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**AN EVALUATION OF A STEM MAGNET PROGRAM THAT UTILIZES
PROJECT-BASED LEARNING TO IMPROVE STUDENT ACHIEVEMENT**

LeShea Boromei Serrano

Educational Leadership Doctoral Program

Submitted in partial fulfillment
of the requirements of
Doctor of Education
in the Foster G. McGaw Graduate School

National College of Education

National Louis University

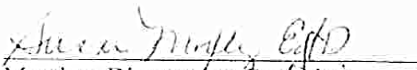
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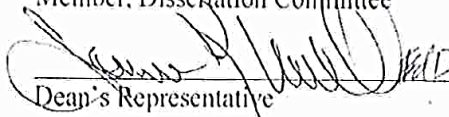
A DISSERTATION:
AN EVALUATION OF A STEM MAGNET PROGRAM WITH PROJECT-BASED
LEARNING TO IMPROVE STUDENT ACHIEVEMENT

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Educational Leadership Doctoral Program

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For the dissertation requirement, doctoral candidates are required to plan, research, and implement a major project within their school or district that relates to professional practice. The three foci of the project are:

- Program Evaluation
- Change Leadership
- Policy Advocacy

For the **Program Evaluation** focus, candidates are required to identify and evaluate a program or practice within their school or district. The “program” can be a current initiative; a grant project; a common practice; or a movement. Focused on utilization, the evaluation can be formative, summative, or developmental (Patton, 2008). The candidate must demonstrate how the evaluation directly relates to student learning.

In the **Change Leadership** focus, candidates develop a plan that considers organizational possibilities for renewal. The plan for organizational change may be at the building or district level. It must be related to an area in need of improvement and have a clear target in mind. The candidate must be able to identify noticeable and feasible differences that should exist as a result of the change plan (Wagner et al., 2006).

In the **Policy Advocacy** focus, candidates develop and advocate for a policy at the local, state or national level using reflective practice and research as a means for supporting and promoting reforms in education. Policy advocacy dissertations use critical theory to address moral and ethical issues of policy formation and administrative decision making (i.e., what ought to be). The purpose is to develop reflective, humane and social critics, moral leaders, and competent professionals, guided by a critical practical rational model (Browder, 1995).

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ABSTRACT

This program evaluation analyzes three areas of a secondary level STEM Magnet program that implements Project Based Learning (PBL) of Engineering, Biomedical Science, and Game Design and the relationship to student achievement. My program analysis examines multiple stakeholders' perceptions on the efficacy of STEM-PBL curricula implemented with a cross-curricular framework integrating multiple content standards to solve real-world issues. Through the curricula, students develop the 21st century skillset of communication, collaboration, critical-thinking, and problem solving. The findings indicate STEM teachers maximize curriculum with relevant hands-on activities enhancing student collaboration and industry certifications. Additional findings indicated a lack of planning time for cross-curricular collaboration between content areas, appropriate state and national prioritization of Science STEM-PBL lessons, and a lack of district funding.

PREFACE

My educational background spans 27 years including 19 years in a science classroom teaching physical science and chemistry combined with 8 years in administration, as an assistant principal in student affairs and currently over curriculum. My tenure in curriculum that initiated my passion began as an Assistant Principal for Magnet Curriculum over a STEM magnet at the high school level. The context for my program evaluation that initiated my interest is driven by my professional experience in my current role observing first-hand the potential academic advantages found in a STEM-PBL environment as it relates to student motivation and achievement. This method fosters the 21st century skillset students need to meet the needs of the future career demands taught by universities and technical colleges.

I feel my topic is relevant to all stakeholders as it directly compliments instruction across all content areas. The idea that a STEM-centric environment culminates content standards to promote students critical thinking and problem solving while fostering teamwork and collaboration can produce positive instruction affects. This process makes the learning real and relevant while reinforcing all content standards together as they occur in a real-world scenario. The long-term vision leading to organizational change would be to extrapolate this concept to all schools at all levels vertically to become a way of work facilitating problem solving for all students to become tomorrow's innovators.

My significant leadership lessons learned begin with knowing the players that would impact the success of the initiative. These leadership lessons include establishing a sense of urgency describing the importance and benefits of this STEM methodology of learning. Another lesson is the plan of action should be collaborative to include all

stakeholders of teachers, administration, parents and community business leaders to support and brainstorm through the process. The process must have a coalition of support both internally within the school and externally within the district and community to ensure that the proper professional development and funding is procured to ensure success. Another key leadership lesson learned is to clearly communicate the process and plan with a common language to ensure the efficacy of its implementation. I also learned that this process would benefit from a structural change to provide the needed planning time for cross-curricular collaboration for these problem-based projects. A final leadership lesson that I must highlight is to fully understand the political undercurrent that may provide barriers to the implementation, which could be planned for in advance.

This experience has influenced my leadership practice in multiple ways. The process has given me a broader lens applied to my evaluation of data. The components of my learning have taught me that there are physical and abstract components that drive the outcomes related to organizational change in the educational arena. As a leader, I have to be conscious of the political agenda's that may be outside my direct control to create positive outcomes for my students. I have become a deeper and more reflective thinker of not only the topic I am passionate about but also how it may address issues of equity and social justice. I believe this STEM-PBL process can assist with these issues as a positive unintended consequence.

In summary, as a school leader, I feel this process has prepared me for being a principal and beyond with the tools needed to facilitate positive organizational change. This experience has provided me the skills and context to analyze data and relationships utilizing an introspective lens with a system-wide perspective. The process overall has

reinforced my belief in being a servant leader with compassion for all stakeholders keeping my students at the center. I believe when students and teachers are brought together for a common purpose, working as a team, positive outcomes result.

ACKNOWLEDGEMENTS

I wish to thank my committee members for their time, continuous support, and expertise in guiding me through this journey. A special thanks to Dr. Carol Burg, my committee chair for her countless hours of reflection and purposeful feedback that transformed my writing. A special thanks and gratitude to Dr. Susan Moxley for her continuous support and guidance grounding my purpose and encouraging me throughout this process. Another special thanks to Dr. Tamara Cornwell for all of your insight imparted throughout this process grounded in applicable leadership practice.

I would like to acknowledge and thank my school division for allowing me to conduct my research. A special thank you to Dr. Kim D. Moore for introducing me to the world of STEM and being instrumental in revealing its many possibilities. Another special thanks to my 9th grade physical science teacher and lifelong mentor Mrs. Carmen Austin who has remained a constant inspiration. Another special thanks to my dear friend, Dr. Jazrick Haggins who reminds me of my value. A special thank you is to Mrs. Tricia McManus and Mrs. Kim Huff who have cultivated my leadership skills to be a compassionate, collaborative servant leader and change agent for all students. A special thank you to Tammy Dery for being a great support and friend throughout this process. A final special thank you to Mr. Jeremy Johns-Klein, my dear friend and leadership partner, from Future Leaders Academy to Doctorate, I am so grateful to have taken this journey with you. Finally, I would like to thank all the teachers, administrators, guidance counselors, district directors, and parents in my study that assisted me with this project. Their support and feedback were integral in regards to informing on my topic. They each made this research a pleasant and informative process aligned to my passion in science.

DEDICATION

I dedicate my dissertation project to my family. A special thought of gratitude to my loving parents, Mr. Albert J. Boromei and Mrs. Rosalie F. Boromei whose encouraging words I'm reminded of as I complete this journey. In memory of my grandparents Sergio and Theresa Fuentes and Albert and Angie Boromei who instilled in me the values of family and diversity that has made me a caring educator treating all children as if they were my own. To my sister Lennese and brothers Albert and Marty who are always supportive. To my nieces and nephews, as an example to have grit and tenacity and never give up on your dreams.

I dedicate my work and give a special thanks to my best friend and husband Mr. Jose A. Serrano and amazing daughter Dr. Alexis Serrano for being there throughout my complete doctoral process. You both have been my heart and inspiration. Your constant support and encouragement has propelled me forward and given me the strength to get to the finish line. Finally, I give my final dedication to my angel in heaven Arielle Rosalie Serrano whose dream of becoming a teacher was never realized in her short life, yet her spirit continues to provide lessons to us all every day.

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SECTION ONE: INTRODUCTION

The focus of my program evaluation is the exploration of project-based learning in a Science, Technology, Engineering, and Mathematics (STEM) high school as it relates to improving student achievement. The school identified for the study originally opened in 1934 serving only the African American population and was then re-established in 2002 as a pre-collegiate STEM Magnet High School. The Avatar Technological High School's (pseudonym) mission communicates that the school community focuses combined efforts on teaching students to be life-long learners by excelling academically, becoming technologically competent, demonstrating ethical values and taking their place as competitive members of a global community. The STEM programs offered at the school include Engineering, Bio-Medical/Biotechnology Science, Computer Game Design, and Computer Systems Engineering. Two of the programs mentioned, Engineering and Biomedical Science, are aligned with national Project Lead the Way curricula, while the other two program academies, Computer Game Design and Computer Systems Engineering, are aligned with Florida Department of Education curricula frameworks.

All four programs integrate technology and employ hands-on experience combined with project-based learning. In addition, the programs each integrate application-based learning and select students on set criteria that equates to an index score. The index score calculation is based on a combined criterion of 7th grade and first quarter of 8th grade achievement scores, combined with test scores on the FSA. At the time of the study, the total population of the school was comprised of approximately 43% Magnet and 57% Traditional (community) students that are zoned for the school based on

their address. The program was marketed district-wide and cycles through three application periods in November, April, and June.

The STEM high school at the time of the study had a total enrollment of approximately over 1500, with a breakdown of student demographics comprised of Asian 7%, Black 52%, Hispanic 18%, White 19%, and Indian/Multi-Racial 4%, with a free and reduced lunch population of 63%. The traditional population consisted of students from predominantly low socio-economic status with approximately 80% possessing low reading and math ability of a level one or two. The high school has a rich African-American heritage as a school established originally within a predominantly African-American neighborhood community.

Historically, the STEM program at Avatar Technological High School began with low enrollment and has grown through the years since its inception. Throughout my analysis, I investigate teacher perspectives through means of a survey on project-based learning within a STEM curriculum, examining the components that are needed to improve student achievement. I probe and drill down into the components of project-based learning and any possible connection to problem-solving ability, critical thinking, motivation, and interest level as a way to improve student achievement. The Magnet programs examined in this study consist of 210 students in engineering totaling 12.9%, 173 students in Biomedical/Biotechnology Science totaling 10.6%, and 153 students in Computer Game Design totaling 9.4 %.

The cost to support Magnet programs has been an increasing source of discussion in a climate of budget constraints and redeployment of school employees to compensate for the school district's fiscal deficit. The district is presently faced with financial

problems and is right-sizing the budget. Some of the schools are not filled and others have been filled beyond capacity. The district schools' costly air conditioning system maintenance and repair needs have been a continuing concern. In addition to maintenance, the district must find funding in the amount of approximately \$1 billion for new schools required to accommodate projected growth. In this fiscal context, specialized Magnet Programs and academies that require transportation and have experienced some attrition in recent years have been under heightened scrutiny as administrators consider other pressing funding demands throughout the district.

Through a thorough analysis of the school program, I have explored the basis of STEM education and the impact of its project-based instructional method employed to improve student critical thinking, academic interest and motivation level to ultimately increase student academic achievement in these STEM focused areas. In the following quote, leading researchers of Project-Based Learning (PBL) have characterized the PBL teaching method:

Although project-based learning is not a panacea, we can confidently say that PBL is a powerful teaching method that motivates students, prepares them for college, careers and citizenship and meets standards to demonstrate deep learning and critical thinking skills while allowing teachers to teach in a more gratifying manner. (Larmer, Mergendoller, & Boss, 2015, p. 2)

I have identified and assessed the use of PBL components through teacher interviews and survey data collected from teacher perspectives on project-based learning.

Project-Based learning is defined as an instructional process that is inquiry based and results in a product or solution (Krauss & Boss, 2015). Students employ high-level

critical thinking skills and pull from concept knowledge across multiple disciplines to solve real world problems. These are the skills that are in demand for the twenty-first century to prepare students for future careers (Wagner, 2008). Another key component of project - based learning is the fostering of student collaboration and team-work that is a key to the problem-solving process. These skills, which are acquired within the context of the STEM curricula experiences, provide a substantive rationale for costs associated with STEM Magnet schools as an effective means for improving student achievement.

A critical aspect of the argument for STEM Magnet schools is the long-term effect that these skills have for students. Student's long-term retention is said to increase with project-based learning due to the inquiry driven connections that exist in the process. The learning outcomes associated with PBL include deeper levels of conceptual understanding: "Project-based learning helps students articulate concept meaning, applying what they know consolidating their knowledge making learning relevant and memorable" (Krauss & Boss, 2013). Students self-assess during the process and improve the product themselves, applying their content knowledge of many disciplines. These are the cognitive processes students need in order to be successful at the college level. The accurate assessment of these complex skills is another key component to be considered.

The national standing in science and mathematics performance levels as compared to global performance levels suggests that United States students are lagging behind other countries (Wagner, 2008). Project-based learning could be a method of advancing science and mathematics performance levels by integrating the common core curriculum with relevant purpose, creating a generation of future innovators. Educational researchers recommend STEM as a means to advance positive education reform: "STEM

has the potential to be a driving force fostering innovation in education that could align with the contemporary standards-based education providing direction for future educational reform” (Bybee, 2013, p. 2). The basis of my program evaluation revolves around an inquiry into STEM educational practices as a means for providing evidence concerning the efficacy of PBL STEM learning methods. The inquiry considers whether PBL learning methodology provides an efficient means to effect improved student achievement. The cost of PBL STEM learning contexts seems to be worth the expected student achievement gains in science and mathematics. PBL fosters critical thinking and greater content comprehension while meeting and exceeding the curricular content standards needed to prepare our students for future demands.

Purpose of the Evaluation

The purpose of my school program evaluation within the Pandora School District (pseudonym) is to explore the impact of the STEM project-based curriculum as a driving force for advancement of student achievement. The evaluation is undertaken in response to the current fiscal crisis atmosphere in the district that has resulted, in part, to scrutiny of magnet program costs. Magnet programs are being closely re-evaluated for educational efficacy within our Magnet schools programming. The questions being raised relate to whether benefits of magnet programs such as STEM outweigh the costs involved to support them. The program has been steadily growing for the past 5 years, attracting a higher academic level of student than existed at the beginning of the transition to the STEM academy. The school grade has been positively affected by the magnet program valuation in combined assessment with the traditional population. The school grade has

been a steady C for a period of three years consecutively; whereas, the school grade was consistently lower without the magnet program.

The school grade is a driving concern that has directed attention to the instructional methods necessary for enhancing student achievement. STEM programs are proven means to the end of increased student achievement. A recent study indicates that STEM schools provide opportunities for students to engage in inquiry within the project-based activities that contribute to improved graduation rates. A study performed in 2014 with the Network on Deeper Learning that analyzed schools utilizing project-based learning concluded an increase in student collaboration skills and higher test scores which lead to increased graduation rates when compared to traditional schools (Zeiser, Taylor, Rickles, Garet, & Segeritz, 2014). In my analysis, I evaluate current project-based learning instructional practices within identified STEM programs to determine their efficacy toward improving student achievement.

My study explores the impact of the STEM project-based curriculum within these programs as a driving force to improved student achievement when compared to the courses taken without inquiry-based instructional practices. Through a detailed analysis, I have made analyses of the relationship between project-based learning (PBL) and student achievement. PBL efficacy has been examined within the context of magnet programming which sustains diversity and high student interest using the STEM field of study as thematic content. My goal has been to identify an effective PBL instructional structure that rigorously challenges students with core content standards in mathematics and science integrated with other content areas leading to broad academic advancement.

In this way, PBL serves to advance increased student achievement in all classrooms for all students.

Rationale

As an Assistant Principal of Curriculum in a STEM magnet school, I am intuitively deducing in my role as a means for generating a collective awareness of methods for assessing and valuing the efficacy of rigorous programming such as STEM Magnet programs that incorporate PBL instructional practices. The rationale for this desired change of perception is practically based in the need for defending the benefits associated with such programming considering the costs incurred. By presenting a framework for assessing the effects of the programming, objective data become available to inform the discussion about continuing funding for Magnet programs in general on a national level, which in turn, eminently affects schools at the local level. Research support lending clarity of insight into student performance gains associated with STEM Magnet programs integrated with PBL has become a crucial need as a more and more fiscally strained period in the Pandora School District has led to increased scrutiny of the programs and their cost.

Many educational leaders seem to perceive the underlying efficacy in such programs. Despite the financial strains, Assistant Superintendents and STEM/CTE Directors from other counties in the state of Florida have called me frequently with requests for tours of STEM magnet programs who are initiating similar programs in their respective districts. Locally, the Pandora School District's fiscal concerns continue to raise questions related to the benefits of the programs to improve student achievement as compared to the cost to support the programs. The questions of program validity and the

feasibility of continued program sustainability have been the impetus for my investigation into their efficacy.

