Identifying Perceptions That Contribute to the Development of Successful Project Lead the Way Pre-Engineering Programs in Utah

An educational crisis has been reported from many scholarly platforms for the last quarter century. The United States is faced with the challenge of providing a secondary science, technology, engineering, and math (STEM) education, especially in secondary pre-engineering, that will lead its students to the fulfillment of academic and domestic success. In *Rising Above the Gathering Storm,* the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine (2007) concluded:

> We owe our current prosperity, security, and good health to the investments of past generations, and we are obligated to renew those commitments in education, research and innovation policies to ensure that the American people continue to benefit from the remarkable opportunities provided by the rapid development of the global economy and its not inconsiderable underpinning in science and technology. (p. 13)

This report and others suggested that the United States is losing its global competitive edge in the fields of engineering, science, and technology because the U.S. educational system cannot, in its present state, take on the challenge of educating our children to the standards of the future. A follow-up report five years later showed that some improvement had been made, but reaffirmed the importance of change in STEM curriculums across the nation (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2010).

In the report *The Knowledge Economy: Is the United States Losing Its Competitive Edge?* assembled by the Task Force on the Future of American Innovation (2005), they advocated,

> Federal support of science and engineering research in universities and national laboratories has been key to America's prosperity for more than half a century. A robust educational system to support and train the best U.S. scientists and engineers and to attract outstanding students from other nations is essential for producing a world-class workforce and enabling the R&D enterprise it underpins. But in recent years federal investments in the physical sciences, math and engineering have not kept pace with the demands of a knowledge economy, declining sharply as a percentage of the gross domestic product. (p. 1)

Keith McMullin (keith.mcmullin@uintah.net) is a Project Lead the Way teacher at Uintah School District in Vernal, Utah. Edward Reeve (ed.reeve@usu.edu) is a Professor in Technology and Engineering Education, School of Applied Sciences, Technology, and Education, Utah State University.

Educational reform is paramount in defining our goals for the future and in reaching those goals both in secondary education institutions and in our nation. The educational crisis addressed in this research is characterized by K–12 public education not producing students who have the necessary skills or inclination to be successful in college and university engineering programs across the nation. A problem exists with a shortage of engineers in the nation (Johnston, 2001). Public and educational leaders are calling for change in secondary pre-engineering education. Jackson (2004) stated:

> There is a *quiet crisis* building in the United States—a crisis that could jeopardize the nation's pre-eminence and well-being. The crisis has been mounting gradually, but inexorably, over several decades. If permitted to continue unmitigated, it could reverse the global leadership Americans currently enjoy. The crisis stems from the gap between the nation's growing need for scientists, engineers, and other technically skilled workers, and its production of them (p. 1).

A serious shortfall is represented by the gap in our national scientific and technical capabilities. Ignoring this gap may lead to perilous times in our nation's future.

Secondary Pre-Engineering Trend in the United States

To help close the gap in engineering personnel, secondary pre-engineering programs have been implemented in over 4,000 schools in 50 states (National Academy of Engineering and National Research Council, 2009). With this much growth, the perception of pre-engineering programs by school officials and the public seems to be that these programs are really meeting the needs of today's youth and should be considered for implementation in secondary public schools whenever possible.

For the last 30 years we have increased educational efforts and have tried exhaustively to get the latest innovations and policies into place. In the 1960s, a lot of funding went into national curriculum efforts, open-plan schools, and individual instruction, followed in the 1970s by a period of stagnation, regrouping, and recovery (Fullan, 1993). Fullan went on to explain that somewhere along the way, it seems we forgot that one of the main purposes of education is to prepare young people for the workplace. Secondary public schools traditionally have been slow to understand, change, and meet the challenges of the modern-day workplace. Another possible reason for implementing pre-engineering courses is that they reflect the modern-day workplace.

Today, there are many programs available for public schools to participate in pre-engineering. In the report, *Engineering in K–12 Education: Understanding the Status and Improving the Prospects*, the National Academy of Engineering and National Research Council (2009) cited over 30 pre-engineering programs. Table 1 shows a list of the larger programs along with

their participation to provide understanding of the diffusion of pre-engineering programs in the United States.

Table 1
A Brief List of U.S. Pre-Engineering Programs and Their School Participation

Curriculum	Participation
Project Lead the Way	The PLTW curriculum is used in all 50 states and the District of Columbia in 2,700 schools (2,000 high schools and 700 middle schools). About 600 high schools have completed PLTW's program certification process, and 34 middle schools have been recognized by PLTW's "School of Excellence Recognition program."
Materials World Modules	This curriculum has been used in about 500 schools in 48 states by some 35,000 middle school and high school students.
Infinity Project	The high school course has been used in 350 schools in 37 states and some schools in several other countries. A new set of middle school modules is being used in 20 schools in Texas.
Designing for Tomorrow	This curriculum, developed by Ford Partnership for Advanced Studies, is used in more than 300 schools in 26 states.
A World in Motion	This curriculum is used in all 50 states and in 10 Canadian provinces. More than 65,000 AWIM kits have been shipped to more than 16,000 schools since 1990.
Engineering is Elementary	This curriculum is used in about 850 schools in 46 states and the District of Columbia. Approximately 1 million students have been exposed to the EiE curriculum.

Note. These data are presented as reported by the curriculum developers.

Of the programs cited in this list, Project Lead the Way (PLTW) is by far the largest. In a recent press release, PLTW announced that it had been nationally recognized as one of just four high-quality STEM programs that are immediately scalable on a national level (Project Lead the Way [PLTW], 2013). Of the four programs selected, PLTW is the only in-school STEM curricular

program for elementary, middle, and high school students and the only program offering a comprehensive professional development model for teachers. There are other programs, such as Materials World Modules and the Infinity Project, that do have some momentum, but they are not as big as the PLTW program. PLTW is now in all 50 states with over 4,700 participating secondary schools serving over 400,000 students (PLTW, 2013). It is one of the premier pre-engineering programs in the nation. However, even with its diffusion and growth, PLTW is relatively new in the United States, and nascent research is just now yielding precursory findings on its impact on public education.

