

# Evaluation of High School Pre-Engineering Curricula through Missouri University of Science and Technology Student Survey Responses

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## Abstract

Project Lead The Way (PLTW) is an example of a STEM education program that provides structured curriculum to promote college preparation in these areas. There have been several studies that show the benefits of PLTW courses for K-12 students in the preparation for high school students on statewide and national exams, high school academic performance, college level academic performance in particular areas of study, high school student engagement, and other areas. This study examines the impact of PLTW courses on Missouri S&T student career choices. Survey results from 120 current and graduated Missouri S&T (S&T) students are presented. Survey results indicated that: 1) students taking PLTW courses felt better prepared for their S&T experience in terms of hands-on experience, creative problem solving, teamwork and software experience and 2) 72.5% of the student respondents recognized engineering as their original career path and that PLTW promoted their career choices.

## Introduction

In recent years, there have been numerous K-12 programs to promote science, technology, engineering and mathematics (STEM) education programs that have promoted the growth and interest of science and math related fields. These STEM programs branch across a variety of areas and grade levels. Project Lead The Way (PLTW) provides STEM education curricular programs in high schools and middle schools in all 50 states of the U.S. Missouri S&T is the state of Missouri school for providing teacher training, professional development and program information for counselors and administrators in the Midwest region. PLTW provides programs to more than 5,000 elementary, middle, and high schools in all 50 states and the District of Columbia<sup>1</sup>. As a rapidly growing program, the Missouri PLTW network currently has 238 programs in 198 high schools and middle schools [2]. Project Lead The Way (PLTW) [1] currently has PLTW Launch (K-5), PLTW Gateway (Middle), PLTW Engineering (High School), PLTW Biomedical Science (High School) and PLTW Computer Science (K-12) programs [1].

There have been several studies comparing academic performance of PLTW students with non-PLTW students on measures, including High Schools That Work Assessment [3], academic achievement and student engagement [7], ethnic diversity [5,10], improved student grades [8] and improved attendance [9]. The goal of this study is to examine the impact of PLTW courses on Missouri S&T student career choices. In order to examine these research questions, we present results from a survey of 120 Missouri S&T students.

## Missouri S&T Student Survey

A survey was administered in December 2013-January 2014 to Missouri S&T students indicated by the Registrar's office to have taken one or more PLTW courses. The student list consisted of all current and former S&T students up to December 2013 who noted on their admission applications that they had taken at least one PLTW course in high school. These students include current students, students who have completed their undergraduate degree programs, students currently pursuing a graduate degree, and students who have completed their graduate degree programs. There were 120 respondents. Table 1 provides the demographic background of these students.

Table 1. Demographic background of survey respondents.

| <b>Demographic Group</b>  | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|---------------------------|--------------------------------|-------------------------------------|
| Asian or Pacific Islander | 4.2%                           | 5                                   |
| Black or African American | 0.8%                           | 1                                   |
| Hispanic or Latino        | 0%                             | 0                                   |
| White/Caucasian           | 94.2%                          | 113                                 |
| Prefer not to answer      | 0.8%                           | 1                                   |
|                           |                                |                                     |
| Male                      | 75.8%                          | 91                                  |
| Female                    | 24.2%                          | 29                                  |

The survey questions are presented with respondent responses are presented as follows.

Question 1: Taking PLTW courses helped you decide your major area of study at S&T?

| <b>Choice</b> | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|---------------|--------------------------------|-------------------------------------|
| Yes           | 72.5%                          | 87                                  |
| No            | 27.5%                          | 33                                  |

Question 2: Which Project Lead The Way course(s) did you take prior to college (select all that apply)?

| <b>PLTW Course</b>                       | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|------------------------------------------|--------------------------------|-------------------------------------|
| Introduction to Engineering Design (IED) | 93.3%                          | 112                                 |
| Principles of Engineering (POE)          | 94.2%                          | 113                                 |
| Digital Electronics (DE)                 | 45.0%                          | 54                                  |
| Civil Engineering and Architecture (CEA) | 25.8%                          | 31                                  |
| Aerospace Engineering (AE)               | 5.0%                           | 6                                   |
| Biotechnical Engineering (BE)???         | 1.7%                           | 2                                   |

|                                          |       |    |
|------------------------------------------|-------|----|
| Computer Integrated Manufacturing (CIM)  | 5.8%  | 7  |
| Engineering Design and Development (EDD) | 13.3% | 16 |
| Principles of Biomedical Systems (PBS)   | 3.3%  | 4  |
| Human Body Systems (HBS)                 | 4.2%  | 5  |
| Medical Intervention (MI)                | 2.5%  | 3  |
| Biomedical Innovation (BI)               | 1.7%  | 2  |
| Automation and Robotics (AR)             | 0.8%  | 1  |
| Design and Modeling (DM)                 | 0.8%  | 1  |

