests are significant at $p \leq 0.05$.

Table 3
Mean Percentage and Raw MAP and ACT Scores for Each Sample

	Control – Large		Control – Small		PLTW Combined		PLTW BMS		PLTW ENG	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
MAP (%)	79.29	0.03	79.25	0.02	81.17	0.03	80.95	0.02	81.44	0.02
ACT (%)	60.17	0.14	60.41	0.14	69.73	0.14	69.89	0.14	70.26	0.15
MAP Raw Score	709.6	24.6	709.3	21.1	726.5	24.6	724.5	21.7	728.9	20.4
ACT Raw Score	21.66	5.14	21.75	5.11	25.1	5.14	25.16	4.92	25.29	5.37

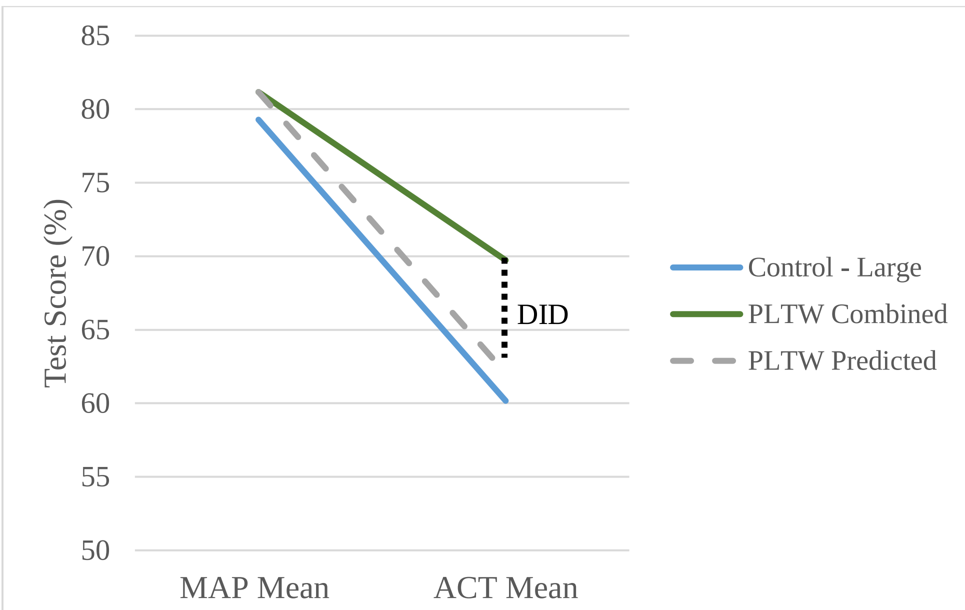

Figure 1. Mean MAP and ACT scores

Table 4
Calculated Differences between ACT and MAP Scores for Each Group

	Control – Large	Control – Small	PLTW Combined	PLTW BMS	PLTW ENG
Test Score Differences (ACT - MAP)	-19.12	-18.84	-11.44	-11.06	-11.18

Table 5

DID Estimates for Combined PLTW, BMS, and ENG Groups vs Control Groups

Comparison	DID estimate (%)	p-value
Combined PLTW vs. large control group	7.68	0.000
BMS PLTW vs small control group	7.78	0.000
ENG PLTW vs small control group	7.66	0.000
BMS PLTW vs ENG PLTW	0.11	0.943

Table 6 shows the DID estimates for students who took varying numbers of PLTW courses compared to the small control group. Taking a single PLTW class resulted in a 5.60% change in achievement gains while taking two classes lead to a 6.85% increase and three classes resulted in a 10.28% increase. Table 7 compares the varying numbers of PTLW courses completed with the addition of one more PLTW course. There was a non-significant increase for taking two or four courses but significant increases in test scores were found for one, three, five and six courses.

