# Project Narrative

**Competitive Preference # 10 - Technology**

This proposal seeks to evaluate and validate *Project Lead the Way®* (PLTW), a nationally used **Engineering** elective curriculum. Currently over 4000 high schools in the United States have implemented this engineering pathway into their master schedules. The technology made available in this program is not only immense; it is also designed to improve student achievement in math and science. PLTW courses are electives, open to all students, and specifically engage youth who thrive in a hands-on, project-based leaning atmosphere.

This proposal also focuses on researching and helping those students that are high-need overcome certain barriers in this instance, such as female students (nontraditional in engineering) and minority students also underrepresented in engineering and who may also be living in poverty with little or no access to advanced technology in their homes. "Studies indicate that insufficient HS mathematics and science preparation and insufficient funding were two key factors that reduce underrepresented minority students enrollment in four-year institutions and engineering. In contrast, disillusionment with engineering and lack of interest in the potential associated lifestyle were common reasons deterring females from enrolling in engineering programs. The presence of negative stereotypes and/or engineering "discipline dynamics and rituals" made engineering programs seem unsupportive. In addition, the perceived lack of faculty contact, role models, and peer support were described as key factors that caused both female and minority students who enrolled to not persist towards the completion of a bachelor's degree in engineering." (Johnson & Sheppard, 2004)

Fortunately, *Project Lead the Way®* also strongly addresses teacher effectiveness and guides instructors in becoming positive role models for engineering and technology use. The "value add" to the required technology being used in the PLTW classrooms is that teachers who

instruct a *Project Lead the Way®* course must attend a two-week intensive summer training and be "officially PLTW certified" to teach the course they are assign to at their school of employment. During the summer "boot camp" trainings, which are conducted by the Project Lead the Way National office and are held at major universities across the United States, teachers must become well versed in using all of the technologies found in the curriculum.

Also during the intensive training, each instructor must do a thorough study of every unit in the course he/she will teach in the fall. Instructors must also practice the PLTW lessons in front of colleagues as both a teacher and a student. It is at this time they are able to access the on-line curriculum which is open to them 24 hours a day. There is no additional cost to schools for the curriculum. The PLTW virtual on-line academy is also available exclusively for PLTW instructors to communicate with each other throughout the school year as well. Teachers take away from the summer training a tremendous understanding of the PLTW curriculum, as well as how to implement new technology and how to evaluate current digital tools and materials. A PLTW teacher's commanding knowledge makes the use of technology and course content highly impactful on students.

Content - wise, Project *Lead the Way®* Engineering curriculum is a pathway of courses that includes both "Foundation" courses and "Specialization" courses. For the schools involved in the quasi-experimental research project in this proposal, the **four core courses** to be offered to student cohorts are: ***Introduction to Engineering Design*** **(IED)** which introduces students to the engineering design process and gives them the opportunity to learn how to use computer-aided sketching (AutoCAD/Inventor) as a means to communicate their ideas as well as the geometry that is used in parametric modeling, assembly and motion constraints. In this course students also use the 3D modeling design software to help design solutions to solve proposed problems.

Students learn how to document their work and communicate solutions to peers and members of the professional community. This course is designed for 9th grade students. The major focus of the IED course is to expose students to the design process, research and analysis, Inventor CAD software, how to work independently and in teams, various communication methods, global and human impacts within engineering fields, engineering standards and technical documentation.

***Principles of Engineering*** **(POE)** takes a more in-depth study into the different types of engineering and the communication and documentation skills that are used by engineers. Mechanisms, thermodynamics, fluid systems, electrical systems and control systems are also explored. Using the appropriate formulas, students make static and strength calculations for various materials, explore and build robotics, and learn the fields of reliability engineering and kinematics. This engineering course exposes student to some of the major concepts they'll encounter in a postsecondary engineering course of study. Designed for 10th grade students, members of this class have an opportunity to investigate engineering and high-tech careers and to develop skills that will help them employ engineering and scientific concepts in the solution of engineering and robotic design problems. They also develop problem-solving skills and apply their knowledge of research and design to create solutions to various challenges. Students also learn how to document their work and communicate their solutions to peers and members of the professional community.

***Digital Electronics*** **(DE)** develops the fundamentals of analog and digital electronics as students learn about the different number systems used in the design of digital circuitry. Students design circuits to solve open ended problems, assemble their solutions and troubleshoot the various issues that may arise during a project. Boolean expressions, application of truth tables, and kmapping techniques are also covered. Students acquire hands-on skills and use

combinational logic, integrated circuits and microprocessors to deal with real-world, project-based assignments. This course is the study of electronic circuits that are used to process and control digital signals. Digital electronics is the foundation of all modern electronic devices such as cellular phones, MP3 players, laptop computers, digital cameras and high-definition televisions. The focus of the DE course is to expose students to the process of combinational and sequential logic design, teamwork, communication methods, engineering standards and technical documentation. This course is designed for high school juniors/ 11th grade.

***Engineering Design & Development*** **(EDD)** is the pathway capstone course that teaches students to apply their research and development skills. Students works as individuals or in teams and draw from all their previous experiences in the other PLTW engineering courses as they select a problem, design a solution, conduct patent research, build a prototype, conduct testing of the prototype, evaluate the test results, and present their conclusions to an engineering panel. This capstone course allows students to design a solution to a technical problem of their choosing; and then experience the full product development life cycle and design process that are used to guide and help a team or individual to reach a solution to the problem. The team or individual then presents and defends the solution discovered to a panel of outside reviewers at the conclusion of the course. This course is for high school seniors, 12th graders, who will also engage in a work-based learning experience during the year relating to engineering.

**Required Hardware –** Laptop or personal computer with Intel i5 or i7 processor; RAM 8 Gig DDR3 with ability to upgrade; Hard Drive with 250 GIG = 7200RPM; Video Card PCI – eXpress 256 MB Dedicated RAM or greater Direct X Capable graphics; DVD-ROM Drive; Operating System with Windows 7, 32 or 65 bit or apple MacBook Pro with Bootcamp.

**Required Software** - Autodesk Rivet Architecture, Revit MEP, AutoCAD Civil 3D, Autodesk Inventor Professional, Robocell, CNC Motion, EdgCAM, LabVIEW full Development system, Logger Pro, MultSim, Open CIM Robotic Software by VEX, UltiboardBasic Stamp, convert, Flowbotics Studio, Gravity Simulator, MD Solids, NIDEFBDrivers, SSA_1000, West Point Bridge Designer, Windows Movie Maker, Xilinx webpack, Adobe Flash Player, IE6, and Microsoft Excel 2003 through 2012.

These hardware and software tools are used for teaching mechanical engineering design, assembly design, data management, product, and motion simulation, routed systems, finite element analysis, mold design, and enhanced CAD productivity. Expert teachers also guide students to create a virtual representation that can validate the form, fit, function, and environmental impact of the product/assignment before it is ever built. The benefits of using software tools such as Inventor 3D and others is that students are working with real-world technology that enables them to generate engineering and manufacturing documentation from digital prototypes, reduce errors and deliver an actual design aligned to current industry standards.

**Structural Stress Analyzers:** The structural stress analyzer is a tool for measuring stress vs. strain for material test samples, bridge models, and other structures. It is used in the Principles of Engineering PLTW class. Stress analysis is applied as a design step for structures that do not yet exist. Students use the stress analyzer analysis to determine whether their prototype structure will be mechanically sound under a prescribed loading. Students perform their analysis using a combination of analytic mathematical modeling, computational simulation, and experimental testing techniques. Microsoft Excel is used to log their tests and computations.

**VEX Robotic Kits:** We believe that it is far better to teach high school students concepts such as proportions and linear and nonlinear functions by having students learn to program a robotic platform that will cause an autonomous robot to drive, turn and respond to sensor data. The discipline of robotics using engineering principles provides unprecedented opportunities for young children to learn about programming, mechanics, sensors, motors, computational thinking and the digital domain. The VEX Robotics Design System required for use in the Project Lead the Way classrooms are all inclusive robotic kits that introduce students to the world of programing robots.

The VEX Robotics Design System kits come with metals, micro-controllers, various sensors, electric motors and a servo, wheels/ high-traction tires, gears, and structural parts. Students are also taught how to use additional parts of the robotic system such as ultrasonic line tracking, optical shaft encoders, bumper switches, limit switches, light sensors, omni-directional wheels, tank treads, chain and sprocket sets, transmitters and receivers, pneumatics, and a programming kit for easyC, robotC, MPLab.

**Prototyping Machines – 3D Printers:** 3D printing is technology that turns digital files into physical reality. Students in the PLTW classrooms design an object using Inventor Software and send it to a 3D printer and wait for it to appear. 3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The use of additive manufacturing takes virtual designs from the computer aided design (CAD) and transforms them into thin, virtual, horizontal cross-sections and then creates successive layers until the model is complete. 3D printers give the student engineering design students the ability to produce parts and concept models that they can hold in their hands in a matter of a few hours.

A wide variety of other parts such as calipers, micro centrifuge, adapters and electronic circuits are also used in the *Project Lead the Way®* engineering courses. Most schools that currently use PLTW have business and industry partners, parent groups or a State Department of Education that help with the purchases of these large-scale technology tools. Highly qualified teachers working to engage students with technology that meets industry standards in a project-based learning environment, gives students immediate work force skills and makes them highly employable right after high school or ready for advanced engineering courses in college.