Through my analysis and observations, as the Assistant Principal who facilitates the programs at my school site, I have researched the components of each STEM program at Avatar Technology High School of Engineering, Biomedical/Biotechnology Science, and Computer Game Design at the secondary level to gather evidence about the relationship between the incorporation of project-based instructional methods to improved student achievement and, ultimately, higher graduation rates. Each of these programs integrates project-based learning within their classrooms. As a previous science teacher, having 20 years of classroom experience in the areas of Physical Science and Chemistry, I have personally utilized hands-on activities with a project-based model to enhance learning and increase the level of motivation and engagement within my lessons. I observed that the PBL method increased students' ability to collaborate and problem-solve throughout rigorous PBL tasks resulting in outcomes that many times over surpassed my expected end-goal and generated new student discoveries for further investigation. Rigorous PBL experiences drives student achievement: "Rigor in projects puts kids right at the edge of what they know to elicit them to reach and grasp new ideas causing students to struggle enough to be challenged without being stressed" (Krauss & Boss, 2013, p. 20). The idea of "rigor" is important to note as a key factor in the process of pushing student thinking beyond their base knowledge to a level of application and problem-solving. Continuously during my research study, I have held to the important value of rigor as a major component for assessing PBL implementation.

As an instructional leader of the STEM program, I embrace the responsibility to ensure the critical need to foster a rigorous curriculum that teaches problem-solving with purpose through project-based learning. I have found during my tenure as an Assistant Principal for Magnet Curriculum that some students who are not successful in PBL exit the program early as a result of having difficulty with some critical issues related to mathematics skills, reading aptitude, and problem-solving ability. In serving my stakeholders, students, parents, and district leaders, my inquiry supports my purpose to ensure that each of the STEM programs continue to promote higher-order thinking, to meet student academic needs, and to provide them with the necessary skills in preparation for the challenges of the future.

Goals of the Program Evaluation

The intended overall goal of my program evaluation has been to show the efficacy of project-based curriculum embedded within the STEM programs at the secondary level to improve student achievement. Three key characteristics of PBL under study include student motivation, collaboration, and academic achievement. Through my research, I have been concerned with generating evidence that validates the idea that project-based learning as a rigorous instructional method yields high student engagement and interest, that positively motivates students to collaborate, and problem solve to overcome challenges incorporating academic-content. This program evaluation provides data and analyses that demonstrate the overall benefit of project-based learning to increase academic performance within all content areas of study.

Further, my research goal has been to demonstrate project-based learning as a highly effective instructional tool. I explore the foundation of PBL as a means for

teachers to create experiential opportunities for students to improve their critical thinking skills, motivation, and academic interest influencing their overall student achievement across all content areas. Finally, as educators implement PBL to improve student achievement, my inquiry has purposefully examined teacher methods for developing student problem-solving resiliency. The following quote drives home the point: “Blended STEM is powerful because it integrates all content areas as a whole, making students broadly skilled enough to innovate in an uncertain future” (Nourbakhsh, 2015, p. 13). Innovation requires critical thinking, problem solving, and resiliency during the problem-solving process. The goal of this inquiry has been to examine the efficacy of PBL environments to generate, integrate, and reinforce these skills in a way that substantially advances student achievement levels.

Research Questions

The primary questions driving my program evaluation research revolve around the effectiveness of STEM programs to increase student achievement levels. The program evaluation focuses on the following thematic programs: Engineering, Biomedical-Biotechnology and Computer Game Design. All three of these programs employ project-based learning to and have been designed to provide a high level of rigor. This rigor has been correlated with improved student achievement. My research is guided by four primary exploratory questions and two secondary exploratory questions.

Primary Exploratory Questions

The primary questions are geared to addressing trends in teacher perspectives on what has been working, what has not been working, the challenges to, and ways to improve the STEM programs. The programs under consideration are specifically

Engineering, Biomedical/Biotechnology Science, and Computer Game Design. The four primary exploratory questions guiding my research include:

Question 1: What do teachers report as working well in the STEM program (Engineering, Biomedical Science and Computer Game Design) as its related to project-based learning opportunities that improve engagement, collaboration, and student achievement?

Question 2: What do teachers report as not working well in the STEM program (Engineering, Biomedical Science, and Computer Game Design) related to project-based learning opportunities that improve engagement, collaboration, and student achievement?

Question 3: What do teachers report as the greatest challenges in the STEM program (Engineering, Biomedical Science, and Computer Game Design) with students involved in project-based lessons?

Question 4: What do teachers report as ways to improve the STEM program-incorporating strategies that improved the project-based outcomes related to student achievement?

Secondary Exploratory Questions

The secondary questions in my program evaluation research are designed to explore more deeply the workings of PBL instruction during classroom practice. These questions have been framed to elicit details about critical aspects of PBL practice and that are connected to the project-based learning activities assessed within the classroom. The two questions guiding my secondary exploration include:

Question 1: According to teachers in all content areas, how does project-based learning increase the overall rigor to promote high levels of student achievement?

Question 2: Second question: According to teachers, how does technological aptitude limit or increase the level of academic achievement with project-based learning?

In addition, my research study explores evidence based on teacher surveys related to the components that correlate to rigor, engagement, and improved student achievement. I investigated the limiting factor of technological knowledge to be able to generate expected outcomes within the STEM curricula in each program.

Conclusion

The potential of PBL integrated STEM programs has become increasingly important to me as an educational leader and magnet program administrator. The need to address deeper levels of content learning and problem-solving as a standard practice of effective instruction is summarized by Larmer, Mergendoller, and Boss (2015), “PBL should be one of the key methodologies in every teacher’s toolbox because it reflects the broad implications and underlying principles of the curricula and enables teachers to teach several specific standards in one context” (p. 11). In my program evaluation, I examined project-based learning within three STEM programs of Engineering, Biomedical-Biotechnology, and Computer Game Design to investigate program efficacy to elicit evidence of the connection between the practices implemented in these specific magnet STEM programs and student academic achievement. I have inquired into the importance of STEM education and its relevance to the present contemporary standards-based curriculum of common-core. I have explored student motivation, academic interest,

and problem solving as it relates to student collaboration within project-based learning. I have focused on the critical aspects of such programming within my review of the research and literature. I have especially focused on research pertaining to project-based learning to extrapolate findings associated with the validity of PBL incorporation into all content areas of study as a means for learning enhancement and student achievement gains.

SECTION TWO: REVIEW OF LITERATURE

Introduction

I have found there is substantial literature in our current national educational climate around the concept of STEM-themed Magnet schools using inquiry-driven project-based learning. The global demand in student aptitude in math and science with the critical thinking ability to problem solve has been established. According to Wagner, “The ability to ask essential questions is directly correlated to critical thinking and problem-solving skills” (Wagner, 2008, p. 15). There have been many United States national reform initiatives implemented in pursuit of an educational solution to this systemic pedagogic dilemma. The national “Race to the Top” initiative goals implemented by President Obama are, “to create educational reform adopting high quality assessments, rigorous standards, teacher evaluations, and professional development to improve student achievement” (Johnson, Peters-Burton, & Moore, 2016, p. 18). The idea of STEM education was born during the global race to be competitive and prepare our students for the demands of the twenty first century. In addition, the Common-Core standards followed to align standards across the nation to prepare students for college readiness and future careers. This initiative embedded key goals driven by federal funding to improve STEM education across our nation to prepare our workforce with the math and reading standards required for future careers (Johnson, et al., 2016). This introduction lays the foundation to the STEM movement that is the focus of my program evaluation.

The literature review is comprised of two subsections. In the first subsection, I have given a brief overview of the historical background as to the evolution of STEM within our national educational system. I have informed the reader of the sequence of

events, through a historical timeline, the aspects that drive our current skill need of the 21st century STEM movement to include social and political issues embedded in its implementation. In addition, I have explained why STEM education is important and have included research on the correlation of its impact utilizing the instructional process of project-based learning (PBL) as a structure to motivate, to increase problem-solving ability, foster collaboration, and improve achievement in science, math, and stem-focused programs. I have included a discussion of STEM education and its impact on educational reform for a greater contextual positioning of STEM initiatives.

The second subsection goes deeper into the efficacy of STEM programs by outlining the potential impact of STEM Education and PBL. I discuss the challenges involved with the implementation of STEM and PBL in the classroom. I explore what research says concerning STEM and PBL and its impact on student motivation, collaboration and increased achievement. My review of STEM education concludes with an exploration of the potential impact, challenges and research that supports STEM education and PBL as a structural shift in educational practice to improving academic achievement while preparing students for the challenges of a competitive global society.

Historical Background of STEM Education

The concept of STEM education is at the forefront and becoming an integral part of how we think through our curricular structures that include science, technology, mathematics, and engineering. I feel it is important to start with the “why” behind its national popularity. The idea of STEM was born from the collaboration resulting from partnerships between the business community and educational leaders. This relationship forged the result of “educators learning the value of STEM alignment to the direct needs

of the business community who demanded knowledge application and collaboration skills” (Wagner, 2008, p. 15). Therefore, the idea of STEM education and project-based methods has become a topic of wider acceptance as a means to preparing our students with the skills they require as successful problem-solvers in the future.

Conceptual Framework-Constructivism

I will begin to frame my study with the philosophy of the constructivist theory from which STEM educational theory has its roots. This framework tells us, “Learner’s bring their own experiences, knowledge, feelings, and skills that impact their views on how the world works” (Glatthorn, Boschee, Whitehead, & Boschee, 2016, p. 465). The assertion here is a baseline of rich knowledge that may fuel a student’s curiosity and ability to critically think through the problem-solving process given the opportunity. In addition, the students continue to develop through their collaborative environments that include the combination of personal interactions that construct broader meaning to their base knowledge (Glatthorn, et al., 2016). Therefore, the combined formula of base knowledge and shared information aid students to develop the connections necessary to resolve problems or seek assistance to gain resolve. Constructivism provides the inquiry-based opportunity for students to enrich learning by, asking key questions that explore the topic leading to a discussion of the possibilities based on their observations, which concludes, with an application to the solution, (Glatthorn, et al., 2016). This constructivist framework allows a student to be curious which motivates them to explore, develop a standards-based concept, and make connections to then apply the learning. This is connected to a broader theoretical framework that connects these ideas to STEM and

PBL. STEM is presently gaining national attention as it directly aligns to the global skill demand of the future.

Theoretical Framework

The purpose of my study is informed by critical theories and scholarly research on STEM and Project-based learning. The PBL learning environment contains key components that encompasses applicable content, critical thinking, collaboration, and autonomy. The beginning of PBL dates to 16th century Italian culture of sculptors and architects (Knoll, 1997). This era was comprised of artisans that prided themselves as being skilled workers and was considered professionals. Their educational base was primarily lecture and deemed inadequate as students advanced in their craft. Architectural historians sought, “to apply their knowledge and test their learning about art form and its function termed project” (Larmer, et al., 2015, p. 25). These projects or “progetti” were organized as competitions, which translated into creating models of architecture. The word project introduced and organized learning to address and apply knowledge. The concept of progetti allowed for organic problem solving, critical thinking and application of concepts. As Dewey highlighted the belief that learning was a progressive and social process (Dewey, 1930, p. 18), this instructional structure was modeled in medical school.

Medical school utilizes the practice of project-based learning under the mentorship of an experienced facilitator. The Gold standard PBL contains success skills elements that include critical thinking, problem-solving, collaboration, and self-management (Larmer, et al., 2015, p. 36). The project design critical attributes consist of the following components: a challenging problem, inquiry, authenticity or real-world applications, student voice or input, reflection, revision, and an end product (Larmer, et

al., 2015, p. 37). This leads us to the historical sequence of events that gives the perspective-impacting math and science education in our present educational system.

Historical Perspective of STEM

The term STEM as we understand it today originated around the 1990's by NSF, the National Science Foundation organization. The term STEM is used by many in the science community and can mean different things. The introduction of this acronym can be traced to the era of Sputnik that in turn heightened the transformation of science standards and related topics between 1950 and 1960. This resulted in science and mathematics educational reform. In response to the Soviet launching of Sputnik, Max Beberman (1958), lead reform through a mathematics committee at the secondary level to improve standards in math curriculum (Bybee, 2013). In addition to this movement of mathematics enrichment came the work in 1956 of Jerrold Zacharias, who spearheaded reform on physical science with an organization seeking to improve physical science curriculum standards (Bybee, 2013). The stage for mathematics and science educational reform is now set which was a turning point in our national awareness for the need in these respective content areas and their importance in developing problem solving skills. I would like to turn a focused attention on how this influenced the social and political landscape of STEM education.

Social and Political Perspectives of STEM

I have surmised there is a clear case to be made for STEM education that impacts the social and political climate of education. As Dewey explains, whenever education experiences a pedagogical shift, it is essential to consider the overarching social impact (Dewey, 1902). As an educator, I feel we must always consider the impact of our systems

decisions as a governing body encompassing the needs of the school community we serve. These aspects may become the drivers of reform and the need for social and political change.

A social issue developed which resulted from the civil rights movement that included the decision of *Brown vs. Board of Education* (1950), and the Vietnam War era spanning 1960-1970. These events influenced the direction of education to highlight the impact of civil rights and poverty on our nation's youth. These topics gave rise to political protests that further influenced the need for increased standards. According to Bybee, these social and political stirrings drive academic excellence and higher curricular standards and are a means to transforming education to include greater STEM concepts and methodology (Bybee, 2013). Ironically, these political and social aspects set into motion by Sputnik drove educational reforms that paralleled the forces that prevailed within our domestic political and social issues.

These factors reaffirmed the need for higher standards for all students. This led to the establishment of state and national policies that brought economic support from the federal government. As a part of the STEM movement, business leaders and schools have combined their efforts to focus on standards-based learning to include, science standards, professional development, and inquiry-based fostering curiosity and innovative thinking (Glatthorn, et al., 2016). These factors all contributed to the evolution of STEM education and accentuated its relevance in training student thinking to be future innovators.

In this transformational period of standards-based curricular shifts, some key points were overlooked that would create a sustained capacity within the STEM

movement. As pointed out by Bybee, our educational system neglected to proactively establish systems that would sustain these innovative programs at both the state and local levels (Bybee, 2013). This implication further validates the basis for my program evaluation to uncover an educational methodology that may improve student achievement in STEM programs that may be extrapolated to all content areas. This structure may be integrated as a sustainable component of science and math curriculum. Hence, PBL may be a structural framework that can sustain higher standards and increase the problem – solving ability of students to prepare them for the demands of the 21st century. This movement transformed schools of choice and began the trend of specialized STEM themed magnet programs to address the disparity of achievement within our minority students in STEM careers.

STEM-Themed Magnet Schools

A brief history behind the inception of the structure of magnet schools' dates back to the 1960's as an alternative to traditional education. Magnet schools were designed to create equity and counter the effects of schools that were racially segregated. It is important to note that these schools offered a choice for parents and their students to have another option other than private schools that were often outside the reach of opportunity for these students. This grassroots educational movement provided the perfect educational incubator for STEM-themed academic environments that aligned to the twenty-first century skills needed for student success. As Wagner, has clearly stated that students need to be equipped for the future by challenging them to demonstrate critical thinking, problem solving, collaboration, adaptability, initiative, communication, analytical thinking, curiosity and imagination or innovation. (Wagner, 2008, p. 14-38).

The STEM Magnet themed high school’s curricula and programs focused on the integration of science, technology, engineering and mathematics in ways that address and meet the needs of the 21st century. In a study by Judson on the effects of STEM–focused Magnet and Charter schools, the findings conclude that as compared to a comparison group the specialized schools demonstrated higher achievement in the third year (Judson, 2014). This supports the relevance of developing a STEM pipeline of educational programming that correlates to higher standards on the National Guidelines of Science Standards (NGSS) to provide all students exposure to STEM education.

Stem-focused standards and curricula are on the rise with a high demand aligned to skills embedded in future careers. The pathway to STEM involves the instructional structure of project-based learning. Project-based learning may provide the framework to improve standards-based learning as outlined in STEM Roadmap, which explains project-based learning provides an opportunity for active learning that collaboratively conceptualizes science (Johnson, et al., 2016). This point reinforces the road to STEM and the potential positive impact on students’ critical thinking skills and academic achievement.

STEM Education and PBL

The Potential Impact of STEM Education and PBL. I will begin with the idea of the potential impact of STEM education with project -based learning. The “No Child Left Behind” initiative of the last decade initiated by the Bush administration, introduced high stakes testing and accountability aligned to state standards (Glatthorn et al., 2016). This initiative failed in its resolve and resulted in the realization that the United States students continue to fall behind. Project –based learning may be a process that fosters

facilitation by teachers to promote inquiry in a student-driven environment. As clarified by Krauss and Boss, project -based learning is a catalyst driving students to think critically which ignites their curiosity to go beyond their base knowledge leading to ownership of meaning and intrinsic application to of what is learned (2013). In a British study completed over three years a comparison in math achievement was analyzed in a traditional math program compared to the use of PBL at the comparable school. The results were students in both environments were able to solve formulaic problems but the PBL students were superior with the conceptual application of the problems (Boaler, 1999). The conclusion here was students acquired a higher level of knowledge from the PBL approach.