Table 6

DID Estimates for PLTW Students with Varying Numbers of Courses vs Control Group

Comparison	Sample Size	DID Estimate (%)	p-value
Combined PLTW – 1 course vs. small control group	319	5.60	0.000
Combined PLTW – 2 courses vs. small control group	129	6.85	0.000
Combined PLTW – 3 courses vs. small control group	105	10.28	0.000
Combined PLTW – 4 courses vs. small control group	46	13.03	0.000
Combined PLTW – 5 courses vs. small control group	4	30.48	0.000
Combined PLTW – 6 courses vs. small control group	1	14.02	0.000

Table 7

DID Estimates for PLTW Students with Varying Numbers of Courses vs One Additional Course

Comparison	DID Estimate (%)	p-value
Combined PLTW – 1 course vs. small control group	5.60	0.000
Combined PLTW – 1 course vs. 2 courses	1.25	0.349
Combined PLTW – 2 courses vs. 3 courses	3.43	0.032
Combined PLTW – 3 courses vs. 4 courses	2.76	0.205
Combined PLTW – 4 courses vs. 5 courses	17.45	0.008
Combined PLTW – 5 courses vs. 6 courses	-29.80	0.000

Chapter 5

Discussion

Overview

The purpose of this study was to examine potential student achievement gains in science testing after taking courses in the PLTW curriculum. Several similar studies exist to explore the effects of the engineering PLTW curriculum, as well as the middle school level Gateway PLTW curriculum; however, there is a clear lack of longitudinal biomedical science PLTW curriculum research. This study aims to expand on previous engineering research, as we all as compare the effects of the engineering program against the biomedical program. Finally, the number of PLTW courses completed was explored as a possible predictor of science achievement gains.

Conclusion

The results of the analyses illustrated an increase in science achievement gains from eighth grade MAP scores to eleventh grade ACT scores for students who participated in the PLTW curriculum. As a combined group, PLTW participants experienced a 7.68% increase compared to their non-PLTW peers. Specifically, the BMS PLTW curriculum lead to a 7.77% increase while the ENG PLTW curriculum lead to a 7.66% increase. These results suggest that the PLTW curriculum does contribute to skills that are necessary on standardized tests such as problem solving and critical and creative thinking. The null hypotheses for research questions 1-3 can be rejected and the alternative hypothesis can be accepted. In each of the comparisons studied, PLTW curriculum lead to higher achievement gains compared to students who did not participate. The BMS PLTW curriculum did lead to a slightly higher achievement gain compared to the ENG PLTW curriculum (7.77% compared to 7.66%); however, this different was not statistically significant and is likely not practically significant as the test score increase would be minimal. This leads the researcher to accept the null hypothesis for research question 4.

With the exception of the single student who took six PLTW courses, the trend in Table 5 shows that the higher the number of PLTW courses completed, the larger the effect size on the science achievement gain. A single PLTW course resulted in a 5.60% increase in achievement gains with the largest gain of 30.48% occurring for students who took five PTLW classes. The single student who completed six PLTW courses experienced a smaller achievement gain of 14.02% compared the group of students that took five courses; however, the 14.02% increase was still higher than taking only four courses and follows the same general trend. A larger sample size is necessary to illustrate the true trend in the achievement gains. The null hypothesis for research question 5 is rejected and the researcher accepts the alternative hypothesis.

Limitations

Several limitations exist for this project. The sample of students was limited to a single school district and may not reflect the true effects of the PLTW curriculum in different districts. The analyses performed in this study do not account for additional student difference that may lead to changes in science achievement gains. For example, other advanced science courses or ACT preparation coursework outside of the PLTW courses may lead to improved ACT scores. Finally, teacher ability is not accounted for in this study. Although all teachers in the district went to the required PLTW training and implemented the curriculum provided by PLTW, teaching styles may account for variation in effects of PLTW coursework.

Future studies should include a wider range of socioeconomic situations. In addition, further research could explore the computer science program specifically as well as the effects of the PLTW elementary program, Launch. Traditional ACT preparation coursework should also be examined to determine the effects of learning specific test-taking strategies rather than broad critical thinking skills as emphasized by the PLTW coursework.

Implications

The results of this study suggest that the PLTW curriculum does improve student critical thinking and problem-solving skills as used on the ACT. Administrators with the financial means to implement the PLTW curriculum should consider offering the PLTW BMS or ENG curriculum as an important tool for improving skills necessary to be successful on the science portion of the ACT. Both PLTW programs studied show a similar increase in student achievement gains and can provide a variety of topics for students exploring additional STEM education beyond their core courses. Combined with previous research, this study indicates that specific STEM curricula incorporated into traditional coursework starting in middle school can boost student confidence, improve perceptions of STEM careers, and increase student achievement gains for both middle and secondary students.

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