Influence of Project Lead the Way STEM Courses on the State Achievement Test

BY

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Courses: 2

Abstract

The following study was conducted to determine if there is a difference between the academic performance of middle and high school students participating in Project Lead the Way. State-assessment data was used to measure and compare student achievement data of schools implementing in Project Lead the Way STEM courses to schools not implementing. These schools were at the same social economic status. Eighth grade science and math MAP percentage of proficient and advance from 2011 to 2015 were compared for middle school student achievement. Algebra, Algebra II, Geometry and Biology EOC percentage of proficient and advance from 2011 to 2015 were compared for high school students. The data displayed a significant difference in student achievement for 8th grade science and mathematics academic performance. There was not a significant difference in student achievement for Biology I, Algebra I, Algebra II and Geometry.
Courses: 3

Introduction

Background, Issues and Concerns

In today’s twenty-first century, society relies heavily on technology, science, engineering and mathematics, STEM. Adequately preparing students to be knowledgeable, skilled and innovative thinkers in these fields of study is the goal of PLTW STEM courses. Incorporating PLTW STEM courses into the course curriculum does involve issues and concerns.

According their website, Project Lead the Way began in 1986 with Richard Blais, a upstate New York high school teacher, who offered pre-engineering and digital electronic classes. Mr. Blais desired to encourage students to pursue a study in engineering. In 1997, the Liebich family’s Charitable Leadership Foundation provided the support necessary for Mr. Blais to establish the Project Lead the Way’s high school engineering program and launch it in twelve schools. By 2007, Project Lead the Way partnered with National Aeronautics and Space Administration, received endorsement from Aerospace Industries Association and Bayer Foundation as well as developed a middle school program called Gateway. During the following fourteen years Project Lead the Way involved a partnership with VEX Robotics, Lockheed Martin and American Institute of Aeronautics and Astronautics, Analytical Graphics Inc., a Biomedical course were added at the middle and high levels and a Computer Science program. During these years Project Lead the Way also experienced tremendous growth to over 6,500 schools providing 7,500 programs. (PLTW, 2014)

Implementation of Project Lead the Way into a school district naturally would experience issues and concerns. Two major concerns were funding and scheduling the courses. Funding encompassed proper training for teachers in instructing PLTW STEM courses along with quality facilities which contain lab equipment and materials. Teachers struggled to effectively impact
Courses: 4

student learning without proper training, equipment and materials. Grants exist for funding and would lessen the financial cost. Scheduling entailed addition time created during the school day as a core subject or elective class, which students would be allowed to participate, the class size and addition curriculum content to teach. Change would never be easily welcomed and teachers may not desire of an addition new curriculum or instructional pieces they must learn.

Practice under Investigation

This investigation is to determine the effect of PLTW STEM programs on student achievement of science content.

School Policy (practice) to be Informed by Study

Based on the results of this investigation, the benefit to student achievement will become evident. Knowing the degree of impact of PLTW STEM courses will influence the incorporation of these courses into the curriculum and the distribution of district funding. A positive impact potentially results in developing interdisciplinary units within these fields. Meaning, science teachers would be expected to integrate technology, engineering and mathematics practices in classroom instruction. This would be similar for the other fields also. Teachers of these areas would require expertise in these other areas as well.

Conceptual Underpinning

Project Lead the Way STEM courses were designed utilizing specific educational theory. The Project Lead the Way website elaborated on the program approach. Programs utilized Wiggins and McTighe’s *Understanding by Design* principles to cultivate a deliberate instructional path. Project Lead the Way STEM courses were problem-based with a design activity, scaffolding and require student application of content knowledge. Additionally, the interdisciplinary approach was found in Project Lead the Way STEM courses. Learning was a
Courses: 5

PLTW Stem

cognitive endeavor and Project Lead the Way courses involved students making connects
between information both new and old. The other disciplines provided the context for the subject
to be learned. This context and connections form through an active learning process. Kinesthetic
learning has been well documented through multiple intelligences research and utilized in Project
Lead the Way STEM courses. These educational strategies had shown its impact regardless of
ethnicity, gender and socio-economic status.