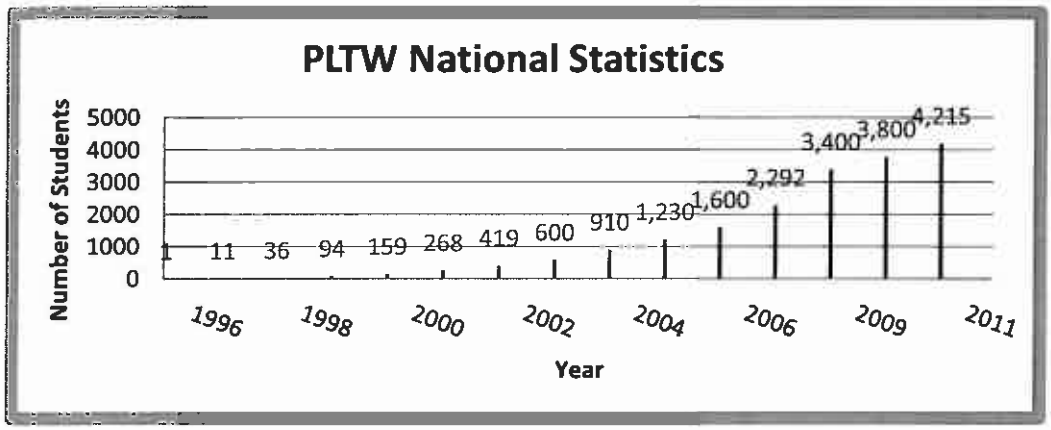



Figure 0

- 400,000+ students across the United States
- 4,200 + school sites, 4,500 + programs
- 50 states & District of Columbia
- 10,500 trained teachers across the country
- 100 Affiliate Universities
- 280 Schools in California
- 32 Schools in the Capital Region Network

## A. Quality of the Project Design

This proposal addresses **Absolute Priority 2 – Promoting STEM Education.**

**A. (1):** *The extent to which the proposed project has a clear set of goals and an explicit strategy*

The eligible applicant for this proposal, LEED – Linking Education and Economic Development a non-profit 501(c)3 currently manages the **Capital Regional Project Lead the Way Network of 60 schools**, a subcommittee of its Board of Directors, in the greater Sacramento region of California. The LEED Board of Directors is the P-20 Council for the region and is comprised of 49 members from business/industry/local government, higher education and K-12 school districts. (See Appendix J) LEED works to strengthen the economy of the greater Sacramento region by linking the leaders of key industries with educational institutions to strive for alignment to meet current and forecasted regional workforce needs. (See www.leed.org)

LEED, as a non-profit 501(c)3 in partnership with a 40 member consortium/network of high schools is an a eligible applicant for this 2012 investing in Innovation Validation grant proposal in that our organization has demonstrated our ongoing ability to drive education reform initiatives by conducting and leading the implementation of the **High School Redesign Strategy** within the Sacramento City Unified School District.

LEED's work as an intermediary with the Bill and Melinda Gates Foundation, Carnegie Foundation of New York and the Sacramento City Unified School District provided the infrastructure for successful transformation of high schools in Sacramento. The Redesign Initiative was born out of grants awarded by Gates and Carnegie Foundations totaling $12 million. LEED was the fiscal agent and grant director for the initiative. This effort known as *Education for the 21st Century (e21,)* extended from 2002 to 2009 and the outcomes clearly show

that LEED as Project Manager in partnership with Sacramento City Unified School District considerably moved the dial in increasing graduation rates, and closing the achievement gap. The initiative created small career-themed high school and pathway programs (Small Learning Communities) that created dynamic change throughout the community and were the catalyst for district wide transformation. (See Appendix C for detailed results)

Now, in our current efforts to help develop robust STEM opportunities for high school youth who will eventually become a workforce pipeline for the greater Sacramento area, LEED has developed a partnership with Project Lead the Way (also a 501(c)3) and a consortium of 40 high schools. In this capacity LEED acts as a Northern California outreach hub for this nationally known STEM education program. In this application, LEED sets forth the following goals and explicit strategy aligned with **Priority #2, Promoting STEM Education.**

**Goal 1:** Provide up to 1600 students with increased access to rigorous and engaging coursework in Science, Technology, Engineering, and Mathematics (STEM), by implementing a 4 year engineering pathway at 40 high schools utilizing *Project Lead the Way®* curriculum.

**Goal 2:** Increase the number of individuals from groups traditionally underrepresented in STEM including minorities and female students, helping them overcome barriers and providing them rigorous and engaging learning experiences in STEM, thus preparing them for postsecondary training and/or college coursework in the STEM fields.

**Goal 3:** Determine through a quasi-experimental research design the impact of Project Lead the Way® discovering to what extent the curriculum improves the academic achievement of student in math and science, influence their choices in math and science , increases their intentions to study STEM subjects at college or university, and increases their intention to pursue STEM-related careers.

The goals and strategy of this project are directly aligned with the research questions in our evaluation. Our strategy for this proposal is to address the one noticeable void in the current Project Lead the Way programs in the greater Sacramento region and nationwide, which is the **lack of research in the form of a quasi-experimental design** to validate the efficacy and effectiveness of PLTW in our schools. With funding from an Investing in Innovation I3 grant, this experimental research will be conducted over a four year period following a cohort of 40 students at 40 different high schools as the students make their way through the engineering pathway that utilizes the *Project Lead the Way®* curriculum. (See Appendix D) The unprecedented product from this research will validate the past, current and future work of the Capital Region Project Lead the Way Network.

**A. (2):** *Potential and Planning for the incorporation of project purposes that benefit the ongoing work of the eligible applicant and any other partner at the end of the grant.*

The potential and planning for the incorporation of this project is a natural fit for LEED because one of our four core programs is facilitating the Capital Region the Project Lead Network of schools. In this capacity, the Director of Educational Innovation at LEED convenes an Executive Committee of business/industry partners along with educational administrators six times a year in ongoing work to engage in fund development and technical support for high schools and middle schools utilizing the *Project Lead the Way®* curriculum in our region.

The PLTW curriculum is founded in the fundamental problem-solving and critical-thinking skills taught in traditional career and technical education (CTE), but at the same time integrates national academic and technical learning standards and STEM principles, creating what U.S. Secretary of Education Arne Duncan calls one of the "great models of the new CTE succeeding all across the country." PLTW was recently cited by the Harvard Graduate School of Education as a "model for 21st century career and technical education." More than 4,200 schools

in all 50 states and the District of Columbia are offering PLTW courses to their students in the 2011-12 school year. In addition, PLTW has trained more than 10,500 teachers to instruct its engaging, rigorous STEM education curriculum.

For clarity purposes, we reiterate that Project Lead the Way is a non-profit organization, that produces a curriculum, also entitled *Project Lead the Way®* (see PLTW.org for more information) The PLTW National non-profit organization not only publishes this on-line curriculum, but it also provides rigorous, intensive professional development for teachers who teach the *Project Lead the Way®* courses - which in this proposal will focus on the **Engineering** strand. The National organization of Project Lead the Way (PLTW) relies on post-secondary partners, state offices of education and other non-profit partners to provide outreach the schools and create fund development opportunities to help schools implement the program. These partners are not "paid" by Project Lead the Way National; rather it is an organic partnership between these entities - all seeking to further STEM opportunities for youth.

Linking Education and Economic Development (LEED) has been the outreach hub in Northern California for Project Lead the Way for the past five years. During that time, LEED has grown the network of schools implementing PLTW from five middle and high schools to now having twenty middle schools, and for the purposes of this proposal - having forty high schools continuing their programs or starting a new PLTW program for the fall of 2012-2013.

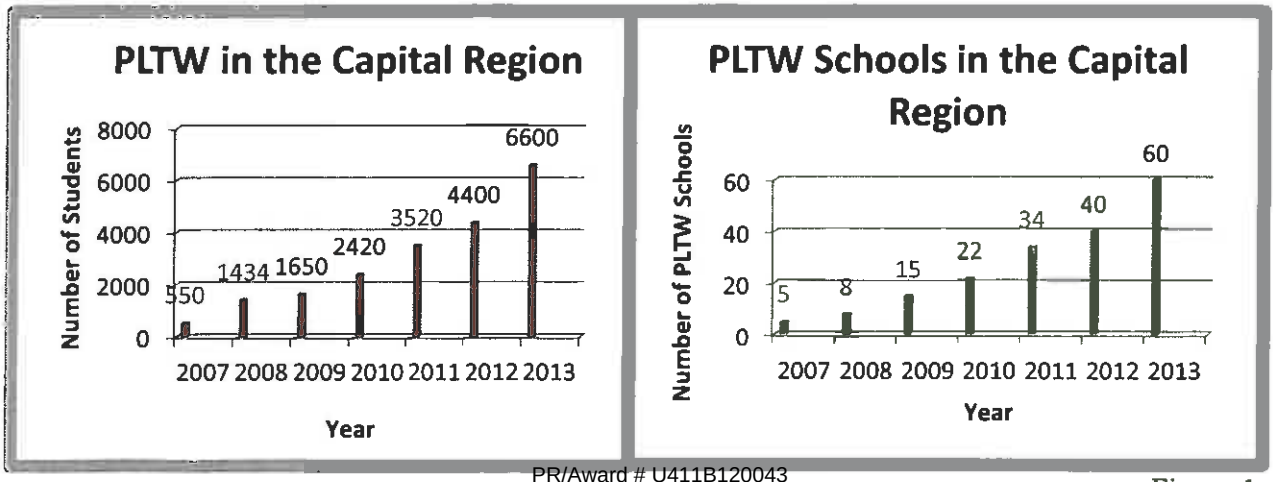



Figure 1

- 6,500+ students across the Capital Region
- 60 + school sites
- 40 High Schools & 20 Middle Schools
- 80 teachers trained or in training across the region
- 8 Counties

LEED's local business and industry partners who join in to support the schools with funding for implementing, training, and sustaining PLTW programs are Chevron, Intel, Sacramento Municipal Utility District, Roebbelen Construction, North State Building and Industry Association, and Gencorp/Aerojet. The collective dollars contributed and/or raised by these partners is $150,000 annually. LEED is the intermediary that these organizations work with to ultimately fund PLTW startup costs at new schools, teacher training/professional development, engineering summer camps focusing on minority and female students and college scholarships for graduating high school seniors who have taken two or more Project Lead the Way courses.

