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Effective Practices of Project Lead the Way Partnership Teams

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EFFECTIVE PRACTICES OF PROJECT LEAD THE WAY PARTNERSHIP TEAMS

by

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ABSTRACT

Best Practices of Project Lead The Way Partnership Teams

by

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The purpose of this study was to gather information from Project Lead The Way (PLTW) partnership team experts. This project follows the methodology of a modified Delphi study. A review of literature in the areas of curriculum development, pre-college engineering, and the Delphi research technique provided the background for the structure utilized. Top programs from across the country were questioned to identify and come to a consensus on top components essential to developing and utilizing a successful PLTW partnership team. The components were categorized into two lists: effective practices utilized to make a program successful and effective practices employed by team coordinators to make a leadership team successful. The initial information provided was revised through the blind collaboration of 17 experts. Information gathered between each revision was coded and analyzed to achieve two final lists.

(114 pages)

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CHAPTER I

PROPOSAL

Introduction

The number of engineering programs at the high school level has steadily increased over the past decade to meet recent demands of society. A report produced by the U. S. Department of Education (2006) noted the recommendations of the National Academies, which gives the following warning:

> Schools must help students develop the skills they will need to compete and succeed in higher education and the workforce, which are increasingly connected in this changed world. They must develop a pool of technically adept and numerically literate Americans to ensure a continual supply of highly trained mathematicians, scientists, and engineers. (p. 18)

In reaction to recent educational reform, several pre-college engineering curriculums have been developed. These new high school engineering programs combine both academic and vocational elements to create a hybrid laboratory experience. There are a variety of high school engineering curriculums. Project Lead The Way (PLTW) is perhaps the most popular and widely implemented of these engineering curriculums. In this curriculum students apply mathematic and scientific concepts learned in the classroom on projects in the laboratory. Because these new engineering programs do not necessarily fit the mold of past programs, new concerns and questions have emerged with this content area. One of these new concerns deals with the development and utilization of advisory committees.

Whether it is at the high school or college level, advisory committees have been a long-standing tradition for technical programs. Technical programs are often guided by

industry leaders' needs and expectations. Technical programs focus on job training. Their objective is to prepare students to perform specific tasks in career settings. Academic areas have challenges and goals different from technical areas. They focus on general knowledge and education. Students gain knowledge that they may or may not utilize in their careers. Academic programs are directed by separate factors such as national standards, textbooks, and college entrance requirements. Both of these areas have established models and practices that are different from one another. These are based on the needs and priorities in their respective areas. High school engineering programs have needs and priorities from both areas, and in addition, face unique challenges of their own. They are hybrid in that they involve rigorous academic content and the application of this content in laboratory settings. In addition, they deal heavily with the design process, which requires high-level cognitive skills in both analysis and synthesis where there is often more than one correct answer. To provide guidance to these new programs, PLTW has mandated the implementation of local partnership teams for their engineering programs.

Problem Statement

The problem of this study was to identify effective practices in the development and utilization of partnership teams in successful Project Lead The Way programs. There were two specific questions investigated in this study: What are effective practices that partnership teams engage in to make their programs successful? and What are effective practices that the coordinators of partnership teams engage in to make their partnership

teams successful? These practices were identified through experts in the field using a Delphi technique.

Need Statement

Due to the recent emergence of high school engineering programs, there is limited data. Because of the rapid increase of and popularity in the number of high school engineering programs, there is a demand for data to guide the future of these programs. According to recent statistics, Project Lead The Way (PLTW) "has swiftly grown to include about 2,200 schools in 49 states" (Cech, 2007, p. 26). This new type of program is a hybrid of vocational education and general education. One area of concern is the partnership teams which guide them. Educators trained and licensed in vocational education typically have a background in utilizing some type of advisory committee, but those licensed in general education content areas would lack this type of experience. In addition, the partnership teams in an engineering education setting have a different mission. Partnership teams require a different focus than that of their vocational advisory committee counterpart. There is a need for research information to gain insight into this type of program and their partnership teams. PLTW partnership team coordinators need guidance and direction in developing and utilizing these new partnership teams.

Many high schools and colleges alike have been using and even mandating the use of advisory committees. Project Lead The Way has mandated their use in the form of a partnership team. The intention of these teams and committees is to build and guide programs at all levels toward their specified goals. Teacher, administrators, and other school officials may speculate about the effective practices of PLTW partnership teams.

Many questions remain. Are they being implemented to achieve their full potential? What practices are effective? What ideas have been tested and found to be successful? Project Lead The Way has provided general guidelines, but more specific guidance or effective practices need to be identified.

Project Lead The Way engineering programs have been mandated to develop and utilize a partnership team. They may vary in many ways, but the assumption is the same: the team positively impacts their program. Donations, curriculum development, technical mentoring, and guest speakers are speculated benefits of partnership teams. Due to lack of information, these programs are forced to speculate concerning the effective management of these teams. Most programs would benefit from this information in making decisions concerning how to form and direct a meaningful leadership team.

In a Project Lead The Way registration document (2008), PLTW educators were asked to provide their employment position. PLTW educators provided responses such as technology education teacher, mathematics instructor, science educator, PLTW teacher, and vocational education teacher. Due to the wide variance of responses (n = ~106) provided in this field, many responses were not able to be classified. This field was collapsed into categories of general education, vocational education, and other. The number of educators who declared a general education position outweighed the vocational education positions by over eight times. The vocationally trained educators have been exposed to and educated on the effective use of advisory committees. This is not true for most educators trained for general education programs in technology, mathematics, and science. Educators trained in these areas have a need for guidance in

developing and operating any type of advisory committee, especially in the utilization of partnership teams. Although it is true that vocationally trained educators have likely been exposed to advisory committees, the purposes of advisory committees and leadership are different. The purpose of an advisory committee is to keep vocational programs abreast to industry standards and trends in order to train future workers. A partnership team's purposes pertain to general education programs that are intended to educate students in a broad area. Many of the purposes of partnership teams are still being discovered. Because of this distinction, vocational educators would also benefit from information on developing and utilizing partnership teams.

Assumptions

The following assumptions were made about the research for this study:

1. The state leaders have expertise and insight into which programs are successful in developing and utilizing effective PLTW partnership teams.

2. The recommended participants have expertise and insight into developing and utilizing effective PLTW partnership teams.

Limitations

The following four limitations were inherent in this study.

1. The research only included PLTW programs. Because this was a study identifying best practices of partnership teams in PLTW programs, the only valid data was the data gathered from these programs.

2. The second limitation pertained to the schools within PLTW that would be studied. No schools outside the recommendation of the experts were studied.

3. The best practices were gathered through the schools identified as exemplary.

4. The study focused only on the practices used by local partnership teams. State or regional teams/committees were not included.

Procedure

The following is the procedure used in accomplishing this study:

1. The problem statement was developed.

2. The proposal was written, which included the introduction, problem statement, need statement, assumptions, limitations, procedure, terminology, and acronyms.

3. A letter to the state supervisors was drafted.

4. The letter to the state supervisors was revised and finalized.

5. State leaders were contacted via e-mail to gather the names and contact information for leaders of top 2-3 rank-ordered PLTW programs from each state.

6. A letter to the potential experts was drafted.

7. The letter to the experts was revised and finalized.

8. Leaders of the top PLTW programs were contacted via e-mail to provide an introduction and invitation to participate in the study as experts.

9. Nineteen participants responded to the e-mail and were taken into the study to form the panel of experts. The participants were selected based on who replied with an e-mail indicating their acceptance to participate. Two of nineteen respondents were selected as alternates.

10. The first round of the modified Delphi study began with an initial e-mail. This e-mail contained two questions. The participants were asked to list the top 3-5 practices that the partnership team did to make the program successful and list the top 3-5 practices that they, as the coordinator of a partnership team, did to make the partnership team successful. Participants were instructed to reply to the e-mail with their response.

11. The responses from each question were grouped with similar responses. The groupings were counted to compile the rank-ordered lists for each question.

12. The rank ordered list was sent back to the 17 experts. They were instructed to review the lists and give their opinion of each item on a Likert scale that was rated from strongly disagree to strongly agree. These responses were later coded as strongly disagree equaling a 1, up to strongly agree equaling a 5. Because each item would not fit each location, the participants were prompted to consider the items from a generic and global perspective. The participants were then directed to send the information back in a reply e-mail. Additional items could also have been added by the participants at this time.

13. The responses to each item were tallied onto a spreadsheet. The mean score, mean rank order change, and standard deviation of each were calculated using the Likert data. The mean scores were used to create the new rank ordered lists. The mean rank order change and standard deviation were used to gauge the movement toward consensus among the participants. The mean rank order change was a process that measured the amount of item movement along the respective lists from the previous round to the current round. This mean rank order change was used as the primary

measure of consensus. This updated list was sent back to the experts with the same instructions included in the previous round.

14. The final list was prepared following the procedure used in the previous round.

15. The results of the study were shared with state supervisors and expert participants.

Terminology

The following working definitions were used throughout this study:

Advisory committee: a group united in developing and guiding a vocational or technical program.

Partnership team: a local group united in developing, utilizing, and guiding a PLTW engineering program toward specified goals.

Project Lead The Way (PLTW): A four-year curriculum that introduces students to the discipline of engineering and technology prior to entering the college environment (Project Lead The Way, 2006a).

Project Lead The Way State Leader: State representative of the PLTW programs in the respective state.

Successful Project Lead The Way Program: A PLTW program utilizing an effective partnership team, identified by a PLTW state leader.

Acronyms

The following acronyms were used throughout this study:

ATE: Advanced Technological Education Program

CTE: Career and Technical Education

BALS: Bay Area Longitudinal Surveys

DACUM: Developing a Curriculum

NSF: National Science Foundation

PLTW: Project Lead The Way

CHAPTER II

REVIEW OF RELATED LITERATURE

Curriculum Development

Vocational Education

Curriculum development is approached differently depending upon the content area. Vocational and technical education curriculum is often developed using occupational and task analysis and advisory committees. General education curriculum is often developed from state and national standards, textbooks, and college entrance requirements.

Occupational and Task Analysis

The primary method of curriculum development in vocational and technical education is an occupational and task analysis. This method has been utilized historically by vocational programs in determining content and curriculum. Emphasizing the importance of occupational analyses, McMahon (1972) stated, "Anyone with experience in vocational teacher education will vouch for the value of analysis as the basis for a sound program of job training" (p. 121). More recently Finch and Crunkilton (1999) concurred by writing, "Few content determination strategies have seen such widespread use as task analysis" (p. 147).

An occupational analysis involves systematically identifying the tasks and responsibilities which are necessary for employees in a specific occupation. They are then organized into the steps necessary to perform the task. Rather than identifying

duties, which fit into a broader category, an occupational analysis identifies the tasks that are performed by the entry-level workers on a regular basis. An integral component to completing a successful occupational and task analysis is the involvement of workers to verify the tasks identified (Finch & Crunkilton, 1999). The analysis of the occupation and job-specific tasks are then used to develop the curriculum.

In attempting to better understand the transition from school to work and thus reform career education, Neumark (2007) referred to the Bay Area Longitudinal Surveys (BALS). This was an analysis of the skills required by employers for entry-level positions. Four hundred and five employers participated in the analysis. The information gained from this analysis was given as a recommendation to schools for program and curriculum changes. Neumark offered the following suggestion to schools: "the evidence from this study also suggests that schools might want to tackle the challenge of creating programs that provide students with needed labor-market skill" (p. 274).

Norton (1997) described DACUM as a proven form of an occupational analysis which can serve as a "solid base upon which new competency-based education or training programs can be developed or existing programs updated" (p. 6). Norton continued by detailing the three basic premises which DACUM relies on in developing career curriculum: the workers and experts must be able to describe their occupation effectively, defining the tasks and duties of an occupation must be an accurate way of defining a job, and a worker must posses certain skills and knowledge to perform that job.

Norton (1997) explained that in order to provide a high level of education to a workforce, the duties and work processes must be detailed for the curriculum

development. The best method of gathering this information is by conducting an occupational and task analysis. Norton concluded by stating, "…DACUM is the best means of conducting job/occupational analysis available" (p. 13).

Advisory Committees

The purposes of advisory committees are extensive. Advisory committees, noted Kerka (2002), may do many things to contribute to a program, school, or department. Curriculum development, instruction, program evaluation, career placement, and other resources are areas in which an advisory committee may be valuable. A common responsibility of a committee is to develop and integrate curriculum. They may contribute points of emphasis that should be covered in the instruction. Through this relationship the goals of the program may be revised to meet the needs of local industry employers as identified by committee members.

Finch and Crunkilton (1999) pointed to advisory committees as an effective way to evaluate and develop curriculum. An advisory committee with close relations to industry can provide relevance to curriculum in a vocational program. It is also indicated that properly designed advisory committees are often more valid than a group of instructors when developing curriculum.

A handbook published for Minnesota vocational and technical education intended to guide vocational and technical programs gives the following definition:

> An effective advisory committee provides ongoing evaluation, consultation, and research on the curriculum to keep it current with the knowledge, skills, attitudes, and values collaboratively identified by representative of the education and industry partnership. The resulting curriculum provides the necessary foundation for lifelong learning and employability. (Mercer & Dillon, 1997, p. 11)

The handbook continues by explaining that the principal purpose of an advisory committee is to review current issues and provide curriculum direction.

Advisory committee members. In a description of effective advisory committees in the past, McMahon (1972) provided the following recommendations:

> The technical advisory committee should be small but dynamic. Its members should consist of practicing technicians from the parent field, shop or business owners, plant foremen, and even a civic-minded citizen who is genuinely concerned with human needs. Successful committees may be composed of oddly assorted individuals so long as each member is sincerely interested in the program. (p. 117)

A publication by the South Carolina Department of Education recommends that members of the general public be included in an advisory committee. Members should include business representatives, industry leaders, industry laborers, and others to create a cross section of management and floor workers. It is also suggested that 12-15 members will provide enough attendance while making it possible to reach consensus on advisory issues (Tenenbaum, Jackson, & Couch, 2000).

In 1990, the Perkins Act defined the purpose of "tech prep systems" as preparing students to compete in the international workforce. To advise and guide these programs, consortia (tech prep systems' form of an advisory committee) are employed. Key and Key (1992) emphasized the importance of consortia by explaining, "by law, tech prep systems must develop through 'consortia that link representatives from secondary and postsecondary education, business, industry, labor, government, and community-based entities'" (p. 17). Guidelines for these consortia are also stated. Member recommendations include teachers from targeted areas, students, parents, politicians, state agency personnel, principals, curriculum supervisors, and other community

volunteers. It is also suggested that half of the consortium consists of local business and industry leaders.

Effective practices of advisory committees. Kerka (2002) stated that as a program or school sets its goals, the purpose of an advisory committee is established. Continuous review and evaluation are commonly found to be used in effective committees. When the members and the committee as a whole understand their role, the process seems to be more successful.

Tenenbaum, et al. (2000) outlined the duties of members of advisory committees. It is suggested that a member from the private sector is appointed as the chairperson. This chairperson should preside over meetings, review and sign committee documents, act as the spokesman for the committee, and direct committee actions. The school administrator should appoint and recommend committee members, educate members concerning their duties, and primarily communicate between the advisory committee and the school board. It is also suggested that members regularly attend meetings, become familiar with the program as well as career and technology education in general, and evaluate committee issues.