During Project Lead the Way STEM courses, students build their understanding through
a series of experiences. Learning in this form roots itself in the constructivist learning theory
which fosters learning through student experimentation and formulating their own
understanding. This learning theory is well established and allowed for differentiation and
challenging of students to learn in new ways. Constructivism, connections and kinesthetic
learning are the foundational learning psychology Project Lead the Way STEM courses were
designed upon.

Statement of the Problem

Students are not pursuing the fields of science, technology, engineering and mathematics
as careers. A lack of student understanding of the scientific community or display an adequate
preparation for pursuing scientific fields exists.

Purpose of the Study

The purpose of this study is to determine the impact of STEM courses on student
achievement of science and mathematics content.

Research Question(s)

Is there a difference in science and math state test scores between student participating in
STEM courses and students not participating in STEM courses?
Courses: 6

Null Hypothesis(es)

There is no difference between the percentage of proficient and advance students on state assessment for science and math for students participating in Project Lead the Way STEM courses and students not participating in Project Lead the Way STEM courses.

Anticipated Benefits of the Study

This study will benefit educators by evaluating the influence of Project Lead the Way STEM courses on student achievement of science and math.

Definition of Terms

STEM—Acronym for science, technology, engineering and mathematics content areas.

Effect size—Degree of impact an educational practice had on student learning.

End of course exams—Assessments taken after a student has received instruction on the Missouri Learning Standards for an assessment, regardless of grade level.

MAP—Acronym for the Missouri Assessment Program. This program assessed students' progress toward the Missouri Learning Standards, which were Missouri's content standards.

PLTW—Project Lead the Way is the nation's leading science, technology, engineering, and math (STEM) solution by delivering STEM course curriculum and teacher training to more than 8,000 elementary, middle, and high schools in all 50 states and the District of Columbia.

Summary

This research study strives to pragmatically advance and improve the quality of student learning in science, technology, mathematics and engineering. Students participate in a realistic hand-on course where students create, analyze and synthesize information for their own learning.
Courses: 7

and benefit. If PLTW STEM courses increase the quality of student learning there will be a significant difference between the percent of proficient and advance state assessment scores of students participating in PLTW STEM courses and students who do not.

Review of Literature

Examination of the research literature on STEM, science, technology, engineering and mathematics, education provided a more complete grasp of this educational initiative. The literature focused on multiple points of consideration for general STEM. These points included defining characteristics of STEM and why STEM was important in education. In addition the structure of courses and best practice implementing STEM courses. Finally, the research literature provided insight on the student benefits of participating in STEM courses.

A common theme within the literature was the subjects of mathematics, science, technology and engineering being interwoven into each course. This means interdisciplinary activities where other content integrated with other discipline’s content (Ejiwale, 2012, p.87-88; Chen, G, 2014, p.2). The definition of STEM elaborated on by Sanders (2009) as, “…teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects” (p.21). This led to varying degrees of integration with a single discipline or multiple disciplines simultaneously. Some STEM programs in schools partnered with professionals in the industry to assist with lessons and participate with students (Ejiwale, 2012, p.87). Becker, K., & Park, K. (2011) reported in the Journal of STEM Education the types of integrative approaches displayed a vast range of effect sizes. This varying integration was a result of a couple aspects. Chen (2014) suggested the varied integration was because integration is at the teacher’s discretion and few guidelines exist for
Courses: 8

educators to follow. The sequencing of content was also different depending on the integration of topics, the teacher, school district and state. Staff members qualified and competent in mathematics, science, engineering and technology were limited (p.3-4).

STEM research literature provided structure and organization suggestions to facilitate effective STEM courses and minimize these issues. Sanders (2009) states, “Integrative STEM education is not intended as a new stand-alone subject area in schools accompanied by new “integrative STEM education” licensure regulations, as some might suspect” (p.21). Earlier on the page Sanders (2009) mentioned STEM is “purposeful design and inquiry” where a technological design problem is intentionally combined with scientific inquiry. The notion was to support the development of each discipline within each other’s discipline.