The Capital Region Project Lead the Way (PLTW) Network is the most robust network of PLTW schools in California (other networks are located in San Diego, Los Angeles, and the San Francisco Bay Area). Because of its five year active history with Project Lead the Way, the LEED Board of Directors, its PLTW Executive Committee, participating school districts and business/industry partners are all strongly committed to growing, maintaining and sustaining Project Lead the Way programs in our region. Due to the drastic budget cuts to schools in our state, PLTW is in some cases the **only** way to enhance and grow STEM programs, particularly engineering programs, in our schools today. At the end of the grant, not only will this research impact our region but it will be both a landmark and benchmark study for the National Network of Project Lead the Way schools which are in excess of 4000; none of which having engaged in experimental research evaluation.

**A. (3)(4):** *The extent to which costs are reasonable and estimate of the per pupil costs*

We believe the costs are reasonable in relation to the objectives, design and potential significance of this proposed project: Start-up and operation costs per student /per year (including indirect costs, and research/evaluation costs)

Estimate for our sample size: 1600 students = $635.36

Estimate of the costs to reach: 100,000 students = $63,536,424

Estimate of the costs to reach: 250,000 students = $158,841,060

Estimate of the costs to reach: 500,000 students = $317,682,119

Based on the assumption that **no** school has an existing computer lab that meets the PLTW/Industry standards, start-up costs include 30 new laptops for each school @ $800 per laptop. This is a $960,000 expenditure for the first year only. After year one, schools will receive $5000 a year for computer lab upgrades and maintenance while participating in the research study. Software licensing is an additional cost @ $3000 a year for 125 seats. This is included in the budget and the PLTW Network Coordinator will aim to work with the Studica vendor to bundle the seats for districts with multiple high schools in order to cut down on costs. $150 per student for general PLTW supplies including a Stress Analyzer, VEX Robotic Kits, 3D printers and consumables to supplement the curriculum activities will also be given to each cohort every year of the study.

There is no cost for curriculum as it is all on line and teachers have access 24 hours a day once they are certified to teach Project Lead the Way. Teachers will also receive a $3500 scholarship each year to attend the PLTW summer teacher training to ensure they are highly qualified to instruct the course. While initially seeing a price tag of $635.36 per student per year, it might seem high; however this is about the same cost as powering a cell phone for a year, and

considerably less than funding students for certain athletic programs or other extracurricular activities. We strongly believe that preparing students for engineering and other STEM professions is well worth the investment.

## B. Significance

***B.* (1)**: *The extent to which the proposed project represents an exceptional approach to the priority*

The Project Lead the Way National organization, its curriculum, and the network of 40 high schools in the Capital Region Project Lead the Way Network represent an exceptional approach to the Investing in Innovation's priority #2 – Promoting STEM Education. One of the most integral yet absent parts of STEM (science, technology, engineering and mathematics) education is **Engineering.** What is exceptional about a Project Lead the Way (PLTW) engineering classroom is that it is truly unlike any other. It is a space filled with the latest design software, advanced materials, cutting-edge equipment and buzzing with project-based assignments. Students are applying mathematical and scientific concepts to the programming of robots, the creation of machines that work autonomously and the design of durable modern bridges that can withstand the stress beyond normally prescribed loading capacity. *Project Lead the Way*® curriculum allows students to experience an approach to learning that fuels imaginative thinking, creative problem solving and innovative solutions which are precisely the skills students need to have in order to succeed in college and careers.

The PLTW program is designed to serve high schools students of diverse backgrounds, with an emphasis on offering access to (underrepresented) minority and female students. Project Lead the Way classes are taught during the school day as an elective, but are all approved in California by the California State University and University of California State systems as official college preparatory courses. PLTW addresses the learning needs of students already

interested in STEM-related fields to those who are more inspired by the application of STEM than they are by traditional math and science courses.

The schools in the Capital Region Project Lead the Way Network in Northern California tap into the generous support of LEED and the active involvement of some of America's leading corporations, philanthropic foundations and prestigious colleges and universities. All of these efforts help ensure that PLTW classrooms have the latest technology, material and equipment and that PLTW students are learning the latest information found in such fields and information technology, engineering design architecture and aerospace. All of the Project Lead the Way courses use computer-aided instruction.

**B. (2):** *The extent to which services to be provided by the proposed project reflect up-to-date knowledge from research and effective practice*

In keeping with the US Secretary of Education's desire for grant applicants to submit research evidence that is directly applicable to a proposed project, we searched the What Works Clearinghouse data base for studies to support the efficacy and success of STEM education at the high school level. Surprisingly, for all of the expressed urgency by President Obama and noted economic and education experts throughout America that the United States needs to increase and further develop STEM education, there doesn't seem to be a tremendous amount of research supporting programs that have empirical evidence of success, particularly in engineering, as it pertains to this proposal. Therefore our desire to engage our own quasi-experimental research to determine the merits of *Project Lead the Way®* is highly warranted.

This proposal presents a plan to fund a 4 year high school engineering pathway at 40 different high schools that will allow 40 students in a cohort at each school to engage in the foundation courses of *Project Lead the Way®*. Students will take one course as an elective each year of high school. Their results in science and mathematics will be compared to students not in

the engineering pathway, and it will also be determined if *Project Lead the Way®* influences students' choices on post-secondary training and/or college majors. Because of the engineering focus, all of the courses are heavily reliant upon computer-aided instruction, and the curriculum is turn-key for teachers.

Over the last ten years, numerous academic institutions have released reports highlighting *Project Lead the Way's®* success in engaging the hearts and minds of students through STEM education. Among other things, the reports find that PLTW students are outperforming their peers in school and that they are more focused on attending college than non-PLTW students. The studies are all unique in how they were conducted – some of them cover PLTW programs in certain regions, some in specific school districts, while others take a look at how PLTW alumni are performing in college. Every report is different, yet the results say the same thing: PLTW is igniting the imagination and innovation of students through learning.

A group study in 16 states that compared PLTW student results on the 2008 *High Schools That Work* Assessment test with the results of students in other pre-engineering programs and Career Technical Education (CTE) programs found that significantly more PLTW students met the readiness goals on the 2008 *High Schools That Work (HSTW)* Assessment tests in reading, mathematics and science compared with *HSTW* students in similar career/technical fields and *HSTW* students in all career/technical fields. (Southern Region Educational Board, 2009)

A University of Wisconsin report on a control group study that evaluated the impact of PLTW on largely Latino-populated middle schools in Wisconsin finds that all of the PLTW students in this study begin middle school at lower proficiency in math, reading and science and with lower attendance rates than the control group of non-PLTW students. The study shows that by 8th grade, those gaps had been eliminated. (University of Wisconsin, Milwaukee 2009)

A three-year study of PLTW high schools in Wisconsin published in the *University of Wisconsin-Madison Center on Education and Work Report – June 2009,* found that both academic achievement and student engagement are enhanced through PLTW. Students raise mathematics achievement and increase school attendance while participating in a PLTW elective course. PLTW seniors were significantly more likely to achieve both a higher ACT composite score and higher ACT math and science scores. Seniors who completed PLTW courses at two urban high schools attended school an average of eight more days during their senior year when compared to non-PLTW seniors.

A three-year analysis of Galt High School, a member of the Capital Region Project Lead the Way Network in the greater Sacramento Area, shows that PLTW student progress compared to non-PLTW students, including the Latino student population, founds that Project Lead the Way has been an effective program during 2004-07. During three years, there was a significant narrowing of the achievement gap for Hispanic/Latino students in all four core areas. "For the third year in a row, students participating in PLTW scored higher than non-PLTW students at Galt High School in all five subject areas on the 2006 California Standards Tests (CSTs): English Language Arts, Mathematics, Science, History/Social Science, and Life Science. For the third year in a row, Hispanic/Latino students in PLTW scored higher than other Hispanic/Latino students at Galt High and higher than the total student scores for all students in all five subject areas of the 2006 *California Standardized Tests.* (Crane, 2007)

A study of more than 7,500 high school students in the Minneapolis Public School district found that in Minneapolis, PLTW CTE students outperformed non-CTE students on *Minnesota Basic Skills Tests* in reading, math and writing. PLTW students had stronger

attendance than non-CTE students. PLTW students had stronger graduation rates than non-CTE students. PLTW underserved students outperformed non-CTE students. (Minneapolis PS, 2009)