Utah Pre-Engineering Education: The *Project Lead the Way* Curriculum

One of the purposes of PLTW is to provide a complete curriculum with a scope and sequence for students to follow in secondary pre-engineering. The PLTW pre-engineering program at the secondary school level consists of curricula for three tiers of education. The first tier includes two foundation courses, introduction to engineering design (IED) and principles of engineering (POE). After successful completion of the tier one courses, students may then take one or more of the tier two specialization courses, which include digital electronics (DE), aerospace engineering (AE), biotechnical engineering (BE), civil engineering and architecture (CEA), and computer integrated manufacturing (CIM). The last course in the program is the tier-three capstone course, engineering design and development (EDD). In addition to providing curriculum for the classes, PLTW contracts with the school to provide program support and training for teachers and counselors.

Utah has offered PLTW classes in their public schools since 1999. Presently PLTW classes are offered in over 28 different Utah schools in 10 districts serving over 2,100 students. However, some of the districts offer PLTW classes in a central school setting where many schools are represented with only one program being taught.

The PLTW curriculum emphasizes the nature of engineering and presents an engineering educational track. It teaches students and teachers how to engage in the field of engineering. The PLTW (2009) curriculum philosophy included having students:

- work as a contributing member of or lead a team;
- use appropriate written and/or visual mediums to communicate with a wide variety of audiences;
- participate in public speaking;
- listen to the needs and ideas of others;
- understand the potential impact their ideas and products may have on society;
- use problem solving methods and skills;
- manage time, resources, and projects;
- participate in researching ideas and concepts including data collection and

analysis;
- go beyond the classroom for answers; and
- be better prepared for success in two- and four-year college programs.

This philosophy seems to enable students to succeed inthe workforce or the university. PLTW classes also have students thinking outside the box to engineer solutions for today's problems, meaning that students may offer engineered solutions that are sometimes more efficient, cheaper, more practical, and possibly have less environmental consequence. With this philosophy, PLTW hopes to close the gap between education and the workplace.

A critical component of PLTW is its teacher training, which was developed to provide the most intensive and comprehensive professional development for teachers becoming part of PLTW (2009). Teachers gain access to PLTW curriculum only after completing approved PLTW in-service training. The various curriculums use a variety of labs and multi-media presentations, including PowerPoint, to make the lessons both standard and easy to use. PLTW is a nonprofit organization. Its major stated goals are to: (a) increase the number of young people who pursue engineering and engineering technology programs requiring a 4- or 2-year college degree, (b) provide clear standards and expectations for student success in the program, (c) provide leadership and support that will produce continuous improvement and innovation in the program, (d) provide equitable opportunities for all academically qualified students without regard to gender or ethnic origin, (e) reduce the future college attrition rate with 4- and 2-year engineering and engineering technology programs, and (f) contribute to continuing national prosperity.

PLTW also attempts to attract a higher percentage of middle grade point average students into their classes to introduce them to the field of engineering instead of limiting student participation to the academic top. Their can-do philosophy suggests that students who thought they had no aptitude for engineering fields of occupation may find success in the PLTW program and learn that they could possibly pursue an engineering field of occupation.

PLTW involves universities in its quest to strengthen the pipeline connection between secondary schools and universities. At some colleges and universities, PLTW classes are offered for concurrent enrollment. Students are usually required to pass an end-of-course exam before credit is granted. The credit received by students at universities and colleges is usually basic, which could fill the role of elective courses.

Schools planning to offer four or more high school PLTW courses are eligible for PLTW certification and may begin the process for certification at the end of the second year. The purpose of certification is to ensure implementation of a high quality PLTW program and to verify college credit eligibility for select PLTW courses. The benefits of certification include the opportunity: (a) "to receive college-level recognition such as college credit, scholarships, and admissions preference;" (b) for PLTW teachers "to become Master Teachers and

receive benefits such as compensation for professional development" and the opportunity "to field test new curriculum;" (c) for schools to apply for Model School status; (d) for schools to receive additional funding; and (e) to have "greater visibility for the program within the school and community" (PLTW, 2012).

Counselors of schools implementing PLTW are also required, by the PLTW contract with the school, to attend PLTW workshops. Counselor training plays a major role in the PLTW concept. PLTW utilizes affiliate universities to provide teacher and counselor training for schools that have the PLTW program. University affiliations have changed in Utah since the program was first established. The PLTW workshops provide counselors with (a) an understanding of how to best implement PLTW in their school, (b) knowledge of the benefits that PLTW provides for students, and (c) methods of advising students who are interested in enrolling in the PLTW program.

Studies about Pre-Engineering and PLTW

Studies about PLTW and its impacts in schools have been limited in scope. However, a recently developed instrument that can be used to assess pre-engineering programs shows promise that more research will be conducted to investigate pre-engineering programs. For example, the Engineering Education Beliefs and Expectations Instrument (EEBEI) was developed by Nathan, Tran, Atwood, Prevost, and Phelps in 2010 to: (a) develop an instrument to measure "teachers' beliefs and expectations about pre-college engineering instruction," (b) measure teachers views and "identify differences that exist among teachers with different training," and (c) "examine teachers' decisions in advising fictional students" (p. 409). Research using the EEBEI, and the EEBEI-T for teachers has shown, "High school STEM teachers report their instruction was influenced by students' interest, family background, and prior academic achievement" (Nathan et al., 2010, p. 409). The study also discussed that in a comparison between PLTW and non-PLTW teachers, the latter are of the opinion that engineering students must demonstrate high abilities in math and science, but PLTW teachers tend to integrate the math and science skills into the project or activity at hand while they are teaching. Although socioeconomic status (SES) was not reported as a factor that influenced their teaching, it did influence situational decision-making tasks (Nathan et al., 2010). This research indicates that interest, family background, and prior academic achievement are factors that may be tested in this study to see if CTE directors, school administrators, and teachers in Utah agree or disagree on their merit.