Mercer and Dillon (1997) have defined practices that they recommend to Minnesota technical advisory committees. More specifically, Mercer and Dillon have detailed the process of appointing committee members and the duration of the appointment.

> An effective advisory committee has established practices and policies for appointing members to the advisory committee and determining the duration of member terms. The length of term is usually three or four years. Normally one-fourth or one-third of the members' terms expires each year. The expiration does not necessarily mean the loss of a 'good' member as he or she may be reappointed to serve a subsequent term. Experienced members should be

> encouraged to suggest candidates for new membership. Rotational membership assists in providing a committee with diverse options and viewpoints, allowing it to remain viable and effective. (p. 14)

It is also recommended that committees discuss and decide together how often to meet. An effective advisory committee meets often enough to accomplish the following:

a. Give the members opportunities to become acquainted, establish working relationships, and develop a sense of community.
b. Develop, implement, and evaluate all aspects of the committee's biennial work plan designed to provide evaluation and consultation for the program's continuous curricular development and renewal.
c. Ensure that education and employment transitions are seamless. (p. 14)

Adequate staff support is also included as an effective practice. Staff is needed for taking notes, transcribing, and distributing materials. Another effective practice recommended is to elect a chairmen and vice-chairmen who should develop an agenda for committee meetings.

Summary of Vocational Education Curriculum Development

Occupational and task analysis and advisory committees have been analyzed and tested throughout the past and have been found to be effective. An occupational and task analysis is effective in detailing the duties and tasks necessary for success in an occupation. The information gathered from these analyses has been found to be useful in developing content and curriculum for vocational programs. Advisory committees have been valuable in many areas of vocational and technical education. The purposes have extended from curriculum development to general program guidance. Advisory committees provide insight into the needs of local industry and the skills valued by the

local employers. A well-organized and managed advisory committee can be a valuable asset to the development of curriculum and vocational and technical programs in general.

General Education

Curriculum development in general education is approached differently than vocational education. There are three primary guiding factors influencing the current and future general education curriculum: educational standards, textbooks, and college entrance requirements.

Educational Standards

Educational standards exist at the state and national level. Each type of standard provides guidance for the general education curriculum. State and National assessments are developed from these educational standards. A document generated to assist in aligning curriculum to standards states, "standards and test specifications are the starting point for developing tests and test items" (Timms, Schneider, Lee, & Rolfhus, 2007, p. 5). This assessment format creates an incentive for school leaders to develop curriculum that adheres to these standards.

The state standards are intended to be the base for curriculum throughout the schools in a state. Reinforcing this point, Reys and Lappan (2007) reported that "since 2002, 38 states have developed or revised their mathematics curriculum standards, some of which are intended to serve as 'models' for local districts, while others are mandatory and specify the mathematics all students in the state are expected to learn at particular grades" (p. 676).

> At a national level, No Child Left Behind (NCLB) has mandated the installation of standards that specify what students should know and be able to do in many content areas. It is also demanded that these standards be rigorous and teach advanced skills. The schools within each state must make an effort to offer curriculum which is in alignment with these demands. (Reys & Lappan, 2007, p. 676)

Textbooks

The curriculum in some states is dependant on the textbooks selected. Schools are often given a list of textbooks that they may use. Hoffman, Sailors, and Patterson (2002) proposed the following: "Educators and politicians in Texas have played significant roles in the pushing of early reading instruction from one extreme position to another through shifts in textbook adoption requirements…these policy actions are shaping a national curriculum for reading" (p. 2). The curriculum then follows the objectives throughout the book. Ediger (2003) suggested that "one source of mathematics objectives is the manual section of a carefully selected basal textbook…these objectives have been selected by writers who are specialists in the field of mathematics" (p. 3).

Textbooks also guide the general education curriculum at the college level. Unsatisfied with the broad range of curriculum taught in general psychology, Altman, Ericksen, and Pena-Shaff (2006) sought to develop a method of selecting a department-wide textbook. This was important in teaching comparable content throughout the department. Altman et al. explain that "to ensure equivalent content across these sections, the psychology department uses a common text" (p. 228).

College Entrance Requirements

Beyond the general education curriculum guides of standards and textbooks, the requirements and expectations of colleges and universities have begun to shape curriculum. A report detailing the 2005 National Education Summit on High Schools, which included the attendance of education and business leaders and 45 governors, informs, "During the past two years, a majority of governors have made it a top priority to raise standards and improve the preparation of high school students. States have taken concrete steps to align standards, raise graduation requirements and increase the value of the high school diploma so that all students graduate better prepared for college…" (Achieve, 2007, p. 3).

Wilensky (2007) voices anxiety about the influence of college entrance requirements but admitted, "education reformers have been proposing that high school graduation requirements align with the requirements for college entrance and that high schools organize themselves to ensure that all of their graduates are successful in college" (p. 248). While some may disagree with the influence of college entrance requirements, it is still a driving force behind the development of general education curriculum.

A program in California takes this college influence to an elevated level. San Diego State University has formed a partnership with Sweetwater Union High School District to accept all students who graduate from their high schools while completing a curriculum of college preparatory courses. These students have been preparing through rigorous curriculum in mathematics and language arts, designed to fulfill college

entrance demands, from as early as seventh grade. The entire curriculum has been developed in aim of college preparation (Hebel, 2007).

While it is difficult to document, the influence of school counselors and administrators also shapes the curriculum toward college entrance requirements. The prestige of graduating students who are "prepared" for college is a factor which impacts the decisions and suggestions of these key members' course and curriculum selection.

Summary of General Education Curriculum Development

The general education curriculum is formed through educational standards, textbooks, and college entrance requirements and expectations. National standards function as a structure for state standards. These standards are followed when creating large-scale performance assessments. The assessments are then applied to the achievement of schools and districts; therefore, the state and national standards highly influence the general education curriculum. Textbook selections by states, districts, and departments also influence the general education curriculum. Instructors are often given the option of a few textbooks, which in turn affects what will be taught throughout the course. To the dismay of some, college entrance requirements currently play a strong role in the curriculum of upper grade level courses and programs. Certain programs have devoted themselves solely to the demands and expectations of colleges and universities. The combination of these three factors develops and forms the current general education curriculum.

Hybrid Programs

Historically, most courses and programs at any level have been either academic or vocational. The academic programs focus on general education and are usually contained in a non-laboratory setting. The vocational programs focus on career preparation and exploration. These programs are often taught in a laboratory environment. Recently, programs are beginning to integrate these two focuses to create hybrid programs.

One such recent development is the Advanced Technological Education (ATE) program which has been funded by the National Science Foundation (NSF). This program was created in 1994 for two-year colleges that encourage and emphasize the integration of academic and vocational curriculum. It utilizes innovative curriculum by involving college faculty and administrators. Over 400 ATE grants have been awarded in advancing these programs (Bailey & Matsuzuka, 2003).

Pundt, Beiter, and Dolak (2007) have written an article detailing the successful techniques which they have used in aligning and integrating career education with academic study:

> All public schools are required to meet Adequate Yearly Progress (AYP) in order to avoid stiff penalties, per the No Child Left Behind (NCLB) Act. This presents a unique challenge for comprehensive career and technical (CTE) schools. While there is an emphasis on the CTE path that students are interested in pursuing, academic areas must be mastered with proficiency in order for a school to be successful. (p. 1)

This program relies on a sustainable teaching model that unites the academic and vocational instructors. First, the academic teachers teach a lesson to the students. The

vocational teachers follow by teaching a lesson which directly incorporates the lesson taught by the academic teachers.

Many believe that these types of programs are necessary for the advancement of education. Bailey and Matsuzuka (2003) introduced their study of a hybrid college program by explaining, "…technical jobs typically filled by workers with a two-year education require a stronger base of scientific and mathematical knowledge" (p. 3). Citing recent federal reports and legislation, Bailey and Matsuzuka pointed to the emphasis of educational policy makers in integrating occupational education and academia.

While there is emphasis being placed on this type of hybrid program, there are only small pockets of research being conducted in the area of developing curriculum that integrates vocational and general education. PLTW is at the forefront of this development at the secondary level.

Pre-College Engineering

Societal Need

In recent years there has been an increase in the demand for engineers. The need for future engineers to keep the United States competitive in a global economy has become an issue ushered into the forefront of public concern. The demand for these engineers has prompted many to reconsider their educational path toward engineering. This path has, in the past, been neglected. Recently, there has been a movement to integrate this career path and its required skills into the educational norm.

Demand for Earlier Engineering Education

In the book *Rising above the Gathering Storm* (Committee on Prospering, 2007), the need for engineers is stressed by noting, "knowledge acquired and applied by scientists and engineers provides the tools and systems that characterize modern culture and the raw materials for economic growth and well-being" (p. 43). It is mentioned as a concern that some science and mathematics test scores of students in the United States are lagging behind those of their counterparts in competing nations. There is fear that the interests of today's students are not compatible with those of scientists and engineers.

Looking toward the future, the Committee on Prospering (2007) suggested, "A new generation of bright, well-trained scientists and engineers will transform our future only if we begin in the 6th grade to significantly enlarge the pipeline and prepare students to engage in advanced coursework in mathematics and science" (p. 129). The committee encouraged the inclusion of rigorous mathematics and science concepts in the middle and high school curriculum. Engineering education curriculum has the potential to combine these subjects with technology to better prepare undergraduates to succeed in earning engineering and science bachelor's degrees.

Pre-College Engineering Programs

Throughout the past decade, there has been an increase in the number of hybrid programs integrating laboratory skills with mathematics and science knowledge. Many new pre-college engineering curriculums have combined these skills to attempt to better prepare students to succeed in college engineering majors and engineering careers. At the national level, there are three promenade programs outlined below: Project Lead The Way, The Infinity Project, and The CAD Academy.

Project Lead The Way

Project Lead The Way (PLTW) is a non-profit organization which has developed a four-year engineering and technology curriculum designed to integrate rigorous mathematics, science, and engineering content into middle and secondary schools (Project Lead The Way, 2006a). According to the PLTW website (Project Lead The Way, 2006b), the mission and vision of PLTW is to "create dynamic partnerships with our nation's schools to prepare an increasing and more diverse group of students to be successful in science, engineering, and engineering technology" (p. 1). In a report detailing many of the successes of PLTW it notes that "the program has swiftly grown to include about 2,200 schools in 49 states" (Cech, 2007, p. 26).

Curriculum. There are seven high school courses offered as part of the PLTW curriculum. The seven courses are Introduction to Engineering Design, Digital Electronics, Principles of Engineering, Computer Integrated Manufacturing, Civil Engineering and Architecture, Aerospace Engineering, Biotechnical Engineering, and Engineering Design and Development. These courses are categorized into foundation courses, specialization courses, and a capstone course. The foundation courses include Introduction to Engineering Design, Digital Electronics, and Principles of Engineering. The specialization courses are Computer Integrated Manufacturing, Civil Engineering and Architecture, Aerospace Engineering, and Biotechnical Engineering. The capstone course is Engineering Design and Development (Project Lead The Way, 2006a).

Gateway to Technology is offered as the middle school technology curriculum which has been developed for grades 6-8. This is a 40-week, hands-on curriculum which is divided into 10-week units. A few of the topics include the science of technology,

design and modeling, automation and robotics, and flight (Project Lead The Way, 2006a).

Partnership Teams. PLTW has included partnership teams as a key component to the success of their engineering programs. These teams are a type of advisory group working to build, guide, and maintain PLTW engineering programs. In encouraging the use of partnership teams, the PLTW website (Project Lead The Way, 2006c) explains, "Project Lead The Way believes a school Partnership Team is an essential piece in linking the school technology program with the community. More important, once formed, the Partnership Team can become a teacher's first community resource in many areas" (p. 1).

Partnership teams are groups of school officials and engineering-related community members. The teams provide direction and support to the program. The teams also create a connection between the school and the community. Possible members of the team can be identified through personal contact, recommendation of others, or program interest. Parents are often valuable assets for locating members and becoming contributing members of the committee. The number of members can vary from four to more than eight, depending on the needs and comfort level of the program or school (Project Lead The Way, 2006c).

The Infinity Project

According to The Infinity Project (2008) website, "The Infinity Project was developed in 1999 by The Institute for Engineering Education and Texas Instruments - working in partnership with the U.S. Department of Education, the National Science Foundation and others" (p. 1). The Infinity Project is a package of engineering

curriculum, classroom technology, and professional development created by a team of college faculty, secondary educators, engineers, and researchers. There are 34 states currently teaching the Infinity Project curriculum (The Infinity Project).

Curriculum. The Infinity Project curriculum is designed for one year of engineering to accompany mathematics and science courses. Using many digital technologies such as cell phones, the internet, and digital video, students innovate, design, and experiment in exploring the world of engineering. Following along with the included textbook, there is the possibility of more than 350 engineering and technology education projects. This hands-on curriculum has been developed for students in grades 10-12 who have completed Algebra II and at least one science course (The Infinity Project, 2008b).

The CAD Academy

The CAD Academy (2008a) is a pre-engineering and architecture program which combines the resources of software companies, textbook publishers, and industry professionals.

> The CAD Academy is a collaboration of professionals, industry leaders and educators to create a comprehensive and affordable pre-engineering/pre-architecture program for the education community. The goal of The CAD Academy is to inspire a new generation of engineers and architects through the implementation of industry leading software, curriculum and multi-media content. (p. 1)

Partners include ArchiCAD, SolidWorks, A+CAD, Google, The Discovery Channel, and others (The CAD Academy, 2008a).

Curriculum. The engineering and architecture package includes architectural software, 3-D solid modeling software, PowerPoint presentations, DVD video

presentations, and instructor content resources which aim to reinforce science, technology, engineering, and mathematical concepts. Students are exposed to various career disciplines using segments of mechanical drafting, architectural drafting, marine engineering and naval architects, and engineering drafting and design. This flexible curriculum package is designed for grades 10-12, but a middle school level package is being developed (The CAD Academy, 2008b).

Summary of Pre-College Engineering Programs

There are many committees, companies, and educators attempting to bridge the gap between the current engineering workforce shortage and the need for bright, qualified engineers. Recommendations from the top are encouraging the infusion of mathematics, science, and engineering concepts into American schools at an early age. Groups of educators, researchers, and companies are beginning to develop and establish these types of curriculum. Some curriculum packages provide consecutive years of engineering courses while others simply aim to expose students to the world of engineering. Pre-college engineering programs that integrate mathematics and science and expose students to engineering careers are becoming increasingly popular across the country.

The Delphi Research Technique

The Delphi technique was first used by the Rand Corporation for the U.S. Air Force in the 1950s. A Delphi study is designed to gain consensus among experts through a series of questionnaires. The validity of this concept has been demonstrated many times by a number of Delphi projects (Millet & Honton, 1991). Franklin and Hart (2007)

referred to the Delphi technique as a "hybrid research design" (p. 238) that combines aspects of quantitative and qualitative research. They propose this technique as an alternative to choosing between these two opposing research methodologies. Linstone and Turoff (1975) defined the Delphi technique as "…a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem" (p. 3). The types of problems or questions which may be explored using the Delphi technique are numerous. Circumstances which have no historical information or data are ideal for the use of an expert panel (Martino, 1983). Linstone and Turoff also noted the application of a Delphi study in "gathering current and historical data not accurately known or available" (p. 4). The Delphi technique is utilized in government planning, business predictions, industry trends, education, and other fields requiring the opinion of a panel of experts.

