

A PRELIMINARY ACADEMIC PERFORMANCE ASSESSMENT OF MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY STUDENTS WITH PROJECT LEAD THE WAY COURSE EXPERIENCE

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Abstract

There have been a number of studies examining the impact of Science, Technology, Engineering and Mathematics (STEM) education programs in providing college preparation. These studies have found benefits for pre-college students in STEM related career pursuits, academic performance, pre-college course attendance, retention, student engagement, among many others. In a previous study, our research group compared the academic performance of Missouri S&T students with and without Project Lead The Way (PLTW) course experience based on academic records obtained for students pursuing engineering and computer science degree programs in the Fall Semester 2015 and the Spring Semester 2016. In this paper, we extend the study to assess academic performance results for Missouri S&T students with and without PLTW course experience for the Spring 2015, Fall 2015, Spring 2016, and Fall 2016 semesters for students pursuing 16 engineering and computer science degree programs. We examined the academic records of 3,358, 5,704, 4,817, and 5,063 students who indicated that they have not taken any PLTW courses in their K-12 programs (non-PLTW students) and 309, 628, 517, and 562 students who indicated that they took one or more PLTW courses in their K-12 programs (PLTW students) from the Spring 2015, Fall 2015, Spring 2016, and Fall 2016 semesters, respectively. Results for engineering and computer science majors showed an overall average grade point average improvement of 5.2%, 5.7%, 2.4%, and 4.1%, respectively, from the Spring 2015, Fall 2015, Spring 2016, and Fall 2016 semesters for the PLTW student group over the non-PLTW group. Results from this study also show consistent academic performance improvement for students in their freshman, sophomore, junior and senior years of study, with higher improvements in the freshman and sophomore years, for the 16 engineering and computer science degree programs offered at Missouri S&T. This study of academic performance assessment over the spring and fall semesters for the 2015 and 2016 academic years highlights the potential that students with PLTW course experience have attained tangible improvement in academic performance at Missouri S&T over students with no PLTW course experience.

Background

Many studies have examined the academic benefits and promotion of the pursuit of careers of K-12 science, technology, engineering and mathematics (STEM) education programs throughout the United States. These studies have explored academic achievement and student engagement [1], improved student preparation for higher education [2], attendance [3], ethnic diversity [4], grades [5], among others. This study extends previous survey assessments of Missouri S&T students to examine factors impacting career choices, college selection, and academic performance [6].

Missouri S&T has explored PLTW high school teacher backgrounds for teaching PLTW courses in the Gateway, Engineering, Biomedical Sciences, and Computer Science pathways and high school instructor assessments of the strengths and weaknesses of PLTW courses in benefiting and preparing high school students for post-high school preparation [7]. Previous Missouri S&T research has also investigated Missouri S&T students who had and had not taken PLTW courses in high school [6]. A survey of over 1300 current and graduated Missouri S&T students revealed that: 1) PLTW students had taken higher levels of math and physics in high school than non-PLTW students [6]; 2) PLTW students sought careers in Engineering/Technology/Industry at greater rates than non-PLTW students [6]; and 3) PLTW students

were more involved in Robotics clubs and teams than non-PLTW students [6]. A detailed description of PLTW programs is given in [8] and the Missouri PLTW network in [9]. 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 [6,10]. This study extends the academic performance study from [10] with a more complete data set of Missouri S&T student records for the spring 2015, fall 2015, spring 2016, and fall 2016 semesters.

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 explored in [10].

Methodology

In this study, we worked 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 [10], only Engineering, Computer Science, and Undecided Engineering majors were considered for this study. For degree audit data collection from Institutional Research at Missouri S&T, separate degree collections were obtained for the fall and spring semesters for the 2015 and 2016 academic years.

Experiments Performed

In order to evaluate the academic performance of Missouri S&T students who have taken one or more PLTW courses (PLTW students) and who have not taken any PLTW courses (non-PLTW students) in high school, we examined the academic records of 3358/309, 5704/628, 4817/517, and 5063/562 non-PLTW/PLTW students from the spring 2015, fall 2015, spring 2016, and fall 2017 semesters, respectively, which were obtained from the Registrar's office at Missouri S&T. The academic records included major program of study, ACT score, cumulative Missouri S&T grade point average, number of credit hours completed, and college credit courses. At Missouri S&T, Freshman have between 0-30 credit hours, Sophomores have between 31-60 credit hours, Juniors have between 61-90 credit hours, and Seniors have over 90 credit hours. The academic records collected indicated the student's current BS degree program, with only the following BS degree programs considered for this study: aerospace engineering (AE ENG), architectural engineering (ARC ENG), chemical engineering (CH ENG), computer science (CMP SC), computer engineering (CP ENG), ceramic engineering (CR ENG), civil engineering (CV ENG), electrical engineering (EL ENG), engineering management (ENG MG), environmental engineering (EV ENG), mechanical engineering (MC ENG), geological engineering (GE ENG), mining engineering (MI ENG), metallurgical engineering (MT ENG), nuclear engineering (NU ENG), and petroleum engineering (PE ENG). Using this data, the following comparisons were made: 1) Average PLTW and non-PLTW student grades and ACT scores by year (Freshman, Sophomore, Junior, Senior) from 2015 and 2016; 2) Average