The EEBEI-T was also administered to high school guidance counselors in another study (Nathan, Atwood, Prevost, & Tran, 2011), which found that advising was shaped by student performance. Guidance counselors tend not to use students' culture, home or ethnic backgrounds to inform course selection advising, and guidance counselors overwhelmingly advised students from all

four vignettes in the study to enroll in pre-engineering courses (Nathan et al., 2011). Counselors play a major role in students enrolling in PLTW classes and thus are included as a population to be surveyed in this study to find out what they perceive as factors that contribute to successful PLTW programs.

In a quasi-experimental study using the EEBEI-T to measure how professional development changed high school STEM teachers' beliefs about engineering education, Nathan, Atwood, Prevost, Phelps, and Tran (2011), reported that with regards to which students should enroll in engineering, expectations for engineering learning, and predicting career success of pre-engineering was generally favorable among students who had a high SES through survey logistics even though SES was not a directly tested factor. This study also indicated that nascent PLTW teachers were more likely to increase STEM integration over time into their curriculum, which indicates that math and science were incorporated into the curriculum on a need-to-know basis in order to complete the project. This could also be a factor of their comfort level as they develop mastery over their subject. This research indicates that professional development is a factor that needs to be assessed in this study because teachers need to know how math and science are to be used in their teaching to aid in student's retention of math and science concepts.

A study on PLTW conducted in Indiana found that principals presented obstacles when trying to implement PLTW programs because of their tendency to categorize them as traditional technology education classes (Shields, 2007). Perceptions held by administrators and teachers may be different, creating implementation and maintenance problems with the program and hindering success. Rating factors from the perceptions of program success between administrators and teachers and reasons why PLTW is successful is paramount for testing success factors in this study in Utah.

Secondary education public school administrators and teachers from across the nation are realizing that their schools could provide pre-engineering programs that allow students to investigate their strengths and interests in engineering and engineering technology (Thilmany, 2003). According to Dearing and Daugherty (2004), leaders from both secondary technology education and college-level engineering have called for changes in the high school curriculum to address the need to sufficiently prepare high school graduates for post-secondary progress related to engineering and technology. School districts across the nation are implementing pre-engineering courses into their curriculum. As schools infuse these pre-engineering programs, leaders and teachers in technology education are debating the virtues of pre-engineering education (Lewis, 2004). Student interest in engineering and engineering technology could be factors that contribute to program success and should be part of this study.

Other studies in Indiana have indicated that technology education teachers have embraced pre-engineering education as a valuable component of

technology education (Rogers, 2006). Rogers went on to say that technology education teachers from Indiana also view the pre-engineering curriculum as favorable in developing technological literacy. Rogers and Rogers (2005) concluded that the forward provided by William A. Wulf, president of the National Academy of Engineering, in the *Standards for Technological Literacy: Content for the Study of Technology* provided clear evidence that pre-engineering has become a component of the technology education discipline.

Secondary schools have experienced a rise in the engagement of pre-engineering programs (Douglas, Iversen, & Kalyandurg, 2004). There has also been an increase in the development of engineering-focused curriculum for Grades 9–12 (Dearing & Daugherty, 2004), which gives reason to evaluate the impact of secondary engineering-focused programs on student learning. Indeed,

> as these programs continue to grow, there is a need to build a strong base of rigorous research to provide educated and specific feedback on how to improve existing curricula and build a cohesive research agenda on engineering reasoning development in the K-12 grade spectrum. (Kelly, Brenner, & Pieper, 2010, p. 8)

Research on PLTW is limited, and the research that has been conducted makes it clear that more research needs to be done, especially on a state-by-state basis, to discover and evaluate the elements of successful pre-engineering programs. The research available usually concentrates on the teaching methods that PLTW brings to schools and focuses on the success of student achievement using those methods.

Little research is available in states like Utah, which have only a limited number of PLTW programs and PLTW-certified schools. There is a need to do research in states that do not have large PLTW programs to see if PLTW programs in those states are successful and why.

Purpose of the Study

The purpose of this study was to examine PLTW program success by identifying controllable factors, which may be considered at the time of PLTW program initiation or program evaluation. Achieving this purpose will include creating a theoretical framework for identifying and implementing successful pre-engineering programs in Utah secondary public schools. Examining these controllable factors may lead to stronger success of the program upon implementation or improvement of existing programs, making them more successful by manipulation of these factors.

Method

This research used a mixed method design. Both quantitative and qualitative research methods were utilized to answer the research questions. This research was divided into two phases, and both phases employed the aspects of qualitative and quantitative inquiry. Prior to the study the instruments were pilot

tested in two adjacent states to test the instruments for content, validity, and reliability. Feedback from participants was used to make necessary improvements.

Phase I of the study used an interview process to question all career and technical education (CTE) directors ($N = 10$) in the state of Utah that have PLTW programs in their districts. In the interview questions, CTE directors were asked to identify goals or reasons for implementing PLTW in their schools, they were also asked about their perceptions and information related to how they view successful programs. Phase I of this study sought to answer the following research questions.

- *Research Question 1:* What do CTE directors in Utah perceive as the goals or reasons that the PLTW program was originally implemented into their districts?
- *Research Question 2:* What do CTE directors in Utah that have the PLTW program in their districts perceive about how their PLTW programs are presently meeting implementation goals in serving public education?
- *Research Question 3:* How do CTE directors in Utah that have the PLTW program in their districts define what success means in their PLTW programs?
- *Research Question 4:* What do CTE directors in Utah that have the PLTW program in their districts perceive the factors are that contribute to their PLTW program success?