PLTW's Programs Are Inclusive, Reaching a Diverse Group of Students. A 2009 national demographic analysis of PLTW students found that PLTW programs are distributed across the entire economic spectrum including the least affluent schools; it is still the mission of Project Lead the Way National to have completely proportional representation from all ethnic groups and non-traditional genders. PLTW High School Graduates Are College and Career Ready according to a 2009 survey of PLTW seniors at the end of their senior year found that 92% intend to pursue a four-year degree or higher, 51% intend to pursue a graduate degree, and 70% intend to study engineering, technology, or computer science. By comparison, 67% of all beginning postsecondary students intended to pursue a bachelor's degree or higher as reported by the National Center for Education Statistics. (NCES, 2009)

These results are consistent with results and conclusions of additional survey for the past two years conducted by *True Outcomes*. 90% of PLTW students who were surveyed at the end of their senior year said they had a clear and confident sense of the types of college majors and jobs they intended to pursue. Those students also said that their PLTW experiences were very significant in developing this self-knowledge and their PLTW experiences significantly increased their ability to succeed in postsecondary education. (Cengage Learning, 2009)

A national analysis of 200 college transcripts of PLTW students found that college transcripts of PLTW students who graduated in 2007 or 2008 showed 31% of PLTW students study engineering and engineering technology in their first year of college compared with 8% of all first-time freshmen in baccalaureate institutions or 5% of all postsecondary students. PLTW

students are four times more likely to study engineering or engineering technology in college compared to first-time freshmen at four-year institutions. (Cengage Learning, 2009)

A report released by Milwaukee School of Engineering, one of the leading undergraduate engineering programs in the country found that the average freshman GPA total for Milwaukee School of Engineering in 2007 was 2.85; the average GPA for PLTW freshmen students in 2007 was 3.03. In 2006-2007, first-year retention (freshmen to sophomore) was 76% (76% stayed with their declared major). 100% of Milwaukee Schools of Engineering's PLTW students remained in their declared major. (Milwaukee School of Engineering, 2008)

While all of these findings are compelling, and report evidence gathered by acquiring test scores and survey responses, **none have been conducted/validated using a quasi-experimental research design.** The research problem in our study addresses six questions:

Research Question 1: To what extent does the four-year PLTW experience improve the academic achievement of students in math and science?

Research Question 2: To what extent does the four-year PLTW experience help close the achievement gap for minority and female students?

Research question 3: To what extent does the four-year PLTW experience increase the intentions of students to study STEM subjects at a college or university?

Research Question 4: To what extent does the four year PLTW experience increase the intentions of student to pursue a STEM-related career?

Research Question 5: To what extent does the four-year PLTW experience implemented by treatment schools align with the program model?

Research Question 6: How does the four-year PLTW experience differ from that of students in the same school who are not participating in the four-year PLTW experience?

The evidence gathered in this quasi-experimental research project will determine if PLTW substantially and measurably improves student achievement in math and science, closes achievement gaps for minority and female students in math and science, decreases dropout rates, increases high school graduation rates and whether or not it increases college enrollment and career choices in the STEM fields.

**B. (3):** *The importance and magnitudes of the effect expected to be obtained by the research-based evidence provided by the eligible applicant.*

Research conducted by Barrow, Markman & Rouse (2009) utilized a randomized study of a well-defined use of computers in schools and a popular instructional computer program for pre-algebra and algebra. Students were randomly assigned to computer-aided instruction and their academic results were compared to a control group receiving traditional algebra instruction. This study (see Appendix D for full study) has been chosen to reflect up-to-date knowledge from research and effective practice because of the similar nature and design to our proposed evaluation. The review of the literature by Barrow et al, yields mixed evidence of the impact of investing in computer technology and its input in the education production function. The population studied in the Barrow et al research experiment includes three US urban schools districts using a turn-key, popular instructional computer program, *I Can Learn*©, designed to improve mathematical skills. Our population comes from both urban and suburban public schools, and public charter schools (see figure 2) and while our number of schools and districts involved is much higher, our student *n* is approximately half the amount in the Barrow et al study.

Collaborating High Schools

| High School | Total Enroll 9-12 | ELL | Title I | Amer.-Indian | Asian | Pac. Island. | Filip. | Hisp. | Blk. / Afr. Amer. | White |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Inspire School of Arts&Sciences | 272 | 0.4% | 22.4% | 1.8% | 2.2% | 0.0% | 0.7% | 8.8% | 4.8% | 80.5% |
| 2. Del Oro High School | 1,696 | 0.3% | 13.3% | 1.1% | 1.4% | 0.1% | 0.1% | 9.0% | 0.4% | 80.5% |
| 3. Placer High School | 1,368 | 3.6% | 28.7% | 1.2% | 1.5% | 0.1% | 0.6% | 14.8% | 0.7% | 75.7% |
| 4. Colfax High School | 855 | 0.4% | 20.9% | 0.9% | 0.5% | 0.2% | 0.0% | 7.4% | 0.2% | 88.1% |
| 5. Forest Hill High School | 267 | 0.0% | 38.2% | 2.2% | 0.0% | 0.4% | 0.7% | 12.4% | 1.1% | 82.0% |
| 6. Madiu High School | 122 | 0.0% | 13.9% | 2.5% | 0.8% | 0.0% | 0.0% | 11.5% | 2.5% | 81.1% |
| 7. Adelante High School | 174 | 6.9% | 63.2% | 1.7% | 2.9% | 0.6% | 1.7% | 35.6% | 2.9% | 52.9% |
| 8. Antelope High School | 1,763 | 3.9% | 40.9% | 0.3% | 9.8% | 0.9% | 2.8% | 17.1% | 10.6% | 52.6% |
| 9. Granite Bay High School | 2,173 | 0.3% | 4.1% | 0.8% | 7.3% | 0.2% | 1.3% | 8.0% | 0.7% | 74.2% |
| 10. Oakmont High School | 1,570 | 2.4% | 26.4% | 1.0% | 5.9% | 0.4% | 2.4% | 15.6% | 3.8% | 66.8% |
| 11. Roseville High School | 2,035 | 7.3% | 30.7% | 0.7% | 6.1% | 0.4% | 2.8% | 24.8% | 3.7% | 57.7% |
| 12. Woodcreek High School | 2,116 | 1.7% | 16.9% | 0.5% | 4.2% | 0.4% | 2.2% | 14.3% | 2.3% | 69.3% |
| 13.Woodcreek High School | 2,116 | 1.7% | 16.9% | 0.5% | 4.2% | 0.4% | 2.2% | 14.3% | 2.3% | 69.3% |
| 14. Lincoln High School | 1,514 | 0.0% | 36.4% | 0.6% | 2.8% | 0.6% | 2.4% | 24.8% | 2.0% | 65.1% |
| 15.Folsom High School | 1,857 | 2.2% | 8.9% | 0.6% | 13.8% | 0.5% | 2.3% | 9.6% | 2.7% | 69.3% |
| 16.Vista Del Lago High School | 1,429 | 0.8% | 5.0% | 0.8% | 9.9% | 0.3% | 1.3% | 8.5% | 1.9% | 75.8% |
| 17.Folsom Lake High School | 108 | 3.7% | 11.1% | 0.0% | 1.9% | 0.0% | 0.9% | 24.1% | 5.6% | 63.0% |
| 18.Cordova High School | 1,845 | 13.3 % | 48.5% | 0.8% | 6.8% | 1.4% | 3.8% | 23.4% | 15.9% | 47.2% |
| 19.Kinney High School | 165 | 14.5 % | 41.2% | 0.0% | 2.4% | 1.2% | 2.4% | 38.2% | 21.2% | 29.1% |
| 20. Galt High School | 1,194 | 8.3% | 51.8% | 0.8% | 1.9% | 0.8% | 0.7% | 49.0% | 1.3% | 43.6% |
| 21.Community Collaborative Charter School | 873 | 32.0 % | 69.1% | 3.3% | 2.9% | 0.3% | 0.7% | 23.4% | 9.0% | 58.3% |
| 22. Futures High School | 306 | 33.0 % | 79.7% | 0.0% | 0.3% | 0.0% | 0.0% | 0.3% | 0.0% | 99.3% |
| 23.Sacramento Academic&Vocational Academy | 745 | 8.1% | 44.6% | 2.1% | 10.7% | 0.8% | 1.1% | 47.4% | 16.6% | 20.0% |
| 24.Center High School | 1,351 | 4.7% | 45.7% | 0.8% | 8.7% | 1.6% | 4.2% | 18.0% | 14.3% | 51.3% |
| 25. Foothill High School | 1,318 | 12.9 % | 68.0% | 1.9% | 6.2% | 1.2% | 1.8% | 28.8% | 21.7% | 35.3% |
| 26. Highlands High School | 1,100 | 13.0 % | 59.0% | 0.5% | 5.5% | 0.8% | 1.4% | 33.2% | 16.9% | 36.9% |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **27. Rio Linda High School** | 1,928 | 13.1 % | 65.2% | 0.8% | 13.1% | 1.3% | 1.5% | 32.2% | 8.4% | 39.8% |
| **28.Grant Union High School** | 2,062 | 24.8 % | 87.0% | 0.6% | 25.5% | 4.0% | 0.7% | 35.3% | 25.3% | 7.2% |
| **29.Pacific High School** | 131 | 6.1% | 64.1% | 2.3% | 1.5% | 2.3% | 2.3% | 20.6% | 35.1% | 22.1% |
| **30.Vista Nueva High School** | 123 | 35.0 % | 61.0% | 0.0% | 10.6% | 6.5% | 0.0% | 28.5% | 37.4% | 10.6% |
| **31. Keema High School** | 703 | 12.9 % | 55.2% | 0.4% | 4.8% | 1.0% | 0.8% | 32.9% | 15.7% | 36.5% |
| **32. Heritage Peak Charter School** | 1,037 | 0.0% | 61.9% | 0.2% | 2.3% | 0.4% | 1.1% | 18.9% | 7.0% | 21.4% |
| **33. Lodi High School** | 2,063 | 0.0% | 41.3% | 0.6% | 2.8% | 0.3% | 1.6% | 35.5% | 1.0% | 57.5% |
| **34. Bear Creek High School** | 1,987 | 0.0% | 52.1% | 0.7% | 23.5% | 1.3% | 10.1% | 27.9% | 16.6% | 19.5% |
| **35. Rio Valley Charter** | 155 | 0.0% | 0.0% | 0.0% | 1.0% | 0.5% | 0.0% | 47.6% | 0.5% | 6.3% |
| **36. Albert Powell High School** | 211 | 9.5% | 61.6% | 1.9% | 2.4% | 0.9% | 0.0% | 42.7% | 5.2% | 44.1% |
| **37. Yolo High School** | 134 | 12.7 % | 69.4% | 1.4% | 3.0% | 0.7% | 0.0% | 47.8% | 9.0% | 29.9% |
| **38. River City High School** | 1,884 | 9.8% | 65.4% | 1.3% | 11.2% | 0.8% | 3.0% | 39.0% | 7.6% | 36.4% |
| **39. River Valley High School** | 1,751 | 8.2% | 51.2% | 0.9% | 24.7% | 0.9% | 1.3% | 27.8% | 2.8% | 35.8% |
| **40. Yuba City High School** | 1,683 | 10.2 % | 52.7% | 0.9% | 15.2% | 0.2% | 0.7% | 40.8% | 1.5% | 36.5% |