The Delphi Procedure

Winzenried (1997) submits:

> The Delphi technique is designed to collect opinions from a group of experts in a given discipline. By collecting these opinions, resubmitting them a number of times and providing continuous feedback with each new round of consideration, a satisfactory consensus may be reached. This consensus may be considered as a relevant and valid measure...." (p. 3)

In a Delphi study performed by Winzenried (1997), a defined basic procedure was used. The procedure included an initial contact of the expert members. Winzenried estimates that Delphi studies of as few as fifteen expert participants can provide acceptable conclusions. Jones and Twiss (1978) also agree that 15 is a sufficient panel size. When Wicklein (1993) conducted a Delphi study to identify the critical issues in

technology education, 25 expert panelists were included. The relationship of the number of members can become unacceptable when too many participants are included, but the exact number of panelist included varies widely depending on the goal and context of the study. Experts are most commonly chosen for their areas of expertise. Other factors such as demographics should be considered secondary or even excluded. Scheele (1975) indicated there are three types of expert panelists that create a successful group: stakeholders, experts, and facilitators. Stakeholders are panelists who will be directly involved with the final outcome, experts have relevant knowledge and understanding, and facilitators provide organization and clarification to the process. Martino (1983) suggested, "Peer judgment is usually the best criterion for identifying an expert" (p. 28). Martino continues by explaining that selection of experts should come through the nomination of at least two peers. In selecting the participants in Wicklein's study, representatives of technology education were chosen through nomination by peers and supervisors. Participants were selected from three separate groups: classroom teachers, teacher educators, and supervisors of secondary and collegiate education.

Colton and Hatcher (2004), Martino (1983), and Winzenried (1997) considered the anonymity of the expert participants to be an important component of the Delphi method. As an advantage of anonymity, Martino explains, "This avoids the possibility of identifying a specific opinion with a particular person. The originator can therefore change his mind without publicly admitting he has done so" (p. 16-17). Winzenried stated that "keeping an element of anonymity directs the panel's attention to the topic" (p. 4). In consideration of the current Delphi, he continues by noting, "the issue of anonymity was considered of primary importance" (p. 4).

The experts were then given a topic to discuss and work toward building consensus on. In any Delphi, a clear initial problem or question needs to be formulated as a starting point for the panel to discuss. Winzenried's (1997) procedure called for posing an initial question to the experts. The following steps included a cycle of questioning rounds and analysis.

After the experts have given answers, an analysis is performed to combine the experts' responses. Scheele (1975) advised, "It is important to begin 'interpreting' responses during interactions, even at the start. This makes interpretation subject to review by the panelists and can include their refinements, which I have found most insightful" (p. 70). Colton and Hatcher (2004) submitted that a reasonable amount of time is needed for the experts to contemplate further revisions and suggestions. The refined information is then given back to the experts. Winzenried's prescribed cycle was repeated for three rounds. Most sources recommend 3-4 rounds to gain reliable conclusions (Linstone & Turoff, 1975). Martino (1983) added, "Experience indicates that four rounds is usually sufficient" (p. 21). The final analysis included synthesis of responses and identification of consensus and disagreements. Martino submitted, "Ordinarily committees are judged as successes if they reach agreement or consensus" (p. 19).

Measures of Consensus

Martino (1983) asserted, "Delphi sequences are judged as successes when they reach stability…" (p. 19). The measures of this stability are not widely agreed upon. In attempting to solidify learning outcomes for high school engineering students, Childress and Rhodes (2008) used the inter-quartile range (IQR), which measures variability, to

indicate consensus. The point of consensus was set at an IQR of one or less. Childress and Rhodes referenced Wicklein (1993) in using the IQR to measure consensus, but Wicklein included standard deviation along with IQR in illustrating the participant responses. Scheibe, Skutsch, and Schofer (1975) disputed the use of IQR by stating, "Measures of this sort do not take full advantage of the information available in the distributions" (p. 277). Scheibe et al. (1975) instead suggested a method which measures the stability of the responses rather than the variability. The suggested method of comparing distributions involves subtracting the histograms for each item column-wise and computing the percent change from round to round. Delbecq, Van de Ven, and Gustafson (1975) submitted another measure in indicating consensus. This method uses a 5-point Likert scale and describes consensus as 75% of the responses within 1 point. Stability as a measure of consensus is agreed upon, but a widely adopted method of measuring stability is not.

A Web-Based Delphi Study

When faced with creating an online adult learning inventory, Colton and Hatcher (2004) utilized a web-based Delphi method. This type of technology-based Delphi was used for the following reasons: decreased paper, decreased postage, ensured anonymity, and ease of accessibility for the experts. The similar base Delphi methodology was used, but components unique to this online environment were introduced. It utilized the use of e-mail correspondence, a web site devoted to the study, and online chat rooms. It allowed the experts to communicate efficiently through the use of these technologies. The web-based method was described as an excellent tool that was very successful in establishing content validity.

Summary of the Delphi Technique

The Delphi research technique has been tested repeatedly over the years by many researchers for an array of purposes and goals. It has components of both qualitative and quantitative research. Undergoing the correct procedure is crucial in obtaining accurate results. The procedure is widely agreed upon. A clear question is posed to a panel of carefully selected expert panelists who are chosen based on their expertise in a particular area. The panelists then, through a series of 3-4 rounds of feedback, work toward coming to a consensus concerning a solution or prediction. A measure of consensus has not been widely adopted. Recent Delphi studies have utilized technology, such as the internet, to achieve desired results.

Review of Related Literature Summary

Vocational and technical education programs have employed occupational and task analyses and advisory committees in developing curriculum. These techniques are optimal when developing curriculum to prepare students to succeed in a specific industry or occupation. Both techniques can be successful in identifying the expectations, needs, and unique skills that will be necessary for future workers to succeed.

General education programs as a whole have relied on educational standards, textbooks, and college entrance requirements in developing and maintaining curriculum. Educational standards are established by state and national leaders. Performance assessments are based on these standards, creating a looming incentive for schools and teachers to adhere closely to them.

Textbooks frequently shape the outline and structure of general education courses and curriculum. Once a particular textbook is selected by a state or department, the objectives of the course are often based on the content of the textbook. The selection of specific textbooks can be seen as beneficial in aligning curriculum between instructors, or it can be seen as exclusive in allowing only certain content.

College entrance requirements also affect the general education curriculum. Many schools find themselves striving to align their requirements with those of colleges and universities. There have been schools and even entire districts that have structured their curriculum to align directly with certain college entrance requirements. There are disagreements with this type of policy, but these entrance requirements definitely influence curriculum decisions across the country.

The United States is currently emphasizing the necessity of preparing qualified scientists and engineers. This emphasis is fueled by the global competition for cutting edge technology. This increased awareness of the need for engineers in America has spurred the recent development of pre-college hybrid programs. These hybrid programs infuse the laboratory skills needed to build with the academic skills needed to envision and design. Various programs are aiming to prepare students to succeed through the inclusion of mathematic and scientific concepts that are used in engineering. Numerous options are available for students to explore the many disciplines of engineering and technology.

With the recent development of pre-college engineering programs, there is a need to gather information to continue their early success. Coordinators of these hybrid programs have been trained in certain areas, but they lack the expertise in combining

vocational and general education aspects. This is particularly true in the development and utilization of PLTW partnership teams. The idea of any type of advisory committee is new to general educators, and partnership teams are unique from vocational advisory committees. A Delphi research study is suggested by experts in gathering information on issues that lack historical data or are new and complex problems. A Delphi study involves the identification of a panel of experts. Effective panels include stakeholders, experts, and facilitators. Through 3-4 rounds of response and feedback, these experts anonymously collaborate to form a conclusion. This process is deemed successful if consensus is reached along with the conclusion.

CHAPTER III

METHODOLOGY

Identifying the Experts

In order to gather accurate and useful information, the correct experts needed to be identified and included in the study. Contacting Project Lead The Way (PLTW) officials was the logical source for information concerning PLTW programs. This contact provided the names and contact information of the state leaders for all affiliated states. The state leaders are the connection to the local PLTW programs. They are also the most knowledgeable concerning the quality of local PLTW programs and their partnership teams. Their program recommendations were the starting point to identify participants in this study.

Contacting the State Leaders

With the contact information that the PLTW officials provided, the process of contacting each state leader began. The first method of contact was a generic e-mail sent to each state leader. The e-mail explained the purpose and problem statement of the study and introduced the researchers (see Appendix A). It explained that the study was being conducted to gather and analyze data relating to local partnership teams of individual PLTW programs from across the country. It also emphasized that their input and local knowledge would be greatly appreciated and necessary in gaining further knowledge concerning the development of future successful partnership teams. The results of the study were offered as incentive to become involved. The introduction of

the researchers was included to provide the state leader with a contact in case of questions, comments, or any other needs. This also attempted to create a working connection between the state leaders and the researchers.

Identifying Top Programs

In the contact e-mail to the state leaders, it was asked that the programs with the top 2-3 partnership teams in each respective state be recommended. The question was worded as follows: Please rank-order the top 2-3 local PLTW partnership teams in your state. The state leaders were then prompted to send a reply e-mail containing the names and contact information of the coordinators of these partnership teams. The reply from the state leader was taken as the recommendation of top leadership teams.

Reducing to a Manageable Number

Because the study was given a list of top programs from each state across the country, there was the possibility of a large amount of program recommendations. Linstone and Turoff (1975) and Winzenried (1997) recommend that Delphi studies of as few as fifteen expert participants can provide valid conclusions. Adhering to this recommendation, this study identified 14-19 programs. To refine the total number given, the first 17 responses from the state leaders were taken into the study. Two respondents after this number were taken and retained as alternate participants.

Contacting the Experts

All communication with the participants was made through e-mail. The initial e-mail commenced by informing the potential participant that they had been identified by their respective state leader as the coordinator of an excellent program and more specifically, for managing an effective partnership team (see Appendix A). An introduction to the study, an explanation of the study, and a short introduction of the researchers and their contact information was provided. This communication was meant to serve as an explanation of the duration and purpose of the study. The participants were also informed that the information provided would be greatly appreciated, and that the results of the study would be made available to them. It invited the reader to send a reply e-mail indicating their status and willingness in participating in the study.

The First Delphi Round

The initial question to the expert needed to be open-ended enough to provide each participant the freedom to express his or her ideas; however, the answers needed to be focused enough to be analyzed and categorized into general areas. Considering these limitations, there were two questions. The first question was: Please list the top 3-5 practices that your leadership team does to make your PLTW program successful. The second question was: Please list the top 3-5 practices that you, as the coordinator of a leadership team, do to make your leadership team successful. These questions were piloted to ensure that they elicited the desired responses. Because of the lack of local PLTW programs, local vocational programs were used to pilot the instrument. The coordinators of five local advisory committees participated. After reviewing the results

from the pilot, and determining the pilot a success, the instrument was prepared to be sent to the study participants.

The e-mail explained that this was the first of three to four rounds that would be conducted in completing this Delphi study. The questions, as previously specified, were then given (see Appendix A). The experts were prompted to outline some of their ideas, and answer the questions as fully as possible. It was recommended that each question be given some thought and collaboration.

The first round contact also served as a tool to gather the demographics of the programs and schools studied. Generic questions were asked, such as How many students attend your school? What is the population of the city in which the school is located? What state is your school located in? and Is your school public, private, charter or another type? Questions more specific to this study were also asked, such as What is the estimated number of students enrolled in your Project Lead The Way program this year? Is your program PLTW certified? How many teachers are in your program? What is the estimated percentage of males and females enrolled in your program? and What is the estimated percentage of minorities enrolled in your program?

Participants were then invited to send this information in a reply e-mail to the address provided. They were thanked for their time and asked to wait for the second Delphi round.

The responses received from the participants were printed and analyzed on an individual basis. This process was a qualitative analysis. The main goal of the initial analysis was to summarize and categorize the two sets of 3-5 responses given by each participant. The responses were coded to fit into categories. Although the answers from

the participants varied, each response was placed into a category among similar statements. This task of categorizing was performed by a team of researchers. For example, if two different participants described the type of members that serve on their committee, these responses were coded into the same category.

The next step was to tally the number of responses falling into each statement category. All responses were included in the count. This information was analyzed and tallied to create a rank-ordered list of the top partnership team practices and the top coordinator practices, as identified by the experts. These lists were organized and labeled to be included in the second contact e-mail.

The demographics information was also gathered and organized. This information was retained for future use as a gauge to identify the diversity of the sampled participants. This information was also used to describe the participants and the environmental context of each respective program.

The Second Delphi Round

The second e-mail was a follow-up question created through the combination of the answers given, as described above. This e-mail (see Appendix A) thanked the participants for their involvement in the first round of the study. The rank-ordered list of partnership team practices and coordinator practices was then given. The e-mail proceeded to explain how the list was formulated. It described that through the analysis and combination of all the answers given by the participants, the following answers were found to be the most common as rank ordered. It explained that the list is rank ordered from the most commonly mentioned responses, down to the least commonly mentioned

responses. At this point the participants were asked to review the list. Next to each practice on each list, the participants were asked to place one of the following responses: SD, D, N, A, or SA. These responses were associated with a Likert scale, ranging from "strongly disagree" to "strongly agree." The participants were asked to indicate one of these responses next to each practice. Participants were also given the freedom to add new items to the lists. Two new items were added to the first list. These new items were marked with an asterisk in the e-mails and in the data analysis.

Participants were again directed to send this information in a reply e-mail to the address given. They were thanked for their additional time and asked to wait for the third Delphi round needed for the study.

The information received from the second contact e-mail required quantitative analysis. The e-mail replies were again printed and analyzed. The analysis involved coding the Likert scale as follows: "strongly disagree" as a 1, "disagree" as a 2, "neutral" as a 3, "agree" as a 4, and "strongly agree" as a 5. Each practice was tallied to find the mean and the standard deviation of each item on the respective lists. The mean change in rank order in each respective list was calculated. These numbers provided insight into the importance of each item and the amount of consensus among the participants. Items with tying mean scores were ranked according to the ranking from the previous round. Items with a higher previous round ranking were placed before items with a lower previous ranking. This process involved finding the absolute value of the number of rankings each item moved along the list from the previous round to the current round list. The mean of the movement for each item on both lists was then calculated. This number indicated the amount of consensus for the position of the items on the each rank-

ordered list. The components added to each list were also taken into account. These responses were added to the bottom of the lists in the third round's e-mail. The combination of these numbers was used to create two new rank-ordered lists of the practices of partnership teams and the practices of the coordinators. These new lists were organized and labeled to be included in the third contact e-mail.

The Third Delphi Round

The third communication with the experts (see Appendix A) began by thanking them for their involvement in the study up to this point. The e-mail explained how the new lists of partnership team practices and coordinator practices had been formulated. They were given the lists and asked to review them once again. They were then directed to follow the same instructions given in the previous e-mail. After their review of the list, participants were asked to indicate their response to each practice according to their own opinion. Participants were once again given the freedom to add items to the lists. No new items were added in the third round.