In terms of the component of assessment of PBL, a positive correlation on standardized achievement has been shown in a recent study. A research study by Geier, Blumfeld, Marx, Krajcik, Soloway, and Clay-Chambers (2008) shows, in a comparison to traditional methods, students who engaged in project-based learning outscored in their academic proficiency of the subject. Another key finding on the impact of PBL is the social aspect of these lessons and activities creating a positive environment that promote student success. John Dewey tells us there is a close tie that links personal experiences and formal education (1930). In the process of PBL students construct knowledge and build on their own cultural and background knowledge.

The framework of PBL may be aligned with Dewey's philosophy and perspective and may be a natural setting to promote a positive social environment that fosters collaboration and teamwork. Further research indicates that PBL may promote student engagement and motivation that yields student investment in learning. According to

Doppelt, project-based learning is related to improved self-image, which leads to student success (Doppelt, 2003). These components of PBL give the layers of potential impact that may correlate to student intrinsic motivation and ownership that fuels the desire to understand content on a deeper level.

Challenges of STEM Education and PBL. The challenges of STEM education, within the science community, begin with agreement on what it truly is defined to mean. I have experienced, as a science teacher and assistant principal of curriculum at a STEM Magnet school, within the science community that there is not a working common language and understanding to address the topic of STEM. Bybee's 2010 perception survey findings demonstrate that most STEM-related professionals lack a common working definition for the acronym *STEM* (Bybee, 2013, p. 2). This perception issue creates ambiguity that has impeded the progress of effective STEM implementation (Bybee, 2013).

Another challenge of this topic is the loss of momentum as the acronym, STEM, and its inconsistent interpretation moves through the political arenas of local, state, and national policy makers. The lack of consistency counters the national vision of addressing the global achievement gap and creates barriers to the effective creation and implementation of STEM standards that align to the classroom level. Bybee confirmed this idea with his assertion that the substance of STEM education decreases from the articulation of the national policies towards transformation efforts of STEM education at the state and local levels (Bybee, 2013). Some additional challenges include the integration of technology and engineering while utilizing STEM contexts with the related concepts. These items can assist in transitioning from the acronym of "STEM" to a cross-

curricular, working definition where the PBL framework can be the platform integrated into content area curriculum to increase achievement.

Research of PBL in STEM Education. In this section, I begin my explanation of related research and introduce both qualitative and quantitative paradigms within several studies showing the correlation of STEM education and PBL on student academic motivation, collaboration, and improved achievement. My initial analysis is with the foundational shift on how we implement or teach inquiry-based learning in science and mathematics. The question of what views and perceptions teachers may have on inquiry-based learning that develops problem-solving skills comes into play with the fidelity of its implementation. A qualitative study that focused on developmental learning that develops science knowledge gradually through connections of PBL indicates, that a consensus existed among teachers embracing the belief that this process connects the big ideas and fostered a scientific mindset (Shemwill, Avargil, & Capps, 2015). The overall findings emphasized that this model of developmentally oriented teaching and learning within science curricular instruction should be considered in the NGSS (National Science Standards) frameworks. Thus, this aspect of fundamentally shifting science teaching methods and learning outcomes should be considered as we reform curricular structures.

Another quantitative study analyzed students in a college level Stem-Themed program in their first-year post-secondary with a focus on “autonomous motivation”, which refers to student behaviors triggered by a personal choice composed of intrinsic and self-regulated controls as it is related to academic achievement (Van Soom & Donche, 2014). This analysis explored the contrasting motivation that meets the required needs to be successful in a rigorous STEM program with high demands. The study

showed that female students enter college with a low self-concept (confidence) compared to males that stems from their secondary school experiences. This point is attributed to females being under represented in STEM fields. According to the U.S. Department of Commerce women make up approximately half of the work force at 48% yet comparatively attain less than 25% of STEM-related jobs (Beede, Julian, Langdon, Mskitrick, Khan, & Doms, 2011, p. 1). Another interesting fact is while women are quite capable of attaining the educational requirements for STEM-related careers they tend to gravitate to health and educational fields while men favor engineering. Ironically, as an Assistant Principal who managed a STEM program, I experienced a paralleled effect where the biomedical program is mostly female, and the engineering program is predominantly male. Furthermore, the study explained that females are intimidated by male dominance and confidence in reference to a mathematical self-concept. The key findings indicate there is a positive relationship with academic achievement in male students who have a high level of autonomous motivation, but a low self-concept compared to females whose motivational factors did not positively effect achievement (Van Soom & Donche, 2014). The motivational profiles of both male and female STEM students gave a clear picture on the correlation of autonomous motivation related to self – concept and early academic achievement. In the post-secondary data female students expressed a decreased interest regarding STEM education when compared to male students resulting in a less likelihood of pursuing STEM in college (Van Soom & Donche, 2014). The topic of intrinsic student academic motivation is difficult to correlate but should be considered in the strategies of teaching STEM which can lead to a more equitable exposure for male and female students.

The goal is to elicit an approach to learning that is deep. A motivational approach to deep learning is accomplished with the establishment of, course content that is objective-driven, clearly communicated, and has a high level of student interest related to their goals (Felder & Brent, 2016). This leads us to the idea that PBL may provide value within a curricular structure taking students beyond learning facts to a deeper understanding that connects value to the concepts. Additionally, another view is to explore how PBL may support learners to be self-motivated and engaged in this inquiry driven process of project-based learning and STEM.

Another case study utilizing a mixed-methods approach that provides informed research on my topic was completed over a one-year period to understand the potential of PBL in a “Virtual Reality Classroom” at the high school level. This study parallels one of my programs (Game Design) under my evaluation. The research resulted from a mixed methods evaluation paradigm and analyzed the social interactions of students in correlation with student behavior, learning, and project development. The research results support the value of student-driven collaboration as an important component for successfully achieving deep learning in PBL lessons. Student-driven collaboration serves to add additional rigor to PBL.

The main conclusion of this research showed that PBL in a Virtual Reality (VR) platform correlates to deeper learning for students. A significant part of this finding was that students were able to create advanced projects in Virtual Reality. This outcome was a result of the collective efforts of the group’s skill level and base knowledge pushing them beyond complex concepts increasing their technological ability (Morales, Bang, & Andre, 2013). Students within this study were highly motivated which drove their inquiry

to learn complex concepts. Ultimately, these group interactions within PBL structured learning yielded an increase in technological inquiry beyond the norm present in a general high school computer class.

The overarching benefit correlated in this study revealed an increase in the technological aptitude including collaborative critical thinking skills for future success beyond the secondary level. The premise here is that content application exponentially develops a concept and the knowledge is shared in a team environment. This concept leads to the question of research around the mathematics aptitude needed to prepare students to collaborate on PBL activities of this level.

Han, Rosli, Craparo, and Craparo (2016) conducted a quantitative study analyzing the effects of STEM and PBL on students' mathematics achievement. This study focused on student achievement in the mathematics content area of algebra, geometry, probability and problem solving over a time period of three years. The findings indicated a clear correlation within the four mathematical areas showing a higher overall mean score for STEM-PBL students compared to non-STEM-PBL students in the last year as compared to the initial years showing low statistical significance (Han, et al., 2016). This conclusion also highlighted a focus on instructional practice and implementation of PBL in STEM classrooms.

The study concluded the instructional strategy of STEM-PBL has been assessed to be an effective instructional method to increasing mathematics scores for low achieving students (Han, et al., 2016). A final note from a global perspective is that this research related to the possible positive potential of PBL on increased student achievement aligns to the demands of our digital age. These measures call us to reflect

and rethink how we structure instructional practice around the content standards. In line with this education vision, teachers might consider a shift in their approach to include technology as a catalyst to accelerate learning of complex concepts within a student partnership (Fullan & Langworthy, 2013). This perspective leads us to the understanding that change is eminent. According to Boss, project designed to integrate technology sets the foundation for student engagement with issues around real-world problems outside of the classroom (Boss, 2015). To reinforce this understanding and its correlation to higher level learning I next examine research around the topic of rigor and PBL.

A study by Edmunds, Arshavsky, Glennie, Charles, and Rice (2017) sheds some light on the relationship between rigor and PBL in STEM-themed high schools. The concept of rigor is widely used in education and a required component to increase academic standards and higher-order thinking. In this quantitative research study six principles were used to analyze the concept of rigor to include: college readiness, focus on student engagement in instruction, student support, collaborative environment, time management, and structural support. The study examined data from 10 stem-focused schools. The key findings indicate a higher degree of perceived rigor directly related to high quality structured projects within the instruction (Edmunds, Arshavsky, Glennie, Charles, & Rice, 2017). Therefore, the investigation further inferred that when PBL was correctly implemented the structure could embed rigor into instructional lessons for teachers while also noting that rigor can also be present without PBL in certain instances.

Conclusion

The research reported informs the basis for my program evaluation and validates the value of the topic of STEM and PBL as an instructional structure to improve student collaboration, motivation, and achievement. In my study, I investigate STEM and PBL at the secondary level at Avatar Technological High School in the Pandora school district. The questions addressed in the chosen methodology focus on the participant perceptions about STEM-PBL instructional practice and the relationship to student motivation, collaboration and achievement.

SECTION THREE: METHODOLOGY

Research Design Overview

A program evaluation is a methodical process that allows a researcher to establish a program problem to then investigate driving informed decisions on the program effectiveness, quality, fidelity, value, or sustainability. Patton defines a Program Evaluation as, “A systematic collection of information about activities, characteristics, and results on programs to conclude about its improvement, development, understanding or future programming” (Patton, 2008, p. 39). The utilization focused program evaluation further defines this process to inform a specific group of users about the intended use and viability of the program being analyzed. Patton further details this process with the specification that, “Utilization focused program evaluations is targeted for specific intended users for a primary use” (Patton, 2008, p. 39). This systematic process allows the researcher to identify the key stakeholders related to the purpose or problem and collect relevant data both qualitative and quantitative to assist with triangulation to attain the most thorough assessment or correlation of the findings.

An overview of my research methodology is mixed methods having components of both the qualitative and quantitative paradigm to give detailed information on my topic. The purpose of the combination of both paradigms is to seek a thorough triangulation of the data. As described by Patton, “Qualitative methods have gained respectability as an adjunct to quantitative methods in mixed-methods evaluations” (Patton, 2008, p. 421). The chosen diverse groups of participants that include teachers, parents, high school principals, and district leaders in the area of STEM will give a complete picture that can cross reference for effectiveness as perceived by most stakeholders. The purpose of this effort was influenced by Patton who suggested that,

“gathering data from different groups such as teachers, parents, and school leaders is known as triangulation and checks for consistency in the data” (Patton, 2008, p. 442). The ultimate end goal of the data collection is to investigate a relationship to student achievement in STEM-PBL environment with an inclusion of most stakeholders.

In this study to address the primary exploratory questions I have chosen a research process of mixed methodology containing qualitative and quantitative data. My data include surveys, interviews, focus groups that address the primary and secondary exploratory questions. I am seeking teacher perceptions by collecting qualitative and quantitative data that are directly correlated to and elicits information about teachers’ thoughts and ideas on what is or not working well within each of the STEM programs or content areas of Science and Math. Further, I will explore their perceptions on how they think the process can be improved with complete STEM-PBL implementation in the classroom.

Participants

The high school level participants selected are STEM teachers in Game Design, Engineering and Biomedical Science, core subject teachers in mathematics and science, School Principals and Assistant Principals for Curriculum at a STEM themed school and district directors in STEM and CTE. These participants each bring value to the collection of information for this study as follows:

STEM Teachers in each of the Programs. I selected up to 40 teachers based on criteria of their expertise and background in science and mathematics education or a stem related program in assessing their perceptions of PBL related to the exploratory questions on what is or is not going well within the science and math content areas related to the STEM programs. These teachers have classroom experience in the area of teaching

STEM content in a STEM-PBL environment associated with products and outcomes in a STEM-Themed high school. The cumulative experience of these educators provides trends in data that identify some areas of the curriculum within the STEM program that are working well or that may be improved.

Math, Science and STEM Core Teachers. I selected 35 teachers in the core areas of mathematics, science, and STEM to be surveyed giving a reference comparison to correlate their perceptions in a traditional classroom setting to that of the STEM Magnet environment. The core subjects of mathematics and science are extensively applied in the STEM-PBL curriculum. In addition, these teachers provided insight within the survey questions as to the effectiveness and usage of PBL in the science, mathematics, and STEM classrooms as related to the areas of student motivation, collaboration, and academic achievement. Further, a selected group of 6 STEM core teachers in each program were interviewed in a Focus Group setting to get more in-depth information about STEM-PBL practice as it is related to improving student achievement.

High School Principals at STEM-Focused Schools. I selected 2 school-based administrators to be interviewed. The perception data from the interviews of the Principals and Assistant Principals for Curriculum of both the STEM-Themed and traditional high school have been utilized as a source to identify the perceived value of stronger integration of PBL into a cross-curricular framework to assist teachers in attaining deeper mastery of the standards in mathematics and science. The data from these participants inform on the viability of the vertical articulation within the science and math curriculum at their school as related to the primary and exploratory questions about the STEM programs. In addition, I elicited their perception on the effectiveness of

implementation at the classroom level as evidenced by student products to inform on what is working well or what may be improved.

District Leaders in STEM/ CTE/Magnet. I selected 2 district level directors in the Stem and CTE areas to be interviewed. The district directors in STEM, CTE, and Magnet were interviewed to identify trends in their perceptions of STEM and PBL in future curricular standards across all content areas. The input of these district directors provides information on the district philosophy about STEM curriculum and their perception on the intended direction as it is related to my primary and exploratory questions. Also, as an extension their perception data inform future national, local, and district policies and procedures related to STEM education and implementation.

Parents of STEM Program Completers. I selected 2 parents to be interviewed who have had students complete each of the programs. The parents of graduates from each STEM program are interviewed to gain a perception of the quality of each program as it translated to their student's college preparation. The parent's data trends inform on aspects related to the quality of their student's mathematics and science ability foundation that translates to their STEM fields. In addition, the parent's data indicate their perception on what is working well with the program or what improvements if any could be made. Finally, parents were able to indicate if their student is in a STEM related program in college.

Data Gathering Techniques

I utilized a plan to collect data that support a mixed-methods approach, which includes collection of relevant and useful qualitative and quantitative data. This process provides sufficient information to thoroughly address my program evaluation. he information collects perceptions and insights from various stakeholders: teachers,

parents, and district related officials. The inclusion of a wide spectrum of stakeholders assists in establishing context for advocating future policy change. Student achievement data trends provide quantitative evidence to present a broader student achievement correlation. The quantitative data assist with triangulation of program effects in terms of student performance variables.

Ultimately, it is the overall impact of these components on student achievement that matters the most. The specified data and paradigms associated with my methods of data collection serve as a means to generate pertinent information to analyze in reference to my primary and secondary exploratory questions. The qualitative data that I collected through the means of interviews include the responses from administrator interviews, Focus Group interviews, interviews with parents of program graduates, and district director interviews. Quantitative data collected include teacher surveys, student GPA, graduation rates, and industry certification earnings.

Qualitative Data Collection

Administrator Interviews. I conducted administrator interviews (Appendix B) of 2 administrators and 2 guidance counselors (Appendix C). These questions elicited administrative perceptions about the STEM program that utilizes PBL relating to student achievement. The interviews have been done at the convenience of the participants schedule and timeline.

Focus Group Interviews. I conducted Focus Group interviews (Appendix F) with 6- teachers who represent each of the program focus areas: Game Design, Engineering and Biomedical Sciences. The interview questions elicited teacher

perceptions that are program specific. The Focus Group was done during non-instructional time.

Parents of Program Graduates Interviews. I conducted 2-parent interviews to gain insight on the perception of student participant parents (Appendix E). These parents have had children who have graduated from each of the programs being analyzed. The interview questions inquired about their perceptions of the components of student motivation and collaboration as it relates to student achievement and future success. These interviews have been done during the summer, as these students have graduated which collects a parent perspective and input from parents of students who completed the four-year STEM program. The interviews were scheduled and conducted at the convenience of the participant.

District Director Interviews. I have conducted interviews to gather the perceptions of 2-key district directors (Appendix D) in the areas of Magnet Schools of Choice, STEM, or CTE Educational programs. I have analyzed the data as related to the components of student interest, motivation, collaboration, student achievement, success and future policy change. These interviews have been done in the summer and at the convenience of the participant's schedule.

Quantitative Data Collection

Teacher Surveys. I conducted an online teacher perception survey (Appendix A) of 35 teachers in the core areas of math, science and stem, using the Likert scale to quantify results including CTE and core content area teachers to analyze the critical elements related to PBL and STEM integration into lessons and their perception of the correlation to student motivation, collaboration and achievement. The survey has been

conducted during the spring to allow time for achievement data to be accessible for teacher evidence and input. The survey has been done during non-instructional time. Several of the Teacher Survey questions are open-ended response questions to garner responses which are not prompted by provided choices, so the findings for these questions are discussed as qualitative data.