Figure 2

Based on the population and demographics of our collaborating high schools, we anticipate that up to 50% of the students who randomly select into the Project Lead the Way Pathway will be minority students, and approximately 30% will be female.

Barrow, Markman, and Rouse, (2009) research questions and hypothesis are also similar to our proposed study in that they test for an average effect of instruction enhanced by the use of technology, and attempt to understand why a turn-key curriculum like *I Can Learn*© and computer-aided instruction might improve achievement. They also look for evidence consistent with some of the common hypotheses such as will instructional time, individualized instruction with the computer, attendance and academic achievement all be effected by students using the stated curriculum. In gathering data and results for academic outcomes, they assess the impact of I Can Learn and computer-aided instruction using test instruments which is identical to our

proposed research. Barrow et al used both a test closely aligned to reflect the curriculum taught, as well as the norm-referenced statewide test administered to all students on a yearly basis.

The 2009 study by Barrow et al had to take into consideration the motivation of teachers. Our experiment will differ in that area because all of the teachers in our study will have had the intensive "boot camp" training before teaching their assigned PLTW course. Their level of expertise is extremely high and because it is an elective course, teachers are usually very motivated when teaching *Project Lead the Way®*. The empirical findings by Barrow et al revealed that the *I Can Learn©* curriculum with computer-aided instruction is highly individualized and students can move at their own pace (very similar to many aspects of PLTW) thus teachers can offer more individual instruction to students who could benefit from increased attention from the teacher.

In their final finding report, Barrow, Markman & Rouse conclude that computer-aided instruction has the potential to significantly enhance student mathematics achievement in high school and that the gains are comparable to those achieved with class size reduction ant that the costs are likely somewhat lower that the cost of reducing the average class size for all algebra classes. They also suggest that computer aided instruction also deserves additional rigorous evaluation and policy attention since it may be much easier for schools and districts to implement technology enhance education over other interventions.

Barrow et al. also point out that the gains in math scores from computerized instruction do not come free. In their study, (2009) the 30 seat computer labs cost $100,000 each, with additional $150,000 for the course work software, and $17,000 for teacher training, support and maintenance of the lab. This scenario regarding technology mirrors the Project Lead the Way classroom. In order to obtain academic achievement that can reach students both an individual

level and as a whole, the technology must be up-to-date, and in the case of PLTW should meet industry standards. In order to conduct the quasi-experimental model in this proposal, the applicant is budgeting up to $50,000 per school for a computer lab and for maintaining an "engineering shop" on site that would be the classroom wherein students can build prototypes and work with robotics and large circuit boards. As Barrow et al. point out, all of the expenditures are necessary when using computer-aided instruction, without adequate supplies to carry out the curriculum, PLTW courses would not be able truly address skills needed for engineering fields.

All findings and evidence from our quasi-experimental study of *Project Lead the Way®* will be researched – based and support our project goals and research questions. And, notably, our research will have a significant magnitude effect by providing benchmarks for all of the ~ 4000 schools across the nation that currently utilize *Project Lead the Way®.*

## C. Quality of the Management Plan

**C. (1):** *Clearly defined responsibilities, timelines, and milestones for accomplishing the project*

**5 Year Project Management Plan**

| Time Period | Major Activities and Milestones Year 1 | Person(s) Responsible |
|---|---|---|
| January thru February - 2013 | • Hold Program Launch Meeting with LEED/ P-20 Council and all other stakeholders<br>• Confirm match funding support<br>• Collect signed MOUs from partnering school districts | • LEED P-20 Council<br>• Project Director<br>• LEED, CEO<br>• Gargani + Co.<br>• PLTW Network Superintendents<br>• High school principals<br>• Project Coordinator |
| March thru May - 2013 | • Hold Teacher and Parent Informational Meetings at all collaborating school districts with evaluator to explain grant expectations<br>• Collect Initial Data for Evaluation<br>• P-20 Council meeting | • Project Director<br>• Project Coordinator<br>• PLTW Teachers -District level administrators and school site principals |

| | | |
|---|---|---|
| | • Capital Region Project Lead the Way Executive Committee Meeting | • Gargani + Co<br>• LEED Board of Directors<br>• LEED – CEO<br>• Capital Region PLTW Executive Committee |
| June thru August - 2013 | • All PLTW Teachers attend sanctioned intensive summer "boot camp" training or refresh training for year one of pathway – Intro to Engineering Design<br>• PLTW Executive Committee meeting<br>• Analyze Data | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW National Training Centers<br>• PLTW Ex. Comm. members |
| September thru December - 2013 | • Study Cohort of Project Lead the Way Pathway students begin Intro to Engineering Design at their respective collaborating high schools<br>• P-20 council meeting (2)<br>• PLTW Executive Committee meeting<br>• Capital Region PLTW Counselors Conference/mid-year check in on data gathering and student progress | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW Ex. Comm. members<br>• Gargani + Co |
| **Time Period** | **Major Activities and Milestones Year 2** | **Person(s) Responsible** |
| January thru May - 2014 | • P-20 Council meeting (2)<br>• PLTW Executive Committee meeting<br>• Ongoing collection of year-one data from PLTW schools and school districts | • LEED P-20 Council<br>• Project Director<br>• Project Coordinator<br>• Gargani + Co |
| June thru August - 2014 | • All PLTW Study Cohort Teachers attend sanctioned intensive summer "boot camp" training or refresh training for year one of pathway – Principles of Engineering<br>• PLTW Executive Committee meeting<br>• Analyze data/Check for corrections | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW National Training Centers<br>• PLTW Ex. Comm. members<br>• Gargani + Co |
| September thru December - 2014 | • Study Cohort of Project Lead the Way Pathway students begin Principles of Engineering at their respective collaborating high schools<br>• P-20 council meeting (2)<br>• PLTW Executive Committee meeting<br>• Capital Region PLTW Counselors | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW Ex. Comm. members<br>• Gargani + Co |

| | | |
|---|---|---|
| | Conference/mid-year check in on data gathering and student progress<br>• Analyze and record data | |
| **Time Period** | **Major Activities and Milestones Year 3** | **Person(s) Responsible** |
| January thru May - 2015 | • P-20 Council meeting (2)<br>• PLTW Executive Committee meeting<br>• Ongoing collection of year-two data from schools and school districts | • LEED P-20 Council<br>• Project Director<br>• Project Coordinator<br>• Gargani + Co |
| June thru August - 2015 | • All PLTW Study Cohort Teachers attend sanctioned intensive summer "boot camp" training or refresh training for year one of pathway – Digital Electronics<br>• PLTW Executive Committee meeting<br>• Analyze Data | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW National Training Centers<br>• PLTW Ex. Comm. members<br>• Gargani + Co |
| September thru December - 2015 | • Study Cohort of Project Lead the Way Pathway students begin Digital Electronics at their respective collaborating high schools<br>• P-20 council meeting (2)<br>• PLTW Executive Committee meeting<br>• Capital Region PLTW Counselors Conference/mid-year check in on data gathering and student progress<br>• Analyze and record data | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW Ex. Comm. members<br>• Gargani + Co |
| **Time Period** | **Major Activities and Milestones Year 4** | **Person(s) Responsible** |
| January thru May - 2016 | • P-20 Council meeting (2)<br>• PLTW Executive Committee meeting<br>• Ongoing collection of year-three data from schools and school districts | • LEED P-20 Council<br>• Project Director<br>• Project Coordinator<br>• Gargani + Co |
| June thru August - 2016 | • All PLTW Study Cohort Teachers attend sanctioned intensive summer "boot camp" training or refresh training for year one of pathway – Engineering Design & Development<br>• PLTW Executive Committee meeting | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW National Training Centers<br>• PLTW Ex. Comm. members |

| | | |
|---|---|---|
| | • Analyze Data | • Gargani + Co |
| September thru December - 2016 | • Study Cohort of Project Lead the Way Pathway students begin Intro to Engineering Design & Development at their respective collaborating high schools<br>• P-20 council meeting (2)<br>• PLTW Executive Committee meeting<br>• Capital Region PLTW Counselors Conference/mid-year check in on data gathering and student progress | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW Ex. Comm. members<br>• Gargani + Co |
| **Time Period** | **Major Activities and Milestones Year 5** | **Person(s) Responsible** |
| January thru May - 2017 | • P-20 Council meeting (2)<br>• PLTW Executive Committee meeting<br>• Collect all year-four data from schools and school districts | • LEED P-20 Council<br>• Project Director<br>• Project Coordinator<br>• Gargani + Co |
| June thru August 2017 | • In depth analysis and recording of data from entire quasi-experimental study<br>• PLTW Executive Committee meeting<br>• Report preliminary finding to LEED Board/P-20 Council | • Project Director<br>• Project Coordinator<br>• PLTW Ex. Comm. members<br>• LEED P-20 Council |
| September thru December - 2017 | • P-20 council meeting (2)<br>• PLTW Executive Committee meeting<br>• Large – Scale publication and dissemination of research findings in partnership with Project Lead the Way National | • Project Director<br>• Project Coordinator<br>• PLTW Teachers<br>• PLTW Ex. Comm. members<br>• Gargani + Co<br>• PLTW National |