Participants were again invited to send this information in a reply e-mail to the address given. They were thanked for their additional time and asked to watch for the possible fourth e-mail needed for the study. They were thanked for their continued commitment and valuable input.

The information received from the third contact e-mail was gathered to compile the next lists. The e-mail replies were again printed and analyzed. The analysis involved coding the Likert responses as was described for the second round data. The mean and standard deviation were again calculated. The responses were tallied to determine the

new rank-ordered lists of practices. The indicator of the movement of each items' ranking in each respective list was again calculated. This process involved finding the absolute value of the number of rankings each item moved along the list from the previous round to the current round list. The mean of the movement for each item on both lists was then calculated. It was decided that practices on the list that received only strongly disagree or disagree responses were removed from the list for the fourth round. No practices were removed due to this criterion.

The Fourth Delphi Round

This round followed the exact same format as the third round e-mail (see Appendix A), with the fourth round labels. At the conclusion of this e-mail, it was indicated that this would be the final round. It informed the participants that their input was appreciated and that the results would be made available to them, their state leaders, and PLTW.

The treatment of the fourth round data was identical to the processes used in the treatment of the third round. At this juncture, the mean change in rank order had moved very little from the previous round. The same was true of the standard deviation on each respective list. This indicated to the researchers that little or no more consensus would be reached. The fourth round was the final.

The Treatment of the Overall Data

Though the final list was likely of the greatest importance, all of the information gathered throughout the study was considered. The processes previously detailed were

once again employed in finding the mean scores, the mean rank order change, and the standard deviation. The purpose of this was to uncover any significant trends and patterns that occurred throughout the progression of the study. While detailing the outcomes of the research, the comparison of the initial information and the final list was also necessary.

The concluding step was to write detailed results of the study. The lists were organized, and the mean and standard deviations were calculated. The practices on the two lists were accompanied by the statistics gathered throughout the collaboration of the participants. This final information was provided along with the demographics of the participants. The diversity of the participants was noted and described. This was helpful in describing the results and defending the practicality of the information gathered. It also aided readers in determining their utilization of the information. The results were made available to PLTW, the involved state leaders, and the participants of the study.

CHAPTER IV

PRESENTATION OF DATA

Introduction

The purpose of this study was to determine effective practices in the development and utilization of Project Lead The Way (PLTW) partnership teams. This was fulfilled by posing two questions to a panel of identified experts who manage PLTW programs and partnership teams. The first question was: What are the top 3-5 practices that your partnership team does to make your PLTW program successful? The second question was: What are the top 3-5 practices that you, as the coordinator of a partnership team, do to make your leadership team successful? The panel of experts refined each list through a series of three additional rounds of input and feedback, for four rounds. The first round prompted the expert participants to provide 3-5 practices for each question. These practices were categorized with similar responses to create two rank ordered lists that were based upon the frequency of responses assigned to each category. The categories were then referred to as items throughout the study. The following rounds involved the rating of each item using a Likert scale. The mean, standard deviation, and the mean each item changed in rank order, were calculated for rounds two through four. The combined data was reported and showed each round and the changes that occurred.

Participant Demographics

The participants were asked to provide demographic information (see Appendix A) in the first round. This information was gathered in order to describe the characteristics of the schools and the PLTW programs represented by each participant. This data was intended to answer any questions concerning the nature and diversity of the PLTW programs represented in this study. To gain general information, the participants were asked how many students attended their school, the type of area where their school was located, and the type of school. To gain information more specific to PLTW programs, participants were asked to provide information concerning the number of students enrolled in their program, program PLTW certification status, number of PLTW teachers in the program, percentage of males and females enrolled in the program, and the percentage of minorities enrolled in the program. Table 1 summarizes the responses to the demographic questions. The data returned for the number of students that attended each school had the following approximate distribution: a range of 550-2800 students, and a mean of 1388 students. Six participants were from a rural area, five participants were from a suburban area, and six participants were from an urban area. All seventeen participants were from public schools, with none at private or charter schools. The distribution for the number of PLTW students enrolled in each program had the following characteristics: a range of 55-650 students and a mean of 177 students. Fifteen participants were from

locations of the participants had the following distribution: a mean of 3.65 teachers with a standard deviation of 2.67, and a median of 3 teachers with an IQR of 2. The questions regarding female and minority populations in the PLTW programs requested responses

Table 1

Participants Demographic Information

Participant	Total Students	Area	State	School	PLTW Teachers	Certification Status	PLTW Students	Female %	Minority %
1	550	S	UT	Public	2	N	55	30	10
2	1500	U	SC	Public	9	Y	650	20	30
3	2400	U	ID	Public	2	Y	230	2	9.5
4	702	R	KY	Public	1	Y	165	17	15
5	1100	R	IN	Public	3	Y	100	5	3
6	3100	S	SC	Public	4	Y	240	18	5
7	1067	U	IN	Public	3	Y	200	35	50
8	2800	R	IN	Public	3	Y	119	13	6
9	672	R	KY	Public	4	Y	196	18	1
10	1000	U	OH	Public	2	Y	120	35	15
11	400	R	NY	Public	2	Y	75	10	1
12	1200	S	MN	Public	2	Y	110	9	15
13	750	S	OK	Public	5	Y	125	16	10
14	2680	U	OK	Public	11	Y	411	20	25
15	1312	S	IN	Public	5	Y	112	25	1
16	960	R	AR	Public	2	N	50	2	0
17	1400	U	ME	Public	2	Y	48	13	1
$\bar{x}$	1388	-	-	-	3.65	-	177	16.94	11.62

Note. In the Area column, "R" = rural area, "S" = suburban area, and "U" = urban area.

in the format of percentages. The percentage of female students in the PLTW programs of the participants had the following distribution: a range of 2-35% and a mean of 16.94%. The percentage of minority students in the PLTW programs of the participants had the following distribution: a range of 0-50% and a mean of 11.62%.

Effective Practices Lists

Round One

The expert participants were e-mailed in the first round, which included the two questions aforementioned (see Appendix A). The 3-5 responses (see Appendix B) from

each participant were categorized with similar responses and given a representative title. Table 2 shows the category titles, each item's rank order, and the frequency of the responses within the category for list one. Table 3 shows the same data for question two. In the following rounds, participants were allowed to add additional items to the original lists. The two items which were added in round two are included in the list for question two and are marked with an asterisk.

Table 2

Round One List of Items for Question One: Effective Practices That Partnership Teams Do to Make PLTW Programs Successful

Item Rank	Category Title	Frequency
1	Arrange and provide guest speakers	8
2	Arrange field trips and tours	7
3	Evaluate and critique student work and competitions	7
4	Meet to plan, develop, and evaluate the program	7
5	Provide internships and summer training	6
6	Provide mentorship and career counseling for students	6
7	Provide "real-world" industry insight, trends, and knowledge	5
8	Provide job shadowing opportunities	4
9	Assist in recruiting through involvement of middle schools	3
10	Assist in recruiting through communication with the community	3
11	Assist in recruiting through open houses and parent information nights	3
12	Lobby for and provide funds from state and local sources	3
13	Provide opportunities to highlight student successes	3
14	Provide and assist with acquiring equipment donations	3
15	Organize teamwork activities as part of the curriculum	2
16	Provide support and mentors for FIRST robotics	2
17	Serve as general advocate for the program when dealing with school board, administration, and community	2
18	Assist with inclusion of minorities and females	1
19	Assist with PLTW certification application	1
20	Establishment of an e-mail list serve for communication	1
21	Enables the program to operate under one CTE director (administrator)	1
22	Hosts an engineering day in March and invite industry leaders	1

Table 3

Round One List of Items for Question Two: Effective Practices That Partnership Team Coordinators Do to Make PLTW Partnership Teams Successful

Item Rank	Category Title	Frequency
1	Establish and maintain communication with partnership team members concerning all facets of the program (e.g., meetings, open houses, successes, etc.)	7
2	Provide detailed agenda of short and long term needs/goals to everyone ahead of time	5
3	Provide welcoming atmosphere with food	5
4	Organize opportunities for partnership team members to become involved in classroom activities	4
5	Schedule regular meeting dates and time well in advance	4
6	Strategically invite individuals to become team members who fulfill needs of the program	4
7	Encourage partnership team members to be involved with other community groups to promote the program	3
8	Establish goals and expectations for the partnership team and see that they are met	3
9	Include partnership team members in the planning and implementation of all aspects of the program	3
10	Limit the number of meetings and keep them on schedule	3
11	Provide information regarding the district's mission, the program's status, and future needs	3
12	Utilize partnership team's input and provide feedback as to resulting changes	3
13	Collaborate with department PLTW teachers to establish an agenda	2
14	Encourage partnership team members to mentor competitive teams (e.g., FIRST robotics)	2
15	Inform members of program needs	2
16	Invite partnership team members to attend student presentations	
17	Record the minutes of meetings	2
18	Encourage partnership team to develop relationships with suppliers and potential employers	1
19	Expand and refresh the partnership team each year to create a large local network	1
20	Focus each partnership team meeting on one PLTW course	1
21	Enlist partnership team members to evaluate the scope and sequence of the curriculum	1
22	Invite student representatives to attend partnership team meetings	1
23	Utilize the partnership team in evaluationg the program as it relates to industry and college or university programs	1
24	Utilize two representatives from each partnering business and assign specific responsibilities to each -- one assists in meeting and curriculum issues; the other assists with financial needs, internships, and major decisions	1
25	Utilize local newspapers and radio to communicate program events and successes	1
26*	Show the Partnership team this list	1
27*	Subcommittees are directed to report on their progress toward current goals	1

Rounds Two, Three, and Four

The procedure in rounds 2-4 was identical. The rank-ordered lists from the previous round were sent back to the participants. The participants were directed (see Appendix A) to rate each item on both lists. The participants were requested to consider the items on each list from a global perspective. It was asked that the items be analyzednot for one specific program, but as generalized items for all PLTW programs. A Likert-scale rating system was used with the options of strongly disagree, disagree, neutral, agree, or strongly agree. These responses were correlated to the numbers 1-5, with strongly disagree represented with the number one, and strongly agree as number five. To rank order the items, the mean score was used. Table 4 shows the mean score and the item rankings for question one in rounds 2-4. Items with equal mean scores were organized according to their ranking from the previous round. To illustrate movement toward consensus among the expert participants, two measures were calculated for each item on list one. Table 5 shows the mean each item changed in rank order between rounds 2-4, and the standard deviation of each item in rounds 2-4. The procedure used for list one (question one) was also used for list two (question two). Table 6 shows the mean score and the item's ranking in rounds 2-4. Table 7 shows the mean each item changed in rank

order between rounds 2-4, and the standard deviation of each item in rounds 2-4. The item numbers in tables 4-7 are the original item rankings.

Table 4

Ranking Measures for List One: Effective Practices That Partnership Teams Do to Make PLTW Programs Successful

	Mean Score			Item Ranking		
Item No.	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
1	4.31	4.53	4.53	7	6	3
2	4.56	4.59	4.47	3	4	5
3	4.50	4.18	4.29	4	12	11
4	4.63	4.35	4.35	1	7	9
5	4.06	4.18	4.47	12	14	6
6	4.25	4.24	4.29	10	11	10
7	4.63	4.88	4.77	2	1	1
8	4.31	4.69	4.77	8	3	2
9	3.81	4.00	3.94	16	17	17
10	4.00	4.35	4.41	13	8	7
11	3.88	4.00	3.77	15	16	18
12	3.69	3.94	4.00	19	18	16
13	3.94	4.29	4.24	14	10	12
14	4.31	4.29	4.18	9	9	14
15	3.50	3.88	3.71	21	19	20
16	3.81	4.06	4.18	17	15	15
17	4.50	4.77	4.47	5	2	4
18	4.50	4.53	4.35	6	5	8
19	4.19	4.18	4.24	11	13	13
20	3.56	3.59	3.77	20	21	19
21	3.73	3.44	3.47	18	22	22
22	3.47	3.77	3.71	22	20	21

Final Results

The final rank-ordered lists are shown in Table 8 and Table 9, respectively. The mean score determined the rank of each item. Each table contains the category titles, the final item ranking, and the item's mean score.

Table 5

Consensus Measures for List One: Effective Practices That Partnership Teams Do to Make PLTW Programs Successful

	Ranking Change			Standard Deviation		
Item No.	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
1	6	1	3	0.793	0.514	0.514
2	1	1	1	0.629	0.507	0.468
3	1	8	1	1.200	1.286	0.920
4	3	6	2	0.500	1.057	1.115
5	7	2	8	0.998	0.883	0.624
6	4	1	1	0.577	0.831	0.772
7	5	1	0	0.619	0.332	0.562
8	0	5	1	0.873	0.479	0.437
9	7	1	0	1.223	1.000	1.144
10	3	5	1	1.033	0.786	0.795
11	4	1	2	1.088	1.000	1.250
12	7	1	2	1.195	1.028	0.935
13	1	4	2	0.998	0.772	0.752
14	5	0	5	1.078	0.772	0.809
15	6	2	1	1.095	1.053	1.160
16	1	2	0	1.276	0.998	1.074
17	12	3	2	0.817	0.562	0.717
18	12	1	3	0.894	0.780	0.786
19	8	2	0	0.981	0.809	0.664
20	0	1	2	1.530	1.176	1.200
21	3	4	0	1.280	1.315	1.125
22	0	2	1	1.187	1.091	1.047
	$\bar{x} = 4.36$	$\bar{x} = 2.46$	$\bar{x} = 1.73$			

Number of Participants

Round one included the responses from all 17 expert participants. Round two included responses from 16 expert participants. One participant's response was received after the deadline and after the next round e-mail had already been sent out. Items 21 and 22 on the first list for question one reported fifteen responses due to miscommunication. Round three included responses from 17 expert participants. Items eight, seventeen, and eighteen, have 16 responses due to miscommunication. Round 4 included the responses from all 17 expert participants on each item.