The interview questions were designed to generate a list of possible factors that may contribute to the success of PLTW programs. This list was used to add, eliminate, or adjust questions on the survey instrument used in Phase II of the study.

Phase II of the study polled all PLTW teachers in the state ($N = 33$) and a counselor ($N = 29$) and school administrator ($N = 29$) from each PLTW school who had the most responsibility for PLTW in their school. The poll had the same questions for each group and was conducted using an internet-based questionnaire about the credibility of the factors identified primarily in Phase I of the study. The data collected in CTE directors' interviews (Phase I) and the data collected for surveyed populations was compared to define the characteristics associated with perceptions of successful PLTW programs. The research questions addressed in Phase II were as follows:

- *Research Question 5:* What factors do teachers who teach PLTW in Utah believe contribute to developing, implementing, and sustaining a successful PLTW program?
- *Research Question 6:* What factors do Utah administrators who oversee PLTW programs believe contribute to developing, implementing, and sustaining successful PLTW programs?

- *Research Question 7:* What factors do counselors in Utah schools that offer PLTW classes believe contribute to developing, implementing, and sustaining a successful PLTW program?

The questionnaires used closed-ended questions with an ordinal scale to ask the opinion of each of the factors presented in the questions. At the end of each question was a comment box so the participant could express reasons why their answer was selected if they choose. Using methods suggested by Nardi (2003) in his book, *Doing Survey Research*, to construct survey items. The following is an example of a question using the possible factor of student environment:

1. Classes in the PLTW program use a hands-on technological environment with computers and lab equipment as one of its key teaching elements. In your opinion, how many of the students taking PLTW classes in your school primarily take the class in order to take advantage of this type of learning?

☐ More than 75%
☐ Most (between 50% and 75% of the students)
☐ Some (between 25% and 50% of the students)
☐ Few (Less than 25% of the students)
Please feel free to comment on this question

Factors contributing to PLTW program success as suggested by CTE directors, conversation with state administrators and dissertation committee members, and interaction with PLTW that were addressed in Phase II of the study included:

- The students' interest in the subject matter.
- The students' family influences.
- The students' influence from peers.
- The teacher's competencies or charisma for making the class appealing.
- The type of credit received for the PLTW class.
- The classroom setting where students could be attracted by a problem-solving technological environment.
- Guidance received from a counselor, especially if the counselor has had the PLTW training.
- Students not informed about the PLTW courses.
- Concurrent enrollment where students may opt for college credit.
- College preparation where students take advantage of PLTW classes to better understand the rigors of a competitive collegiate environment.
- Improvement of student prerequisites, meaning that students achieve better in STEM classes.

- The credentials of the teacher, which may provide better instruction and possibly give the class a more sophisticated theoretical engineering framework.
- Teacher preparation time is insufficient to provide the quality of instruction needed.

In Phase I of this study that interviewed CTE directors, two overarching themes for program success emerged. The first concluded that mechanisms had to be in place that promoted adequate student enrollment. The second was that students were expected to achieve academically. Phase I of the study addressed research questions one through four.

Research Question #1

The first research question asked of the CTE directors was: *What do CTE directors in Utah perceive as the goals or reasons that the PLTW program was originally implemented into their districts?* The findings revealed in Figure 1 show that CTE directors believe that the PLTW programs in their schools were established to introduce a high quality secondary pre-engineering program that included professional development to help teachers with state-of-the-art techniques in teaching engineering concepts for students that had an aptitude for achieving academically. They also wanted a program that gave students an outlet in engineering and technology education where students could participate in a pathway that could lead to a career in engineering or engineering technology by forming partnerships between schools, industry, and the community. Implementers wanted a program that coincided with the national and economic trends affecting education that was compatible with math and science where it could possibly help boost core test scores.

In this study, the CTE directors believed PLTW was implemented for many reasons. It is interesting to note that the most common reason was to "improve teacher training by providing professional development." It appears that this reason may have been selected first because the directors value quality teaching. Also, this is in keeping with recent efforts in Utah aimed at improving teaching by providing professional development to implement the Utah State Common Core Curriculum in STEM subjects. In the CTE director's interviews, it was mentioned by several directors that new programs implemented by schools in their district should provide extensive training for teachers. Another reason for training teachers could be that CTE directors believe that the methods of instruction need to change. Traditional "stand-and-deliver" may need to be replaced with more discovery—project-based educational methods of instruction. The findings also showed three other strong reasons for PLTW program implementation that included the following: introduce pre-engineering into their schools' curriculum, gaining a perceived high quality pre-engineering program, and strengthening the schools' STEM curriculum. The mean value range between these three factors was 0.4. This seems to show that all three

reasons are valuable and important for implementation and seems to indicate that CTE directors want high quality pre-engineering programs with trained professional teachers in their schools where the classes integrate well with other STEM courses. This may also be in keeping with President Obama's push to increase STEM education.

Forming partnerships between schools, industry, and the community also ranked high with an approval mean of 4.0. This seems to show that CTE directors believe that schools should not be isolated islands but should be collaborating with all the educational players. The reason for this could be that CTE directors recognize that opportunity for students increases when a partnership with collaboration exists between public secondary schools, industrial organizations, and the local community. CTE directors could also believe that PLTW is a good fit with professional learning communities where one of the key elements is collaboration between all the members to discuss the needs of students.
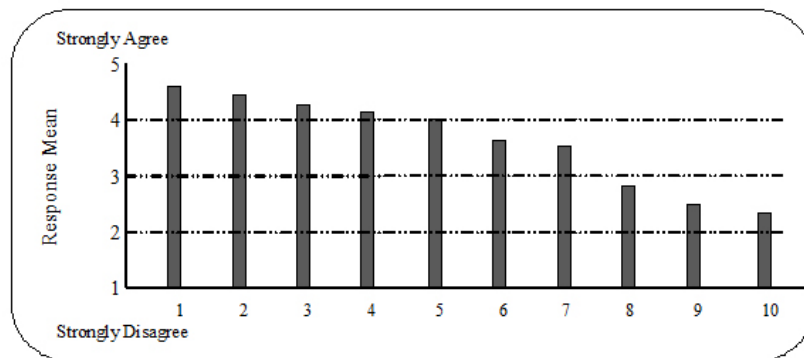
1. *Improve teacher training by providing professional development*
2. *Introduce "pre-engineering" into their schools' curriculum*
3. *Gain a perceived high quality pre-engineering program*
4. *Strengthen the schools' STEM curriculum*
5. *Provide a program that partnerships schools, industry and community*
6. *Send more students to university engineering programs*
7. *Have a way for students to get university concurrent enrollment credit*
8. *Meet the needs of community pressure to have a pre-engineering curriculum*
9. *Gain the prestige of having a pre-engineering program*
10. *Gain the opportunity to bring additional funding into the school*