Student GPA. I have collected and statistically analyzed Pandora Technological Magnet's overall student achievement in GPA for up to 1700 students' times 4 grades (=6800 students' data) 9-12 in the STEM magnet programs course achievement in Engineering, Biotechnology, and Computer Game Design and non-STEM students during the 2014-15, 2015-16, 2016-17, and 2017-18-school years to show growth, interest, and sustainability in the STEM programs. The data were available at my school site and through the district.

Graduation Rates. I collected and statistically analyzed overall student graduation rates of up to 1700 total students' times 4 years over time (= 6800 students' data) from 2014-15, 2015-16, 2016-17, and 2017-18, at Pandora Technological Magnet compared to a Traditional High School to assert an inferential correlation of STEM education and graduation rates. The data were attainable by the district.

Industry Certifications Earned. I collected and statistically analyzed industry certification data over time for up to 1700 magnet STEM students' times 4 (=6800 students' data) grades 9-112 in Engineering, Biotechnology, and Computer Game Design from 2014-15, 2015-16, 2016-17, 2017-18 school years comparing Pandora Technological High School to the Traditional school that relates to building technological skills for the projects within the STEM coursework. This analysis was further used to

investigate a student connection to motivation and their future aspiration in the STEM field through the attainment of industry certifications to add to their skillset for future jobs and careers. The industry certification data have been attainable by the district.

Ethical Considerations

All participants, teachers (Appendix G), parents (Appendix I), principals (Appendix H), assistant principals for curriculum (Appendix H), guidance counselors (Appendix H), district directors (Appendix H) in STEM and CTE, and parents (Appendix I), and the STEM teacher focus-group (Appendix J), have signed a written informed consent form before the interview was conducted. This form was thoroughly explained to each participant and was clearly outlined to elicit participant understanding. The consent form indicates and acknowledges the participants understanding of the process with their agreement to participate without pressure. In the case of the online teacher survey, each participating teacher has acknowledged agreement of the embedded consent (Appendix G) via the online survey by clicking to complete the survey.

Each participant and institution involved in my program evaluation is guaranteed anonymity and has been identified by an anonymizing pseudonym. The privacy and confidentiality of all participants and data collected are protected for the purpose and use of this study. There are minimal risks involved in this program evaluation of which the goal and purpose is to seek information that correlates to the effectiveness of the STEM-PBL curricular framework to improve academic motivation, student collaboration, and achievement in the area of science, mathematics and STEM. The benefits that relate to the academic return on investment of the data collection serve to inform on the teacher perception of the effectiveness of STEM-PBL, which can influence the value placed on

its use within the science curriculum. This has added clarity to the quality of student outcomes and increased skill level with collaborative problem solving in the classroom while addressing the NGSS standards.

Data Analysis Techniques

I have analyzed qualitative data comprised of focus groups and individual interviews for trends and coded to identify themes of common perceptions among the teachers, principals, and district directors in STEM, CTE, and Magnet education. I have analyzed the quantitative data of the survey put on a Likert scale to identify trends in the perception data on STEM-PBL lessons and techniques and their overall effectiveness in creating motivation, collaborative groups, critical thinking skills and improved academic achievement. I utilized the SPSS (Statistical Package for Social Scientists) process to analyze the questionnaire data to be able to apply inferential descriptive statistics exploring the relationships within the program analysis. I compiled the collected data and created a visual display graph reporting the frequency of the perceptions as correlated to the exploratory research questions. The researcher has analyzed comparison quantitative data of overall graduation rates, using descriptive comparison statistics of central tendency, to compare Magnet STEM themed schools' students to traditional school students within the same school mean, median, and mode. I have done a further analysis of the data for variance comparisons.

Conclusion

In conclusion, my investigation plan, overall research design, and methodology demonstrate an inquiry into student academic assessment as a critical aspect of STEM and PBL practice. Student assessment in STEM and PBL may be viewed as a barrier or limitation of PBL. I explore the types of student assessments used within each program

with the projects producing an outcome. I probe the types of assessment for fidelity and accuracy of what is being measured and how the assessments align to the standards-driven assessments of the common core, as well as national standardized tests such as the PSAT and SAT.

The data have been selected for collection to generate both qualitative and quantitative information to serve as a means to conduct a triangulation of many perspectives and student performance outcomes. In this way, I have sought to capture a broad view of program efficacy for a clearer picture of the outcomes assessed. The survey and interview questions have been crafted to elicit responses that are relevant to the exploratory questions addressed in the study. The goal of the survey instruments has been to capture evidence of substantial significance for correlation to additional rigor variables being analyzed within this study; these additional variables include student motivation, collaboration, and academic achievement within a STEM-PBL environment.

CHAPTER FOUR: RESULTS

Findings

Overview

The research tools I utilized to evaluate the STEM-PBL programs of engineering, biomedical science, and computer game design included surveys and interviews targeting five specific populations of participants related to the STEM program. The five populations chosen were representative of the STEM program bringing different perspectives: teachers, administrators, guidance counselors, district directors, and parents. I conducted an online teacher survey (Appendix A) with teachers representing each of the STEM programs; interviews were conducted with administrators (Appendix B), guidance counselors (Appendix C), district directors (Appendix D), and parents (Appendix E); a group of teachers also participated in a STEM-teacher focus group (Appendix F). These information-gathering tools allowed for a triangulation of the data giving insight to the programs from different perspectives.

Teacher Survey Questions

In order to maintain the sequential, logical progression of the survey questions, they are presented numerically in this findings section. Several of the teacher survey questions were formulated as open-ended questions in order to capture thematically similar responses without providing prompted response choices; these questions are 14, 16, 18, 19, 22, and 24. Note that the headings below indicate the survey question groupings as well as identify whether the data discussed in the section are quantitative or qualitative in nature.

Teacher Survey Questions 1 - 13: Quantitative Data. I emailed an online teacher survey (Appendix A) with the goal of attaining responses from 35 teachers who all are classroom teachers of STEM in one STEM high school program. I emailed the invitation to participate, the consent form, and the link to the online survey to each participant. I received 9 teachers' responses out of 35 giving me a 25% response rate.

The online teacher survey consisted of two initial demographic questions regarding the number of years of teaching experience and the number of years taught at their present school to gain a perspective of the amount of time spent in the STEM program. In response to the teacher survey question #1, the years as high school classroom teacher category with the highest response rate was 5-10 years of teaching in their certification area with 4 teachers (44%) responding. The next highest category was 0-5 years with 3 teachers (33.3%) responding. The lowest category of response was teaching 10-20 years with 2 teachers (22.2%) responding. No (0) teachers responded for the 4th category option of 20+ years of teaching. The average number of high school classroom teaching experience years of the respondents shows most teachers, 7 out of 9, (74.7%) having between 0-10 years of classroom teaching experience at the high school in STEM. I am not surprised to see that the majority, 7 out of 9 teachers (74.7%), reported having taught between 0-10 years in the area of STEM since Title 1 schools tend to attract teachers with lower years of experience due to the challenging nature of the population and since STEM is a relatively new specialization among traditional science, mathematics, and science teachers.

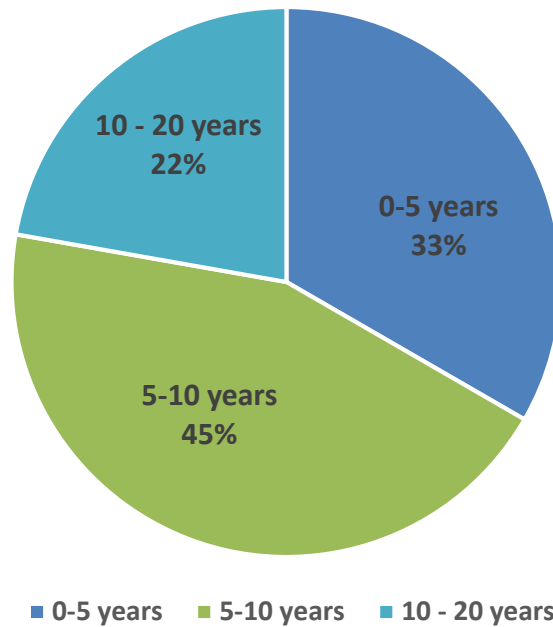


Figure 1. Survey question 1: teacher survey participants' years of high school teaching experience percentages.

In response to teacher survey question #2, the respondents reported the highest frequency in the category of teaching at their present school for 0-5 years with 5 teachers (55.6%) selecting this option; the next highest was 3 teachers (33.3%) teaching 5-10 years; and the lowest frequency, 1 teacher teaching the longest 10 -20 years. I am pleased with the higher representation of experienced teachers in the survey sample group, as their reflections about STEM education may provide greater breath of insight into the classroom implementation of STEM.

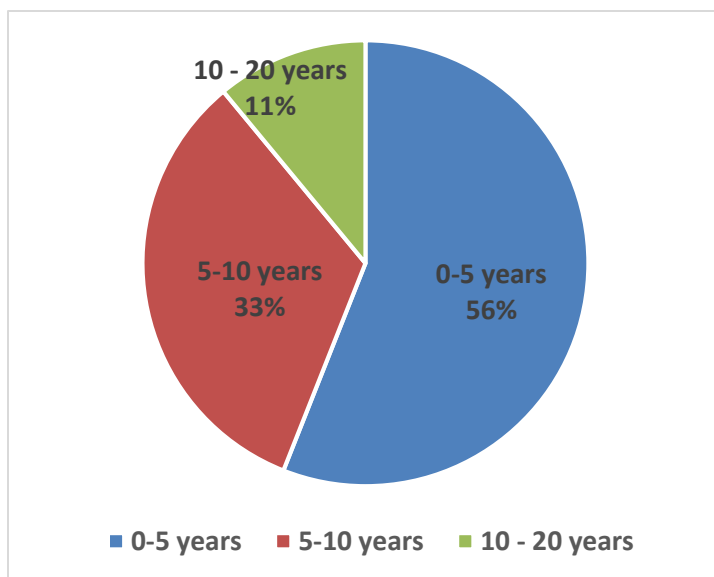


Figure 2. Survey question 2: teacher survey participants' years at present school.

In response to teacher survey question #3 asking *yes* or *no* if their teaching responsibilities included any of the following standards: math, science, engineering, game design, and biotechnology. Of the 9 teachers (100%) responded that *yes*, they taught one or more of the various courses and the course content standards. In evaluating the data, I am pleased to see that teachers in the STEM program are versed in teaching standards in various subject areas associated with STEM: math, science, engineering, game design, and biotechnology. A cross section of these subject standards and the integration of these subject areas are foundational for a rigorous STEM program, and, therefore, contribute to a viable STEM context for this evaluation. Teaching to the standard is a critical expectation and also embedded in the teacher evaluation rubric.

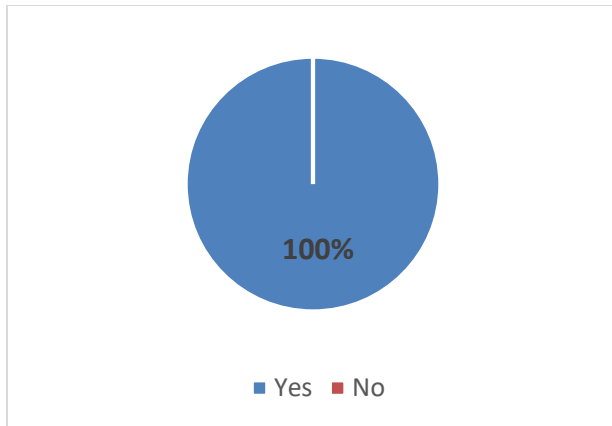
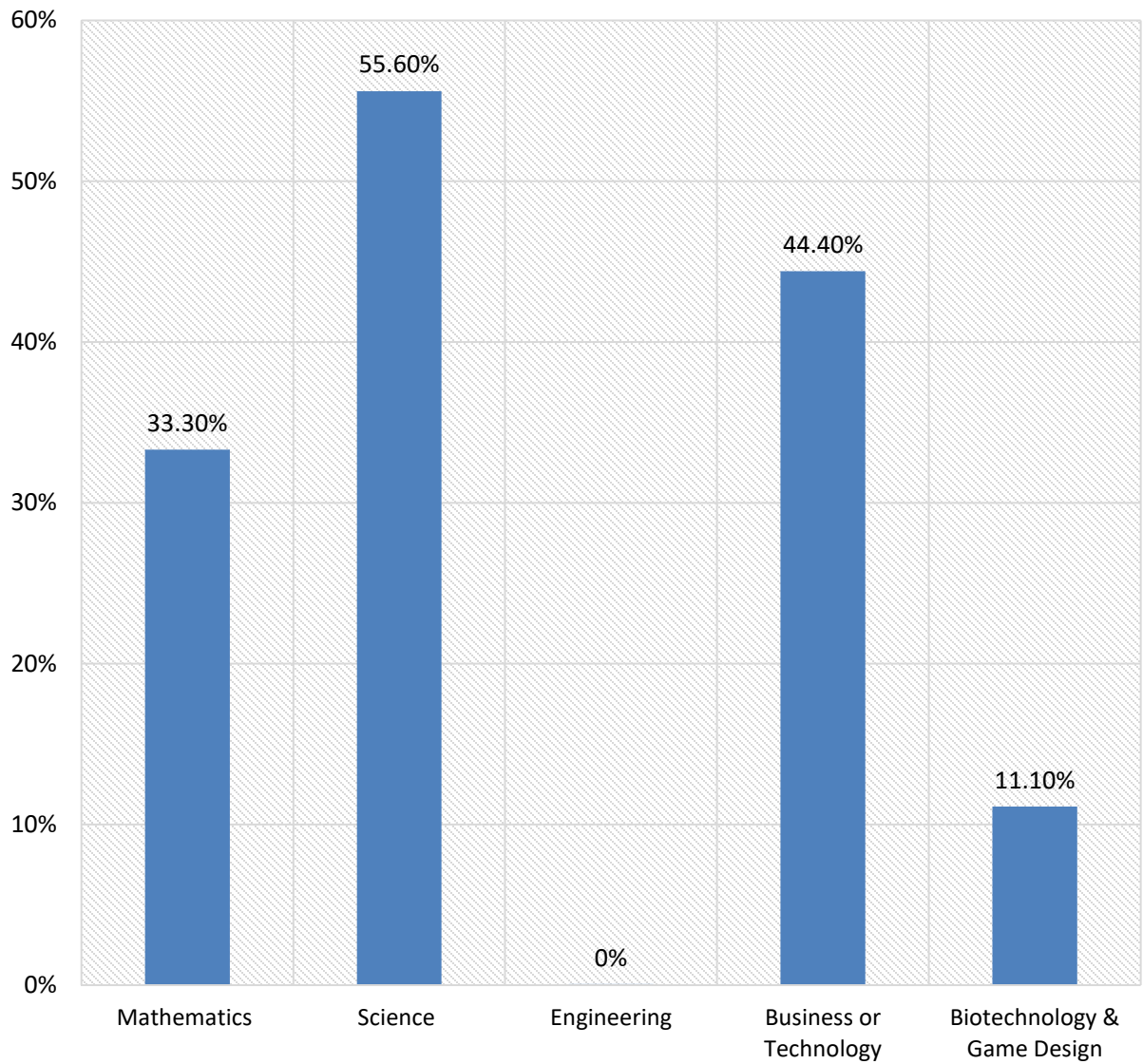


Figure 3. Teacher survey question 3: participants with teaching responsibilities that include standards in mathematics, science, engineering, game design, and biotechnology.

In response to question #4 of the teacher survey about the teachers' area of concentration in which they are certified to teach, the participants were asked to mark all that applied of the possible choices: mathematics, science, engineering, business or technology, biotechnology, or game design. The category with the highest frequency was certification in science with 5 teachers (55.6%). The next highest frequency reported were 4 teachers (44.4%) who were certified in business or technology. The next highest frequency reported was 3 teachers (33.3%) certified in mathematics. The least frequency of 1 teacher (11.1%) indicated certification in both biotechnology and game design. In addition, 0 teachers reported a certification specifically in engineering.



■ Frequency of teacher responses to types of certifications held (several teachers hold multiple certifications)

Figure 4. Question 4: frequency of teacher responses to the types of STEM area certifications held (5 of the 9 responding teachers hold multiple certifications): mathematics, science, engineering, business or technology, biotechnology, and game design.

In evaluating the data, I am impressed to observe that 55% of the teachers hold certifications in multiple STEM-related areas considering that these are critical, hard to staff content areas in education and teachers with these certifications are always in high demand. However, I am pleased to see that 56% of the responding teachers have specialized certification concentrations relating to STEM education other than mathematics and science: biotechnology, business or technology, game design. This shows that these teachers have credentials that are specific to the program focus as opposed to general math and science alone. I was expecting 0% state certifications in Engineering since only few teachers have additional district certifications with a bachelor's degree in Engineering or certified in Business Technology or as an expert in field in Engineering. A teacher who is considered an expert in field possesses 6 or more years' credit of experience in the field: of these, 0 are technical teachers of engineering design.