Table 6

Ranking Measures for List Two: Effective Practices That Partnership Team Coordinators Do to Make PLTW Partnership Teams Successful

	Mean Score			Item Ranking		
Item No.	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
1	4.81	4.76	4.71	2	3	4
2	4.69	4.71	4.65	4	4	5
3	4.38	4.12	4.06	12	19	20
4	4.44	4.59	4.47	8	9	11
5	4.81	4.94	4.82	3	1	1
6	4.94	4.88	4.82	1	2	2
7	4.00	3.82	3.77	21	22	22
8	4.44	4.06	4.35	9	20	16
9	4.06	4.12	4.17	19	18	18
10	4.56	4.71	4.65	6	5	6
11	4.44	4.38	4.47	10	12	14
12	4.50	4.65	4.59	7	8	8
13	4.25	4.59	4.71	17	10	12
14	4.06	4.19	4.10	20	16	19
15	4.38	4.71	4.82	13	6	3
16	4.63	4.65	4.59	5	7	7
17	4.31	4.47	4.47	16	11	13
18	3.81	3.88	4.00	22	21	21
19	4.38	4.29	4.53	14	14	9
20	2.38	2.82	2.94	25	27	27
21	3.31	3.71	3.59	23	23	23
22	4.34	4.24	4.53	15	15	10
23	4.44	4.29	4.47	11	13	15
24	3.06	2.82	3.12	24	26	26
25	4.25	4.18	3.24	18	17	17
26*	-	3.41	3.47	-	25	25
27*	-	3.59	3.59	-	24	24

Table 7

Consensus Measures for List Two: Effective Practices That Partnership Team Coordinators Do to Make PLTW Partnership Teams Successful

	Ranking Change			Standard Deviation		
Item No.	Round 2	Round 3	Round 4	Round 3	Round 4	Round 5
1	1	1	1	0.544	0.752	0.588
2	2	0	1	0.479	0.470	0.493
3	9	7	1	0.806	0.858	0.827
4	4	1	2	0.814	0.712	0.800
5	2	2	0	0.403	0.243	0.393
6	5	1	0	0.250	0.332	0.393
7	14	1	0	1.095	0.951	1.147
8	1	11	4	0.629	0.827	0.862
9	10	1	0	1.063	0.781	0.883
10	4	1	1	0.629	0.470	0.786
11	1	2	2	0.629	0.719	0.624
12	5	1	0	0.516	0.493	0.507
13	4	7	2	0.683	0.507	0.588
14	6	4	3	0.929	0.981	0.899
15	2	7	3	0.885	0.470	0.393
16	11	2	0	0.500	0.493	0.712
17	1	5	2	0.873	0.624	0.624
18	4	1	0	0.981	1.054	1.120
19	5	0	5	0.885	0.920	0.515
20	5	2	0	0.806	1.185	1.300
21	2	0	0	1.250	0.920	1.420
22	7	0	5	0.806	0.903	0.717
23	12	2	2	0.727	0.849	0.624
24	0	2	0	1.124	1.237	1.320
25	7	1	0	1.125	1.015	0.752
26*	-	1	0	-	1.228	1.231
27*	-	3	0	-	1.176	1.176
	$\bar{x} = 4.96$	$\bar{x} = 2.44$	$\bar{x} = 1.26$			

Table 8

Final Rank Ordered List for Question One: Effective Practices That Partnership Teams Do to Make PLTW Programs Successful

Item Rank	Category Title	Mean Score
1	Provide "real-world" industry insight, trends, and knowledge	4.77
2	Provide job shadowing opportunities	4.77
3	Arrange and provide guest speakers	4.53
4	Serve as general advocate for the program when dealing with school board, administration, and community	4.47
5	Arrange field trips and tours	4.47
6	Provide internships and summer training	4.47
7	Assist in recruiting through communication with the community	4.41
8	Assist with inclusion of minorities and females	4.35
9	Meet to plan, develop, and evaluate the program	4.35
10	Provide mentorship and career counseling for students	4.29
11	Evaluate and critique student work and competitions	4.29
12	Provide opportunities to highlight student successes	4.24
13	Assist with PLTW certification application	4.24
14	Provide and assist with acquiring equipment donations	4.18
15	Provide support and mentors for FIRST robotics	4.18
16	Lobby for and provide funds from state and local sources	4.00
17	Assist in recruiting through involvement of middle schools	3.94
18	Assist in recruiting through open houses and parent information nights	3.76
19	Establishment of an e-mail list serve for communication	3.77
20	Organize teamwork activities as part of the curriculum	3.71
21	Hosts an engineering day in March and invite industry leaders	3.71
22	Enables the program to operate under one CTE director (administrator)	3.47

Table 9

Final Rank Ordered List for Question Two: Effective Practices That Partnership Team Coordinators Do to Make PLTW Partnership Teams Successful

Item Rank	Category Title	Mean Score
1	Schedule regular meeting dates and time well in advance	4.82
2	Strategically invite individuals to become team members who fulfill needs of the program	4.82
3	Inform members of program needs	4.82
4	Establish and maintain communication with partnership team members concerning all facets of the program (e.g., meetings, open houses, successes, etc.)	4.71
5	Provide detailed agenda of short and long term needs/goals to everyone ahead of time	4.65
6	Limit the number of meetings and keep them on schedule	4.65
7	Invite partnership team members to attend student presentations	4.59
8	Utilize partnership team's input and provide feedback as to resulting changes	4.59
9	Expand and refresh the partnership team each year to create a large local network	4.53
10	Invite student representatives to attend partnership team meetings	4.53
11	Organize opportunities for partnership team members to become involved in classroom activities	4.47
12	Collaborate with department PLTW teachers to establish an agenda	4.47
13	Record the minutes of meetings	4.47
14	Provide information regarding the district's mission, the program's status, and future needs	4.47
15	Utilize the partnership team in evaluating the program as it relates to industry and college or university programs	4.47
16	Establish goals and expectations for the partnership team and see that they are met	4.35
17	Utilize local newspapers and radio to communicate program events and successes	4.24
18	Include partnership team members in the planning and implementation of all aspects of the program	4.18
19	Encourage partnership team members to mentor competitive teams (e.g., FIRST robotics)	4.06
20	Provide welcoming atmosphere with food	4.06
21	Encourage partnership team to develop relationships with suppliers and potential employers	4.00
22	Encourage partnership team members to be involved with other community groups to promote the program	3.76
23	Enlist partnership team members to evaluate the scope and sequence of the curriculum	3.59
24	Subcommittees are directed to report on their progress toward current goals	3.59

(table continues)

25	Show the partnership team this list	3.47
26	Utilize two representatives from each partnering business and assign specific responsibilities to each -- one assists in meeting and curriculum issues; the other assists with financial needs, internships, and major decisions	3.12
27	Focus each partnership team meeting on one PLTW course	2.94

Presentation of Data Summary

The participant demographics illustrated an array of experts. There were 17 expert participants from 11 states. While all participants represented public schools, there was a wide range in the amount of students, type of area, PLTW students, and PLTW teachers. Fifteen participants represented certified PLTW programs and two did not. The percentage of female and minority students in the represented PLTW programs varied from 0% to 50%.

In round one, the participants responded to two questions. These responses were categorized into similar groups. These categories were then called items. The items on both lists were rank ordered based upon the frequency. These lists were then sent back to the participants.

Rounds 2-4 shared the same procedure. The e-mail sent to the participants asked that items on each list for questions one and two be rated. A Likert scale was used to rate each item. The participants then returned their responses. The lists were then re-rank ordered based upon the mean score given from all the participants. Measures to gauge consensus were also calculated. The measures used were standard deviation and the mean rank change of each item from round to round.

Following round four, the final lists for questions one and two were formulated.

The list for question one included 22 total items, while the list for question two included 27 total items.

CHAPTER V

ANALYSIS OF DATA AND RECOMMENDATIONS

Introduction

The purpose of this study was to determine effective practices in the development and utilization of Project Lead The Way (PLTW) partnership teams. Two questions were developed to achieve this purpose. The first question was: What are the top 3-5 practices that your partnership team does to make your PLTW program successful? The second question was: What are the top 3-5 practices that you, as the coordinator of a partnership team, do to make your leadership team successful? These questions were posed to a panel of identified experts who manage PLTW programs and partnership teams. The first round prompted the expert participants to provide 3-5 practices for each question. The panel of experts identified top practices for each question. These practices were categorized with similar responses to create two rank ordered lists which were based upon the frequency of responses assigned to each category. The expert participants then refined the lists through a series of three additional rounds of input and feedback, for a total of four rounds. Marshall (1984) indicated that three rounds of feedback are sufficient, as more rounds will not produce greater consensus. The following rounds involved the rating of each item using a Likert scale. The mean, standard deviation, and the mean each item changed in rank order, were calculated for rounds two through four. The data developed in the final round was interpreted to formulate the final list for questions one and two.

Participant Demographics

As previously stated in the literature review, there are several key components in compiling a successful panel of experts for a Delphi study. The number of participants, the types of participants, and the process used in selecting the participants must be considered. The suggestions set forth by researchers in the field of Delphi studies are closely paralleled in this study.

Wicklein (1993) suggested that the number of expert participants included in a Delphi should be between 15 and 20. This study included 17 participants and two alternate participants.

In selecting the types of participants, Scheele (1975) indicated there are three types of participants that create a successful panel. The first type is stakeholders who will be directly involved with the final decisions. The second type is experts who have relevant knowledge and understanding in the respective area. The third is facilitators who provide organization and clarification to the process. The participants in this study were stakeholders who hold positions that involve decision making and future outcomes of the partnership teams. The participants had direct knowledge pertaining to the implementation and development of partnership teams. Martino (1983) and Wicklein (1993) proposed that the preferred method of selecting Delphi panelists is through the nomination of peers and supervisors who are representative of the area of study. The process utilized in identifying the panelists for this study involved contacting state supervisors of PLTW programs. These supervisors were asked to recommend coordinators of outstanding PLTW programs and partnership teams. The participants

were also facilitators in the creation and adjustment of policies and procedures employed in fulfilling the purposes of a partnership team. Based on the review of literature, the panel utilized in this study fits the criterion of an excellent panel.

According to Wicklein (1993), experts are most commonly chosen for their areas of expertise. Other factors such as demographics should be considered secondary or even excluded. In selecting the expert participants for this study, the demographics were regarded as secondary. The demographics of the participants and the programs they represented were considered only after the completion of the study. The intention of the demographic information was to answer possible inquiries concerning the diversity of the expert panel.

It was hoped that the panel would be diverse. An even representation from rural, suburban, and urban areas would have been ideal. Programs with large and small numbers of students were desired. It would also have been ideal to include participation of experts from programs with a range of minority representation from across the country. A wide range of female representation was also considered ideal. These ideals would maximize the opportunity to generalize the results of the study to other PLTW programs.

The findings of the expert panel's demographics are illustrated in Table 10. The number of students that attended each school had the following approximate distribution: a range of 550-2800 students and a mean of 1388 students. Six participants represented a rural area, five represented a suburban area, and six represented an urban area. All seventeen participants' programs were in public schools, with none in private or charter schools. The distribution for the number of PLTW students enrolled in each program

Table 10

Participants Demographic Information

Participant	Total Students	Area	State	School	PLTW Teachers	Certification Status	PLTW Students	Female %	Minority %
1	550	S	UT	Public	2	N	55	30	10
2	1500	U	SC	Public	9	Y	650	20	30
3	2400	U	ID	Public	2	Y	230	2	9.5
4	702	R	KY	Public	1	Y	165	17	15
5	1100	R	IN	Public	3	Y	100	5	3
6	3100	S	SC	Public	4	Y	240	18	5
7	1067	U	IN	Public	3	Y	200	35	50
8	2800	R	IN	Public	3	Y	119	13	6
9	672	R	KY	Public	4	Y	196	18	1
10	1000	U	OH	Public	2	Y	120	35	15
11	400	R	NY	Public	2	Y	75	10	1
12	1200	S	MN	Public	2	Y	110	9	15
13	750	S	OK	Public	5	Y	125	16	10
14	2680	U	OK	Public	11	Y	411	20	25
15	1312	S	IN	Public	5	Y	112	25	1
16	960	R	AR	Public	2	N	50	2	0
17	1400	U	ME	Public	2	Y	48	13	1
$\bar{x}$	1388	-	-	-	3.65	-	177	16.94	11.62

Note. In the Area column, "R" = rural area, "S" = suburban area, and "U" = urban area.

had the following characteristics: a range of 55-650 students and a mean of 177 students. Fifteen participants were from PLTW certified programs and two were not. The number of PLTW teachers had the following distribution: a mean of 3.65 teachers with a standard deviation of 2.67, a median of 3 teachers, and an Inter-Quartile Range (IQR) of 2. Two programs stated nine and eleven PLTW teachers respectively. The median and IQR were included in describing the number of teachers in each program to account for these two outlying responses. The percentage of female students in the PLTW programs had the following distribution: a range of 2-35% and a mean of 16.94%. The percentage of minority students in the PLTW programs of the participants had the following distribution: a range of 0-50% and a mean of 11.62%.

The demographics data was adequate in describing the programs which the participants represented. The results illustrate diversity among the participants' PLTW programs. Because the panel is representative of the range of PLTW programs across the country, generalization of the results of this study was legitimate. Furthermore, according to the review of literature, the panel of experts utilized in this study was capable of achieving valid results.

Final Analysis

Martino (1983) considered the amount of consensus among the panel to be the primary measure of success of Delphi studies. As the consensus among the participants increases, so does the validity of the results. In gauging consensus among the participants in this study, two measures were employed. The first was to measure the change in rank order of each item between rounds. The second was the standard deviation of each item.

Question One/List One

The list created from question one is shown in Table 11. The table includes the original item rank, the category title, and the frequency of the response. The consensus measures for each item are shown in Table 12. The ranking change was calculated by taking the absolute value of the change in each item in order from the previous round to the current round. The mean change for each item in rank order was then calculated for

Table 11

Round One List of Items for Question One: Effective Practices That Partnership Teams Do to Make PLTW Programs Successful

Item Rank	Category Title	Frequency
1	Arrange and provide guest speakers	8
2	Arrange field trips and tours	7
3	Evaluate and critique student work and competitions	7
4	Meet to plan, develop, and evaluate the program	7
5	Provide internships and summer training	6
6	Provide mentorship and career counseling for students	6
7	Provide "real-world" industry insight, trends, and knowledge	5
8	Provide job shadowing opportunities	4
9	Assist in recruiting through involvement of middle schools	3
10	Assist in recruiting through communication with the community	3
11	Assist in recruiting through open houses and parent information nights	3
12	Lobby for and provide funds from state and local sources	3
13	Provide opportunities to highlight student successes	3
14	Provide and assist with acquiring equipment donations	3
15	Organize teamwork activities as part of the curriculum	2
16	Provide support and mentors for FIRST robotics	2
17	Serve as general advocate for the program when dealing with school board, administration, and community	2
18	Assist with inclusion of minorities and females	1
19	Assist with PLTW certification application	1
20	Establishment of an e-mail list serve for communication	1
21	Enables the program to operate under one CTE director (administrator)	1
22	Hosts an engineering day in March and invite industry leaders	1

each round. The mean ranking change of the items from round one to round two was 4.36. Items 1, 5, 9, 12, 15, 17, 18, and 19 changed in ranking by more than five places. The questioning format changed from round one to round two. In rounds 2-4, the participants were directed (see Appendix A) to rate each item on both lists from a global perspective. It was asked that the items be analyzed not for one specific program, but as generalized items for all PLTW programs. The mean change between rounds two and three was reduced by approximately two rankings down to 2.46. Only items 3 and 4 changed in ranking by more than five places. In the last round, the mean ranking change from the previous round changed by less than one ranking down to 1.73. Only one item, item 5, changed in rank order by more than five places. Twelve of the 22 items changed

in rank order by one or less ranking. The mean ranking change of items in rounds 2-4 shows a noticeable trend toward consensus concerning the item rankings on list one. The standard deviation, which was calculated as another measure of consensus among the participants, is shown in Table 12. The standard deviation was chosen rather than the Inter-Quartile Range (IQR). The reason for this was that the concept of a Delphi differs from other types of survey methods. The foundation of a Delphi study is the panel of experts. The purpose of a Delphi is to achieve results that are agreed upon by the panel who are chosen for their expertise. Because of this process of selection and expertise, the opinion of each member on the panel is valued and taken into account. Unlike the process in a Delphi study, a typical survey seeks to gather opinions and ideas from a large, randomized group. The background and knowledge of the subjects is relatively unknown. For this reason, it is important to discount the outlying responses in a survey. If there are strong opinions in a Delphi study, these opinions should not be ignored. These strong opinions from selected experts may be ideal in creating new ideas and innovations. In explaining the applications of a Delphi study, Martino (1983) mentions that circumstances that have no historical information or data are ideal for an expert panel. The innovations of one expert may not be discovered if discounted. The IQR is successful in minimizing the effects of outliers and strong opinions; however, in the case of a Delphi study that uses a Likert scale, these strong opinions are valued. For this reason it was decided that IQR was not conducive to the purpose of a Delphi study, and the standard deviation was utilized in measuring the spread in the distribution of individual responses.