PLTW and non-PLTW student grades by degree program from 2015 and 2016; 3) Average PLTW and non-PLTW student grades by degree program and by year from 2015 and 2016; 4) Retention by year for PLTW and non-PLTW students from 2016; 5) Overall average student grades for PLTW and non-PLTW students from 2015 and 2016. For experiments based on year and major, the number of students for each year and major are provided.

Experimental Results

In this section, the comparison results for the PLTW and non-PLTW student groups are presented for the different experiments. Table 1 shows the number of Missouri S&T students without/with PLTW course experience as indicated on the admission applications by year (Freshman, Sophomore, Junior, Senior) and total students for the spring 2015, fall 2015, spring 2016, and fall 2016 semesters. Table 2 presents the average ACT scores for Missouri S&T students with PLTW course experience by year for the spring 2015, fall 2015, spring 2016, and fall 2016 semesters. Table 3 gives the percentage improvement in average ACT scores by year for the Missouri S&T students with PLTW course experience over the students without PLTW course experience. Note that the average ACT scores by year for the students without PLTW course experience are not shown. Rather, the percentage difference is given in Table 3 using the Missouri S&T students with PLTW course experience from Table 2 as a reference. Table 4 shows the average high school grade point average (GPA) by year for the Missouri S&T students with PLTW course experience. Table 5 gives the percentage improvement in average high school GPA by year for the Missouri S&T students with PLTW course experience over the students without PLTW course experience. Note that the average high school GPAs by year for the students without PLTW course experience are not explicitly provided. Table 6 presents the average Missouri S&T GPA for Missouri S&T students with PLTW course experience. Table 7 provides the percentage improvement in Missouri S&T GPA for Missouri S&T students with PLTW experience over students without PLTW course experience. Tables 8-11 show the improvement in Missouri S&T average GPA by engineering degree program and computer science for spring 2015 (Table 8), fall 2015 (Table 9), spring 2016 (Table 10), and fall 2016 (Table 11) for Missouri S&T students with PLTW course experience. The number of students for each degree program with and without PLTW course experience is given.

Table 1. Number of Students without/with PLTW Course Experience as Indicated on Admissions' Applications.

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

Table 2. Average ACT Scores for Missouri S&T Students with PLTW Course Experience.

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshman	28.1	27.6	26.8	28.9
Sophomore	28.3	28.8	28.6	28.3
Junior	28.4	28.5	28.6	29.0
Senior	28.7	28.5	28.5	28.9

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

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshman	2.5%	-1.1%	-2.1%	4.1%
Sophomore	0.6%	1.7%	1.1%	-0.1%
Junior	0.7%	0.4%	0.4%	2.7%
Senior	2.9%	2.4%	1.5%	2.2%

Table 4. Average High School GPA for Missouri S&T Students with PLTW Course Experience
Note that all high school GPAs were normalized to a 4.0 scale.

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshman	3.61	3.58	3.64	3.57
Sophomore	3.57	3.61	3.57	3.61
Junior	3.57	3.56	3.59	3.58
Senior	3.58	3.56	3.58	3.57

Table 5. Percentage Difference in Average High School GPA for Missouri S&T Students with PLTW Course Experience. Note that all high school GPAs were normalized to a 4.0 scale.

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshman	2.0%	0.8%	2.5%	1.5%
Sophomore	0.3%	1.0%	-0.1%	0.6%
Junior	-0.6%	-1.1%	-0.5%	0.2%
Senior	0.2%	-0.2%	0.0%	-0.4%

Table 6. Average Missouri S&T GPA for Missouri S&T Students with PLTW Course Experience.

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshman	2.91	3.03	2.83	3.03
Sophomore	3.11	3.23	3.09	3.04
Junior	3.28	3.19	3.20	3.26
Senior	3.38	3.29	3.26	3.24
<i>All Students</i>	3.20	3.18	3.13	3.14

Table 7. Percentage Improvement in Missouri S&T Average GPA for Missouri S&T Students with PLTW Course Experience.