In my experience as an administrator, these areas are critical and difficult positions to fill at the high school level. The 78% representation of multiple STEM certifications among the sample group of responders represents what I believe is a strength to the sample in that such hybrid qualifications are needed for infusing rigorous, real-world knowledge to the STEM concepts in the classroom.

Question 5 of the teacher survey asks how often the teachers taught the subjects of math, science, engineering, business, technology, biotechnology, and game design as a single subject standards-based course, lessons or projects. The question was phrased to capture all possible STEM content (math, science, engineering, business, technology, biotechnology, and game design) as well as all possible delivery contexts (a single

subject standards-based course, lessons or projects). In this way, I hoped to communicate to the teachers a sense of inclusivity and a wide interpretation of what STEM-related education means in order to gain the most accurate responses possible, since the traditional culture of subject compartmentalization limits the conceptualization of STEM and Problem Based Learning instruction as integrated, interdisciplinary practices. To further capture insight into the teachers' instructional content, the teachers were asked to use the following rating scale: *never*, *sometimes*, *frequently*, or *always*. The category with the highest response rate was *always*, with 7 teachers (78%) reporting that they are always involved in STEM-related instruction. The least frequent response is tied to 2 of the teacher survey sample group (22%) who reported that they are *sometimes* involved in STEM-related instruction. It is of importance to my study that most of the teachers who participated in, and responded to, the survey has experience working in a full time STEM instructional context. This brings relevant input for analysis from pertinent instructional level practitioners that informs my inquiry on the specifics of each program as it is related to STEM and PBL.

Question 5 also asks teachers how often the teachers taught the subjects of math, science, engineering, business, technology, biotechnology, and game design as an interdisciplinary project with other subjects. The category with the highest response rate was *sometimes* with 3 teachers (33%) responding. The next category with the highest response was 2 teachers (22%) reporting *always*. The category with the least frequent response with 1 teacher (11%) for each, were tied to the responses *frequently* and *never*. For some reason, perhaps several of the teachers overlooked the second part of question 5, with only 7 participants responding to whether or not they presented subjects that they

taught using interdisciplinary projects. In reviewing the responses to #5b, I am not surprised by the result considering the compartmentalized structure of high schools. I anticipated that only 5 teachers out of 9 (55%) were applying STEM subject content to interdisciplinary projects. This is a point to investigate further as a possible change in practice to increase collaboration between subject areas so that the application of skills across the curriculum becomes a rigorous norm for improved STEM programming resulting in higher levels of student achievement.

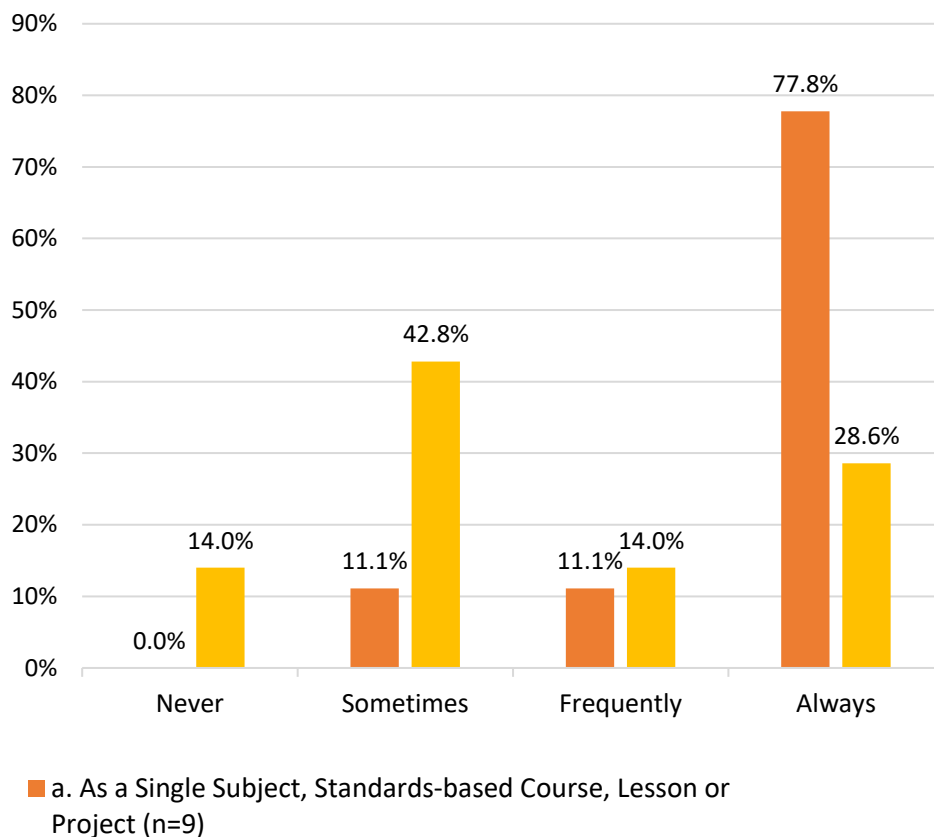


Figure 5. Teacher Survey Question 5 Responses: Instances of teaching STEM subjects of mathematics, science, engineering, business, technology, biotechnology, game design as a single subject, standards-based course, lesson or project (n=9); and, as an interdisciplinary project with other subjects. (n=7)

Teacher survey question #6 asked often each teacher taught or integrated any of the subjects related to STEM of computer technology, multi-media arts, career technology, art-music-drama, internships-community service, capstone, senior projects, extracurricular-project, or out-based products. The teachers were asked to check all that applied to their classroom work. Of the nine, 7 teachers responded. The category with the highest response rate was 7 teachers (100%) who integrated computer technology or multi-media. The next highest category had a response rate of 6 teachers (85.7%) who integrated a capstone senior project or outcome-based project. The next highest category had a response rate of 5 teachers (71.4%) who indicated that they integrate career-technology course standards. The next highest category had a response rate of 4 teachers (57.1%) who integrated internships and community service. The category with the lowest frequency response rate of 1 teacher (14.3%), were those teachers who included art, music, or drama in their instruction. I interpret the data to mean that teachers within the STEM program regularly integrate technology into their instruction in such a way that students produce an outcome or product that relates to standards. STEM teachers have been encouraged to integrate the humanities (art, music, or drama) into STEM but often feel less comfortable with the humanities as most are mathematics and science teachers and untrained in the arts.

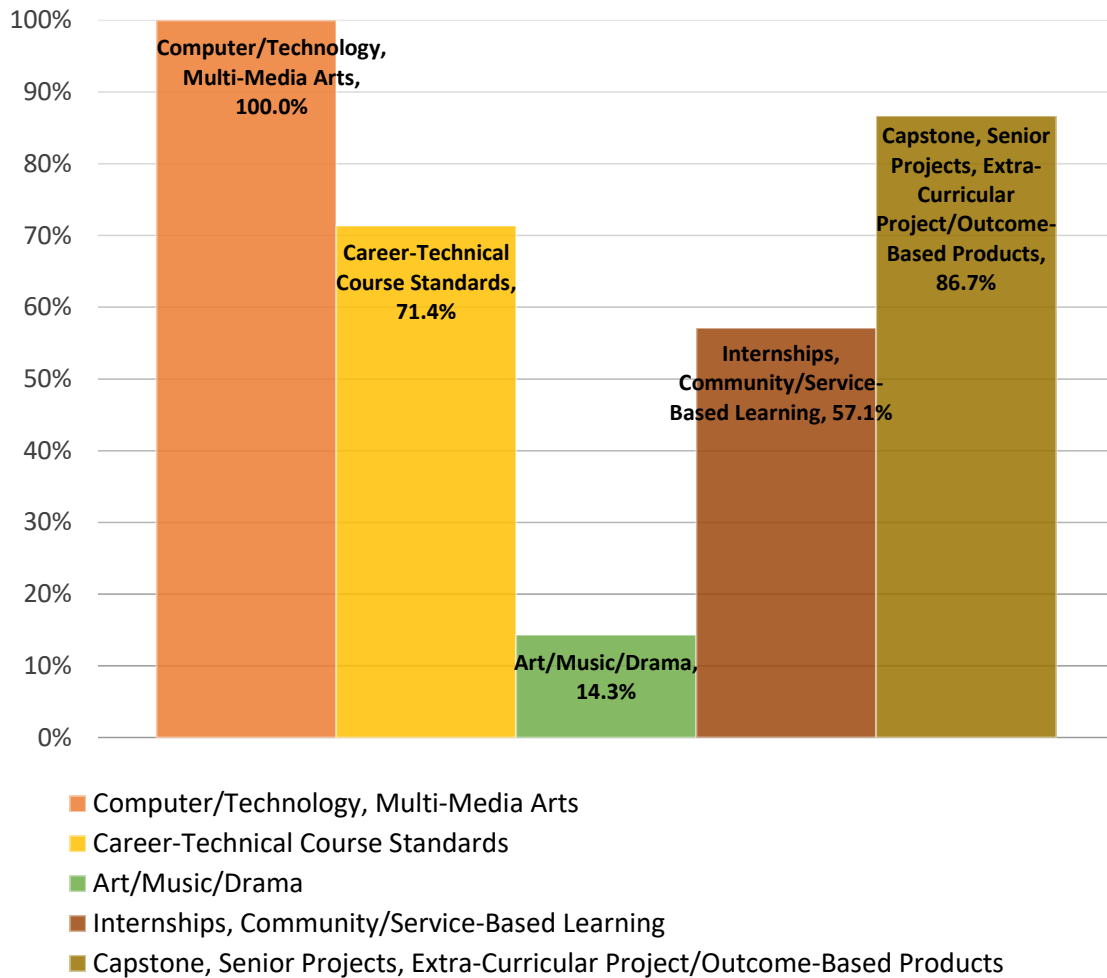


Figure 6. Teacher Survey Question 6 Responses: Instances of course content integration by subject-area of integration within teacher survey responders' classroom instruction. (n=9)

In response to teacher survey question #7, regularly scheduled professional learning community meetings focused on PBL and student learning, the category with the highest response rate of *frequently* was 5 teachers (55.5%). The category with the next highest response rate of *always* was 3 teachers (33.3%). The category with the least highest response rate of *sometimes* was 1 teacher (11.1%). I interpret the data to mean that teachers within the structure of the STEM program regularly participate in professional learning communities to collaborate on best practices.

Question 7 also asked how often teachers in the STEM program had received PBL instructional coaching or mentoring. The category with the highest response rate reporting *frequently* was 4 teachers (44.4%). The category with the next highest response rate was tied reporting *always* and *never* were 2 teachers (22.2 %) for each rating. The category with the least highest response rate reporting *sometimes* was 1 teacher (11.1%). I interpret the data to mean the majority of the teachers within the STEM program have received some instructional coaching or mentoring focused on their area of academic concentration.

In addition, teacher survey question #7 asked how often teachers in the STEM program collaborated with school leadership to address student and teacher needs to improve achievement. The category with the highest response rate reported *always* was 4 teachers (44%). The category with the next highest response rate reported *frequently* was 3 teachers (33.3%). The category with the next highest response rate was tied with *never* and *sometimes* reported by 1 teacher (11.1%) for each. I interpret the data to mean that the majority of the teachers within the STEM programs reported having collaborated with school leadership to enhance the programs in response to teacher and student needs driving overall achievement.

Finally, teacher survey question #7 asks how often teachers in the STEM programs collaborate with school leadership to set policies and procedures in decision-making. The categories with the highest response rate have a tied rating of both *always* and *frequently* with 3 teachers (33.3%). The category with the next highest response rated *sometimes* with 2 teachers (22.2%). The category with the least amount rated, *never*, was 1 teacher (11.1%). I interpret the data to mean that teachers within the STEM program

were active participants in driving the improvement of the program. The school leadership elicited input from teachers and departments to drive policy and program enhancements that met the needs of the students to improve their skills. This is a critical point to consider in a STEM program as a means for keeping the curriculum relevant and current to industry demands.

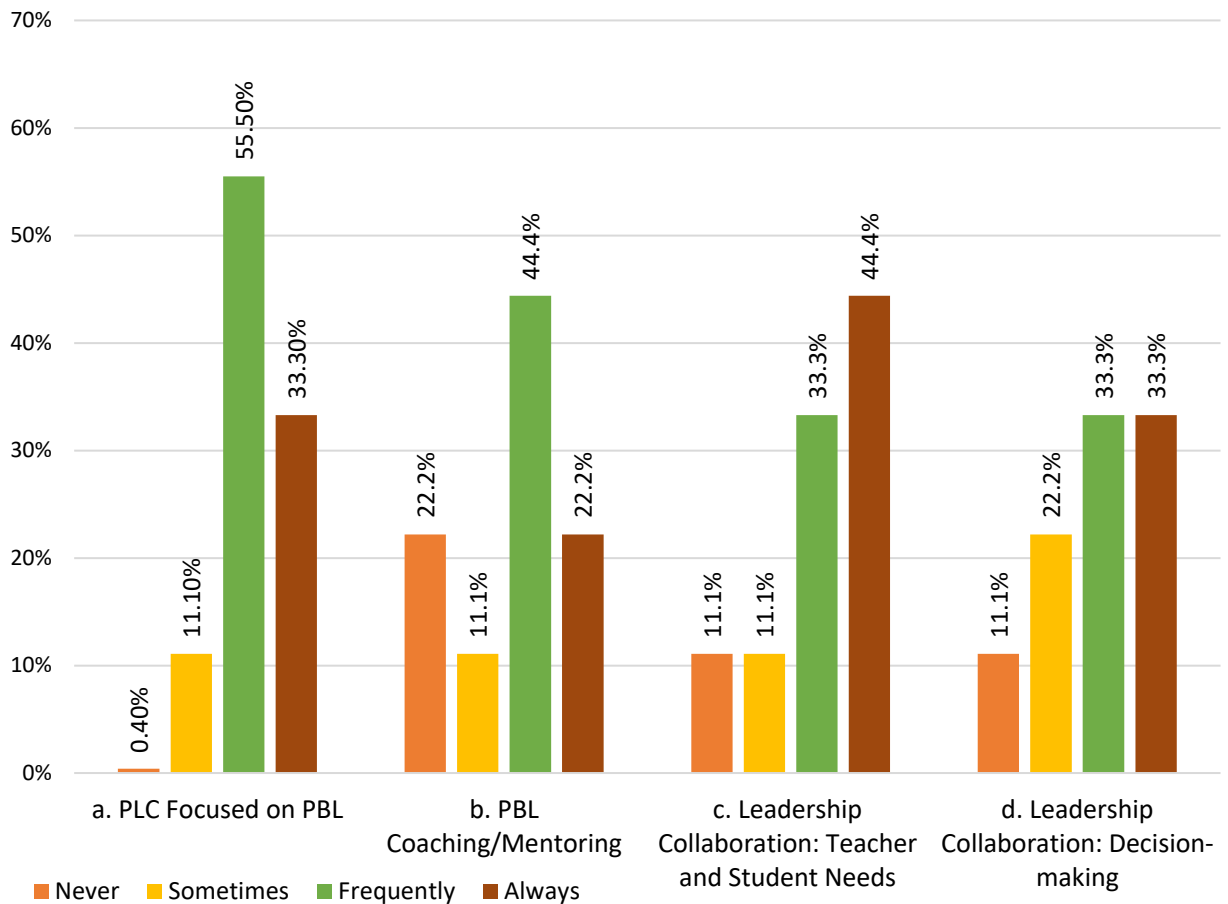


Figure 7. Teacher Survey Question 7 Responses: Instances of STEM teacher support and collaboration: a. PLC Focused on PBL: STEM program teacher has regularly scheduled professional learning community (PLC) meetings that focused on PBL instructional practice and student learning; b. PBL Coaching/Mentoring: STEM program teacher has received PBL instructional coaching-mentoring formally and from peers; c. Leadership Collaboration – Teacher and Student Needs: STEM program teacher has collaborated with school leadership in addressing teacher and student needs to improve achievement; d. Leadership Collaboration – Decision-making: STEM program teacher has collaborated with school leadership to set policies and procedures in decision making for the STEM program. (n=9)

Survey question #8 has multiple responses (a.-e.) so the following reporting divides the responses into parts (part a. etc.). In response to teacher survey question #8, part a., which asks how often teachers observed their students inquiring on their progress to seek academic support. The category selected by teachers with the highest response rate was *frequently* by 4 teachers (44.4%). The category with the next highest response rate, *always* was selected by 3 teachers (33.3%). The category with the least highest response rate was *sometimes* by 2 teachers (22.2%). The category with a response rate of 0 teachers was *never*. I interpret the data to mean that students within these STEM programs actively seek out academic support through inquiry based on teacher feedback on their progress.