Table 12

Consensus Measures for List One: Effective Practices That Partnership Teams Do to Make PLTW Programs Successful

	Ranking Change			Standard Deviation		
Item No.	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
1	6	1	3	0.793	0.514	0.514
2	1	1	1	0.629	0.507	0.468
3	1	8	1	1.200	1.286	0.920
4	3	6	2	0.500	1.057	1.115
5	7	2	8	0.998	0.883	0.624
6	4	1	1	0.577	0.831	0.772
7	5	1	0	0.619	0.332	0.562
8	0	5	1	0.873	0.479	0.437
9	7	1	0	1.223	1.000	1.144
10	3	5	1	1.033	0.786	0.795
11	4	1	2	1.088	1.000	1.250
12	7	1	2	1.195	1.028	0.935
13	1	4	2	0.998	0.772	0.752
14	5	0	5	1.078	0.772	0.809
15	6	2	1	1.095	1.053	1.160
16	1	2	0	1.276	0.998	1.074
17	12	3	2	0.817	0.562	0.717
18	12	1	3	0.894	0.780	0.786
19	8	2	0	0.981	0.809	0.664
20	0	1	2	1.530	1.176	1.200
21	3	4	0	1.280	1.315	1.125
22	0	2	1	1.187	1.091	1.047
	$\bar{x} = 4.36$	$\bar{x} = 2.46$	$\bar{x} = 1.73$			

The standard deviation of the responses for each item on list one typically decreased from round two to round four. The standard deviation increased slightly from round two to round four in items 4, 6, 11, and 15. Each of these items ended with a lower ranking than they began with: item 4 ended at nine, item 6 ended at ten, item 11 ended at eighteen, and item 15 ended at twenty.

It is notable that the upper-ranked items generally had lower standard deviations than the lower-ranked items. To demonstrate the difference in standard deviations

between upper items and lower items, the mean standard deviation of the upper third was calculated and compared to the mean standard deviation of the lower third. The mean of the standard deviations of the upper seven (~1/3) items on the final list for question one was .59. The mean of the standard deviations of the lower seven (~1/3) items on the final list for question one was 1.12. The items in the upper group that received strong support also received greater consensus. Greater consensus signals validity in implementing these practices.

Final Analysis of Question One/List One

When answering the research question of this study, a question was posed to a panel of experts that asked them to list top practices that a partnership team does to make a PLTW program successful. The final rank ordered list in response to question one is shown in Table 13.

Martino (1983) noted, "Delphi sequences are judged as successes when they reach stability…" (p. 19). Scheibe et al. (1975) also agreed that stability is the ultimate goal in achieving consensus. Scheibe et al. explained dissatisfaction in measuring consensus by stating, "Measures of this sort do not take full advantage of the information available in the distributions" (p. 277). A method that measures consensus through the stability of a list was preferred in this study. For this reason, the primary measure of consensus was the mean of the rank order changes.

According to the mean rank order change in the final round, the items on this list had a $\pm$ 1.73 rankings. The validity of list one is solidified by the consistent movement

Table 13

Final Rank Ordered List for Question One: Effective Practices That Partnership Teams Do to Make PLTW Programs Successful

Item Rank	Category Title	Mean Score
1	Provide "real-world" industry insight, trends, and knowledge	4.77
2	Provide job shadowing opportunities	4.77
3	Arrange and provide guest speakers	4.53
4	Serve as general advocate for the program when dealing with school board, administration, and community	4.47
5	Arrange field trips and tours	4.47
6	Provide internships and summer training	4.47
7	Assist in recruiting through communication with the community	4.41
8	Assist with inclusion of minorities and females	4.35
9	Meet to plan, develop, and evaluate the program	4.35
10	Provide mentorship and career counseling for students	4.29
11	Evaluate and critique student work and competitions	4.29
12	Provide opportunities to highlight student successes	4.24
13	Assist with PLTW certification application	4.24
14	Provide and assist with acquiring equipment donations	4.18
15	Provide support and mentors for FIRST robotics	4.18
16	Lobby for and provide funds from state and local sources	4.00
17	Assist in recruiting through involvement of middle schools	3.94
18	Assist in recruiting through open houses and parent information nights	3.76
19	Establishment of an e-mail list serve for communication	3.77
20	Organize teamwork activities as part of the curriculum	3.71
21	Hosts an engineering day in March and invite industry leaders	3.71
22	Enables the program to operate under one CTE director (administrator)	3.47

toward consensus. The mean rank order change began at 4.36, moved to 2.46 in round three, and came to rest at 1.73 in the final round. This low number of item movement between rounds illustrates a strong degree of stability. The overall stability of list one matched with the quality of the panel of experts used in this study, make the items and their respective rank orders valid. These results should be generalized to most PLTW programs in developing and utilizing partnership teams.

On the Likert scale used in this study, a score of five represented "strongly agree,"a score of four represented "agree," and a score of three represented "neutral." A score of 4.5 would represent response between "agree" and "strongly agree." Items 1-6 on the final rank ordered list (see Table 13) for question one had mean scores which fell between 5 and approximately 4.5 (4.47). As indicated by the exceptionally high mean scores, these items should be very seriously considered by PLTW programs seeking to develop and utilize partnership teams. A score between 4.5 and 4 would equate to being above "agree" but lower than "strongly agree." Items 7-16 had mean scores which fell between 4 and 4.41. These items should also be seriously considered by PLTW programs. A score between 4 and 3.5 would equate to being above "neutral" but below "agree." The remaining items, 17-22, had mean scores between 4 and approximately 3.5 (3.47). These items should be considered by PLTW programs as well. No item on the list for question one had a mean score below "neutral," indicating that no item was rated negatively by the panel of experts.

Implications for PLTW Programs

Many items on list one were rated high by the panel of experts but the top two items were very important. A natural break occurred between the top two items and the

following items on list one. This natural break was large (.24) in comparison to the difference (.05) between items three and four. Considering the statistical importance placed on items one and two, PLTW programs should seek to implement these items through a partnership team. Partnership teams should provide "real-world" industry insight, trends, and knowledge. Partnership teams should also provide job-shadowing opportunities. These practices have been identified and agreed upon as the top items utilized by partnership teams in creating a successful PLTW program.

The list developed from question one also provides, from the perspective of the panel of experts, many of the purposes of a partnership team. Programs can target areas of improvement through the implementation of effective practices utilized by partnership teams. In analyzing list one, three themes became apparent as purposes of a partnership team: providing engineering career insight, integrating the PLTW program into the community, and providing support for competitions.

According to the ratings given to the items, these items may be the most important to consider. Six items are ranked in the top ten in providing engineering career insight. The top-ranked item (by tie)—provide “real world” industry insight, trends, and knowledge—had a mean score of 4.77. Programs attempting to understand the current state of the industry should consider this item. The second top-ranked item (by tie)—provide job shadowing opportunities—also had the very high mean score of 4.77. This item should be considered in providing students with career insight. Another advantage of partnership teams as identified by the panel of experts is for the team to arrange and provide guest speakers. This item ranked third, with a mean score of 4.53. The following considerable items also abide by this theme:

- Arrange field trips and tours (rk. 5, $\bar{x} = 4.47$)
- Provide internships and summer training (rk. 6, $\bar{x} = 4.47$)
- Provide mentorship and career counseling for students (rk. 10, $\bar{x} = 4.29$)

A second theme which emerged from list one was to integrate a PLTW program into the community. This theme contained the largest amount of responses. Eight of the 22 items on list one followed this theme. Two of these items were ranked in the top ten. While the items following this theme are considerable, the mean scores indicate that they may be less important than the items following the first theme. The fourth-ranked item serves as a general advocate when dealing with school board, administration, and community and may be very helpful in guiding a partnership team towards integrating the program into the community. This item had a mean score of 4.47, indicating the panel of expert's support for this item. Another item that was ranked in the top ten had a final ranking of seventh, with a mean score or 4.41. This item—assist in recruiting through communication with the community—may be helpful in gaining community support in recruiting new students for the program. Item 12 may assist in providing positive relations between a PLTW program and the community. Item 12, with a mean score of 4.24, suggests that providing opportunities to highlight student successes is important. Many other purposes of a partnership team exist that may be helpful in integrating a PLTW program into the community:

- Provide and assist with acquiring equipment donations (rk. 14, $\bar{x} = 4.18$)
- Lobby for and provide funds from state and local sources (rk. 16, $\bar{x} = 4.00$)
- Assist in recruiting through involvement in middle schools (rk. 17, $\bar{x} = 3.94$)

- Assist in recruiting through open houses and parent information nights (rk. 18, $\bar{x}$ = 3.76)
- Host an engineering day and invite industry leaders (rk. 21, $\bar{x}$ = 3.71)

The third theme which emerged from list one was for partnership teams to provide support for competitions. This theme included two items, item 11 and item 15. The volume and mean scores indicate that these items may be less important than the items following the other themes in list one. Item 11—evaluate and critique student work and competitions—had a mean score of 4.29. This may be a consideration for partnership teams attempting to gain support for locally based student competitions. Item 15 ($\bar{x}$ = 4.18)—provide support and mentors for FIRST robotics—indicates the importance of support for competitive student activities. The items on list one are especially important in providing guidance to programs and in fulfilling the purposes of a partnership team.

Question Two/List Two

Table 14 shows the original item rankings, the category titles, and the frequency of the responses for list two (question two). The consensus measures for list two are shown in Table 15. As done for list one, the rank order change measure was again created by taking the absolute value of the number of rankings that each item changed from the previous round to the current round. These numbers were then used to calculate the mean each item changed in ranking. The mean rank order change of the items from round one to round two was 4.96. Items 3, 7, 9, 14, 16, 22, 23, and 25 changed in

Table 14

Round One List of Items for Question Two: Effective Practices That Partnership Team Coordinators Do to Make PLTW Partnership Teams Successful

Item Rank	Category Title	Frequency
1	Establish and maintain communication with partnership team members concerning all facets of the program (e.g., meetings, open houses, successes, etc.)	7
2	Provide detailed agenda of short and long term needs/goals to everyone ahead of time	5
3	Provide welcoming atmosphere with food	5
4	Organize opportunities for partnership team members to become involved in classroom activities	4
5	Schedule regular meeting dates and time well in advance	4
6	Strategically invite individuals to become team members who fulfill needs of the program	4
7	Encourage partnership team members to be involved with other community groups to promote the program	3
8	Establish goals and expectations for the partnership team and see that they are met	3
9	Include partnership team members in the planning and implementation of all aspects of the program	3
10	Limit the number of meetings and keep them on schedule	3
11	Provide information regarding the district's mission, the program's status, and future needs	3
12	Utilize partnership team's input and provide feedback as to resulting changes	3
13	Collaborate with department PLTW teachers to establish an agenda	2
14	Encourage partnership team members to mentor competitive teams (e.g., FIRST robotics)	2
15	Inform members of program needs	2
16	Invite partnership team members to attend student presentations	
17	Record the minutes of meetings	2
18	Encourage partnership team to develop relationships with suppliers and potential employers	1
19	Expand and refresh the partnership team each year to create a large local network	1
20	Focus each partnership team meeting on one PLTW course	1
21	Enlist partnership team members to evaluate the scope and sequence of the curriculum	1
22	Invite student representatives to attend partnership team meetings	1
23	Utilize the partnership team in evaluating the program as it relates to industry and college or university programs	1
24	Utilize two representatives from each partnering business and assign specific responsibilities to each – one assists in meeting and curriculum issues; the other assists with financial needs, internships, and major decisions	1
25	Utilize local newspapers and radio to communicate program events and successes	1
26*	Show the Partnership team this list	1
27*	Subcommittees are directed to report on their progress toward current goals	1

Table 15

Consensus Measures for List Two: Effective Practices That Partnership Team Coordinators Do to Make PLTW Partnership Teams Successful

	Ranking Change			Standard Deviation		
Item No.	Round 2	Round 3	Round 4	Round 3	Round 4	Round 5
1	1	1	1	0.544	0.752	0.588
2	2	0	1	0.479	0.470	0.493
3	9	7	1	0.806	0.858	0.827
4	4	1	2	0.814	0.712	0.800
5	2	2	0	0.403	0.243	0.393
6	5	1	0	0.250	0.332	0.393
7	14	1	0	1.095	0.951	1.147
8	1	11	4	0.629	0.827	0.862
9	10	1	0	1.063	0.781	0.883
10	4	1	1	0.629	0.470	0.786
11	1	2	2	0.629	0.719	0.624
12	5	1	0	0.516	0.493	0.507
13	4	7	2	0.683	0.507	0.588
14	6	4	3	0.929	0.981	0.899
15	2	7	3	0.885	0.470	0.393
16	11	2	0	0.500	0.493	0.712
17	1	5	2	0.873	0.624	0.624
18	4	1	0	0.981	1.054	1.120
19	5	0	5	0.885	0.920	0.515
20	5	2	0	0.806	1.185	1.300
21	2	0	0	1.250	0.920	1.420
22	7	0	5	0.806	0.903	0.717
23	12	2	2	0.727	0.849	0.624
24	0	2	0	1.124	1.237	1.320
25	7	1	0	1.125	1.015	0.752
26*	-	1	0	-	1.228	1.231
27*	-	3	0	-	1.176	1.176
	$\bar{x} = 4.96$	$\bar{x} = 2.44$	$\bar{x} = 1.26$			

ranking by more than five places. It was not possible to calculate the mean rank order change for items 26 and 27 between rounds one and two b they were not added to list two until round two. The mean change between rounds two and three was cut almost in half, to 2.44. Only

items 3 and 4 changed in ranking by more than five places between rounds two and three. The mean rank order change from round three to four was reduced to 1.26. In the final round, no items changed in ranking by more than five places. Seventeen of the twenty-seven items changed in rank order by one place or less. The mean rank order change of items in rounds 2-4 steadily decreases toward consensus concerning the item rankings on list two.

The standard deviation of most of the responses for each item on list two decreased from round two to round four. As was the case with list one from question one, the ranking of the items which had increasing standard deviations was low. The mean of the standard deviations of the top nine (1/3) items on the final list for question two was .53, as opposed to the bottom nine (1/3) items, which was 1.16. Most of these items ended with a lower ranking than they began. The increased standard deviation of these items from round two to round four was less than .25 in all but item 20.

Final Analysis of Question Two/List Two

In answering the research question of this study, a second question was posed to a panel of experts which asked them to list top practices that a coordinator of a partnership team does to make a partnership team successful. The final list of items formulated by the panel of experts is shown in Table 16.