Figure 1. CTE director responses to: Why was PLTW implemented into their district?

Despite believing these are still positive reasons for implementing PLTW programs, CTE directors did not seem to think that sending more students to university engineering programs and having a way for students to get university concurrent enrollment ranked quite as high as the aforementioned reasons. The reason for this could be that CTE directors are very concerned with the education that students are receiving in their schools, which is more important than contributing to the university engineering student pipeline. Another reason for the ranking of these two reasons could be that although receiving university credit and informing students of university engineering programs is one of the reasons for implementation, they may be tend to think of it as an autonomous part of any high-quality program.

It was also noted among the reasons given in the interview's probing questions that community pressure, prestige, and bringing additional funding into the school were not reasons for implementing PLTW. The reason for this could be that CTE directors want the focus of building quality programs, and those reasons do not directly relate to that.

Research Question #2

The second research question asked of CTE directors was: *What do CTE directors in Utah, that have the PLTW program in their districts perceive about how their PLTW programs are presently meeting implementation goals in serving public education?* The findings revealed that the overall majority (7 out of 10) of the directors felt like PLTW was doing a good job in meeting the goals set at the time of implementation. The other three schools had issues with instructors, administrators, or other domestic issues inhibiting program success.

One interesting finding was about the PLTW organization itself. Originally the PLTW organization wanted schools to become certified and pressured schools to offer enough PLTW classes to meet this expectation. But, in the director interviews, it was noted that PLTW seems to have backed off this position. Perhaps PLTW realized that smaller schools may not be able to sustain all the classes and therefore offered more support to schools that offer just one or two classes to students without the intention of becoming certified.

Research Question #3

The third research question asked of CTE directors was: *How do CTE directors in Utah that have the PLTW program in their districts define what success means in their PLTW programs?* All CTE directors interviewed either agreed or strongly agreed that successful PLTW programs have the following characteristics:

1. The ability to attract students and maintain adequate enrollment.
2. The ability to promote student achievement.
3. The perception of having met the goals of implementation.
4. The program has met the present educational goals.

5. The program produces desirable student outcomes.
6. The program creates good public relations.
7. The program platform brings to the school a way to develop partnerships between school, community, and industry.

Research Question #4

The fourth research question asked of CTE directors was: *What do CTE directors in Utah that have the PLTW program in their districts perceive the factors are that contribute to their PLTW program success?* Figure 2 lists 12 different factors mentioned by all CTE directors that are required for program success. However, two directors not agree that teacher credentials were important, and one director did not agree that providing university credit was important. From this list it can be seen that having quality people facilitate the program ranks in the highest two places on the list. CTE directors seem to believe that providing quality teachers and knowledgeable counselors are paramount in making the program successful. They are the people who are in the trenches interacting with the students. The reason for this may be that if students do not have positive interactions between teachers and counselors, enrollments may drop. The reputation of the class may be such that students do not take a PLTW class initially, or they do not sign up for more than one class in the program. Also, if there is not harmony between teachers, counselors, and students, then achievement in the class may not be as high, making the class or program less successful. Directors want to provide a teacher who is personable with students and has the right credentials.

CTE directors felt that if students could count PLTW classes towards required math and science courses, more students may sign up for the classes. The feeling from the interviews was that students use sufficient amounts of math and science in PLTW classes, so they should count for required credit. Perhaps directors believe that students would prefer learning in the PLTW classroom environment as opposed to the traditional math or science classroom setting. The PLTW class Principles of Engineering can have a science credit attached to it if the teacher has a science endorsement from the USOE. But, this is currently the only class that may carry a required credit. Maybe the future of required classes is to make sure sufficient math and science topics are included into PLTW classes to generate required credit.

The environment and method of instruction can influence learning. CTE directors believe that one of the reasons PLTW may be successful in their schools is because of how the classes are taught. Perhaps the learning environment and the projects, along with the style of instructional presentation in PLTW classes, may be more conducive to learning in today's technical world. The use of a high-tech learning environment to facilitate collaborative learning may help students better achieve. Providing adequate funding for these classroom settings was also mentioned as a factor for PLTW program success.

In reviewing these factors, all the directors noted that one strong factor in program success was to sufficiently inform students about the program and what its classes offer so good choices can be made according to the needs of the students. In order to do this, a concerted effort must be made to get information about the program out to family members, students' peers, counselors, teachers, and the students themselves. The directors also considered the counselor training provided by PLTW a credible factor for program success in guiding students into the program. This was important to make sure the "right kids" signed up for the program and that students had enough room in their schedules to take the PLTW classes. Counselors can also aid in screening students to make sure students entering the program appear to have a high interest in the subject matter, which ranked eighth in the success factor list.
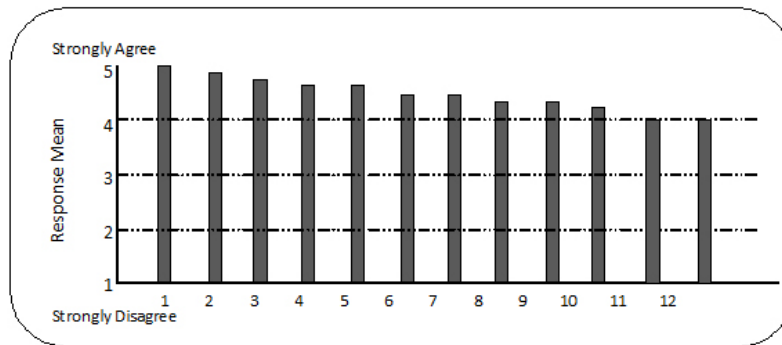

Figure 2. CTE director responses to: What factors contribute to a successful PLTW program?

