Targeted Academic Performance Assessments from Missouri University of Science and Technology Students with Project Lead The Way Course Experience

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Abstract

Opportunities for K-12 students to gain exposure to science, technology, engineering and mathematics (STEM) education programs are on the increase thanks in part to programs such as Project Lead The Way (PLTW). Our research group has explored the backgrounds of Missouri S&T students through surveys intended to assess the benefits of PLTW on student learning, college preparation, and career pursuits. In this study, we focus on a series of courses that specific target larger groups of students who are both in their field of study and common courses that are required by all students. Specifically, we examined courses grades for courses taken by students pursuing engineering and computer science degree programs with at least 50 students with PLTW experience over the Spring 2015, to the Fall 2016 semesters. Using this criterion, we compared the average course grades for Missouri S&T students with and without PLTW experience for 41 courses in subject areas covering math, speech, English, statistics, chemistry, economics, physics, freshman engineering, and seven engineering programs. Students with PLTW course experience had higher average course grade results in 34 of the 41 courses. We explore student backgrounds that could contribute to the success of the students with PLTW course experience.

Background

The academic benefits of PLTW as a science, technology, engineering and mathematics (STEM) education program continues to be studied throughout the United States. Missouri S&T has explored the benefits of PLTW courses in preparing students for post-high school preparation [1]. Additionally, researchers surveyed Missouri S&T students who had and had not taken PLTW courses in high school [2]. Approximately 1300 current and graduated students were surveyed. In summary the results indicated that: PLTW students had completed higher levels of math and science courses while in high school [2]; 2) More PLTW students sought careers in Engineering/Technology/Industry than their counter parts [2]; and 3) PLTW students were more involved in technology affiliated clubs like robotics than non-PLTW students [3]. PLTW program descriptions can be found at the Missouri PLTW network [4]. In previous academic studies from 2015-2016, the academic records of 2812 Missouri S&T students with indicated PLTW course experience and 314 students without PLTW course experience were examined, with results showing: 1) an overall average grade point average improvement of 4.68% and 3.18% from 2015 and 2016, respectively, for the PLTW student group over the non-PLTW group; 2) students showed academic performance improvement by year in the students' program of study and by degree program for the 17 engineering and computer science degree programs offered at Missouri S&T; 3) Missouri S&T students appear, on average, to have benefited in their academic performance at Missouri S&T [5].

Rationale

This paper presents academic performance results from the spring and fall semesters for the 2015 and 2016 academic years which are being examined as part of an ongoing 5 year research study comparing retention, academic performance in and outside of the classroom for Missouri S&T students pursuing engineering and computer science degree programs with and without PLTW course experience. This study is an extension of the preliminary analysis using propensity scores to evaluate student preparedness [6].

Methodology

Working with Institutional Research and the Registrar's Office at Missouri S&T to obtain grade information for students who indicated on their admission's application that they took one or more PLTW courses for comparison with students who did not indicate that they took any PLTW courses. Following the initial study from [6], only Engineering, Computer Science, and Undecided Engineering majors were considered for this study. Separate degree collections were obtained for the fall and spring semesters for the 2015 and 2016 academic years.

In this research, we examined courses grades for courses taken by students pursuing engineering and computer science degree programs with at least 50 students with PLTW experience over the Spring 2015, Fall 2015, Spring 2016, and Fall 2016 semesters. Using this criterion, we compared the average course grades for Missouri S&T students with and without PLTW experience for 41 courses in subject areas covering math, speech, English, statistics, chemistry, economics, physics, freshman engineering, and seven engineering programs. Students with PLTW course experience had higher average course grade results in 34 of the 41 courses. We explore student backgrounds that could contribute to the success of the students with PLTW course experience. The remainder of the paper includes the following sections: Student Survey Details and Results, Summary of Survey, and Conclusions.

Student Survey Details and Results

Missouri S&T Office of Institutional Research identified over 1300 current and former students who indicated on their admission applications that they are pursuing a degree in engineering, computer science, or the biological sciences. Over 400 of these students noted that they had taken one or more PLTW courses in high school. The remaining students provided no indication of taking any PLTW courses (non-PLTW students). In the Fall of 2015 a survey was administered to the group. Tables 1-3 provide the demographic information for the survey respondents. Table 4-18 provide the targeted course comparisons.

Table 1. Engineering and Computer Science Majors

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshmen	9.8%	7.0%	5.8%	9.2%
Sophomore	4.0%	10.4%	5.6%	3.9%
Junior	6.2%	4.7%	2.8%	6.2%
Senior	6.0%	3.2%	0.7%	0.8%
All Students	5.2%	5.7%	2.4%	4.1%

Table 2. Number of Students without PLTW Course Experience/with PLTW Course Experience

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshmen	508/56	1517/187	729/87	1215/127
Sophomore	792/82	1230/171	1011/125	1008/156
Junior	756/82	1187/102	1169/132	1125/118
Senior	1302/84	1770/168	1908/173	1715/161
All Students	3358/309	5704/628	4817/517	5063/562