In response to teacher survey question #8, part b., which asks how often teachers observed their students reflecting or refining their work, the category selected with the highest response rate was *always* and *sometimes* by 4 teachers (44.4%). The category with the least highest response rate of *frequently* was selected by 1 teacher (11.1%). The category with a response rate of 0 teachers was *never*. I interpret the data to mean that students within these STEM programs self-reflect on the quality of their work striving for improvement. The data strongly suggest that these academic environments foster a classroom culture allowing students to self-diagnose their own learning gaps.

In response to teacher survey question #8, part c., which asks how often teachers observed their students inquiring to gain deeper knowledge, the category with the highest responses was *always* by 4 teachers (44.4%). The category with the next highest response was *frequently* selected by 3 teachers (33.3%). The category with the least highest response rate of *sometimes* was selected by 2 teachers (22.2%). The category with a

response rate of 0 teachers was *never*. I interpret these data to mean that students within these STEM programs initiate inquiry to gain deeper knowledge of the content for a greater purpose. These data are pertinent to having the characteristic of a strong PBL environment that allows students to inquire beyond the base content and build their skills for application purposes related to a given outcome or product.

In response to teacher survey question #8, part d., asks how often teachers observed their students initiating student-driven decisions about what to learn. The category with the highest response rate was *frequently* by 5 teachers (55.5%). The category with the next highest response rate of *sometimes* was selected by 3 teachers (33.3%). The category with the least highest response rate was *always* selected by 1 teacher (11.1%). The category with a response rate of 0 teachers was *never*. I interpret these data to mean that students within these STEM programs have less opportunity to drive what is being learned. This result aligns to the nature of the instructional pacing constraints giving teacher limited time to complete their content.

In response to teacher survey question #8, part e., asking how often teachers observed their students initiating student-driven decisions about how to problem-solve, the category with the highest response rate was *frequently* by 6 teachers (66.6%). The category with the next highest response rate was *always* by 2 teachers (22.2%). The category with the least highest response rate was *sometimes* selected by 1 teacher (11.1%). The category with a response rate of 0 teachers was *never*. I interpret these data to mean that students within these STEM programs are given autonomy to problem solving in their own way. This environment allows students to think through the

possibilities on their own increasing their skills to arrive at solutions through self-correction.

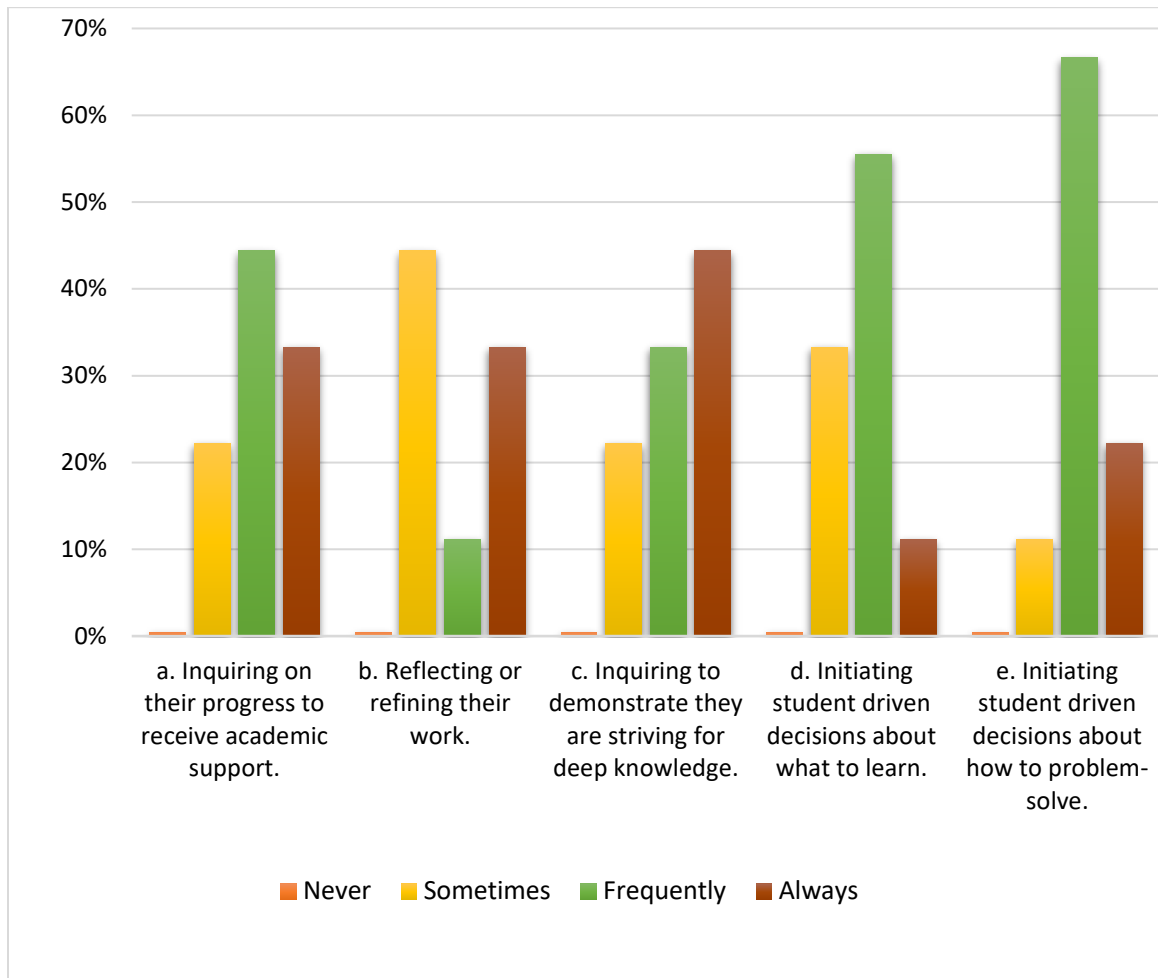


Figure 8. Teacher Survey Question 8 Responses: Instances of STEM teacher observation of STEM students engaged in the following behaviors: a. Inquiring on their progress to receive academic support; b. Reflecting or refining their work; c. Inquiring to demonstrate they are striving for deep knowledge; d. Initiating student driven decisions about what to learn; e. Initiating student driven decisions about how to problem-solve. (n=9)

Question #9 has multiple parts a.- g. In response to teacher survey question #9, part a., which asks how often teachers used multiple-choice or short answer questions to assess student performance, the category with the highest response rate was *frequently* by 6 teachers (66.6%). The category with the next highest response rate was *sometimes* which was selected by 2 teachers (22.2%). The category with the least high response was

always selected by 1 teacher (11.1%). The category with a response rate of 0 teachers was *never*. I interpret these data to mean that teachers used multiple-choice and short answer questions on a regular basis on some level when assessing student knowledge. This form of assessing student learning can inform instruction but usually requires less from the student with respect to deep thinking.

In response to teacher survey question #9, part b., which asks how often teachers used open-ended questions or problems to assess student performance, the category with the highest response was *frequently* selected by 5 teachers (55.5%). The category with the next highest response rate was *always* with 2 teachers (22.2%). The category with the least highest response rate was *sometimes* selected by 1 teacher (11.1%). The category with a response rate of 0 teachers was *never*. I interpret these data to mean that most teachers reported using open ended or problem-based questions when assessing student knowledge. This form of assessing student learning requires deeper thinking, which builds connections of the key concepts.

In response to teacher survey question #9, part c., asking how often teachers used portfolios of student work to assess student performance, the highest response selection was a three-way tie reporting *always*, *frequently*, and *sometimes* by 3 teachers (33.3%) for each category (totaling 99.9%). The category with a response rate of 0 teachers was *never*. I interpret these data to mean that teachers used portfolios or products of student learning very often to assess student performance. This form of assessing student learning can be a complement to traditional forms of standardized assessments as it is based on content mastery allowing teachers to differentiate for their students to showcase their understanding of the STEM concepts.

In response to teacher survey question #9, part d., asking how often teachers used group projects to assess student performance, the category with the highest response rate was *frequently* selected by 5 teachers (55.5%). The category with the next highest response rate was *sometimes* by 3 teachers (33.3%). The category with the least highest response rate *always* was selected by 1 teacher (11.1%). The category with a response rate of 0 teachers was *never*. I interpret these data to mean that teachers used group projects frequently varying depending on the content. This form of assessing student learning can create opportunities for students to collaborate on the topic or problem being asked.

In response to teacher survey question #9, part e., which asked how often teachers used individual projects to assess student performance, the highest response rate was *frequently* selected by 5 teachers (55.5%). The categories with the next highest response rates were *sometimes* and *always* each selected by 2 teachers (22.2%) totaling (44.4%). The category with a response rate of 0 teachers was *never*. I interpret these data to mean that teachers used individual projects quite frequently when assessing student knowledge. This form of assessing student learning fosters independent thinking and can clearly identify gaps and inform instruction in a STEM program.

In response to teacher survey question #9, part f., which asks how often teachers used projects that yield a working product, the category with the highest response rate was *frequently* selected by 5 teachers (55.5%). The category with the next highest response was *sometimes* selected by 3 teachers (33.3%). The category with the least highest response rate was *never* chosen by 1 teacher (11.1%). The category with a response rate of 0 teachers was *always*. I interpret these data to mean that teachers

frequently created projects that resulted in a working product as an outcome. This form of assessing student learning has a built-in component ensuring quality. The students would self-assess within a STEM project and be given time to test the product for quality. This method allows students to revise the design as needed to perform at a level of the expectation.

In response to teacher survey question #9, part g., asking how often, teachers used hands-on demonstrations or oral presentations to assess student performance, the selection with the highest response rate was *frequently* selected by 5 teachers (55.5%). The categories of *always* and *sometimes* were selected by 2 teachers (22.2%). The category with a response rate of 0 teachers was *never*. I interpret these data to mean that teachers in the STEM program frequently used student demonstrations and oral presentations as a method of assessing their performance. This method also elicits high quality results requiring planning and analysis of the problem or content being explored.

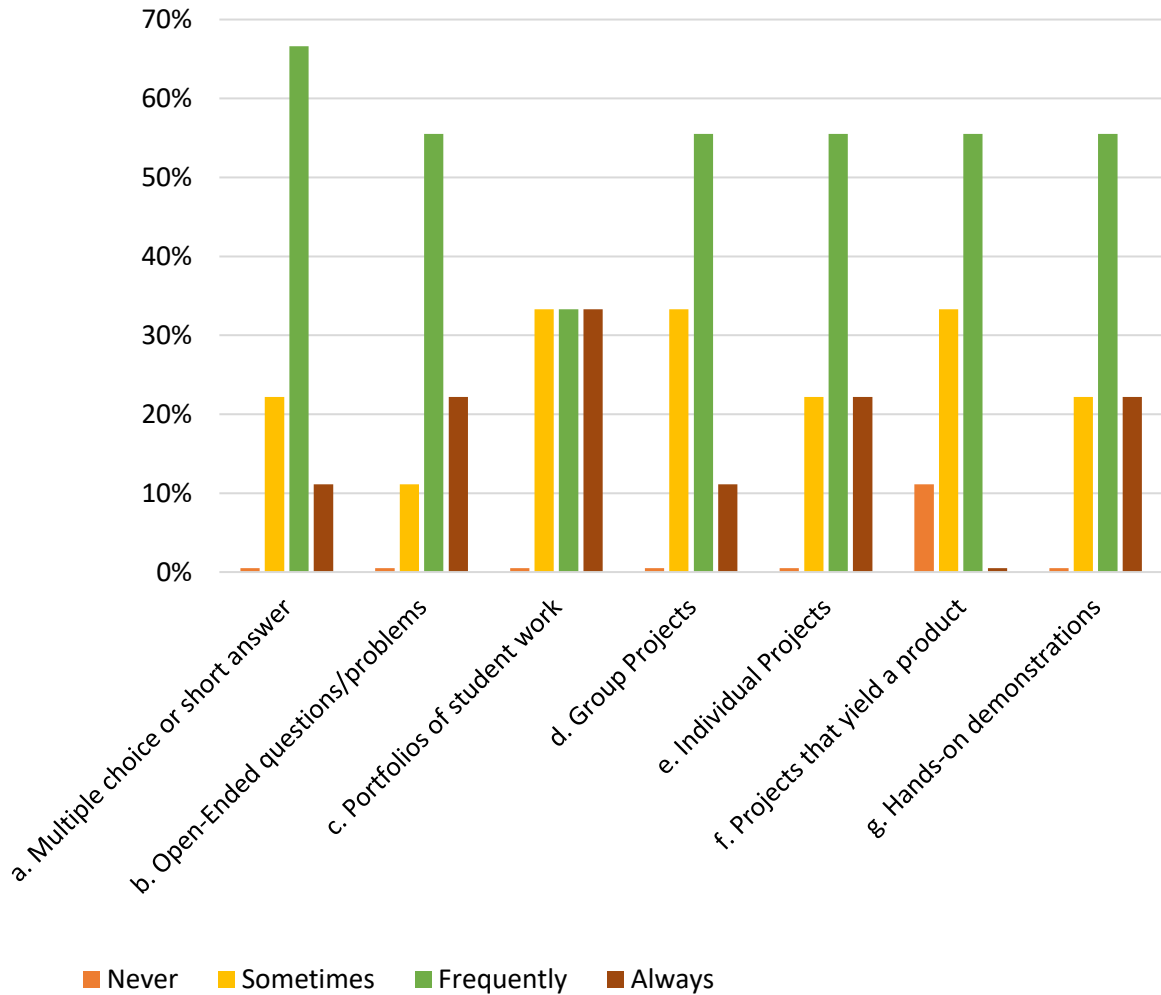


Figure 9. Teacher Survey Question 9 Responses: Instances of STEM teacher use of the following methods to assess student performance in their STEM program courses: a. multiple choice or short answer; b. open-ended questions/problems; c. portfolios of student work; d. group projects; e. individual projects; f. projects that yield a product; g. hands-on demonstrations, exhibitions or oral presentations. (n=9)

In response to teacher survey question #10, part a., how often teachers observed students collecting, organizing, and analyzing information, the category tied with the highest response rates were *always* and *frequently* with 4 teachers (44.6%) selecting each category. The category with the next least highest response rate was *sometimes* with 1 teacher (11.1%). The category with a response rate of 0 teachers was *never*. I interpret

these data to mean that students analyze data at a high frequency within these STEM programs.

In response to teacher survey question #10, part b., which asks how often teachers observed students solving real-world problems, the category tied with the highest response rates were *always* and *frequently* with 4 teachers (44.6%) for each category. The category with the next least highest response rate was *sometimes* with 1 teacher (11.1%). The response *never* was selected by 0 teachers. I interpret these data to mean that students analyze data at a high frequency within these STEM programs in order to solve real world problems.

In response to teacher survey question #10, part c., asking how often teachers observed students deciding how to present their learning, the category with the highest response rate was *sometimes* selected by 5 teachers (55.5%). The category tied with the least highest response rate was *frequently* and *sometimes* selected by 2 teachers (22.2%) each. The response *never* was selected by 0 teachers. I interpret these data to mean that teachers within these STEM programs allow their students autonomy on how to present their learning. This process allows students the freedom of creative design in communicating their learning.

In response to teacher survey question #10, part d., which asks how often teachers observed students orally presenting their work to peers, staff, parents and others, the category with the highest response rate was *frequently* selected by 5 teachers (55.5%). The category tied with the least highest response rate was *always* and *sometimes* selected by 2 teachers (22.2%) each. The response *never* was selected by 0 teachers. I interpret

these data to mean that student outcomes include oral presentations to peers, parents and other professionals that provide actionable feedback to student work.

In response to teacher survey question #10, part e., which asks how often teachers observed students researching content deeply to become experts, the category with the highest response rate was *frequently* chosen by 5 teachers (55.5%). The category with the next highest response rate was *always* was 3 teachers (33.3%). The category with the least highest response rate was *sometimes* selected by 1 teacher (11.1%). The response *never* was selected by 0 teachers. I interpret these data to mean that teachers in these STEM programs set high expectations within their lessons that require students to research the content beyond the standards to gain a high level of understanding of the concepts.

In response to teacher survey question #10f, which asks how often teachers observed students evaluating and defending their views, highest response rate was *frequently* selected by 4 teachers (44.4%). The category with the next highest response rate was *always* chosen by 3 teachers (33.3%). The least highest response rate was for *always* which was selected by 2 teachers (22.2%). The response *never* was selected by 0 teachers. I interpret the data to mean that teachers in these STEM programs set high expectations within their lessons that require students to research the content beyond the standards to gain a high level of understanding of the concepts.

In response to teacher survey question #10, part g., asking how often teachers observed students working on multi-disciplinary projects, the category with the highest response was *frequently* selected by 4 teachers (44.4%). The category with the next highest response was *sometimes* chosen by 3 teachers (33.3%). The category with the

least high response was *always* chosen by 2 teachers (22.2%). The response *never* was selected by 0 teachers. I interpret the data to mean that teachers in these STEM programs frequently create project-based lessons that are multi-disciplinary requiring students to apply content from many areas to formulate a result or outcome.