Phase II: Research Questions 5, 6, and 7

Phase II of the study addressed research questions five through seven and involved collecting data from the three groups of respondents that included teachers, counselors, and school administrators. The same question was asked of each group and tailored to that group. The question asked was: *What factors do (teachers, counselors, or school administrators) in Utah schools that offer PLTW classes believe contribute to developing, implementing, and sustaining successful PLTW programs?* To answer this question, a questionnaire was developed and administered using an Internet-based survey system (i.e. SurveyMonkey).

To answer this research question, the group was asked their opinions about why PLTW is successful. The response rates shown for the group in Figure 3 indicates that three of the strongest factors necessary for a successful PLTW program include supportive school administrators, supportive counselors, and dynamic teachers. The group tended to support each other's efforts. The questionnaire findings also support the findings from Phase I of this study in

which all the CTE directors interviewed indicated that the right teacher was instrumental to the programs' success.

Figure 3 also shows that PLTW is perceived as being successful because of high-quality curriculum and because their programs are meeting the implementation expectations and goals. Teachers had a mean response near 3.0, which is neutral, when asked if programs were successful because of their association with the state affiliate university. However, there was a difference between the teachers' mean and the administrators and counselors mean to this question. It seems that teachers think that the affiliate university has been less of a contributing program success factor than administrators or counselors. Perhaps this is because teachers are more closely involved with students' outcomes and are more apt at measuring teacher professional development impact on students.
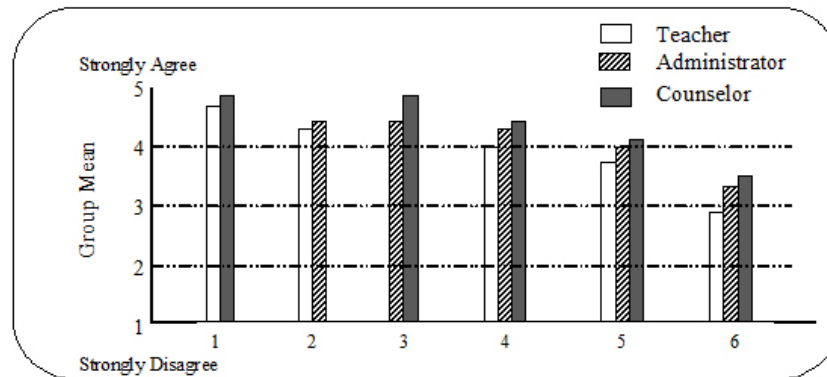
1. *PLTW is successful because of a supportive administrator*
2. *PLTW is successful because of a supportive counselor*
3. *PLTW is successful because of a dynamic teacher*
4. *PLTW is successful because it has high quality curriculum*
5. *PLTW is successful because it is meeting the goals of implementation*
6. *Utah's PLTW affiliate university has adequately met our program needs*

Figure 3. Response rates as to why PLTW is successful

Part of research questions five through seven was to ask the group what they believed were goals for implementing PLTW into their districts. The number one answer with 42 (82.3%) answering this way was to provide a career pathway for students. The next highest response with 36 (70.6%) was to provide students with more opportunity in engineering related education. From these answers, it appears that the group in agreement that PLTW gives students pathways in engineering education that are important for their futures.

Sufficient student enrollment in PLTW classes has been perceived to be an

indicator of program success. The questionnaires asked the group about why students enroll in PLTW classes. To facilitate discussion concerning the findings in this part of the questionnaire, the questions were broken into two sections according to the two different types of responses used. The first section consists of four questions, which were answered by selecting the degree in which the respondents agreed or disagreed with a given statement. The second section consists of 10 questions, which were answered by choosing the percentage of students they thought best represented the question asked. The group response rate means for the first section of questions are shown in Figure 4, and group response rate means for the second section of questions are shown in Figure 5.

In Figure 4, it can be seen that the group agreed that student enrollment in PLTW classes would increase if the state would offer more math and science credit for taking the class. At present a science credit may be granted for taking the PLTW course Principles of Engineering, as long as requirements are met. Because PLTW uses extensive math and science in their curriculum, students might take more PLTW classes to obtain these credits. This also coincides with students having room in their schedule to take PLTW classes. Sometimes students do not have the room in their schedules to participate in all the PLTW program classes because of the required classes they have to take, released time for seminary, or other non-credit classes. If space in their schedules could be opened up, more students might participate in PLTW classes.
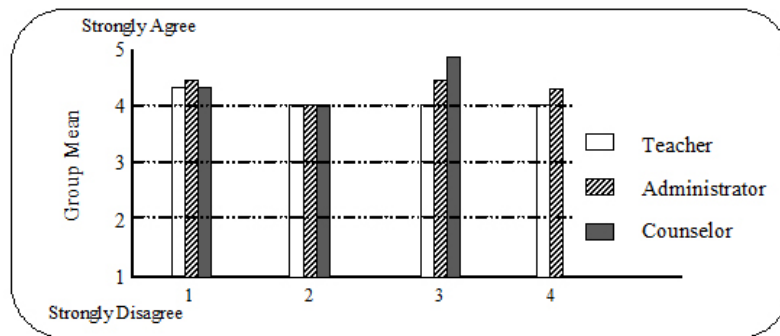