Since staff highly qualified in each STEM area was rare, teacher professional development is a part of success STEM courses. Professional development and training was explicitly mentioned in the work of Sanders (2009) and Larmer & Mergendoller (2010). Effective STEM courses required extended professional development and not in conventional teaching methods. Resources for adequate facilities with tools, materials and technology were essential. Ej iwale (2012) claimed these resources further create the realistic scenario for students.

Lack of financial support for training and facilities infringes on the impact of STEM courses.

The research literature focused on STEM in the K-12 education system. Bao et al. (2009) displayed numerous rigorous STEM courses throughout middle and high school have a direct impact on the science content knowledge student possess. “Successful STEM education provides students with science, math, and engineering/technology in sequences that build upon each other and can be used with real-world applications,” according to Chen (2014) on page 3. A broad curriculum of topics counteracted a deep understanding STEM courses promote. Feuer (2013)
alluded to a major flaw in American education is covering a wide range of topics at a shallow level (p.2). Curriculum adjustments would further support STEM courses

Fostering the deep learning was a result of best particular practices during STEM courses. Bao et al. (2009) supported this claim stating, “It Seems that it is not what we teach, but rather how we teach, that make a difference in student learning of higher-order abilities in science reasoning” (p.587). These practices begin with a focus on the teacher. Highly effective STEM teachers were described as being well organized, planned, enthusiastic, productive and a high-efficacy according to Ejiwale (2012) on page 89. This author continued stressing the teacher role as a facilitator of student learning. This teacher role is not a custom for most teachers so Ejiwale (2012) mentioned teacher be taught the facilitator role.

Student learning opportunities implemented by the teacher was an additional factor influencing STEM course effectiveness. STEM learning opportunities to Sanders (2009) centered on being constructivist, problem based learning and inquiry in a design challenge. Learning activities were integrated meaning a purposeful connection is made to science, mathematics, engineering and technology which promotes a context of learning (p.21-24). Chen (2014) further described the learning opportunities as real world application of content (p.3). Ejiwale (2012) offered more insight about the learning opportunities noting activities are open ended exploration with multiple perspectives explaining the concept (p.91). Weekly student journal entries promoted a reflection of content in the course (p.89). Activities provided time for student thought, discussion and problem solving (p.90). The final suggestion was learning opportunities be guided by instructional goals and objectives (p.89).

Teachers and the learning activities influenced the learning environment. Freeman et al. (2014) stated STEM classrooms are interactive meaning students are actively learning (p.8410).
This idea is further supported by Ejiwale (2012) on page 88 mentioned STEM courses utilize hands on learning in an interactive learning atmosphere. Students were active participations in their learning quest to discover and conceptualize the content.

An effective teacher, student learning opportunities and classroom environment in STEM courses provided numerous student benefits. A major benefit Ejiwale (2012) stated, “...students are more confident and competent in these subjects” (p.88). STEM students benefit by having possessed a higher self-efficacy, motivation and interest according to Sanders (2009) (p.24). Becker & Park (2011) elaborated noting additional observations indicate an increase in student motivation and a more positive perspective towards subjects (p.25). Cognitive abilities of students benefited in STEM courses through problem solving, evaluating, predicting and reflection. Bao et al. (2009) mentioned students increase their scientific thinking (p.1). Chen (2014) similarly claimed students in STEM courses further developed their critical thinking abilities. This author additionally discusses STEM courses developed students independent innovation mind set (p.3). Students benefited academically from STEM courses. Sanders (2009) reported students in STEM courses score higher than traditional classrooms on national standardized and state tests (p.24). The depth at which students learn about the subjects increased which Chen (2014) concludes will result in an increase in subject matter achievement (p.3). Becker & Park (2011) reported they observe a significant increase in the student content knowledge and a diminishment in the science achievement gap for particular student populations (p.24-25). A final student benefit Freeman et al. (2014) discussed a lower failure rate for students in STEM courses (p.8410).