In response to teacher survey question #10, part h., which asks how often teachers observed students participating in community projects, internships, or apprenticeships, the highest response rate was for *frequently* by 3 teachers (33.3%). The category tied three ways with the least high responses of *always*, *sometimes*, and *never* with 2 teachers (22.2%) for each. I interpret these data to mean that the STEM programs frequently allow students opportunities to enhance their learning with internships or shadowing opportunities within the program focus. In terms of apprenticeships, it was noted that due to criteria regarding liability, students under age 18 are restricted from working in these environments and thus not as common.

In response to teacher survey question #10, part i., asking teachers to rate how often they observed students participating in competitive organizations where students applied learned skills, the highest response rate was the selection *always* by 4 teachers (44.4%). The category with the next highest response rate was *frequently* chosen by 3 teachers (33.3%). The category with the least highest response rate was *sometimes* selected by 2 teachers (22.2%). The response *never* was selected by 0 teachers. I interpret these data to mean that all these STEM programs have organizations or extracurricular clubs that allow their students to compete within each area at local and state levels as an extension of the classroom learning.

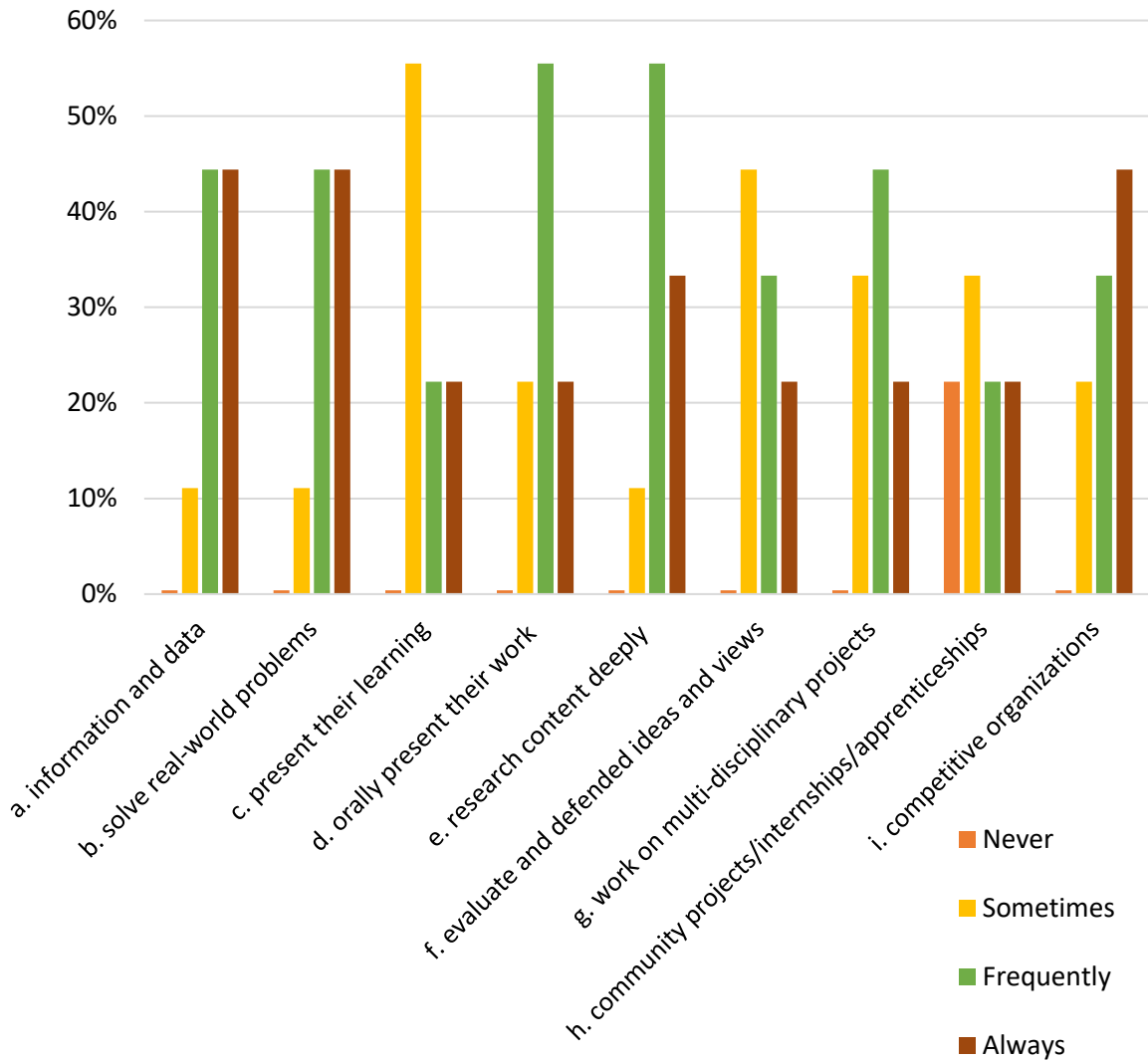


Figure 10. Teacher Survey Question 10 Responses: Instances of STEM student behaviors: a. collects, organizes and analyzes information and data; b. solves real-world problems; c. decides how to present their learning; d. orally presents their work to peers, staff, parents or others; e. researches content deeply to become experts on the topic; f. evaluates and defends their ideas and views; g. works on multi-disciplinary projects; h. participates in community projects/internships/apprenticeships; i. participate in competitive organizations that applied learned skills. (n=9)

Teacher survey question #11, part a., asks teachers if they involve students in researching competing views on an issue and holding a Socratic debate as a part of their STEM-PBL lessons. The category with the highest response report was the answer *yes* by 6 teachers (66.6%). The category with the least high response was the response *no* by 3

teachers (33.3%). I interpret the data to mean that most of the teachers reported their STEM-PBL lessons within these programs involve high-level discussion eliciting the views of their students. These data also indicated that students are provided opportunities to debate their views among their peers to enrich and push their thinking.

Teacher survey question #11, part b., asks teachers if creating a presentation describing a product was a part of their STEM-PBL lessons; the question indicates student articulation of their plan or design of their final product. The category with the highest response was *yes* with 7 teachers (77.7%). Two teachers selected *no* (22.2%). I interpret these data to mean that most of the teachers reported their STEM-PBL lessons within these programs involve a process that requires the students to be able to articulate the design of their product to their audience. This requires a deep understanding of the concept and takes student learning to the next level for themselves and their audience.

Teacher survey question #11, part c., asks teachers if researching a community issues to offer a real-world solution was a part of their STEM-PBL lessons. The c highest response rate was *yes* with 5 teachers (55.5%). Four teachers responded *no* (44.4%). I interpret these data to mean that a little over half of the teachers reported their STEM-PBL lessons within these programs involve a connection to resolving a real-world community problem. This could be an area that requires some further thought for improving the program by creating opportunities that tie the learning to serving the community.

Teacher survey question #11, part d., asks teachers if constructing simulations such as computerized bridges, buildings, robotics, or computer-generated 3D products was a part of their STEM-PBL lessons. Four teachers responded with *yes* and 5 teachers

responded *no* (55.5%). I interpret these data to mean that approximately 44% of the teachers reported their STEM-PBL lessons integrated the construction of a physical structure. This is a logical finding in that such physical structures or conceptual displays would naturally be emphasized in the Engineering or Game Design programs.

In response to teacher survey question #11, part e., teachers who developed artistic products or performances as a part of their STEM-PBL lessons were 6 (66.6%), who responded *yes*, and 3 teachers responded *no* (33.3%). I interpret these data to mean that approximately 66.6 % of the teachers reported their STEM-PBL lessons included opportunities for students to design and develop artistic products and performances.

Survey question #11, part f., in response to teacher use of STEM–PBL lessons using student role-play as stakeholders to solve simulated problems, 6 teachers (66.6%) said *yes*. Three teachers (33.3%) responded *no*. I expected this to be closer to 100% as all these programs in the areas of Engineering, Biomedical Science, and Game Design would have simulated applications of the concepts embedded in the curriculum. This area may require further research into the curricula and teacher instructional practices to discover why this is not happening at a higher frequency.

Teacher survey question #11, part g., responses about creating a working version of a physical product or device as a part of their STEM–PBL lessons resulted in 5 teachers (55.5%) responding in the affirmative. Four teachers (44.4%) responded *no*. With 55.5% % of the teachers reporting that their STEM-PBL lessons included components that allowed students to generate a working product or device, I determine this a reasonable finding as such instructional practices would be emphasized in the Engineering program more so than Biomedical or Game Design.

Survey question #11, part h., concerning teacher incorporation of creating a computer-based product or program such as a web page, computer program, or video game in their STEM–PBL lessons resulted in 6 teachers (66.6%) responding *yes*. Three teachers (33.3%) responded *no*. This is a reasonable finding and was expected due to this component being emphasized within robotics in the Engineering and Game Design program more so than Biomedical technology.

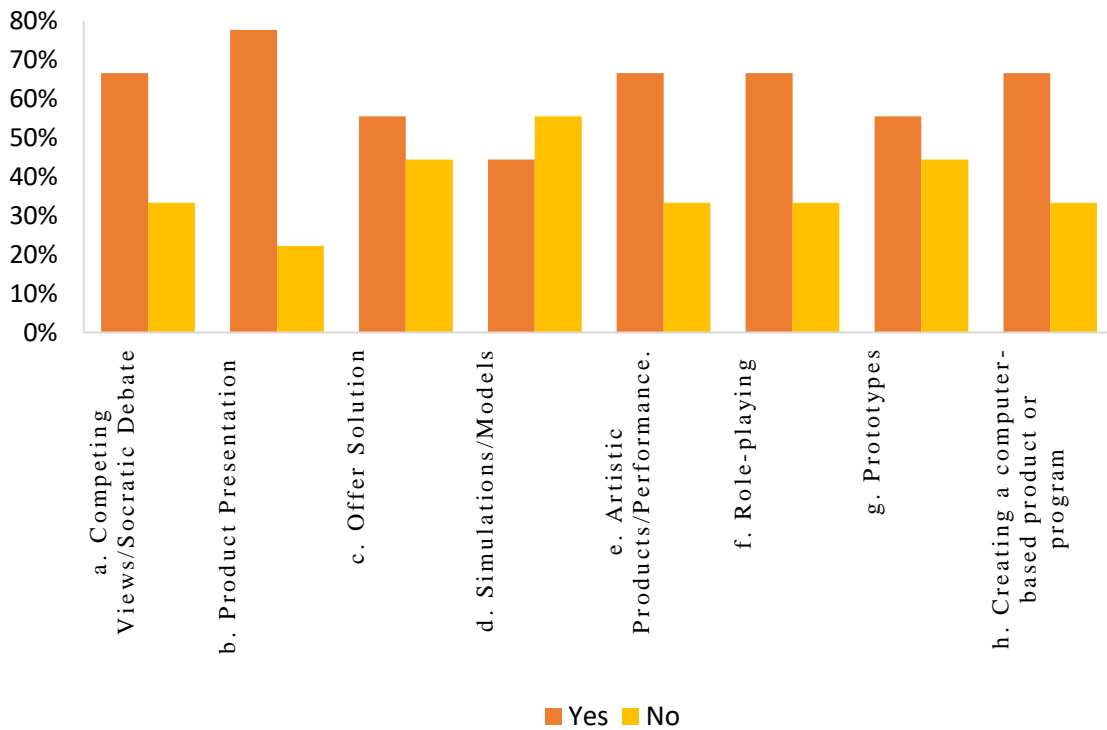


Figure 11. Teacher Survey Question 11 Responses: Instances of kinds of projects or activities your STEM-PBL lessons include: a. Researching competing views on an issue and holding a Socratic debate; b. Creating a presentation describing a product; c. Researching a community issue to offer a solution; d. Constructing simulations, models (e.g., physical or computerized models of bridges, buildings, robotics, 3D products); e. Developing artistic products or performances; f. Role-playing as stakeholders to solve simulated problems; g. Creating a working version of a physical product, device, etc.; h. Creating a computer-based product or program (e.g., web page, blog, video game). (n=9)

In response to teacher survey question #12, part a., asking teachers to rate the importance of integrating PBL in making teaching and learning rigorous in STEM lessons, resulted in the highest response of *very important* by 5 teachers (55.5%). The

category with the least highest response rate was *somewhat important* by 4 teachers (44.4%). The category *not important* had a response rate of 0 teachers. I interpret these data to mean that most teachers find PBL either *very* or *somewhat* important as a component within a rigorous STEM lesson that challenges student thinking. I expected that more teachers would have found this to be a critical component of STEM-PBL. However, with further reflection, I considered the fact that such time-consuming lessons require a great deal of preparatory instruction as a part of the process of project-based learning so would not reasonably take place on a daily basis in the classroom.

In response to teacher survey question #12, part b., which asks teachers to rate the importance of integrating PBL to effectively teach standards-driven content, 6 teachers (66.6%) responded *very important*. The category with the next highest response rated *somewhat important* was 2 teachers (22.2%). The category with the least response rate was *not important* by 1 teacher (11.1%). I interpret these data to mean that most teachers find PBL either *very* or *somewhat important* as a component of STEM lessons that challenge students to meet or exceed the standards. I agree with this finding due to the effect of the multi-faceted nature of PBL to challenge students to utilize their skills across multiple content areas to solve problems resulting in reinforcement of concepts and prior learning while helping students connect and build upon new knowledge and skills.

Teacher survey question #12, part c., resulted in 8 teachers (88.8%) rating the importance of integrating PBL to personalize and tailor learning to student interest and needs as *very important*. The category with the least highest response rate was *somewhat important* by 1 teacher (11.1%). The category *not important* had a response rate of 0. I interpret these data to mean that most teachers find PBL *very important* as a component

within a strong STEM lesson that personalizes student learning to interests and needs. This is an important finding in that it reflects teacher observations that the high interest level associated with PBL lessons motivates students to achieve at higher levels.

In response to teacher survey question #12, part d., which asked teachers to rate the importance of integrating PBL to teach critical thinking skills beyond academic content to promote 21st century skills, 9 teachers (100.0%) rated this *very important*. The categories *somewhat* and *not important* had a rate of 0. I interpret these data to mean that teachers consider PBL as of high importance for teaching 21st century skills. This data informs educational practice in that PBL is indeed a method viable for consideration for future educational reform at all levels.

Six teachers (66.6%) selected the response *very important* when considering the importance of integrating PBL to promote team-mindedness and collaboration in survey question #12, part e. The category with the next highest response of *somewhat important* was 2 teachers (22.2%). The category with the least highest response rate was *not important* with 1 teacher (11.1%). I interpret these data to mean that most teachers find PBL within a STEM lesson as an important means to furthering student collaboration and a team mind set.

In response to teacher survey question #12, part f., asks teachers to rate the importance of integrating PBL to promote students' global perspective. The category with the highest response was *very important* selected by 7 teachers (77.7%). The categories *somewhat important* and *not important* were each selected by 1 teacher (11.1%). I interpret these data to mean that most teachers find PBL within a STEM lesson as important as a means for promoting the advancement of students' global awareness.

In response to teacher survey question #12, part g., asking teachers to rate the importance of integrating PBL to show cross-curricular connections, 7 teachers (77.7%) rated it *very important*. The category with the next highest response rate was *somewhat important* with 1 teacher (11.1%). The category with the least highest response rate of *not important* was 1 teacher (11.1%). I interpret these data to mean that most teachers find PBL within a STEM lesson as a means for opportunities to integrate cross-curricular skills as students create presentations and other tangible outcomes or products.

In response to the importance of integrating PBL to foster problem solving and promote a culture of student inquiry, teacher survey question #12, part h., all 9 teachers selected *very important* and 0 selected *somewhat* and *not important*. I interpret these data to mean that all teachers have observed the importance of PBL as an effective instructional strategy for creating an instructional environment that promotes a problem-solving culture fostering student inquiry and achievement.