**C. (2):** *The qualifications, including relevant training and experience, of the project director and key project personnel, especially in managing complex and rapidly growing projects.*

**David Butler, Chief Executive Officer of LEED** since November, 2006. As CEO, Butler is responsible for all operational functions of the organization, including financial and operational management, board relations, and external affairs. During his tenure, Butler has led a strategic expansion of LEED's board of directors, which now includes over 20 K-12, high

school and county superintendents, who along with representatives of are colleges and universities and key employers, have formed the Capital Area P-20 Council. Prior to joining LEED, Butler was Sr. Vice President for Public Policy and Economic Development for six years with the Sacramento Metro Chamber, the largest chamber of commerce in Northern California. Mr. Butler will manage the LEED Board/P-20 Council and its oversight for the grant operations.

**Linda Christopher, LEED's Director of Educational Innovation,** will serve as Project Director. Christopher holds an M.A. in Education Administration and a B.S in Education. She is a skilled administrator with twenty-seven years of teaching, teacher-leading and administrative work. Ms. Christopher is also currently a doctoral candidate in Education Leadership and Policy with Drexel University. She has done extensive research on Multi-Cultural Education and previously held positions as Grant Coordinator for Community College Apprenticeship, Tech Prep, Visual Arts & New Media, and Teaching American History. Ms. Christopher has facilitated and managed the Capital Region Project Lead the Way Network of schools since 2009. She has recruited new schools and tripled the network in the past three years.

She was also the Chairman of the 1st annual California statewide Project Lead the Way Conference in 2012, bringing together over 250 Project Lead the Way teachers and administrators throughout the state, which also included coordinating a legislative visits with numerous state assembly members and senators to allow the CEO of PLTW National and other PLTW business/industry partners to create a stronger awareness for PLTW at the state capitol. Ms. Christopher also coordinates school partnerships for CareerGPS, an annual large-scale complex career exploration event put on by LEED, and has successfully worked with 61 school districts in the region (total = 6500 students) bringing them all together for CareerGPS at the California State Fairgrounds. For the purposes of this proposal, she will coordinate all

communication and organization for professional growth events, coordinate the fiscal records with the financial director at LEED, update technology, assist with data collection, and report quarterly on progress to the P-20 Council and the Capital Region PLTW Executive Committee. Ms. Christopher will submit all reports to the US Dept. of Education related to this proposal and will also act as the direct supervisor to the PLTW Network Coordinator.

**PLTW Network Coordinator** will be hired upon award, and will report directly to the Director of Educational Innovation at LEED. The grant coordinator's position will be half time and he/she will be directly involved with the collaborating PLTW teachers and school principals. Chief responsibilities include coordinating all purchasing and replenishment of supplies for the PLTW classrooms including technology – hardware and software and related items to meet the requirements of the Project Lead the Way curriculum each year of the grant. The general responsibilities and focus of this position will be to maintain the calendar of grant activity, and assist the grant director in maintaining, updating and/or compiling all granting resource data, documents, reports and materials. The grant coordinator will also work with PLTW teachers to register for the appropriate summer training, procure current student data for the statistician and ensure that all information is accurately presented. In this capacity he/she will acts as liaison to the Capital Region PLTW Network of schools on behalf of LEED and the grant research.

To perform the outlined duties and responsibilities successfully, the person in this position should demonstrate the following competencies:

- Speaks clearly and effectively in positive or negative situations
- Writes clearly and informatively and varies writing style to meet specific needs.
- Demonstrates respect and sensitivity for cultural differences
- Demonstrates ability to effectively balance task-oriented and process-oriented duties
- Demonstrates the ability to work effectively as a member of a team
- Demonstrates strong organizational and time management skills for complex issues

- Undergraduate degree and 2-3 years minimum experience working for nonprofit preferred Familiarity with Microsoft Word and Excel
- Ability to lift 50 pounds.
- Ability to sit for extended periods of time.
- Ability to drive a car throughout the Sacramento region (up to 100 miles in a day)

**Dr. John Gargani – Gargani + Co.** will direct the evaluation. John Gargani, President of Gargani + Company, comes to this project with 20 years of experience in evaluation. He has directed large-scale, multi-year, multi-site randomized trials of educational interventions, including teacher professional development programs and new reading curricula. He has developed student assessments of content knowledge in science, math, and history; a wide array of surveys for students, teachers, and professionals; and classroom observation systems for scoring the quality of classroom instruction. He holds a Ph.D. in Education from UC Berkeley, an MS in Statistics from New York University, and an MBA from the University of Pennsylvania's Wharton School of Business.

Dr. Gargani will be responsible for developing, refining, and validation measurement instruments; designing and implementing the randomized design; collecting data from the field; analyzing data using appropriate, advanced statistical methods; and reporting results internally for program improvement, externally for reporting purposes, and in academic and practitioner venues for dissemination. Dr. John Gargani will be supported by staff (TBD) as needed.

**C. (3)(4):** *Applicant's capacity to bring the proposed project to scale on a regional, state or national level*

**The LEED Board of Directors which is also acts as the P-20 Council for the region,** is volunteer leadership made up of CEO level administrators from major corporations with headquarters or large scale operations in the capital region of Sacramento, California. K-12 and High School District superintendents in the region also have an open invitation to join the P-20

Council with LEED; there are currently 23 school district superintendents participating either on the P-20 Council or the Project Lead the Way Executive Committee. Post-secondary partners include UC Davis, California State University Sacramento, Los Rios Community College District (4 community colleges) and the Yuba Community College District (2 colleges). Private post-secondary partners include the University of Phoenix, Drexel University, and William Jessup University. (See Appendix A for list of P-20 Council Members) As the P-20 Council for the greater Sacramento region, and utilizing current and new fund development opportunities, fostering current and new relationships with local and state legislators and the California State Department of Education, the LEED Board of Directors and its subcommittee, the Capital Region Project Lead the Way Network is committed to bring the proposed project to scale on a regional level, state level, and national level in collaboration with Project Lead the Way National Headquarters in Indianapolis, Indiana.

## D. Quality of Project Evaluation

**D. (1)** *The extent to which the methods of evaluation will include a well-designed experimental study or a well-designed quasi-experimental study*

The independent, external evaluator—Gargani + Company (GCO)—will conduct a randomized trial to estimate the impact of Project Lead the Way (PLTW). Approximately 40 students per school will be randomly assigned to treatment and control conditions within 40 schools, which will act as blocking variables. Each school will operate a four-year PLTW engineering program for one cohort of students as the cohort progresses from grade 9 through grade 12. The evaluation will allow us to understand how rigorous PLTW engineering classes, presented in an articulated fashion over all four years of high-school, impact student achievement; help close the achievement gap for minority and female students; encourage the selection and completion of more rigorous math and science classes; and strengthen STEM-

related college and career intentions. Specifically, the evaluation will address five impact research questions and two implementation research questions.

**Impact Questions**

Research Question 1: To what extent does the four-year PLTW experience improve the academic achievement of students in math and science? (Primary research question)

Research Question 2: To what extent does the four-year PLTW experience help close the achievement gap for minority and female students?

Research Question 3: To what extent does the four-year PLTW experience influence students to take more challenging courses in math and science?

Research Question 4: To what extent does the four-year PLTW experience increase the intentions of students to study STEM subjects at a college or university?

Research Question 5: To what extent does the four-year PLTW experience increase the intentions of students to pursue a STEM-related career?

**Implementation Questions**

Research Question 6: To what extent does the four-year PLTW experience align with the program model?

Research Question 7: How does the four-year PLTW experience differ from that of students in the same school who are not participating in the four-year PLTW experience?