According to the mean rank order change in the final round, the items on this list ranked at ± 1.26 rankings. The validity of list two is solidified by the consistent movement toward consensus. The mean rank order change began at 4.96, moved to 2.44 in round three, and concluded at 1.26 in the final round. The overall stability of list two is apparent in the lack of movement of items in the final round. As with list one for question one, the overall stability of list two for question two, along with the quality of the panel of experts used in this study, make the results valid. The rank order of the items on this list is stable. These results should be generalized to most PLTW programs. The items on this list should be considered when PLTW programs attempt to develop and utilize partnership teams.

Items 1-15 on the final rank ordered list (see Table 16) for question two had mean scores which were between 5 and approximately 4.5 (4.47). This mean score indicated the panel's high confidence in these items. These items should be very seriously considered by PLTW programs seeking to develop and utilize partnership teams. Items 16-21 had mean scores which were between 4.5 and 4. While the panel did not score these items as high as items 1-15, a mean score in this range still indicates the panel's confidence in these items. These items should also be seriously considered by PLTW programs. Items 22-26 had mean scores below "agree" but above "neutral." This mean score indicated that these items should still be considered by PLTW programs. The final item on list two had a mean score of 2.94. This item was essentially rated as a "neutral" item. While this item may not be useful in most programs, it may be helpful in certain situations.

Table 16

Final Rank Ordered List for Question Two: Effective Practices That Partnership Team Coordinators Do to Make PLTW Partnership Teams Successful

Item Rank	Category Title	Mean Score
1	Schedule regular meeting dates and time well in advance	4.82
2	Strategically invite individuals to become team members who fulfill needs of the program	4.82
3	Inform members of program needs	4.82
4	Establish and maintain communication with partnership team members concerning all facets of the program (e.g., meetings, open houses, successes, etc.)	4.71
5	Provide detailed agenda of short and long term needs/goals to everyone ahead of time	4.65
6	Limit the number of meetings and keep them on schedule	4.65
7	Invite partnership team members to attend student presentations	4.59
8	Utilize partnership team's input and provide feedback as to resulting changes	4.59
9	Expand and refresh the partnership team each year to create a large local network	4.53
10	Invite student representatives to attend partnership team meetings	4.53
11	Organize opportunities for partnership team members to become involved in classroom activities	4.47
12	Collaborate with department PLTW teachers to establish an agenda	4.47
13	Record the minutes of meetings	4.47
14	Provide information regarding the district's mission, the program's status, and future needs	4.47
15	Utilize the partnership team in evaluating the program as it relates to industry and college or university programs	4.47
16	Establish goals and expectations for the partnership team and see that they are met	4.35
17	Utilize local newspapers and radio to communicate program events and successes	4.24
18	Include partnership team members in the planning and implementation of all aspects of the program	4.18
19	Encourage partnership team members to mentor competitive teams (e.g., FIRST robotics)	4.06
20	Provide welcoming atmosphere with food	4.06
21	Encourage partnership team to develop relationships with suppliers and potential employers	4.00
22	Encourage partnership team members to be involved with other community groups to promote the program	3.76
23	Enlist partnership team members to evaluate the scope and sequence of the curriculum	3.59

(table continues)

24	Subcommittees are directed to report on their progress toward current goals	3.59
25	Show the partnership team this list	3.47
26	Utilize two representatives from each partnering business and assign specific responsibilities to each – one assists in meeting and curriculum issues; the other assists with financial needs, internships, and major decisions	3.12
27	Focus each partnership team meeting on one PLTW course	2.94

Implications for PLTW Partnership Team Coordinators

While list two contains important insight, these items should be considered secondary to the items on list one. A partnership team should attempt to provide assistance in achieving excellence within the PLTW program. The practices related to achieving program success are primary, while the practices utilized by partnership team coordinators are secondary, existing in the aid of the primary purpose.

Apparent themes which emerged in list one were not so clearly identifiable in list two. What is very apparent is the sheer number of very highly rated items. The top ten items on the final list rated 4.82 to 4.53. This indicates that a majority of the members of the panel of experts "strongly agreed" with the top ten items as contributing to the success of a partnership team. No item was ranked below 4 until item 22 ($\bar{x}$ = 3.76). Twenty-one of the 27 items are ranked as either "agree" or "strongly agree." With the exception of the few bottom-ranked items, every item on list two should be contemplated and many should be implemented. Even the lowest-ranked items should be contemplated, though they may only be applicable in certain situations. At minimum, according to the mean score statistics, coordinators should schedule regular meeting dates and times well in advance (rk. 1, $\bar{x}$ = 4.82), strategically invite individuals who

fulfill the needs of the program to become team members (rk. 2, $\bar{x}$ = 4.82), and inform members of program needs (rk. 3, $\bar{x}$ = 4.82). The item rank order change for the final round indicates that coordinators of successful PLTW programs agree that these items are extremely important practices in creating a successful partnership team.

Recommendations for Future Research

The following recommendations for future research were suggested:

1. Research the future effectiveness of the lists compiled for the two questions in this study.
2. Assess the current status of PLTW partnership teams.
3. Perform a similar modified Delphi study for vocational education advisory Committees.

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APPENDICES

Appendix A

E-mails to Supervisors and Participants

E-mail to State Supervisors

State PLTW supervisor,

My name is Cody Reutzel. Through the support of Project Lead The Way (PLTW) I am conducting a study at Utah State University concerning PLTW partnership teams (advisory committees). The problem of this study is to identify the best practices in the development and utilization of partnership teams within PLTW programs. These practices will be identified through experts in the field using a Delphi technique. The experts will be teachers identified by state supervisors who are coordinating excellent PLTW leadership teams.

To assist in identifying these experts your name was referred to me by Dick Blais at PLTW. Could you please send me a reply e-mail with the names and contact information of the coordinators of, what you believe to be, the top 2-3 local PLTW partnership teams in your state. Please rank-order this list. At the conclusion of this study, the information gathered would be made available to you and the individual participants. Your opinion is extremely important in identifying experts in this area. It is also important as it will assist other PLTW programs in developing effective partnership teams. You may also find it helpful in gaining new ideas and in identifying "best practices" used by other experts. Thank you very much for your valuable time. Please send a reply e-mail to the following address: c.j.reutzel@aggiemail.usu.edu

Cody Reutzel
Utah State University
c.j.reutzel@aggiemail.usu.edu

Initial Contact E-mail to Participants

Project Lead The Way educator,

My name is Cody Reutzel. Through the support of Project Lead The Way (PLTW) I am conducting a study at Utah State University concerning PLTW partnership teams (advisory committees). The problem of this study is to identify the best practices in the development and utilization of partnership teams within PLTW programs. These practices will be identified through experts in the field using a Delphi technique. You have been identified by your state supervisor as a coordinator of an excellent PLTW program and more specifically orchestrating and managing an effective partnership team.

This process will include the development of an initial list and description of best practices as identified by experts in the field, and 2-3 rounds of revisions to refine this list and hopefully develop consensus among the experts. There will be a total of 3-4 e-mail contacts required. This study is projected to begin in January and conclude in April. The time investment for you would be less than thirty minutes for each round of input. At the conclusion of this study, the information gathered would be made available to you, your state supervisor, and PLTW.

Your participation in this study is important as it will assist other PLTW programs in developing effective partnership teams. You may also find it helpful in gaining new ideas and "best practices" used by other experts. If you would be willing to participate in this study, please reply to this message indicating so. Thank you very much for your valuable time.

Cody Reutzel
Utah State University
c.j.reutzel@aggiemail.usu.edu

Round One E-mail

PLTW Partnership Team Coordinator-

This is the first of three to four rounds included in this study. Please provide the following demographic information and then proceed to answer the two study questions. It is recommended that these questions be given some thought and possible collaboration. The following rounds should take much less time. This information should be sent back in a reply e-mail to this address.

Name:
Number of students attending your school:
Is the city where your school located considered rural, suburban, or urban:
State your school is located in:
Is your school public, private, charter or other:
Estimated number of students enrolled in your PLTW program this year:
Is your program PLTW certified:
Number of PLTW teachers in your program:
Estimated percentage of males and females enrolled in your program:
Estimated percentage of minorities enrolled in your program:

Using bullets, please respond to the following questions (brief explanations and descriptions are helpful):

1. Please list the top 3-5 practices that your partnership team does to make your program successful.

2. Please list the top 3-5 practices that you, as the coordinator of a partnership team, do to make your partnership team successful.

Example responses:

- *We contact local business leaders to gain donations.*
    - *Our committee contacts leaders and provides a rationale for why they should donate to the program.*
- *We invite key members from industry and feeder schools.*

Please send your reply and watch for the next round (e-mail). Thanks again for your valuable time and input.

Cody Reutzel
c.j.reutzel@aggiemail.usu.edu
Utah State University

Round Two E-mail

PLTW Partnership Team Coordinator-

Thank you for your participation to this point. The following are the lists of responses received for the two questions in the previous round (e-mail). Responses to both questions were categorized and placed with similar responses. The frequency of each type of response was then recorded to create the rank ordered lists.

Please review and consider the items on each list from a generic perspective. Because some items may not fit your specific location, we are interested in your opinion of each item's value from a global perspective. Please indicate your opinion of each item by placing one of the following codes next to each item: "SD" for strongly disagree, "D" for disagree, "N" for neutral, "A" for agree, or "SA" strongly agree. After considering the list, you may also add new items to the lists. Please send this information back in a reply e-mail.

For example:

- The food at my last STI was spectacular D
- The PLTW curriculum is well organized SA

List One - Practices that your partnership team does to make your program successful.

- Arrange and provide guest speakers
- Arrange field trips and tours
- Evaluate and critique student work and competitions
- Meet to plan, develop, and evaluate the program
- Provide internships and summer training
- Provide mentorship and career counseling for students
- Provide "real-world" industry insight, trends, and knowledge
- Provide job shadowing opportunities
- Assist in recruiting through involvement of middle schools
- Assist in recruiting through communication with the community
- Assist in recruiting through open houses and parent information nights

- Lobby for and provide funds from state and local sources
- Provide opportunities to highlight student successes
- Provide and assist with acquiring equipment donations
- Organize teamwork activities as part of the curriculum
- Provide support and mentors for FIRST robotics
- Serves as general advocate for the program when dealing with school board, administration, and community
- Assist with inclusion of minorities, and females
- Assist with PLTW certification application
- Establishment of an e-mail list serve for communication
- Enables the program to operate under one CTE director (administrator)
- Hosts an engineering day in March and invite industry leaders

List Two - Practices that you, as the coordinator of a partnership team, do to make your partnership team successful.

- Establish and maintain communication with partnership team members concerning all facets of the program (e.g., meetings, open houses, successes, etc.)
- Provide detailed agenda of short and long term needs/goals to everyone ahead of time
- Provide welcoming atmosphere with food
- Organize opportunities for partnership team members to become involved in classroom activities
- Schedule regular meeting dates and time well in advance
- Strategically invite individuals to become team members who fulfill needs of the program

- Encourage partnership team members to be involved with other community groups to promote the program
- Establish goals and expectations for the partnership team and see that they are met
- Include partnership team members in the planning and implementation of all aspects of the program
- Limit the number of meetings and keep them on schedule
- Provide information regarding the district's mission, the program's status, and future needs
- Utilize partnership team's input and provide feedback as to resulting changes
- Collaborate with department PLTW teachers to establish an agenda
- Encourage partnership team members to mentor competitive teams (e.g., FIRST robotics)
- Inform members of program needs
- Invite partnership team members to attend student presentations
- Record the minutes of the meetings
- Encourage partnership team to develop relationships with suppliers and potential employers
- Expand and refresh the partnership team each year to create a large local network
- Focus each partnership team meeting on one PLTW course
- Enlist partnership team members to evaluate the scope and sequence of the curriculum
- Invite student representatives to attend partnership team meetings

- Utilize the partnership team in evaluating the program as it relates to industry and college or university programs
- Utilize two representatives from each partnering business and assign specific responsibilities to each – one assists in meeting and curriculum issues; the other assists with financial needs, internships, and major decisions
- Utilize local newspapers and radio to communicate program events and successes

Round Three E-mail

PLTW Partnership Team Coordinator-

Thank you for your participation to this point. The following are the new lists created from your responses in the previous round (e-mail). The lists were rank ordered according to the mean score of each item. This was done by converting the Likert data: SD, D, N, A, and SA into a scale from 1-5. The items with the highest mean scores were placed at the top of the list and the lowest at the bottom. The very bottom items which are marked with, "*", are items which were added to the list during the previous round.

Please review and consider the items on each list as it pertains to a wide audience (other PLTW programs). At this point we are attempting to build consensus among the experts (you), on the top practices for each category. Please indicate your opinion of each item by placing one of the following codes next to each item: "SD" for strongly disagree, "D" for disagree, "N" for neutral, "A" for agree, or "SA" strongly agree. After considering the list, you may also add new items to the lists. Please send this information back in a reply e-mail as soon as possible.

Note: After attending the ITEA conference in Salt Lake City, PLTW administrators indicated a very high interest in the data you are providing. Keep up the good work!

For example:

- The food at my last STI was spectacular D
- The PLTW curriculum is well organized SA

List One - Practices that your partnership team does to make your program successful.

- Meet to plan, develop, and evaluate the program
- Provide "real-world" industry insight, trends, and knowledge
- Arrange field trips and tours
- Evaluate and critique student work and competitions
- Serves as general advocate for the program when dealing with school board, administration, and community
- Assist with inclusion of minorities, and females
- Arrange and provide guest speakers

- Provide job shadowing opportunities
- Provide and assist with acquiring equipment donations
- Provide mentorship and career counseling for students
- Assist with PLTW certification application
- Provide internships and summer training
- Assist in recruiting through communication with the community
- Provide opportunities to highlight student successes
- Assist in recruiting through open houses and parent information nights
- Assist in recruiting through involvement of middle schools
- Provide support and mentors for FIRST robotics
- Enables the program to operate under one CTE director (administrator)
- Lobby for and provide funds from state and local sources
- Establishment of an e-mail list serve for communication
- Organize teamwork activities as part of the curriculum
- Hosts an engineering day in March and invite industry leaders

List Two - Practices that you, as the coordinator of a partnership team, do to make your partnership team successful.