1. *Enrollment may increase if the state offered more math and science credit*
2. *Enrollment may increase if students were better informed about the program*
3. *Enrollment may increase if students had more room in their schedules*
4. *Counselors play a major role in students taking multiple PLTW classes*

Figure 4. Enrollment factors for PLTW classes

The group also agreed that enrollments in PLTW classes would increase if students were better informed about the course content. This coincides with CTE director beliefs. During their interview one director said, "despite hanging posters in the halls, advertising through school channels and the Internet, and informing counselors, there were still students in the school who had no idea that the PLTW program existed or what it was about." The belief is that students need to be told and retold until they understand what is available through whatever channels can be utilized. Counselors also play a role in informing students and directing them in scheduling. This, of course, is what counselors do, but PLTW formally trains counselors on the aspects of the PLTW program so that they can pass the information on to students. The training is required and is perceived to be helpful with enrollments in PLTW classes. One interesting note is that the teacher mean was closer to 3.0 (*neither agree nor disagree*) and the administrator mean was above 4.0 (*agree*) in response to the question about counselors playing a role in students taking multiple PLTW classes. The difference of opinion may be because teachers do not see how counselors interact with students as much as administrators do. Also, administrators may understand the counseling role better than teachers.

It can be seen in Figure 5 that group (i.e., teachers, counselor, and administrators) believed students were taking PLTW classes because they were genuinely interested in the subject and that they wanted to take advantage of the hands-on learning technological environment where students learn by doing and collaborating with others. These were the two top reasons in this section of questions that the group believed students enrolled for in PLTW classes. The means between teachers, administrators, and counselors suggests that generally they believed that "most" (between 50% and 75%) of the students took PLTW classes for these reasons. Teachers however did tend to select the response that "some" (between 25% and 50%) students enrolled in PLTW classes because of the learning environment more than counselors and administrators did. Perhaps in teaching those classes teachers believe that the PLTW environment and method of teaching is not as strong a reason for students to enroll in the class as administrators and counselors may think.
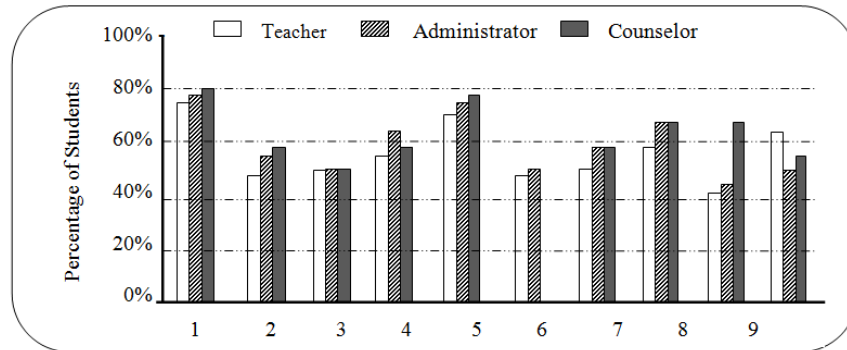
1. *Students enroll because they are genuinely interested in the subject*
2. *Students enroll because of the influence of family members*
3. *Students enroll because of the influence of a peer*
4. *Students enroll because they liked the teacher*
5. *Students enroll to take advantage of the unique learning environment*
6. *Students enroll initially because of the guidance from a counselor*
7. *Students enroll for concurrent enrollment receiving college credit*
8. *Students enroll for college and career preparation*
9. *Students enroll to improve achievement in math and science classes*
10. *How many students you believe will complete the PLTW program*

Figure 5. Factors that influence the percentage of students that enrolls in PLTW classes

The study examined if the groups believed that students enrolled in PLTW classes because of influence from family and friends, they liked the teacher, guidance they received from a counselor, or possibly for college prep and college credit. For this question the teacher's mean was lower in the family influence category than administrators and counselors, which suggest that teachers may generally believe that fewer students were in their classes for this reason. Although there was some fluctuation between a mean of 2.5 and 3.5 in the abovementioned categories, participants tended to select the choice that "some" (between 25% and 50%) of the students were taking PLTW classes for these reasons. Although these may be important factors to consider when implementing or improving a PLTW program, they do not appear to be as individually important as other factors. Another interesting note is that in general the group chose that "some" (between 25% and 50%) of the students taking PLTW classes would complete the programs in their schools by completing all the required PLTW classes.

Compared to the other reasons for students to enroll in PLTW classes, the teacher and administrator means suggests that fewer students enroll to increase their proficiency in math and science than any of the other reasons. The

counselor mean for this question on the other hand suggests that improvement in math and science is a stronger reason for students to take PLTW classes.

These findings about why students enroll in PLTW classes are very important to this research because the reality of keeping any elective class in the school offerings includes the fact that there must be a high enough enrollment to justify the offering. In some schools students who take the course Principles of Engineering may receive a science credit, but the rest of the PLTW classes in the program are elective. These findings seem to indicate that in order for students to want to sign up for a PLTW class they have to fully understand the program and what the classes will teach them. Students may be informed through many different ways as shown in the findings. These different ways must be utilized by program facilitators to attract students into the program. Elective classes have the difficult task of making the class enjoyable for students while still maintaining standards for the grades that are given. A successful PLTW program does depend on facilitators understanding how students receive information concerning PLTW classes and that the information they receive is accurate about what these classes can do for them.

The last section of the questionnaires had questions that asked the group their opinions about factors that enhance student achievement in PLTW classes. Figure 6 shows the responses for the five questions asked of the teachers, administrators, and counselors. The mean for the first questions responses shows that teachers and administrators *agree* and that counselors *strongly agree* that student achievement is enhanced if students have pre-existing knowledge in math, science, and technology when they begin a PLTW class. Because of the nature of a pre-engineering class, it makes sense that the more academic skills in math and science that a student possesses the more success they will have in the class. The respondent's means also indicate that they *agree* that students' achievement is enhanced because of the teacher training provided by PLTW. Teacher and counselor training helps insure that students understand what membership in PLTW classes entails and that they will receive instruction the way it was intended to be presented. As mentioned before, a qualified teacher is considered critical in PLTW program success. It is reasonable that a good teacher-training program will help teachers become better at their craft.