**Figure 3: Research questions, variables and measures, data sources, and analysis**

| Research Question | Variable/Measure | Source | Analysis |
|---|---|---|---|
| Research Question 1: To what extent does the four-year PLTW experience improve the academic achievement | PLTW Content Tests | PLTW | Impact: Treatment and control groups compared |
| | California Standards Test in Math (CST-Math) | School Records | Impact: Treatment and control groups compared |

| Research Question | Variable/Measure | Source | Analysis |
|---|---|---|---|
| of students in math and science? (Primary research question) | California Standards Test in Science (CST-Science) | School Records | Impact: Treatment and control groups compared |
| Research Question 2: To what extent does the four-year PLTW experience help close the achievement gap for minority and female students? | PLTW Content Tests | PLTW | Impact: Treatment and control groups compared (interaction effect) |
| | California Standards Test in Math (CST-Math) | School Records | Impact: Treatment and control groups compared (interaction effect) |
| | California Standards Test in Science (CST-Science) | School Records | Impact: Treatment and control groups compared (interaction effect) |
| Research Question 3: To what extent does the four-year PLTW experience influence students to take more challenging courses in math and science? | Science and math courses taken | School Records | Impact: Treatment and control groups compared |
| | Science and math courses passed | School Records | Impact: Treatment and control groups compared |
| Research Question 4: To what extent does the four-year PLTW experience increase the intentions of students to study STEM subjects at a college or university | Intention to study STEM in college | Student Survey | Impact: Treatment and control groups compared |
| Research Question 5: To what extent does the four-year PLTW experience increase the intentions of students to pursue a STEM-related career? | Intention of work in STEM | Student Survey | Impact: Treatment and control groups compared |
| Research Question 6: To what extent does the four-year PLTW experience align with the program model? | Course components taught | Teacher Log | Descriptive: Treatment teachers' activities compared to standard |
| | PLTW instructional time | Teacher Log | Descriptive: Treatment teachers' activities compared to standard |
| | Quality of classroom instruction | Teacher Videos | Descriptive: Treatment teachers' activities compared to the PLTW standard |

| Research Question | Variable/Measure | Source | Analysis |
|---|---|---|---|
| Research Question7: How does the four-year PLTW experience differ from that of students in the same school who are not participating in the four-year PLTW experience? | Science and math courses taken | School Records | Descriptive: Treatment and control groups compared |
| | Science and math courses passed | School Records | Descriptive: Treatment and control groups compared |
| | Total time in science and math (including out of school time) | Student Survey and School Records | Descriptive: Treatment and control groups compared |

**Data Collection and Measures**

The data for the analyses will come from five sources—PLTW (content test), school records (California Standards Tests in Math and Science; courses taken and passed), a student survey (intentions; time in science and math), teaching logs (course content; instructional time), and video of instruction.

The PLTW content test will cover the domains of math and science, dividing each into three sub-domains—PLTW content for the current year also taught in other classes (what we call *intersection*), PLTW content for the current year NOT taught in other classes (*PLTW-only*), and California standards taught in other classes but not in PLTW (*standards-only*). We expect to find impacts on the PLTW-only and intersection sub-domains. We are curious if the impact of the program carries over to subject matter that is not directly addressed in PLTW, that is the standards-only sub-domain.

School records will be provided by school staff. This staff time will be paid for through the grant. The student survey and teaching logs will be based on instruments developed previously by GCO and PLTW. The teacher videos used to document the fidelity of PLTW instructional practices will be collected and scored using a system previously developed by

GCO. This system allows for inexpensive video capture and derives a score from the ratings of two independent judges. It other settings, it has yielded high levels of rater agreement (ICC measures of 0.90 or higher) and produced scores that, in experimental designs, were sufficiently reliable to reveal small program impacts.

In year 1 of the study, we will develop and pilot test our instruments, finalize institutional arrangements, and prepare for the selection and assignment of 9th grade participants entering high school the following year. In year 2, we will recruit 9th grade students, administer a basic math and science test to determine if student applicants meet minimum qualifications, and randomly assign qualified students to conditions. In years 2 – 5, we will collect all student and teacher data, and conduct interim analysis each year.

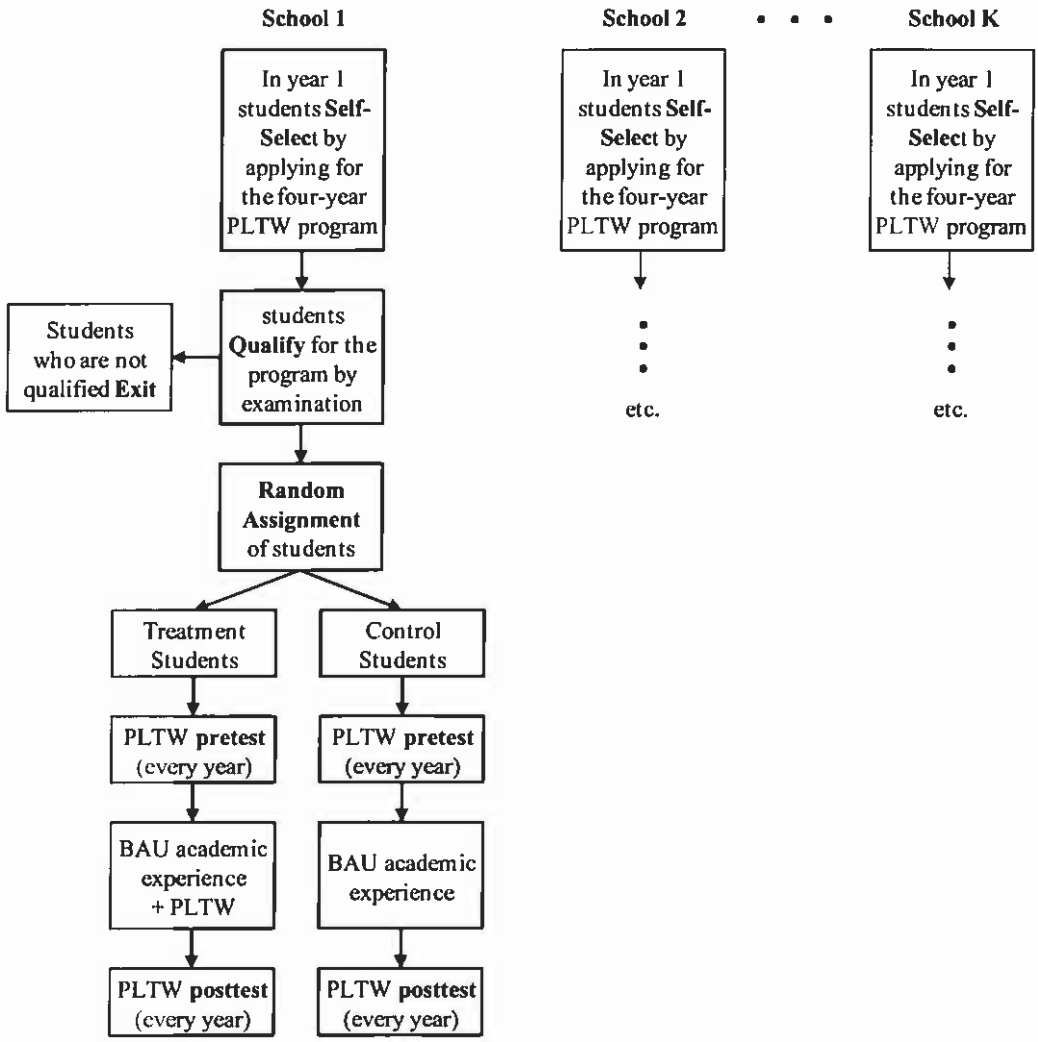
**Sampling, Selection, and Assignment Plan**

Forty schools have been selected in California (see Figure 2). All have had some interaction with PLTW in the past, ranging from an expression of interest in the program to offering a full PLTW program. The schools have agreed to create a four-year experience for one cohort of students in which engineering is taught in consecutive, specially designated classes that follow the PLTW high school engineering curriculum. This represents an additional effort for all schools, made possible by the funding of this grant.

In year 2, after final preparations with each school have been made, 9th grade students will be recruited to participate in the four-year experience. Students will be informed that (1) enrollment in the experience is competitive and students will be tested to ensure they have the basic math skills required, (2) if selected, students are expected to participate for all four years of the program, and (3) if there should be more qualified applicants than seats, students will be

enrolled by lottery. We expect to recruit 50 or more qualified applicants for an average of 20 places per school. Over the course of the four years, if students should leave the program, we will select replacements at random from the control group. Treatment and control students will be tested over the next four years with pre (start of school year) and post (end of school year) PLTW content assessments.

**Figure 4: The sampling, selection, and assignment plan (BAU = "business as usual").**




## Impact Analysis

Research questions 1 through 5 will be addressed by estimating program impacts using two-level hierarchical linear models and hierarchical generalized linear models in which the treatment effect is estimated at level 1 (the student level) and is incorporated as a random effect at level 2 (the school level used to adjust for blocking). Research questions 1, 2, 4, and 5 will be

addressed with hierarchical linear models (continuous outcome measures); Research Question 3 will be addressed with a hierarchical generalized linear model (a logistic regression for binary outcomes designating advanced course versus not advanced course). Research Questions 1, 3, 4, and 5 required the estimation of a treatment main effect, and Research Question 2 requires the estimation of an interaction between treatment and group (female/male or minority/non-minority).