The literature discussed the major aspects of effective STEM courses. STEM courses require not only the proper structure and support in the school curriculum but best practice when
Courses: 11

Implementing such courses. Ultimately, students benefit according to the research literature.

Numerous authors believed further research on STEM would provide additional clarity to the degree of impact.
Research Methods

Research Design

In this investigation the independent variable was the enrollment of students in PLTW STEM course. The dependent variable will be the achievement level on science and end of course exams and MAP scores. Percent proficient and advance assessment scores of students participating in PLTW STEM courses are compared to the scores of students not enrolled in PLTW STEM courses. The control group will be students not participating in PLTW STEM courses.

Study Group Description

This research study will be conducted in the middle and high school setting. Eighth grade and high school students’ science and mathematics scores will be utilized. The PLTW STEM courses involved Gateway for middle schools, high school Engineering and Biomedical Science course. Middle and high schools with free and reduced lunch prices in the twenties were selected. Project Lead the Way’s website provided a list of schools participating in their courses. Schools not doing PLTW STEM courses were selected so the average free and reduced lunch was similar.

Data Collection and Instrumentation

Student achievement scores will be collected through the use of end of course assessment and MAP assessment scores. Scores over the past five years were collected and averaged from the Missouri Department of Elementary and Secondary Education. The assessments utilized for middle schools were the eighth grade science, eighth grade math and algebra one scores. High school assessments utilized were biology, algebra I, algebra II and geometry. If schools did not report a score a zero was not substituted in its place.
PLTW Stem

Courses: 13

Statistical Analysis Methods

To determine the impact of the participation in PLTW STEM courses a t-test comparing the two groups of students will be utilized. Group one are schools participating in Project Lead the Way courses. Group two are schools not participating in Project Lead the Way courses.
Courses: 14

Findings

A t-test was utilized to evaluate the percentage of students scoring proficient and advance on Missouri state assessment scores between schools which participated in Project Lead the Way STEM courses to schools which did not participate in Project Lead the Way STEM courses. Assessment percentages compared between groups were eight grade math, eight grade science, algebra 1, algebra 2 and geometry. The following information, graphs and charts display the assessment scores.

Table 1 Project Lead the Way and 5 year average 8th grade Math MAP Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean</th>
<th>Mean D</th>
<th>t-test</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLTW (n=16)</td>
<td>53.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No PLTW (n=18)</td>
<td>49.83</td>
<td>-3.18</td>
<td>-1.22</td>
<td>32</td>
<td>.23</td>
</tr>
</tbody>
</table>

Note: Significant when p< or =0.25

The independent variable was Project Lead the Way courses implemented or not. The dependent variable was a five year average of the percent of students scoring proficient and advance on the eighth grade math state MAP assessment. Thirty-four middle schools with a free and reduced lunch rate in the twenties were selected. Sixteen schools participated in Project Lead the Way also had a free and reduced lunch rate in the twenties. Eighteen school not participating in Project Lead the Way with a free and reduced lunch rate in the twenties. The mean percentage of proficient and advance eight grade math students on the MAP for schools doing Project Lead the Way was 53.00, while the mean percentage of proficient and advance eight grade math students on the MAP for schools not implementing Project Lead the Way was 49.83. The difference between the mean percentages (Mean D) was -3.18. The t-test was -1.22. The degrees of freedom were 32. The null hypothesis was: There is no difference between the percentage of
Courses: 15
proficient and advance students on state assessment for science and math for students participating in Project Lead the Way STEM courses and students not participating in Project Lead the Way STEM courses. The null is rejected because the p-value was .23, which is less than the alpha level of .25. This means there was a significant difference in the percentage of proficient and advance eight grade math students on the MAP between schools implementing Project Lead the Way STEM courses and schools which were not implementing Project Lead the Way STEM course. Schools implementing Project Lead the Way had a higher percentage of students scoring proficient and advance on the eighth grade math state MAP assessment.

Table 2: Project Lead the Way and 5 year Average 8th grade Science MAP Scores.