Table 3. Percentage Difference in Average ACT Score for Missouri S&T Students with PLTW Course Experience

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshman	2.48%	-1.05%	-2.05%	4.08
Sophomore	0.63%	1.73%	1.05%	-0.07%
Junior	0.74%	0.42%	0.40%	2.67%
Senior	2.85%	2.40%	1.46%	2.22%

Table 4. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience in Select Chemistry Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Chemistry 1100 – Introduction to Lab Safety & Hazardous Materials	1.13%	242	1813
Chemistry 1310 – General Chemistry	20.13%	131	974
Chemistry 1319 – General Chemistry Laboratory I	6.85%	185	1389

Table 5. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience in Select Speech Course

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Speech 1185 – Principles of Speech	1.66%	116	694

Table 6. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Statistics Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Statistics 3113 – Applied Engineering Statistics	-0.14%	46	561
Statistics 3115 – Engineering Statistics	6.79%	46	393

Table 7. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Mechanical Engineering Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Mech Engr 2360 - Dynamics	8.16%	54	399
Mech Engr 2519 - Thermodynamics	12.34%	72	591
Mech Engr 2653 – Intro to Manuf. Processing	0.06%	63	435
Mech Engr 2761 – Intro to Design	2.64%	51	383
Mech Engr 3131 – Thermofluid Mechanics	5.24%	49	377
Mech Engr 3313 – Machine Dynamics	11.30%	54	437
Mech Engr 3521 – Appl. Thermodynamics	-1.15%	54	411
Mech Engr 3525 – Heat Transfer	-4.41%	41	342
Mech Engr 3708 – Machine Design I	5.69%	53	413
Mech Engr 4761 – Engineering Design	-0.37%	40	356

Table 8. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Metallurgical Engineering Course

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Met Engr 2110 – Metallurgy for Engineers	6.22%	113	701

Table 9. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Physics Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Physics 1135 – Engineering Physics I	13.91%	171	1275
Physics 2135 – Engineering Physics II	6.79%	176	1295

Table 10. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Math Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Math 1140 – College Algebra	-9.19%	53	393
Math 1160 - Trigonometry	12.97%	100	883
Math 1214 – Calculus for Engineers I	12.24%	121	984
Math 1215 – Calculus for Engineers II	14.36%	174	1109
Math 2222 – Calculus w/ Analytic Geometry III	6.57%	165	1180
Math 3108 – Linear Algebra	5.60%	41	390
Math 3304 – Elementary Differential Equations	8.58%	128	1149

Table 11. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Geological Engineering Course

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Geo Eng 1150 – Physical and Environmental Geology	8.08%	26	371

Table 12. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Freshmen Engineering Course

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Freshmen Engr 1100 – Study and Careers in Engineering	10.40%	251	1785

Table 13. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select English Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
English 1120 – Exposition and Augmentation	12.18%	114	889
English 1160 – Writing and Research	8.49%	36	207

Table 14. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Engineering Management Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Eng Mgt 1100 – Practical Concepts for Technical Managers	6.39%	85	677
Eng Mgt 1210 – Economics Analysis of Engineering Projects	3.29%	110	987

Table 15. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Electrical Engineering Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
El Eng 2100 – Circuits I	11.09%	45	386
El Eng 2800 – Electric Circuits (non-majors)	-0.06%	58	650

Table 16. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Computer Science Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Comp Sci 1570 – Introduction to Programming	13.27%	79	520
Comp Sci 1580 – Introduction to Programming Laboratory	5.27%	77	503

Table 17. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Computer Engineering Course

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Comp Eng 2210 – Intro. to Digital Logic	11.96%	44	371

Table 18. Improvement in Average GPA for Missouri S&T Students with PLTW Course Experience In Select Civil Engineering Courses

Course	% Improvement	Number of Students w/ PLTW Exp.	Number of Students w/out PLTW Exp.
Civ Engr 2200– Statics	5.85%	138	1091
Civ Engr 2210 – Mechanics of Materials	8.98%	115	1190
Civ Engr 2211 – Materials Testing	-0.24%	71	718

Summary and Conclusion

There are several observations from the table comparisons. First, table 1-3 provide demographic information for the 413 PLTW and 934 non-PLTW Missouri S&T student group surveyed in terms of their class rank and overall ACT scores. Second, when comparing PLTW and non-PLTW student groups in Chemistry course and lab we noted more than 20% and nearly 7% increase in GPA scores for PLTW students. Third, the PLTW student group earned approximately 1.7% higher GPA scores as compared to non-PLTW student group.

Table 8, 6.79% higher GPA score for PLTW students than non-PLTW students for one of the two Statistics courses. The other course showed less than 0.2% difference.

Table 9 compared the two groups to several mechanical engineering courses. Starting with the highest difference, Thermodynamics showed PLTW students had 12.34% higher GPAs then non-PLTW student group. Followed by Machine Dynamics, Dynamics, Machine Design I, Thermofluid Mechanics and Introduction to Design with 11.30%, 8.16%, 5.69%, 5.24% and 2.64% respectively. Introduction to Manufacturing Processing and Engineering Design indicated little change between two groups at 0.06% and 0.37% respectively. Applied Thermodynamics and Heat Transfer, however, saw non-PLTW students earning a higher GPA than the PLTW students at 1.15% and 4.41% respectively.