TABLE 1: Statistical Models Used to Address the Research Questions

| **Impact Research Question** | **Topic** | **Treatment Effect** | **Outcome Variable** | **Type of Statistical Model** |
|---|---|---|---|---|
| 1 (primary research question) | Student Achievement | Main Effect | Continuous | Two-Level HLM |
| 2 | Achievement Gap | Interaction Effect | Continuous | Two-Level HLM |
| 3 | Course Taking | Main Effect | Binary | Two-Level HGLM (Logistic) |
| 4 | College Intentions | Main Effect | Continuous | Two-Level HLM |
| 5 | Career Intentions | Main Effect | Continuous | Two-Level HLM |

Student Level Model

Research Questions 1, 4, and 5 will use the following basic model at level 1,

$$Y_{ij} = \beta_{0j} + \beta_{1j}T_{ij} + \beta_{2j}X_{ij} + e_{ij}, \quad (1)$$

where $Y_{ij}$ denotes the outcome of student $i$ in school $j$ for a given year (scaled scores from the PLTW posttest, CST Math Test, CST Science Test, a measure of college intentions, or a measure

of career intentions); $\beta_{0j}$ is the student-level intercept; $T_{ij}$ is an indicator variable denoting inclusion in the treatment group; $\beta_{1j}$ is the impact estimate we wish to obtain; $X_{ij}$ is the PLTW pretest; $\beta_{2j}$ is a regression coefficient that reflects the strength of the association between the pretest and the outcome measure; and $e_{ij}$ is an error term distributed $N(0,\ \sigma^2_{|X})$ with $\sigma^2_{|X} = (1 - R^2_{XY})\sigma^2$.

For Research Question 3, a hierarchical generalized linear model with a logit link (logistic regression) will be used. In this case, $Y_{ij}$ will be replaced by $\eta_{ij}$, the log of the odds that a student selected (or completed) a challenging science or math course.

For Research Question 2, the model will be expanded to

$$Y_{ij} = \beta_{0j} + \beta_{1j}T_{ij} + \beta_{2j}X_{ij} + \beta_{3j}G_{ij} + \beta_{4j}G_{ij}T_{ij} + e_{ij}, \tag{2}$$

where $G_{ij}$ is an indicator variable denoting a group (either female versus male or minority versus non-minority); $\beta_{3j}$ is an estimate of the achievement gap; $G_{ij}T_{ij}$ is a group-by-treatment indictor; and $\beta_{4j}$ is an estimate of the impact of the program on the achievement gap. The outcome variable in this case will be a scaled test score representing student achievement.

<u>School Level Model</u>

For Research Questions 1, 3, 4, and 5, the corresponding level-2 model will be.

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + u_{0j} \\ \beta_{1j} &= \gamma_{10} + u_{1j} \\ \beta_{2j} &= \gamma_{20} \end{aligned} \tag{3}$$

Here, $\beta_{0j}$ (the student-level intercept) and $\beta_{1j}$ (the student-level impact estimate) are treated as random. Each is comprised of a constant and a random error term, $u$, that is assumed to follow a normal distribution with a constant variance ($\tau_{00}$ and $\tau_{11}$, respectively). The latter, $\tau_{11}$, is the variance of the program impact across schools. The strength of association between the outcome and PLTW pretest, $\beta_{2j}$, is treated as fixed and does not include a random error term.

For Research Question 2, the model will be expanded to

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + u_{0j} \\ \beta_{1j} &= \gamma_{10} + u_{1j} \\ \beta_{2j} &= \gamma_{20} \\ \beta_{3j} &= \gamma_{40} \\ \beta_{4j} &= \gamma_{40} \end{aligned} \quad , \qquad (4)$$

where $\beta_{3j}$ and $\beta_{4j}$ are treated as fixed.

**Statistical Power for Detecting a Treatment Main Effect for Student Achievement**

The within-school design provides substantial statistical power to detect a treatment main effect for student achievement, the primary objective of the evaluation. For student achievement (and other continuous outcomes), we estimate that we will be able to detect yearly program impacts that traditionally are classified as small—between 0.11 and 0.20 standard deviations—with power of 0.80 given a set of input values based on conservative assumptions. These input values and their underlying assumptions are:

| Input Value | Assumptions and Rationale |
|---|---|
| J | *The number of schools.* Our starting sample will include 40 schools. This will provide ample power. Given the volatility of funding for school |

| | |
|---|---|
| | districts, we may experience school attrition. We expect there will be some attrition at the student level. Consequently, we have set 30 schools as a worst-case lower bound for schools remaining in the study after 4 years. This is overly conservative. In addition, we may experience a reduction in power if we use multiple imputation methods to correct for substantial amounts of missing data. Our conservative lower bound of 30 schools takes this loss of power into account. |
| n | *The number of students (treatment + control).* We set this value to 40 students per school, evenly divided between treatment and control groups. Our goal, however, is to recruit 50 students per school. This would allow us to assign more than 20 students to the treatment group and create a control group that is larger than the treatment group at the outset of the study. As treatment students leave the program for any number of reasons (for example, students move to another neighborhood), we will be able to draw replacement students at random from the control group and enroll them in the treatment group. When this takes place, the student leaving the treatment group and the replacement student from the control group will both be treated as missing cases. Multiple imputation will be used to estimate their missing data. |
| B | *The proportion of variance explained by blocking.* This is set to 0, the most conservative assumption. That is, we assume that blocking provides no advantage. |
| $\alpha$ | *The Type I error rate* (i.e. the cutoff for statistical significance for a two-tailed hypothesis test.) This is set to 0.05, the standard value for social science research. |
| $R^2$ | *The proportion of variance explained at the student level by the pretest score.* This is set to 0.50, which is more conservative than the average value that Hedges and Hedberg (2007, Table 2 ) reported—0.62. |
| $\sigma_\delta^2$ | *The variability of the impact effect size across schools.* This is set to two values—.01 (small variance as compared to the minimum detectable effect size) and .10 (large variance). |

Given these assumptions, minimum detectable effect sizes (the smallest standardized effect that can be estimated with power of 0.80) were estimate using the Optimal Design software (Liu, Spybrook, Congdon, Martinez, & Raudenbush, 2006) for a multi-site (blocked) trial. The results of the are presented in Table 1.

**Table 2: The minimum detectable effect sizes for the models and assumptions given above.**

| | Number of Schools | |
|---|---|---|
| $\sigma_\delta^2$ | J=40 | J=30 |
| 0.01 | 0.11 | 0.13 |
| 0.10 | 0.18 | 0.20 |

**Implementation Analysis**

We will investigate Research Question 6—To what extent does the four-year PLTW experience implemented by treatment schools align with the program model?—by comparing teacher logs and video of classroom instruction to rubrics designating the key components and instructional techniques that define PLTW. Similarly, we will investigate Research Question7—How does the four-year PLTW experience differ from that of students in the same school who are not participating in the four-year PLTW experience?—by comparing student survey responses and course-taking behavior for treatment and control students. This descriptive analysis will allow us to characterize the level of implementation fidelity and, as a result, interpret our findings in ways that offer a clear course of action for those wishing to replicate the program.

**Contamination**

Because we are randomizing within schools, contamination is an important issue we will address. First, it is possible that PLTW teachers may be teaching control students in non PLTW classes. We do not believe we should discourage teachers from using general instructional techniques they may have acquired through PLTW, but they will be required not to teach the PLTW curriculum in non PTLW classes. We will monitor this with the teacher logs and videos

of classroom instruction, some of which will come from PLTW teachers in non PLTW classes. For non PTLW teachers, we will collect teaching logs only.

**Attrition and Missing Data**

Attrition may take place at the school, teacher, and student levels. Because we are blocking on schools, the loss of a school does not compromise the treatment-control contrast we seek to understand (i.e., internal validity). It may, however, reduce statistical power and may affect the generalizability of results (i.e. external validity). It may be possible to adjust for missing schools using multiple imputation, depending on the amount and timing of the missing data. Attrition at the teacher level may affect the quality of the PLTW intervention. In the past, PLTW teachers have experienced lower than average attrition because of special institutional protections that were afforded to them. In the event that this is not possible in the current climate of uncertain funding, PLTW will train and support replacement teachers in order to ensure the quality of instruction. Attrition at the student level can be handled with multiple imputation. The PLTW pretest, student CST scores, and other student-level variables can be used to estimate plausible values for the missing data which can be used (with adjustments) in the models described above.

**Crossovers**

If a treatment student exits the PLTW program, a student from the control group will be selected at random as a replacement. When this occurs, the exiting treatment student and replacement control student will be treated as having missing data. This will provide us with the closest answer to the question we are asking—what happens when a student has a four-year PLTW experience.

**D. (2):** *The extent to which the methods of evaluation will provide high quality implementation data and performance feedback and permit periodic assessment of progress toward achieving intended outcomes.*

Every year, GCO will provide feedback to PLTW based on teaching logs, student test results, and videos of classroom instruction. These three sources of data will allow us to characterize adherence to PLTW standards, identify areas in need of improvement, and choose where and how to step up our monitoring, if necessary. Interim impact estimates will be calculated and shared with project staff, and midcourse corrections will be made as warranted.

**D. (3)** *The extent to which the evaluation will provide sufficient information about the key elements and approach of the project so as to facilitate replication or testing in other settings*

PLTW has a well articulated approach to instruction and a curriculum that specifies the content and methods teachers should use. At a conceptual level, key elements and approaches have already been identified. With the teacher logs and video of classroom instruction, we will be able to identify how closely these elements and approaches make their way into the classroom. As a result, we will be able to offer a clear course of action to those wishing to replicate the program.

**D. (4)** *The extent to which the proposed project plan includes sufficient resources to carry out the project evaluation effectively*

GCO has conducted a number of multi-year, multi-site cluster-randomized trials in education. The firm has a number of proprietary tools that it will use to develop and pilot assessments and surveys; collect and score video of classroom instruction; and provide constructive feedback on the implementation of the program. PLTW has a well developed curriculum, teacher professional development program, and online assessment system. The schools that will be participating have prior experience with the model and the capacity to

implement it. All of the participants have the ability, desire, and experience necessary to carry out the project effectively and efficiently.

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