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean</th>
<th>Mean D</th>
<th>t-test</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLTW (n=16)</td>
<td>65.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No PLTW (n=18)</td>
<td>62.65</td>
<td>-2.52</td>
<td>-1.28</td>
<td>32</td>
<td>.21</td>
</tr>
</tbody>
</table>

Note: Significant when p< or =0.25

The independent variable was Project Lead the Way courses implemented or not. The dependent variable was a five year average of the percent of students scoring proficient and advance on the eighth grade science state MAP assessment. Thirty-four middle schools with a
Courses: 16

free and reduced lunch rate in the twenties were selected. Sixteen schools participating in Project Lead the Way also had a free and reduced lunch rate in the twenties. Eighteen school not participating in Project Lead the Way with a free and reduced lunch rate in the twenties. The mean percentage of proficient and advance eight grade science students on the MAP for schools doing Project Lead the Way was 65.16, while the mean percentage of proficient and advance eight grade science students on the MAP for schools not implementing Project Lead the Way was 62.65. The difference between the mean percentages (Mean D) was -2.52. The t-test was -1.28. The degrees of freedom were 32. The null hypothesis was: There is no difference between the percentage of proficient and advance students on state assessment for science and math for students participating in Project Lead the Way STEM courses and students not participating in Project Lead the Way STEM courses. The null was rejected because the p-value is .21, which is less than the alpha level of .25. This means there was a significant difference in the percentage of proficient and advance eight grade science students on the MAP between schools implementing Project Lead the Way and schools which were not implementing Project Lead the Way.

Schools implementing Project Lead the Way had a

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**5 year Average 8th grade Science MAP Scores**

<table>
<thead>
<tr>
<th>Percentage of Students Proficient and Advanced</th>
<th>PLTW (n=16)</th>
<th>No PLTW (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>65.16</td>
<td>62.65</td>
</tr>
</tbody>
</table>
Courses: 17
higher percentage of students scoring proficient and advance on the eighth grade science state
MAP assessment.

The independent variable was Project Lead the Way courses implemented or not. The
Table 3 Project Lead the Way and 5 year Average Algebra EOC Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean</th>
<th>Mean D</th>
<th>t-test</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLTW (n=16)</td>
<td>94.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No PLTW (n=18)</td>
<td>93.45</td>
<td>-1.43</td>
<td>-0.37</td>
<td>32</td>
<td>.71</td>
</tr>
</tbody>
</table>

Note: Significant when p< or =0.25
dependent variable was a five year average of the percent of students scoring proficient and
advance students on the state algebra EOC at the middle school level. Thirty-four middle schools
with a free and reduced lunch rate in the twenties were selected. Sixteen middle schools
participating in Project Lead the Way also had a free and reduced lunch rate in the twenties.
Eighteen middle schools not participating in Project Lead the Way with a free and reduced lunch
rate in the twenties. The mean percentage of proficient and advance students on the algebra EOC
for middle schools doing Project Lead the Way was 94.88, while the mean percentage of
proficient and advance
students on the algebra EOC
for middle schools not
implementing Project Lead
the Way was 93.45. The
difference between the mean
percentages (Mean D) was -
1.43. The t-test was -0.37.
Courses: 18

The degrees of freedom were 32. The null hypothesis was: There is no difference between the percentage of proficient and advance students on state assessment for science and math for students participating in Project Lead the Way STEM courses and students not participating in Project Lead the Way STEM courses. The null was not rejected because the p-value was .71, which was more than the alpha level of .25. This means there was no significant difference in the percentage of proficient and advance students on the algebra on the EOC between middle schools implementing Project Lead the Way and middle schools which were not implementing Project Lead the Way. Middle schools implementing Project Lead the Way did not have a significantly higher percentage of students scoring proficient and advance on the state algebra EOC.