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Freshman	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%
<i>All Students</i>	5.2%	5.7%	2.4%	4.1%

Table 8. Improvement in Missouri S&T Average GPA for Spring 2015 Missouri S&T Students with PLTW Course Experience.

Average S&T GPA	AE ENG	ARC ENG	CH ENG	CMP SC	CP ENG	CR ENG	CV ENG	EL ENG	ENG MG	EV ENG	MC ENG	GE ENG	MI ENG	MT ENG	NU ENG	PE ENG
Difference	-4.3%	2.4%	2.1%	11.4%	9.5%	1.6%	-4.7%	5.6%	-5.1%	20.1%	9.0%	8.9%	11.3%	-11.4%	7.4%	6.3%
No PLTW Experience	277	101	351	360	194	109	222	229	165	71	694	74	129	77	150	155
PLTW Experience	27	11	24	17	20	12	13	22	11	4	104	6	4	10	10	14

Table 9. Improvement in Missouri S&T Average GPA for Fall 2015 Missouri S&T Students with PLTW Course Experience.

Average S&T GPA	AE ENG	ARC ENG	CH ENG	CMP SC	CP ENG	CR ENG	CV ENG	EL ENG	ENG MG	EV ENG	MC ENG	GE ENG	MI ENG	MT ENG	NU ENG	PE ENG
Difference	5.1%	14.9%	3.3%	7.3%	4.8%	3.7%	-1.7%	6.5%	-7.2%	3.3%	6.9%	8.2%	4.1%	0.6%	6.4%	16.2%
No PLTW Experience	467	148	624	666	386	165	387	396	273	112	1188	123	168	93	234	274
PLTW Experience	57	15	52	36	42	19	44	60	18	9	206	10	10	10	21	19

Table 10. Improvement in Missouri S&T Average GPA for Spring 2016 Missouri S&T Students with PLTW Course Experience.

Average S&T GPA	AE ENG	ARC ENG	CH ENG	CMP SC	CP ENG	CR ENG	CV ENG	EL ENG	ENG MG	EV ENG	MC ENG	GE ENG	MI ENG	MT ENG	NU ENG	PE ENG
Difference	-2.2%	7.4%	1.3%	7.0%	-2.6%	8.6%	-4.0%	5.3%	-9.6%	-11.2%	4.4%	13.4%	-5.1%	-2.1%	7.3%	9.7%
No PLTW Experience	402	148	535	526	312	146	319	320	263	77	1001	95	135	104	192	242
PLTW Experience	38	14	43	30	32	14	37	51	17	8	165	10	11	13	18	16

Table 11. Improvement in Missouri S&T Average GPA for Fall 2016 Missouri S&T Students with PLTW Course Experience.

Average S&T GPA	AE ENG	ARC ENG	CH ENG	CMP SC	CP ENG	CR ENG	CV ENG	EL ENG	ENG MG	EV ENG	MC ENG	GE ENG	MI ENG	MT ENG	NU ENG	PE ENG
Difference	2.1%	11.9%	7.3%	11.7%	6.9%	-3.7%	-5.4%	2.7%	-7.1%	20.6%	4.3%	20.7%	3.2%	1.7%	-4.4%	10.7%
No PLTW Experience	420	145	545	622	349	138	372	389	256	108	1035	97	107	90	182	208

PLTW Experience	48	14	43	32	39	14	38	58	16	8	194	10	7	11	18	12
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The results in Tables 1-11 fuel a number of observations. First, the Missouri S&T students for the engineering degree programs and computer science with PLTW course experience comprise 8.4%, 9.9%, 9.7%, and 10.0% of the spring 2015, fall 2015, spring 2016, and fall 2016 students, respectively, based on Table 1. Second, from Table 3, Missouri S&T students with PLTW course experience typically have slightly higher ACT scores, at most 4.1% higher (Freshman in Fall 2016), than students without PLTW course experience. Third, from Table 5, the average high school GPA is slightly higher for Freshman in all semesters examined (Spring 2015, Fall 2015, Spring 2016, Fall 2016). Overall, the average high school GPA does not appear to be a contributor in distinguishing the academic performance of Missouri S&T students with and without PLTW course experience. Fourth, from Table 7, the students with PLTW course experience had an improved Missouri S&T GPA in every semester and every class compared to the students without PLTW course experience. The greatest improvements are in the Freshman class, where the PLTW student group had 9.8%, 7.0%, 5.8%, and 9.2% higher average Missouri S&T GPAs than the non-PLTW group for the Spring 2015, Fall 2015, Spring 2016, and Fall 2016 semesters, respectively. Overall, the PLTW student group had 5.2%, 5.7%, 2.4%, and 4.1% average higher average GPAs for all students from Spring 2015, Fall 2015, Spring 2016, and Fall 2016, respectively. The average GPA improvement for the PLTW group is lowest for the Senior classes. Fifth, from Tables 8-11, the number of students with and without PLTW course experience and the average PLTW student group Missouri S&T GPA improvement are shown for the Spring 2015, Fall 2015, Spring 2016, and Fall 2016 semesters, respectively. The PLTW student group has a higher average Missouri S&T GPA in 12 of the 16 engineering and computer science degree programs for the Spring 2015 semester, 14 of the 16 degree programs for Fall 2015 semester, 9 of the 16 degree programs for the Spring 2016 semester, and 12 of the 16 degree programs for the Fall 2016 semester.