- Strategically invite individuals to become team members who fulfill needs of the program
- Establish and maintain communication with partnership team members concerning all facets of the program (e.g., meetings, open houses, successes, etc.)
- Schedule regular meeting dates and time well in advance
- Provide detailed agenda of short and long term needs/goals to everyone ahead of time

- Invite partnership team members to attend student presentations
- Limit the number of meetings and keep them on schedule
- Utilize partnership team's input and provide feedback as to resulting changes
- Organize opportunities for partnership team members to become involved in classroom activities
- Establish goals and expectations for the partnership team and see that they are met
- Provide information regarding the district's mission, the program's status, and future needs
- Utilize the partnership team in evaluating the program as it relates to industry and college or university programs
- Provide welcoming atmosphere with food
- Inform members of program needs
- Expand and refresh the partnership team each year to create a large local network
- Invite student representatives to attend partnership team meetings
- Record the minutes of the meetings
- Collaborate with department PLTW teachers to establish an agenda
- Utilize local newspapers and radio to communicate program events and successes
- Include partnership team members in the planning and implementation of all aspects of the program
- Encourage partnership team members to mentor competitive teams (e.g., FIRST robotics)

- Encourage partnership team members to be involved with other community groups to promote the program
- Encourage partnership team to develop relationships with suppliers and potential employers
- Enlist partnership team members to evaluate the scope and sequence of the curriculum
- Utilize two representatives from each partnering business and assign specific responsibilities to each – one assists in meeting and curriculum issues; the other assists with financial needs, internships, and major decisions
- Focus each partnership team meeting on one PLTW course
- *Show the Partnership team this list
- *Subcommittees are directed to report on their progress toward current goals

Round Four E-mail

PLTW Partnership Team Coordinator-

Thank you for your participation to this point. *This will likely be the final round*. The following are the new lists created from your responses in the previous round (e-mail). The lists were again, rank ordered according to the mean score of each item. This was done by converting the Likert data: SD, D, N, A, and SA into a scale from 1-5. The items with the highest mean scores were placed at the top of the list and the lowest at the bottom. There were no items added in the previous round.

Please review and consider the items on each list as it pertains to a wide audience (other PLTW programs). At this point we are attempting to build final consensus among the experts (you), on the top practices for each category. Please indicate your opinion of each item by placing one of the following codes next to each item: "SD" for strongly disagree, "D" for disagree, "N" for neutral, "A" for agree, or "SA" strongly agree. Please send this information back in a reply e-mail as soon as possible.

For example:

- The food at my last STI was spectacular D
- The PLTW curriculum is well organized SA

List One - Practices that your partnership team does to make your program successful.

- Provide "real-world" industry insight, trends, and knowledge
- Serves as general advocate for the program when dealing with school board, administration, and community
- Provide job shadowing opportunities
- Arrange field trips and tours
- Assist with inclusion of minorities, and females
- Arrange and provide guest speakers
- Meet to plan, develop, and evaluate the program
- Assist in recruiting through communication with the community
- Provide and assist with acquiring equipment donations

- Provide opportunities to highlight student successes
- Provide mentorship and career counseling for students
- Evaluate and critique student work and competitions
- Assist with PLTW certification application
- Provide internships and summer training
- Provide support and mentors for FIRST robotics
- Assist in recruiting through open houses and parent information nights
- Assist in recruiting through involvement of middle schools
- Lobby for and provide funds from state and local sources
- Organize teamwork activities as part of the curriculum
- Hosts an engineering day in March and invite industry leaders
- Establishment of an e-mail list serve for communication
- Enables the program to operate under one CTE director (administrator)

List Two - Practices that you, as the coordinator of a partnership team, do to make your partnership team successful.

- Schedule regular meeting dates and time well in advance
- Strategically invite individuals to become team members who fulfill needs of the program
- Establish and maintain communication with partnership team members concerning all facets of the program (e.g., meetings, open houses, successes, etc.)
- Provide detailed agenda of short and long term needs/goals to everyone ahead of time
- Limit the number of meetings and keep them on schedule

- Inform members of program needs
- Invite partnership team members to attend student presentations
- Utilize partnership team's input and provide feedback as to resulting changes
- Organize opportunities for partnership team members to become involved in classroom activities
- Collaborate with department PLTW teachers to establish an agenda
- Record the minutes of the meetings
- Provide information regarding the district's mission, the program's status, and future needs
- Utilize the partnership team in evaluating the program as it relates to industry and college or university programs
- Expand and refresh the partnership team each year to create a large local network
- Invite student representatives to attend partnership team meetings
- Encourage partnership team members to mentor competitive teams (e.g., FIRST robotics)
- Utilize local newspapers and radio to communicate program events and successes
- Include partnership team members in the planning and implementation of all aspects of the program
- Provide welcoming atmosphere with food
- Establish goals and expectations for the partnership team and see that they are met

- Encourage partnership team to develop relationships with suppliers and potential employers
- Encourage partnership team members to be involved with other community groups to promote the program
- Enlist partnership team members to evaluate the scope and sequence of the curriculum
- Subcommittees are directed to report on their progress toward current goals
- Show the Partnership team this list
- Utilize two representatives from each partnering business and assign specific responsibilities to each – one assists in meeting and curriculum issues; the other assists with financial needs, internships, and major decisions
- Focus each partnership team meeting on one PLTW course

Appendix B

First Round Responses

All Responses Received for Question One

1. Please list the top 3-5 practices that your partnership team does to make your program successful.

- We meet quarterly as a region of 10 schools and one partnership team - board of directors
- We operate under one CTE director
- We have an email list serve for communication
- We publish a news letter quarterly highlighting student projects / activities and PT involvement in our school programs
- We highlight one aspect of our PLTW program with students from a different high school presenting at each meeting
- We meet quarterly
- We set short term goals for the program
- We host an engineering day in March each year to see results and invite industry leaders (TIMA – Trigg Industrial Managers Association)
- Student interaction: provide shadow-day opportunities, guest speakers, visit classrooms to evaluate student work. Many of our partnership team members participate on panels that evaluate final presentations in CEA and EDD.
- Created a non-profit foundation to raise money for program and obtain donations to the foundation. These donation help fund competitions, equipment, research, etc for the engineering students and faculty
- Lobbies for state funding for the program in the school district CTE Council
- Send the PLTW teachers to our three middle schools to promote PLTW
- Bring all 8th grade students to the Career Center for a tour and explanation of programs
- Provide a parent information night for 8th grade, 9th grade, and 10th grade parents
- Send letters to all 8th, 9th, 10th, 11th grade students and parents explaining programs
- Community partners allow their employees to volunteer as speakers, judges and evaluators
- Community partners assist with recruitment activities
- Partners volunteer with competitions i.e. planning, consulting, evaluating
- Rally community support for equipment funding and donate much needed equipment
- Provide grant sources and assist with grant applications by providing letters of support.
- Arrange student field trips
- Provide advice concerning college education programs, professional organizations, scholarships, summer programs, etc
- Increase enrollment as a result of a well informed partnership team communicating with students and community members
- The partnership team will address weak areas in the program and bring it to the attention of the responsible individual(s)

- Open Communication With Students
- Assist With Critiquing Student Work
- Provide Mentorship Opportunities
- Presentations To Classes
- Support When Dealing With Board of Education
- We meet on a regular basis to discuss curriculum, projects, awards, and business trends. We also have set up some small business work with them prototyping parts for their companies and teaching students about intellectual property rights, ordering/shipping, proofing, etc. The businesses also intern our students either for paid positions, or by allowing them to shadow engineers in the company. We are always brining them into the labs to see what the students have done. We also have an agreement that a new company to our program will have access to calling an existing partner to find out about the program, it's successes, and how it is mutually beneficial
- Members of our partnership team have an "open facility," allowing any time field trips
- PT members come in to give lessons in their specialty discipline.
- PT members have set up communications within their plant to offer students opportunities to learn from machinists and technicians
- Review the curriculum to identify topics that new engineers struggle with ie over tolerance of parts, communication/team skills and provide valuable real word examples to the different topics covered in class
- Presented to the school board to inform community about the importance of the program in preparing needed engineers
- Provided tours of different companies facilities (Toro, ADC, Seagate, AmericanColor, Hennepin Technical College). The tours have been both during the day and at night with the goal of showing different manufacturing processes. Tours were given by a variety of engineers allowing questions to be asked and showing the different aspects of being an engineer
- Visited the classes to provide personal input on specific topics and answer general questions about being an engineer
- Started a job shadowing program which offers the opportunity to students to go even further with job exploration
- Attend 2 or 3 advisory committee meeting a year
- Universities partners -attend college night - Engineering Fairs
- High schools - participate in open houses for prospective students and parents
- Businesses - Arrange field trips
- All - Serve as judges for engineer contests
- All - Serve as guest speakers
- Advise & assists in planning, development & evaluation of program
- Provides up-to-date and futuristic changes in technology employment & training needs, equipment needs, and instructional material
- An advocate of the program
- Provide guest speakers and allows industry/business tours
- Mentors/EDD students
- Assist in certification application

- Assist in establishing corp. partnerships for student internships, funding, donations, guest speakers
- Sounding board for PLTW teachers (ideas, direction, encouragement, etc.)
- Professional Panel for EDD presentations
- Assist with student recruiting
- Partner with local businesses for student internships
- Have former students come speak about their collegiate engineering programs
- Guest speakers from College and University Engineering programs
- Guest Engineers help students see the importance of taking PLTW courses in high school
- Aligned PLTW courses we offer to support our FIRST Robotics team
- Gives specific input of needs of local industry
- Makes opportunities available for job training in summer
- Gives voice to concerns about inclusion of the immigrant population and gender equity
- Emphasis on actual skills in business, such as quality control and communication
- We believe our educational/business partnership will create successful students. As an engineering partnership, our primary focus is fostering an educational climate which encourages positive growth and development for students who choose engineering and engineering technology as a career goal. Our partnership will devote a great deal of time to helping students make appropriate decisions which lead them to successful life choices. We believe in sound data collection to guide our partnership practices, in rigorous curriculum which will lead students to a chosen engineering career pathway, and to sound marketing strategies to celebrate our successes and encourage students to reach their full potential
- Middle School Awareness: Students need to be engaged in math and science activities that will develop the preparatory skills necessary to enter into an engineering career
- Arranges site visits for students to see industry at work
- Arranges teamwork activities to teach teamwork and quality control standards
- C-Progressive contact with students from 9^{th} to 12^{th} grade
    - 9^{th} grade teamwork activitiy
    - 10^{th} grade site visit
    - 11^{th} grade job shadow experience
- 4-12^{th} grade competitive internship opportunities
- Provide mentors and resource support for FIRST Robotics program

All Responses Received for Question Two

2. Please list the top 3-5 practices that you, as the coordinator of a partnership team, do to make your advisory committee successful.

- I communicate often with business and industry in our area asking them for help judging student competitions for example – I believe giving them any kind of duty helps them to feel involved
- I participate in other local organizations that they participate in – The local Purdue Club for example… I am on the board of directors for this club with two key members of our partnership team
- I lead a discussion on PLTW re-certification at each PT meeting – focusing on best practices
- I get together with area PLTW teachers for breakfast outside of the PT meeting to discuss meeting agenda
- I run a school based business where we rapid prototype parts for local business and industry and discuss this with the CIM class – this frequently brings engineers into our building
- I host all meetings and act as the secretary in each meeting
- I email all members and the newspaper/radio about good things that happen in the program
- I make sure the goals are met
- Schedule regular meetings – 4 or 5 times a year
- Keep in contact with all members via email about meetings, program accomplishments, and invitations to participate in program activities (student final presentations, OPEN houses, summer camps, etc.)
- Each year, recruit new members for the partnership team to expand and refresh the team. As the years have progressed we have been able to touch many local professionals who work at many different firms. This has expanded our network of internship positions for students, professionals to mentor our students, and potential sources for donations
- Get committee members involved in the classes
- Get the committee members evaluate scope and sequence of curriculum
- Have the committee evaluate the program as related to industry and post-secondary educational programs
- Advisory committee members communicate with other like groups in the community to develop partnerships and expand our potential for donations
- Promote regular communication with the members to help them feel a part of the program
- Include the members in the planning and implementation of all aspects of the program
- Give the members real leadership roles in the planning and implementation of the program events
- We carefully select the partnership team member so that every constituent that has a stake in the academy is represented.

- A well prepared agenda indicating short-term goals, long-term goals, accomplishments
- Meeting dates are established and communicated a year in advance
- We seek the input of our advisory council and act on it. Whatever we say we are going to do, we follow through. The advisory council is very comfortable in sharing their thoughts
- We maintain open communication with the partnership team through email and invitations to visit. We want them to feel a part of our program
- Provide a Welcoming Atmosphere
- Show Respect Toward Members
- As Much Public Relations As Possible
- I list expectations that I would like to see committee accomplish both on the business side and on the PLTW side. I make sure that I have two representatives from each business that I partner with. One representative helps in meetings, curriculum, and trends; while the other helps in assisting financially, opening up avenues for internships, and has the ability to make major decisions. I also make sure that my teachers are in constant communication with our business partners keeping the in the loop on the progress of the program and its needs and/or successes
- At our PT meetings, we discuss what materials we have and what we would like to have access to in order to make projects more meaningful- which results in donations
- Organize a partnership team that has "connections"
- A board member that has a child enrolled in the program
- An engineer that is also connected to the school (graduate)
- Limit the number of meetings. Instead of meeting every month, we meet every other month, which makes it seem less "time consuming." If materials or supplies are needed, or we would like a guest engineer to come in, we utilize the distribution email feature on Outlook
- We have a set time for meetings, second Thursday of the month, meeting time 6-8:00 pm with food provided. At one time I had the different companies sponsor the meal but I have received a grant to cover the expense of the meal and bussing for tours
- Providing a set agenda based upon my needs as the instructor has worked well, we usually try to focus on one or two topics and pick them apart, refer to attached agendas
- Always being open to the boards input and realizing I am not a practicing engineer and they have valuable input. Also providing feedback about how their contributions have helped/impacted students has been well received and expected by the engineers
- My focus has been more on academics to start in order to show the importance of the classes. After three years I am now starting on focusing more on funding the program
- I have been fortunate to get a large and diverse group of engineers, parents, administrators, students, and teachers involved in the board which is good to get all prospective when discussing topics. I started the group by calling local

industries stated what I was trying to do and asked who might be interested in helping. Since then the involvement has grown inside the companies that are involved and other companies have become involved through word of mouth

- Utilize feedback from advisory committee members to improve processes
- Collaborate with PLTW teachers in organizing advisory committee meetings, which includes preparing the agenda
- Send out invitation letters for the meetings and activities
- Arrange lunch for the committee
- Invite students representatives to attend the advisory meeting
- Record the meeting minutes
- Provides cooperation & communication & support between education, community and business, industry, labor and professional sectors
- Arranges & schedules meetings
- Provides data & information upon request on existing programs, facilities, equipment, staff and students
- Provides direction to align with the District's Mission, Vision, Core Values & Beliefs, and Goals
- Keep meeting short and to the point
- Utilize student presenters whenever possible
- Typically set up one PLTW course as the focus of the meeting
- Limit the number of meetings per year so that they are meaningful
- Arrange for snacks, pizza & cokes at the start of the meeting
- Provide agenda ahead of time to everyone on the partnership team
- Encourage "networking" following the meetings
- Encourage the advisory committee to come to the classes and speak with students about the program
- Have adult mentors from the committee work with students on projects (FIRST Robotics team)
- Work with advisory committee to develop relationships with suppliers and potential employers
- We include members from industry, the community college and a gender equity person
- We have at least one sit down dinner per year with the group
- We keep the members abreast of changes in curriculum and equipment needs
- I facilitate the education/government/business partnership. We meet once a month to discuss critical issues and to hear reports from our working subcommittees (Marketing, Curriculum and Data). We believe it is crucial to stay up-to-date with technology in order to adequately prepare students for the future
- Twice a year advisory committee meeting
- Invite advisory committees to see capstone project presentations
- Encourage advisory committee members companies to encourage employees to mentor FIRST Robotics teams