Both the administrator and counselor means indicate that they *agree* that the partnerships PLTW forms between school, industry, and the community also aid in enhancing student achievement and that student achievement is enhanced because of counselor training. However, in both of these questions the teacher mean suggests that they are more neutral, choosing *neither agree nor disagree* with the statement. This could be because administrators and counselors better understand that student participation in the PLTW program could lead to gainful employment or placement in an educational pathway that could lead to a college degree in engineering, but teachers do not fully understand how these two factors will help their students to be more successful in life. With collaboration

between these entities, student understanding of how the program fits in their life could be more evident.
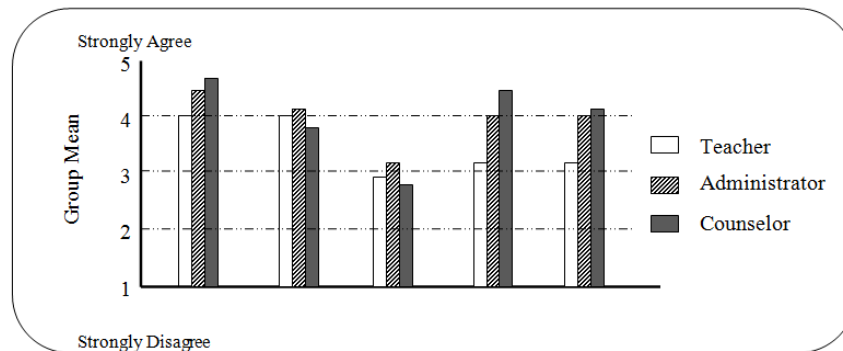
1. *Student achievement is enhanced because of pre-existing student knowledge*
2. *Student achievement is enhanced because of PLTW teacher training*
3. *Student achievement is enhanced because students are motivated to do well on end of course exams*
4. *Student achievement is enhanced because of partnerships formed between the school, industry, and community*
5. *Student achievement is enhanced because of counselor training*

Figure 6. Part IV: Questionnaire response rates.

Recommendations for Implementation or Restructuring PLTW Courses

This research is useful as it provides information to help facilitate the implementation of successful PLTW programs or improve existing programs. The following recommendations should be considered when implementing or improving a PLTW program.

1. *Utilize a dynamic teacher*—It was mentioned multiple times in this study by CTE directors and school administrators how important hiring the right teacher is. They indicated that the right PLTW teacher is willing to go the extra mile to make sure the program satisfies the needs of the program and the students in it, perhaps in public relations, industrial relations, or curriculum preparation. It also meant that the teacher is "genuine" to the students and produces an environment conducive to learning. Directors and school administrators were also supportive of the PLTW teacher training that requires teachers to participate in professional development, which gives them state-of-the-art instructional curriculum and shows them the correct instructional methods. Teacher professional development was thought to enhance student achievement. This research has revealed that teacher training is well thought of and is a valuable part

of the PLTW program. Enrollment and achievement have been perceived by the participants in this research to increase because of a dynamic teacher that students like. A successful PLTW program depends on finding the right teacher.

2. *Capitalize on student interest*—One of the findings from this research was that CTE directors, teachers, school administrators, and counselors agree that students genuinely seem interested in the subject and are thought of as wanting to take advantage of the unique learning environment that PLTW offers. It was generally shown in this research that the people who interact with students such as family members, peers, and counselors do aid in helping students to become interested in the class. Realizing this, all the "players" involved in producing the program should do everything they can to capture the interest of the students by providing information about the PLTW program, the instructional methods used, and what the knowledge learned in the class and the credit generated can do for them.

3. *Maintain unity and collaboration among team players*—Perceptions of the participants in this research indicate that members of the PLTW partnership team must have unity in their sense of mission and purpose and that they support each other. This team includes the teacher, school administrator, counselor, CTE director, school board members, community members, parents, industry partners, and of course students. This research suggests that if all the players recognize and understand the role that each member plays and that their roles should be a collaborative effort in the production of the program, problems are easier to solve, and program efficiency is increased. Collaboration was perceived by the participants in this research to be one of the keys to program success.

4. *Get the word out there and make sure students can readily access information*—The CTE directors interviewed in this research revealed that a concerted effort has to be put into advertising. The goal should be for all students in the school to know about the PLTW program and what pre-engineering is about. Students need to know what the outcomes of the program are; they need to know what they get for their effort both in a professional career and for domestic general knowledge. Students should also know who they can contact should they have any questions about a class or the program in general. It has been shown in this research that counselors are perceived to be making a difference in getting kids into the program, especially if they have a good understanding of the program and class expectations. Students also need to be well-informed about the types of credit available to them for taking PLTW classes. Credits can be for high school graduation in both elective and science areas, but the CTE interviews and the questionnaires brought out the perception that students also need to understand they can obtain concurrent university credit as

well as what type of university credit that is.

5. *Make sure kids understand what PLTW course content is about and can fit it in their schedule*—So often, the students make a class choice on what they read in the school registration catalog. It was shown in this research from the CTE director interviews that considerable effort needs to be put into course descriptions so students get a good sense of what the class they are signing up for is about. The findings also revealed that students have a difficult time fitting all the PLTW classes into their schedule. With all the options students have in secondary education, there needs to be a considerable effort in helping students register. Again, counselors are thought of as being influential in helping students with their class choices so they understand the educational paths they are engaging in.

6. *Make sure resources are available*—This research revealed through the interviews that the PLTW program is expensive. Before implementing the program, everyone involved needs to understand where the funding is coming from and also that there needs to be a suitable facility to operate the classes in.

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