Discussion

Based on the experimental results shown in the previous section, there are several points for discussion. First, based on Table 1, the students with PLTW experience are an overall relatively low percentage of the total Missouri S&T student body. The results presented in this study are based on a more significant data set than previous reported academic performance assessment in [10]. The relatively low numbers of PLTW students, particularly in many of the degree programs (see Tables 8-11) make interpretation of the results still preliminary but showing trends that will be examined in future studies as more student data is compiled for students with and without PLTW course experience. Second, the overall average Missouri S&T GPA for the PLTW student group for all degree programs showed an improvement of 5.2%, 5.7%, 2.4%, and 4.1% for the Spring 2015, Fall 2015, Spring 2016, Fall 2016 semesters, respectively, which is comparable to overall average Missouri S&T GPA improvements of 4.68% and 3.18% from 2015 and 2016, respectively, for the PLTW student group reported in [10]. Third, from Table 7, the Freshman year average Missouri S&T GPA improvement for the PLTW student group is higher (except for the Fall 2015 semester) than for the Sophomore, Junior, and Senior classes, with declines in the Missouri S&T GPA improvements from Freshman to Sophomore year and from Junior to Senior year.

Fourth, the average ACT scores for students with and without PLTW course experience were similar, slightly higher for the PLTW student group. The disparities in average ACT scores may contribute, but not significantly, to the academic performance variations between the students with and without PLTW course experience. Fifth, the overall average high school GPA for the students, from Tables 4 and 5, with and without PLTW course experience are similar for all semesters and for all classes, with the greatest

disparity of 2.5% (higher for students with PLTW course experience) for Spring 2016 Freshman. For the Freshman year Missouri S&T GPA, it is unclear the extent that high school GPA correlates with improved Missouri S&T GPA. This is an area where more student academic data will aid in making more definitive conclusions about academic performance variations between the students with and without PLTW course experience.

Sixth, from Tables 8-11, for the 16 engineering degree programs and computer science, Missouri S&T students with PLTW experience had higher average Missouri S&T student GPA for 12 of 16, 14 of 16, 9 of 16, and 12 of 16 degree programs for the Spring 2015, Fall 2015, Spring 2016, and Fall 2016 semesters, respectively. This observation is based on comparing all engineering degree programs and computer science regardless of the number of PLTW students pursuing the degree program. These results compare to 13 of 16 and 12 of 16 engineering degree programs including computer science for 2015 and 2016, respectively, as reported in [10]. Reassessing the comparisons from Tables 8-11 requiring at least 20 PLTW students yields higher average Missouri S&T GPA for the PLTW student group in 4 of 5 degree programs (AE ENG has lower PLTW student GPA, CH ENG, CP ENG, EL ENG, MC ENG) with higher average Missouri S&T GPA for Spring 2015, 7 out of 8 degree programs (AE ENG, CH ENG, CMP SC, CP ENG, CV ENG has lower PLTW student GPA, EL ENG, MC ENG, NU ENG) for Fall 2015, 4 of 6 degree programs (AE ENG has lower PLTW student GPA, CH ENG, CMP SC, CP ENG has lower PLTW student GPA, EL ENG, MC ENG) for Spring 2016, and 5 of 6 degree programs (AE ENG, CH ENG, CMP SC, CP ENG, CV ENG has lower PLTW student GPA, EL ENG, MC ENG) for Fall 2016.