Table 4: Project Lead the Way and 5 year average of Average Algebra/Algebra 2/Geometry EOC

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean</th>
<th>Mean D</th>
<th>t-test</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLTW (n=13)</td>
<td>64.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No PLTW (n=15)</td>
<td>63.53</td>
<td>-.81</td>
<td>-.18</td>
<td>26</td>
<td>.86</td>
</tr>
</tbody>
</table>

Note: Significant when p< or =0.25

The independent variable was Project Lead the Way courses implemented or not. The dependent variable was a five year average of the percent of students scoring proficient and advance students on the algebra, algebra 2 and geometry EOC. Twenty-eight high schools with a free and reduced lunch rate in the twenties were selected. Thirteen schools participating in Project Lead the Way also had a free and reduced lunch rate in the twenties. Fifteen school not participating in Project Lead the Way with a free and reduced lunch rate in the twenties. The mean percentage of proficient and advance students on the algebra, algebra 2 and geometry EOC for schools doing Project Lead the Way was 64.34, while the mean percentage of proficient and
Courses: 19

advance students on the algebra, algebra 2 and geometry EOC score for schools not implementing Project Lead the Way was 63.53. The difference between the mean percentages (Mean D) was -1.43. The t-test was -0.37. The degrees of freedom were 32. The null hypothesis was: There is no difference between the percentage of proficient and advance students on state assessment for science and math for students participating in Project Lead the Way STEM courses and students not participating in Project Lead the Way STEM courses. The null was not rejected because the p-value was .71, which was more than the alpha level of .25. This means there was no significant difference in the percentage of proficient and advance students on the algebra, algebra 2 and geometry EOC between schools implementing Project Lead the Way and schools which were not implementing Project Lead the Way. Schools implementing Project Lead the Way did not have a significantly higher percentage of proficient and advance students on the algebra, algebra 2 and geometry EOC.

Table 5: Project Lead the Way and 5 year average Biology EOC Scores.

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean</th>
<th>Mean D</th>
<th>t-test</th>
<th>DF</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLTW (n= 6)</td>
<td>76.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No PLTW (n=6)</td>
<td>76.05</td>
<td>.04</td>
<td>.016</td>
<td>10</td>
<td>.99</td>
</tr>
</tbody>
</table>

Note: Significant when p< or =0.25
The independent variable was Project Lead the Way courses implemented or not. The dependent variable was a five year average of the percent of students scoring proficient and advance students biology EOC scores. Thirty-four middle schools with a free and reduced lunch rate in the twenties were selected. Sixteen schools participating in Project Lead the Way also had a free and reduced lunch rate in the twenties. Eighteen schools not participating in Project Lead the Way with a free and reduced lunch rate in the twenties. The mean percentage of proficient and advance students on the biology EOC score for schools doing Project Lead the Way was 94.88, while the mean percentage of proficient and advance students on the biology EOC score for schools not implementing Project Lead the Way was 93.45. The difference between the mean percentages (Mean D) was -1.43. The t-test was -0.37. The degrees of freedom were 32. The null hypothesis was: There is no difference between the percentage of proficient and advance students on state assessment for science and math for students participating in Project Lead the Way STEM courses and students not participating in Project Lead the Way STEM courses. The null was not rejected because the p-value was .71, which is more than the alpha level of .25. This means there was no significant difference in percentage of proficient and advance students on the biology EOC between schools implementing Project Lead the Way and schools which are not implementing Project Lead the Way. Schools implementing Project Lead the Way did not have a significantly higher percentage of proficient and advance students on the biology EOC.
Conclusions and Recommendations

Review of the statistical analysis findings and literature multiple conclusions can be drawn. First, the middle school Project Lead the Way STEM courses, Gateway, had a statistically significant positive impact on the percentage of proficient and advance students on the eighth grade mathematics and science MAP assessment but not on Algebra. Schools with Project Lead the Way had 3.18 higher percentage of proficient and advance students on math than schools not doing Project Lead the Way STEM courses. Science percentage of proficient and advance students was 2.52 higher for schools with Project Lead the Way STEM courses. A school with Project Lead the Way STEM courses had an algebra percentage of proficient and advance students 1.43 higher than schools with no Project Lead the Way STEM courses. Second, high school Project Lead the Way STEM courses, Engineering and Biomedical, did not have a statistically significant positive impact on the percentage of proficient and advance students on Missouri EOC assessment. Schools with the Engineering Project Lead the Way STEM courses had a percentage of proficient and advance students .81 higher on the mathematics EOC than schools without this STEM course. Percentage of proficient and advance students was .04 higher on Biology EOC for schools with the Biomedical Project Lead the Way STEM courses than schools without this STEM course. Third, further research needs to be conducted to further understand and verify the impact of Project Lead the Way STEM courses.