Looking at Math, Table 10 compares the overall GPA for the two groups. Looking at the highest difference Calculus II, Trigonometry, Calculus I, Differential Equations, Calculus III and Linear Algebra showed PLTW students having higher overall GPAs at 14.26%, 12.97%, 12.24%, 8.58%, 6.57% and 5.60%, respectively. College Algebra indicated Non-PLTW students earned 9.19% higher overall GPA.

Table 13 compared the overall GPA scores for both groups in Exposition and Augmentation and Writing and Research for both groups. PLTW students earned 12.18% and 8.49% higher GPAs than the non-PLTW group.

In other engineering fields again starting with the highest differences between PLTW group and non-PLTW group we note the following observations; Table 17 Introduction to Digital Electronics at 11.96%, Table 15 Circuits at 11.09%, Table 18 Mechanics of Materials and Statics at 8.98% and 5.85% respectively, Table 11, Physical and Environmental Geology at 8.08% and Table 14, Practical Concepts of Technology Managers and Economic Analysis of Engineering Projects at 6.39% and 3.29% respectively. The remaining engineering related courses Materials Testing and Electrical Circuits (for non-majors) saw minimal difference.

Table 12, The Study and Careers in Engineering indicated a 10.4% difference between PLTW group to non-PLTW group overall GPA scores. This is an introductory course for all new incoming engineering students take in their first semester on campus.

Finally, from Table 16, Introduction to Programming and the Laboratory, the PLTW group had an overall 13.27% and 5.27% higher GPA respectively. This is a course for computer science majors.

Overall, the study highlighted that PLTW students attained higher overall GPAs in the majority of courses selected in subject areas of math, English and the physical sciences. For math the only subject matter that saw non-PLTW students having an overall higher GPA was in College Algebra at 9.19%. The other math subject areas, Calculus I, II, III, Differential Equations and Linear Algebra saw PLTW students having a higher overall GPA. The study also showed courses such as Applied Engineering Statistics showed little change between the two groups. Engineering statistics saw PLTW with a higher overall GPA of 6.79%. Similarly the study showed PLTW with an overall GPA 12.18% and 8.49% higher in exposition and augmentation as well as writing and research, respectively. The study results also showed that PLTW students having a higher GPA results in both Physics I, Physics II and Chemistry courses with 13.91%, 6.79% and 20.13% respectively.

Within the engineering courses their few exceptions with the majority of the courses indicating PLTW group's higher overall GPA ranged from a 0.06% to 12.34%. The remaining observations had some differences of non-PLTW students higher overall GPA ranged from 0.06% to 4.41%. Within the computer science course and lab the study revealed the overall GPA for PLTW students having a higher GPA score of 13.27% and 5.27% than the group without prior PLTW experience.

In conclusion, this is part of an ongoing 5-year study to examine the benefits PLTW as a recognized STEM education program provides in preparing students to their career paths in engineering and computer science. In this study the overall GPA for two groups were compared for a particular set of courses. Some of the courses were general courses such as Math, Science and English while others were discipline specific such as mechanical, civil, electrical, computer engineering just to name a few. Two groups were defined based on whether or not the student had PLTW experience prior to college.

Table 2 indicates the number of students booth without PLTW experience to those who had PLTW experience that were analyzed based on their academic year. Table 3 shows the difference of the ACT scores was for these groups with the intents to show that both groups are academically at the same level. Bottom line, students with PLTW course experience had higher average course grade results in 34 of the 41 courses.

Some of the factors contributing to the differences in their education may be linked to the type of hands on activities both in the classroom as well as outside of the classroom. Prior studies have shown to improve student engagement as well as retention. The PLTW courses most enjoyed by students are engineering program courses, which have existed longer than courses in the other PLTW programs. As PLTW courses in the other programs are more commonly offered to students, the most commonly taken PLTW courses would be expected to be more distributed among the courses offered through the Engineering, Biological Sciences, and Gateway to Technology programs.

As a result 88.62% of the students taking PLTW courses are seeking careers in Engineering/Technology/Industry compared to 80.60% of the students who have not taken PLTW courses, which are slightly higher than reported in other studies [5, 6, 10, 11].

As Missouri S&T is a technological university with 14 bachelor of science engineering programs, the percentage of students pursuing Engineering/Technology/Industry related careers is expected to be higher than other institutions regardless of whether the students have taken PLTW courses. Missouri S&T students taking PLTW courses most commonly pursued degrees in Mechanical Engineering, Computer Science, Civil Engineering, Electrical Engineering, Computer Engineering, and Chemical Engineering, which consistent with previous Missouri S&T survey results [10, 11]. Survey results also show that PLTW students completed higher levels of math and physics in high school than the non-PLTW students, with no discernible difference between PLTW and non-PLTW students' participation in other high school clubs or teams.

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Editor Note

The authors are faculty members in the Engineering Department of Missouri University of Science and Technology.