Finally, this study reports academic performance results based on a data set of 3358/309, 5704/628, 4817/517, and 5063/562 students without/with PLTW course experience in Spring 2015, Fall 2015, Spring 2016, and Fall 2016, respectively. This compares to a student sample size of 314 PLTW students and 2812 non-PLTW students from 2015 and 425 PLTW students and 3513 non-PLTW students from 2016 reported in [10]. The relatively low sample size of PLTW students limits comparison capability from this study. However, the overall average Missouri S&T student GPA for all classes (Freshman, Sophomore, Junior, and Senior) and by degree program show the potential of PLTW course experience in enhancing student academic performance at Missouri S&T. Future studies involve continued student data collection for a more comprehensive academic performance assessment. Identification of unique students with degree programs pursued will be compiled for this assessment.

Conclusions

In this study, the academic records of Missouri S&T students who have taken at least one PLTW course in the K-12 STEM program (with) and who have not taken any PLTW courses in K-12 (without) were compared from 4 semesters over the 2015 and 2016 academic years for 16 engineering degree programs and computer science. Academic performance results showed an overall average grade point average improvement of 5.2%, 5.7%, 2.4%, and 4.1%, respectively, from the Spring 2015, Fall 2015, Spring 2016, and Fall 2016 semesters, respectively, for the PLTW student group over the non-PLTW group with relatively small positive differences in average high school GPA and average ACT scores between the PLTW and non-PLTW groups. The academic performance data showed that the PLTW group had a higher average grade point average for 12 of the 16 engineering degree and computer science programs in Spring 2015, 14 of 16 degree programs for Fall 2015, 9 of 16 degree programs in Spring 2016, and 12 of 16 degree programs for Fall 2016. This study gives academic performance results based on a larger data set of 3358/309, 5704/628, 4817/517, and 5063/562 students without/with PLTW course experience in Spring 2015, Fall 2015, Spring 2016, and Fall 2016, respectively, compared to 2812/314 and 3513/425 students from the 2015 and 2016 academic years, as reported in [10]. Even with the larger data set, there are relatively few numbers of students in the PLTW group for several of the degree programs, which limits

the ability to make conclusive statements about the impact of PLTW experience on improved academic experience. The academic performance data also shows that the PLTW group had a slightly higher average grade point average by year completed in the degree program, with greater disparities in the freshman year than in the junior and senior years. The relatively small number of students with PLTW course experience compared to the number of students without PLTW course experience, especially in the Freshman year, inhibit the ability to make conclusions based on degree programs and by year in the degree program. Overall, the trend that students with PLTW course experience are achieving higher academic performance in terms of grade point average than students who have not completed PLTW courses is reinforced in this study and builds upon the findings in [10].

References

1. True Outcomes Analysis of End-of-Course Evaluations for PLTW, 2009.
2. G.Bottoms and J. Uhn. Project Lead The Way Works: A New Type of Career and Technical Program. Southern Region Education Board, www.sreb.org, September 2007.
3. A. Phelps, E. Camburn, and J. Durham. Engineering the Math Performance Gap. University of Wisconsin-Madison. The Center on Education and Work. Research Brief, June 2009.
4. R.H. Tai. (2012). An Examination of Research Literature on PLTW. University of Virginia. Publication by PLTW. http://www.cew.wisc.edu/docs/resource_collections/CEW_PTLW_Brief_UWMadison.pdf
5. B. Wentz and C. Raebel, Evaluation of High School Pre-Engineering Curricula on Freshman Architectural Engineering Student Performance, AEI Conference, Milwaukee, WI, March 24-27, 2015.
6. R.J. Stanley and S. Baur, "Assessing the impact of Project Lead the Way high school Pre-engineering curriculum on Missouri University of Science and Technology student academic experience and career choices," Transactions on Techniques in STEM Education, vol. 1, no. 2, pp. 101-112, January-March 2016.
7. S. Baur and J. Stanley, "Survey-based Assessments for Missouri Project Lead The Way Instructors," Transactions on Techniques in STEM Education, vol. 1, no. 3, pp. 34-41, April-June 2016.
8. <https://www.pltw.org/our-programs>. Last accessed July 26, 2017.
9. S. Baur and R.J. Stanley, "Missouri Project Lead The Way Survey Instructor-Based Assessments," Transactions on Techniques in STEM Education, vol. 2, no. 2, pp. 34-43, January-March 2017.
10. J. Stanley and S. Baur, "A Preliminary Academic Performance Assessment of Missouri University of Science and Technology Students with Project Lead the Way Course Experience," Transactions on Techniques in STEM Education, vol. no. 2, pp. 21-33, January-March 2017.

Editor Note

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