Further research is needed due to the following considerations. The sample sizes of middle and high schools were small. Schools with Project Lead the Way STEM courses was sixteen middle schools, thirteen high schools for the Engineering Project Lead the Way STEM course and six high schools for the Biomedical Project Lead the Way STEM course. This was a
Courses: 22

result of limiting the schools to those with free and reduced lunch rate in the twenties to eliminate socio-economic status as an influential factor. The sample size for implemented middle school Project Lead the Way courses would be one-hundred and six, high school engineering course would be one-hundred and twenty-one and high school biomedical course would be forty-three with no limits on free and reduced lunch rates. Involving all schools with implemented Project Lead the Way courses would indicate a more complete comparison of student achievement data and impact of Project Lead the Way courses. School districts having both Gateway and Engineering courses were six districts; one school district had implemented both Gateway and Biomedical courses. Bao et al. (2009) stressed on page 587 the direct impact of K-12 STEM courses. Starting student younger and continuing the STEM development throughout K-12 grades could prove a greater positive statistical impact. Involving more districts and schools within the district would prove more conclusive results.

Schools not only implemented differently but at various years. The number years schools had Project Lead the Way STEM courses implemented varied. Project Lead the Way Gateway middle schools averaged 4.5 years of implementation and schools ranged from nine to one year. Project Lead the Way high school Engineering courses averaged 6.5 years of implementation and ranged from eleven to one year. Project Lead the Way high school Biomedical courses averaged 4.8 years of implementation and schools ranged from six to three years. These years provided experiences and years of refinement of practice which had influenced classroom practice. Years Project Lead the Ways courses were implemented undoubtedly influenced the percentage of students earning proficient and advance on the state assessment.

Consider when and who the state assessments were given. At the middle schools, the MAP assessment was taken by all students and students would have completed the Project Lead
Courses: 23

the Way courses prior to the assessment. The state MAP assessment would validly measure the value added by the courses. According to the Project Lead the Way curriculum website, the middle schools nine week courses consisted of two fundamental and eight specialized courses which possibly resulted in different implementation of courses of different students. High schools generally have students take the algebra, algebra II and geometry EOC after the appropriate mathematics course with algebra as a freshman and the biology EOC as sophomores. According to the Project Lead the Way curriculum website, Biomedical course consist of four one year courses and Engineering consist of two fundamental one year courses with seven additional courses. Project Lead the Way course arrangement and when state EOC assessments were taken would determine if EOC assessment validly measured the value added. A different assessment device would possibly be required for high school courses, different timing of the assessment must be changed or action-research with a pilot course would be possible solutions.

Bear in mind the findings of this study, implementing Project Lead the Way STEM courses is recommended. The conceptual underpinning of a positive influence on student achievement was supported by the results of this study at the middle school level for eight grade mathematics and science. This further supported the learning theories of constructivism, kinesthetic, real-world contexts, students making connections and interdisciplinary curriculum. This study did not focus on the non-academic impact of Project Lead the Way courses on students. It was reasonable to correlate a positive impact in these areas due to a positive academic influence. The mean percentages of proficient and advance students at the middle school algebra and high school level were similar to the percentages of schools not implementing Project Lead the Way courses. Therefore, little academic risk appeared to be present in implementing Project Lead the Way courses besides the cost of resources which various grants
Courses: 24

would offer assistance. Proper resources and implementation throughout a K-12 school district would demonstrate positive effects on preparing students in the subjects of science, technology, engineering and mathematics.
Courses: 25

References


PLTW Stem

Courses: 26