Question 3: Which course(s) do you feel best prepared you for college?

| <b>PLTW Course</b>                       | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|------------------------------------------|--------------------------------|-------------------------------------|
| Introduction to Engineering Design (IED) | 65.0%                          | 78                                  |
| Principles of Engineering (POE)          | 80.8%                          | 97                                  |
| Digital Electronics (DE)                 | 26.7%                          | 32                                  |
| Civil Engineering and Architecture (CEA) | 14.2%                          | 17                                  |
| Aerospace Engineering (AE)               | 1.7%                           | 2                                   |
| Biotechnical Engineering (BE)???         | 1.7%                           | 2                                   |
| Computer Integrated Manufacturing (CIM)  | 4.2%                           | 5                                   |
| Engineering Design and Development (EDD) | 12.5%                          | 15                                  |
| Principles of Biomedical Systems (PBS)   | 1.7%                           | 2                                   |
| Human Body Systems (HBS)                 | 2.5%                           | 3                                   |
| Medical Intervention (MI)                | 1.7%                           | 2                                   |
| Biomedical Innovation (BI)               | 1.7%                           | 2                                   |
| Other (please specify)                   | 0.8%                           | 1                                   |

Question 4: What college degree programs are you pursuing at S&T?

| <b>Degree Program</b> | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|-----------------------|--------------------------------|-------------------------------------|
| Applied Mathematics   | 0.8%                           | 1                                   |
| Biological Sciences   | 2.5%                           | 3                                   |

|                               |       |    |
|-------------------------------|-------|----|
| Computer Science              | 10.0% | 12 |
| Geology & Geophysics          | 1.7%  | 2  |
| Physics                       | 1.7%  | 2  |
| Business & Management Systems | 0.8%  | 1  |
| Economics                     | 0.8%  | 1  |
| Aerospace Engineering         | 5.0%  | 6  |
| Architectural Engineering     | 5.0%  | 6  |
| Ceramic Engineering           | 5.8%  | 7  |
| Chemical Engineering          | 7.5%  | 9  |
| Civil Engineering             | 9.2%  | 11 |
| Computer Engineering          | 9.2%  | 11 |
| Electrical Engineering        | 7.5%  | 9  |
| Engineering Management        | 5.0%  | 6  |
| Environmental Engineering     | 2.5%  | 3  |
| Geological Engineering        | 4.2%  | 5  |
| Mechanical Engineering        | 31.7% | 38 |
| Metallurgical Engineering     | 1.7%  | 2  |
| Mining Engineering            | 0.8%  | 1  |
| Nuclear Engineering           | 3.3%  | 4  |
| Petroleum Engineering         | 3.3%  | 4  |
| Pre-Nursing                   | 0.8%  | 1  |
| Other (please specify)        | 3.3%  | 4  |

Question 5: What aspect of PLTW courses helped you the most?

| <b>Answer Options</b>    | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|--------------------------|--------------------------------|-------------------------------------|
| Math                     | 36.7%                          | 44                                  |
| Software                 | 60.0%                          | 72                                  |
| Science                  | 22.5%                          | 27                                  |
| Hands-on Exercises       | 80.0%                          | 96                                  |
| Written Exercises        | 6.7%                           | 8                                   |
| Team Work                | 61.7%                          | 74                                  |
| Creative Problem Solving | 65.8%                          | 79                                  |
| Time Management          | 25.0%                          | 30                                  |
| Other (please specify)   | 3.3%                           | 4                                   |

Question 6: Based on your S&T experience, would you have taken additional PLTW courses to prepare you for college?

| <b>Choice</b> | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|---------------|--------------------------------|-------------------------------------|
| Yes           | 56.7%                          | 68                                  |

|    |       |    |
|----|-------|----|
| No | 43.3% | 52 |
|----|-------|----|

For those students who responded, “NO,” the most common responses were:

- I took everything they had
- That was all they provided
- I wish they had more

For those who responded, “YES,” the most common responses were:

- DE
- CEA
- Design and Modeling
- As many as I could

Question 7: Prior to taking PLTW courses, what careers were you considering?

| <b>Career Area</b>                                         | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|------------------------------------------------------------|--------------------------------|-------------------------------------|
| Administration (e.g. clerical, secretarial work, etc.)     | 1.7%                           | 2                                   |
| Advertising, Marketing and Public Relations                | 3.3%                           | 4                                   |
| Agriculture, Animals and Plants (veterinary, etc.)         | 0.8%                           | 1                                   |
| Apprenticeships/Trades (carpenter, electrician, etc.)      | 0.8%                           | 1                                   |
| Arts, Design, Sculpture                                    | 2.5%                           | 3                                   |
| Business and Finance (e.g. accounting, banking, etc.)      | 10.0%                          | 12                                  |
| Civil Service, Local Government, Semi-State                | 0%                             | 0                                   |
| Construction Professionals (architecture, surveying, etc.) | 10.8%                          | 13                                  |
| Education Teaching and Lecturing                           | 5.0%                           | 8                                   |
| Engineering/Technology/Industry                            | 72.5%                          | 87                                  |
| Health & Safety                                            | 1.7%                           | 2                                   |
| Human Resources and Recruitment                            | 0%                             | 0                                   |
| Humanities                                                 | 0.8%                           | 1                                   |
| Hotel, Catering                                            | 0%                             | 0                                   |
| Insurance and Pensions and Actuarial work                  | 0%                             | 0                                   |
| Languages (teacher, interpreter, translator, guide)        | 1.7%                           | 2                                   |
| Law Enforcement and Public Protection                      | 4.2%                           | 5                                   |

|                                                           |       |    |
|-----------------------------------------------------------|-------|----|
| Legal Services, Political Sciences                        | 0%    | 0  |
| Leisure, Entertainment (Cultural, Sport, Performing)      | 0.8%  | 1  |
| Library (author, writer, journalist)                      | 0.8%  | 1  |
| Management-General                                        | 3.3%  | 4  |
| Manufacturing and Processing (e.g. products/goods)        | 2.5%  | 3  |
| Maritime, Fishing and Aquatic Business                    | 0%    | 0  |
| Media, Communications, Publishing                         | 2.5%  | 3  |
| Medical, Para Medical, Health Care                        | 10.0% | 12 |
| Motor Industry                                            | 4.2%  | 5  |
| Music                                                     | 5.0%  | 6  |
| Natural Resources and the Environment                     | 1.7%  | 2  |
| Politics                                                  | 0%    | 0  |
| Property Sales/Management                                 | 0%    | 0  |
| Religion                                                  | 0%    | 0  |
| Sales, Retail and Buying                                  | 0%    | 0  |
| Scientific (e.g. laboratory research, physics, etc.)      | 14.2% | 17 |
| Social Care, Psychology and Guidance Services             | 0%    | 0  |
| Tourism                                                   | 0%    | 0  |
| Transport, Distribution (e.g. air, sea, road, rail, etc.) | 0.8%  | 1  |

Note that the labor categories were obtained from the Department of Labor (ref)

Question 8: What is your current status?

| Status Options              | % of Survey Respondents | Number of Survey Respondents |
|-----------------------------|-------------------------|------------------------------|
| Current S&T student         | 87.4%                   | 104                          |
| Earned undergraduate degree | 6.7%                    | 8                            |
| Pursuing graduate degree    | 3.4%                    | 4                            |
| Earned graduate degree      | 2.5%                    | 3                            |

Question 9: Did PLTW influence your career choice?

| Choice          | % of Survey Respondents | Number of Survey Respondents |
|-----------------|-------------------------|------------------------------|
| Yes             | 70.6%                   | 84                           |
| No              | 29.4%                   | 35                           |
| Did not respond | 0.8%                    | 1                            |

Question 10: What careers are you pursuing?

| <b>Degree Program</b>            | <b>% of Survey Respondents</b> | <b>Number of Survey Respondents</b> |
|----------------------------------|--------------------------------|-------------------------------------|
| Applied Mathematics              | 0%                             | 0                                   |
| Biological Sciences              | 2.5%                           | 3                                   |
| Chemistry                        | 0%                             | 0                                   |
| Computer Science                 | 10.1%                          | 12                                  |
| Geology & Geophysics             | 0.8%                           | 1                                   |
| Physics                          | 0.8%                           | 1                                   |
| Business & Management Systems    | 2.5%                           | 3                                   |
| Information Science & Technology | 1.7%                           | 2                                   |
| Economics                        | 0%                             | 0                                   |
| Psychology                       | 0%                             | 0                                   |
| English                          | 0%                             | 0                                   |
| History                          | 0%                             | 0                                   |
| Philosophy                       | 0%                             | 0                                   |
| Teacher Certifications           | 0%                             | 0                                   |
| Technical Communications         | 0%                             | 0                                   |
| Multidisciplinary Studies        | 0%                             | 0                                   |
| Aerospace Engineering            | 4.2%                           | 5                                   |
| Architectural Engineering        | 2.5%                           | 3                                   |
| Ceramic Engineering              | 5.9%                           | 7                                   |
| Chemical Engineering             | 7.6%                           | 9                                   |
| Civil Engineering                | 10.1%                          | 12                                  |
| Computer Engineering             | 7.6%                           | 9                                   |
| Electrical Engineering           | 8.4%                           | 10                                  |
| Engineering Management           | 8.4%                           | 10                                  |
| Environmental Engineering        | 2.5%                           | 3                                   |
| Geological Engineering           | 4.2%                           | 5                                   |
| Mechanical Engineering           | 32.8%                          | 30                                  |
| Metallurgical Engineering        | 1.7%                           | 2                                   |
| Mining Engineering               | 0.8%                           | 1                                   |
| Nuclear Engineering              | 2.5%                           | 3                                   |
| Petroleum Engineering            | 4.2%                           | 5                                   |
| Pre-Law                          | 0%                             | 0                                   |
| Pre-Med                          | 2.5%                           | 3                                   |
| Pre-Nursing                      | 0.8%                           | 1                                   |
| Pre-Veterinary                   | 0%                             | 0                                   |
| Other (please specify)           | 3.4%                           | 4                                   |

Other career choices include Software Engineering, Biomedical Engineering or Pharmaceutical Research/Engineering, Military and Music Therapy.

## Summary of Survey

As previously indicated, Missouri S&T is the state of Missouri university for high school teacher training through the Curriculum Training Institute for the courses offered through the PLTW programs. Missouri S&T began this role in 2006, where only the Pathway to Engineering courses IED, POE, DE, CEA, CIM were taught. The Biomedical Sciences Pathway courses, Computer Science Pathway (2014), Gateway to Technology, and the AE (2013) and EDD courses, which are part of the Pathway to Engineering, have been added after 2008???. The student survey results reflect PLTW high school course availability.

Several observations can be made from the 10 question survey results. First, of the 120 survey participants, 87.4% are currently S&T students. The survey respondents include 75.8% males and 24.2% females. Second, from Question 5, survey participants who expressed having taken at least one PLTW course indicated they are better prepared due to their experience in PLTW courses in terms of hands-on experience (80.0%), software experience (60.0%), team work (61.7%), and creative problem solving (65.8%). Third, as observed from Questions 2 and 3, there are several PLTW courses of significant importance to prepare students for S&T, including: EDD (15 of 16 students), POE (97 of 113 students), IED (78 of 112 students), DE (32 of 54 students), and CEA (17 of 31 students). Fourth, from Question 4, the most common degree programs pursued at S&T by the respondents are Mechanical Engineering (31.7%), Computer Science (10.0%), Civil Engineering (9.2%), Computer Engineering (9.2%), Electrical Engineering (7.5%) and Chemical Engineering (7.5%). Fifth, from Questions 7 and 9, a majority (72.5%) recognized engineering/technology/industry as their original career path choice prior to taking PLTW courses, and taking PLTW courses influenced 70.6% of students in their career choices. Sixth, from Question 10, the most common career paths students are pursuing (or have pursued) include Mechanical Engineering (32.8%), Computer Science (10.1%), Civil Engineering (10.1%), Electrical Engineering (8.4%), Engineering Management (8.4%), Computer Engineering (7.6%), and Chemical Engineering (7.6%).

Overall, the survey results highlight the impact of PLTW courses on student career choices, skills that has prepared students for their college experiences. The survey results also highlight student backgrounds prior to taking PLTW courses, the degree programs pursued by these students and their career path choices. The Question 7 results show the tendency of students taking PLTW courses to have an interest in engineering/technology/industry (72.5%) and the influence of PLTW courses on student career choice (70.6%). These results are consistent with other studies indicating students' intentions to study engineering, technology or computer science [5,6] and that their PLTW experiences were important in the college majors and career choices that the students intended to pursue [7].

## Conclusions

In this study, survey results were examined for 120 current and graduated Missouri S&T students. Of the students surveyed, 94.2% were white/Caucasian and 72.5% were male. Students indicated that EDD, POE, IED, DE, and CEA courses from PLTW's Engineering Pathway positively impacted their college preparation. The survey results showed that PLTW

courses influence 70.6% of the student respondents' career choices. Missouri S&T students taking PLTW courses most commonly pursued degrees in Mechanical Engineering, Computer Science, Civil Engineering, Electrical Engineering, Engineering Management, Computer Engineering, and Chemical Engineering. As PLTW continues to grow in the state of Missouri and in the U.S., it is anticipated that additional PLTW courses from different PLTW programs will positively impact high school students in their college preparation, their choice in degree programs, and in their career choices.

## **Future Directions**

There is an ongoing study of S&T student degree audits for PLTW and non-PLTW students at S&T for academic performance comparison. We have completed a preliminary study of surveying PLTW high school teachers for teacher backgrounds and student assessments. This survey has been extended to a second year for a longitudinal study. We are planning to continue the S&T student survey to evaluate student backgrounds, degree programs pursued, and career choices. These studies are of particular interest with the significant increase in offering of PLTW programs and courses throughout Missouri and the U.S.

## **Acknowledgments**

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