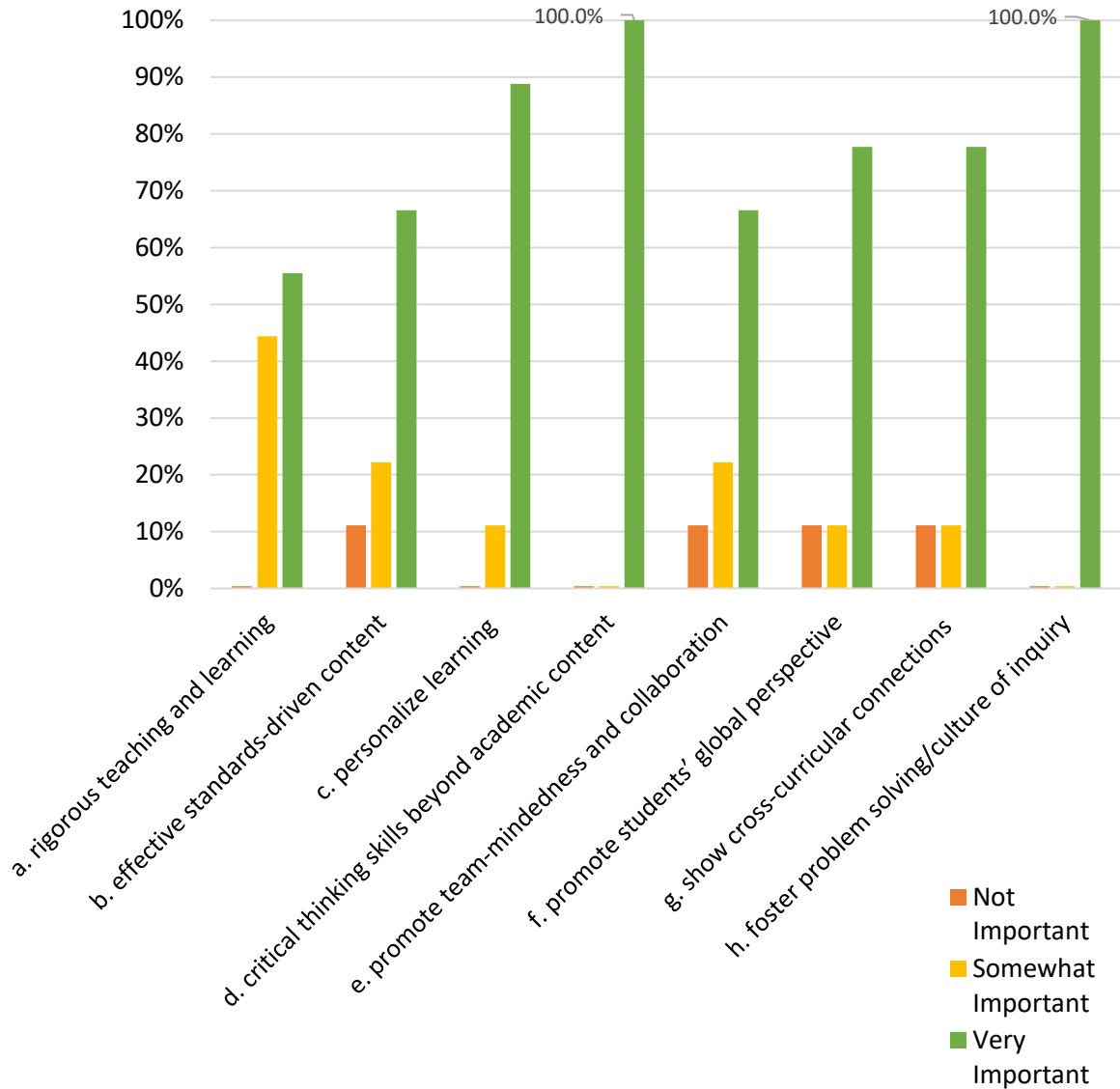


Figure 12. Teacher Survey Question 12 Responses: reasons for integrating PBL into your STEM curricular instruction ratings: a. make teaching and learning rigorous; b. effectively teach standards-driven content; c. personalize and tailor learning to student interest and needs; d. teach critical thinking skills beyond academic content; e. promote team-mindedness and collaboration; f. promote students' global perspective; g. show cross-curricular connections; h. foster problem solving and promote a culture of student inquiry. (n=9)

In response to teacher survey question #13, part a., asking teachers whether they agreed or disagreed with the impact of a STEM program using PBL is an effective teaching strategy for high achieving students, 7 teachers (77.7%), the highest response rate, selected *strongly agrees*. The categories tied with the least highest response rates

were *somewhat agrees* and *somewhat disagrees* with 1 teacher (11.1%) each. The category *strongly disagrees* had a response rate of 0 teachers. I interpret these data to mean that most teachers have a strong agreement that STEM programs using PBL in their experience is an effective teaching model as a means to engage high achieving students in learning.

In response to teacher survey question #13, part b., teachers agreed with the effectiveness of STEM programs using PBL is an effective teaching strategy for average achieving students. The categories tied with the highest response rates were *strongly agrees* and *somewhat agrees* with 4 teachers (44.4%) each. The categories with the least highest response rates were *somewhat agrees* and *somewhat disagrees* with 1 teacher each (11.1%). The category with a response rate of 0 teachers was *strongly disagrees*. I interpret these data to mean that most teachers agree that STEM programs using PBL are an effective teaching model that engages average achieving student's in learning. This finding raises additional questions as to why there is a discrepancy between the impact of PBL as a teaching strategy for average level students as compared to high-level students.

In response to teacher survey question #13, part c., asking teachers whether they agreed or disagreed with the impact of a STEM program using PBL is an effective teaching strategy for low achieving students. The category with the highest response rate was *strongly agrees* with 4 teachers (44.4%). The category with the next highest response rate was *somewhat disagrees* with 3 teachers (33.3%). The category with the least highest response rate was *somewhat agrees* with 2 teachers (22.2%) each. The category *strongly disagrees* had a response rate of 0 teachers. I interpret these data to mean that most teachers agree that STEM programs using PBL is an effective teaching model to engage

low achieving students in learning. These results are interesting in that a third of the teachers have varying levels of agreement, raising a question as to why, in teachers' perception, there is less of an impact of STEM-PBL for certain lower level students. As with the prior question, this concerns me in that teachers seem to view STEM-PBL as most suitable and effective for high achieving students.

Teachers gave a mixed response to teacher survey question #13, part d., which asks teachers whether they agreed or disagreed with the impact of a STEM program using PBL is an effective teaching strategy for students who lack academic motivation. The categories tied three ways were *strongly agrees*, *somewhat agrees*, and *somewhat disagrees* with 3 teachers (33.3%%) each. The category *strongly disagrees* was selected by 0 teachers. I interpret these data to mean that most teachers agree that STEM programs using PBL is an effective teaching model to engage average achieving students in learning. The fact that a third of the teachers somewhat disagree with the idea that students who lack academic motivation are not positively impacted by STEM-PBL concerns me. This finding raises additional questions as to why there is a discrepancy in teacher perception of the impact of PBL as a teaching strategy for average level students as compared to high-level students.

In response to teacher survey question #13, part e., asking teachers whether they agreed or disagreed with the impact of a STEM program using PBL is an effective teaching strategy for students who lack math aptitude. The categories tied three ways with the highest response rate were *strongly agrees*, *somewhat agrees*, and *somewhat disagrees* with 3 teachers (33.3%%) each. The category *strongly disagrees* had a response rate of 0 teachers. I interpret these data to mean that only some teachers are in

high agreement with STEM-PBL as an effective teaching model to engage average achieving students in learning. This perception is plausible when considering the analytical skills required in higher-level mathematics that could often be a part of STEM program PBL experiences.

To teacher survey question #13, part f., 6 teachers (66.6%) responded that they *strongly agreed* to the statement that STEM-PBL provides an effective teaching strategy for students with strong technological skills. The category with the next highest response rated *somewhat agrees* was 2 teachers (22.2%). The categories with a response rate of 0 teachers were *somewhat disagrees* and *strongly disagrees*. I interpret these data to mean that about (66.6%) of teachers strongly agree and (33.3%) do not think that the impact of PBL is necessarily more effective with students having technological skills. This seems to indicate that teachers view technological skills as a prerequisite to effective implementation of STEM-PBL programming.

In response to teacher survey question #13, part g., 6 teachers (66.6%) strongly agreed that a STEM program using PBL is an effective teaching strategy for students with high reading and math ability. The *somewhat agrees* category response rate was 2 teachers (22.2%). The category with the least high response was *somewhat disagrees* with 1 teacher (11.1%). The category *strongly disagrees* had a 0-response rate. I interpret these data to mean that 66.6% of teachers strongly agree that STEM programs utilizing PBL is more effective with students who have high reading and math ability. This again seems to indicate teacher perception that high reading and math ability is a prerequisite to highly effective STEM-PBL implementation. This concerns me since the implementation of STEM-PBL has been, in my professional experience, a means for promoting student

academic acquisition of higher levels of reading and mathematics ability. This in my experience is especially important for tactile/kinesthetic or hands-on learners.

Only 4 teachers (44.4%) selected *strongly agreed* in response to the statement that STEM programs using PBL are an effective teaching strategy for students who struggle with limited English language proficiency (teacher survey question #13, part h.). The category with the next highest response was *somewhat disagrees* by 3 teachers (33.3%). The category with the least highest response rate was *somewhat agrees* with 2 teachers (22.2%) each. The category *strongly disagrees* had a response rate of 0 teachers. I interpret these data to mean that 44.4% of teachers really believe that STEM-PBL supports learning obtainment for limited English language proficient students; however, a high number of teachers, 33.3%, selected *somewhat disagrees*. This finding is expected based on the previous results indicating that STEM-PBL, according to teachers, with most effective for students having high reading and math ability.

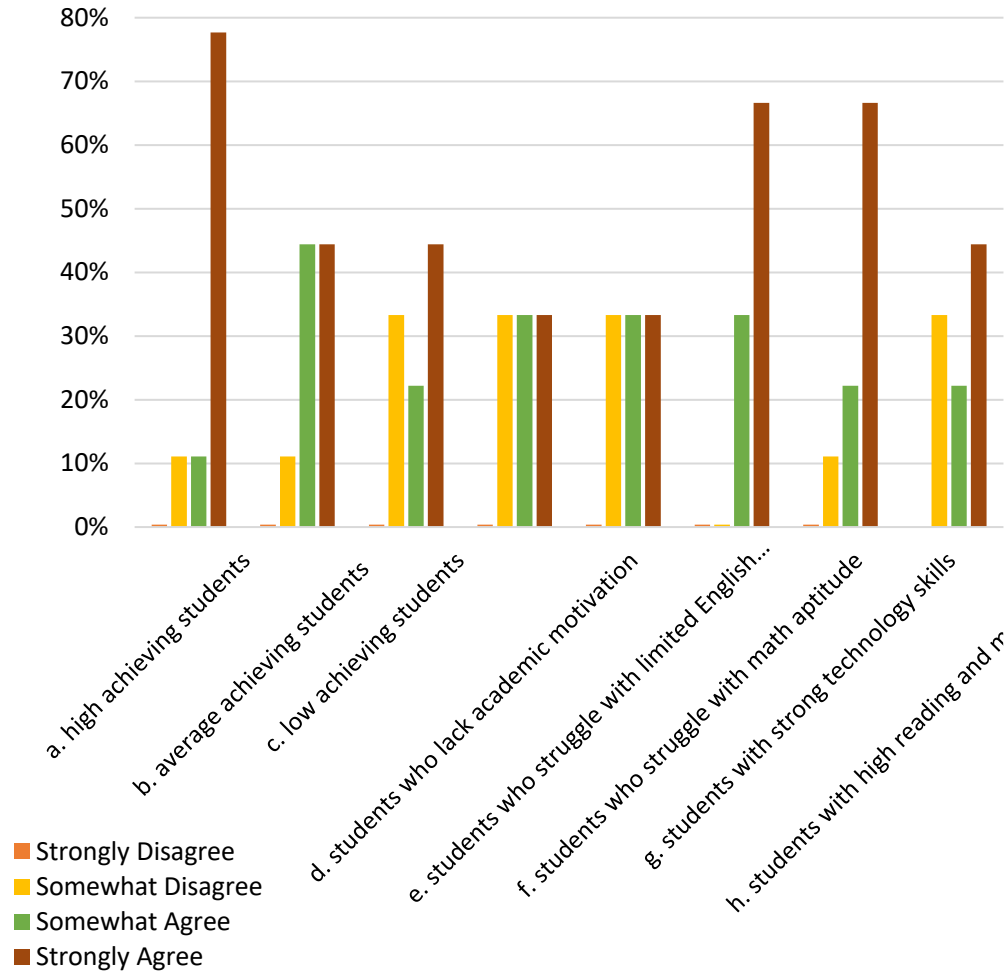


Figure 13. Teacher Survey Question 13 Responses: the extent to which teachers agree or disagree concerning the impact of a STEM program using PBL as an effective teaching strategy by differing groups of students: a. high achieving students; b. average achieving students; c. low achieving students; d. students who lack academic motivation; e. students who struggle with limited English language proficiency; f. students who struggle with math aptitude; g. students with strong technology skills; h. students with high reading and math ability. (n=9)

Teacher Survey Question 14: Qualitative Data.

In response to teacher open-ended survey question #14, which asked teachers what is working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design? The data showed 5 out of 9 teachers responded. The most frequently reported theme was three teachers who said that hands-on activities and real-world application of the content was working well with the program. One other teacher reported that industry certifications were also working well. One other idea reported by a

teacher indicated the application of extracurricular clubs such as robotics or computer game design clubs provided enhancements to the STEM curriculum. These data finding indicates that teachers perceive the component in the STEM-PBL curricula that gives students the opportunity to engage in real-world application to take the learning beyond the standards was working well within the STEM specialized programs. This component provided students with foundational problem-solving skills that are applicable to all subjects and context.

Teacher Survey Question 15: Quantitative Data. Teacher survey question #15, asks if teachers agree or disagree that their lessons involving STEM-PBL are effective in increasing student motivation. The categories tied with the highest response rates were *somewhat agrees* and *strongly disagrees* with 3 teachers (33.6%) each. The category with the next highest response rate was *strongly disagrees* with 2 teachers (22.2%). The category *somewhat disagrees* had the least highest response rate with 1 teacher (11.1%). I interpret this data to mean that many of the teachers, 55.8 %, agree that STEM-PBL is effective with increasing student motivation. This compared to only 44.4% of teachers disagree that STEM-PBL has a positive effect on student motivation. This mixed response seems to indicate that teachers have varying experience with STEM-PBL, as it is associated with student motivation. This finding surprised me since the PBL context by design is promoted as a means to increase student interest and engagement leading to higher levels of motivation.

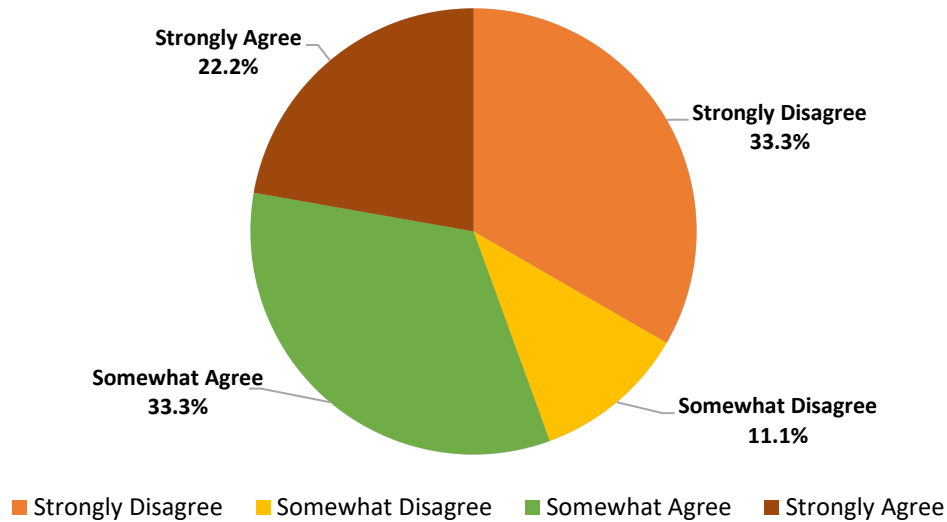


Figure 14. Teacher Survey Question 15 Responses: teacher agreement levels with the idea that lessons involving STEM-PBL are effective in increasing student motivation and interest. (n=9)

Teacher Survey Questions 16: Qualitative Data. In response to teacher open-ended survey question #16, which asked teachers what is not working well with the STEM programs of Engineering, Biomedical Science, and Computer Game Design? The data showed 5 out of 9 teachers responded. The most frequently reported theme was tied with two concerns of what is not working well each having two teachers. The first most frequent response of two teachers reported that funding was an issue for perishable and consumable items as well as the appropriate equipment for inquiry-based labs. Another most frequent response of two teachers reported that student preparation of traditional students to include under-represented groups from the elementary and middle school levels to have the skills necessary to meet the admission requirements to enter the STEM high school. One other idea reported by a teacher that the school perception and location was not working well for retaining students within each program. These data indicate that teachers perceive the lack of funding within a STEM program can negatively impact their ability to complete the lessons with efficacy and thus is not working well. Another

critical point reported that was not working well within the data is the lack of a vertical curricular alignment with STEM education from the elementary to middle school levels that better prepares students with the skills needed for admission into the STEM high school. Lastly, the data indicated that the stigma associated with the school perception and location that was related to safety may deter students from the STEM program.

Teacher Survey Questions 17: Quantitative Data. In response to teacher survey question #17, asking if teachers agree or disagree that PBL lessons integrate multiple content areas to create a solution or end product that indirectly increases academic achievement in those related content areas, the *somewhat agrees* category had the highest selected responses with 4 teachers (44.4%). The *strongly agrees* category was the next highest response with 3 teachers (33.3%). The category tied with the least highest response rate was *somewhat disagrees* with 1 teacher (11.1%). I interpret these data to mean that most of the teachers agree that rigorous PBL lessons indirectly increase academic achievement in related content areas. The implication here is that there is an overarching value added that PBL lessons reinforce concepts by connecting their relevance to solving a real-world issue.

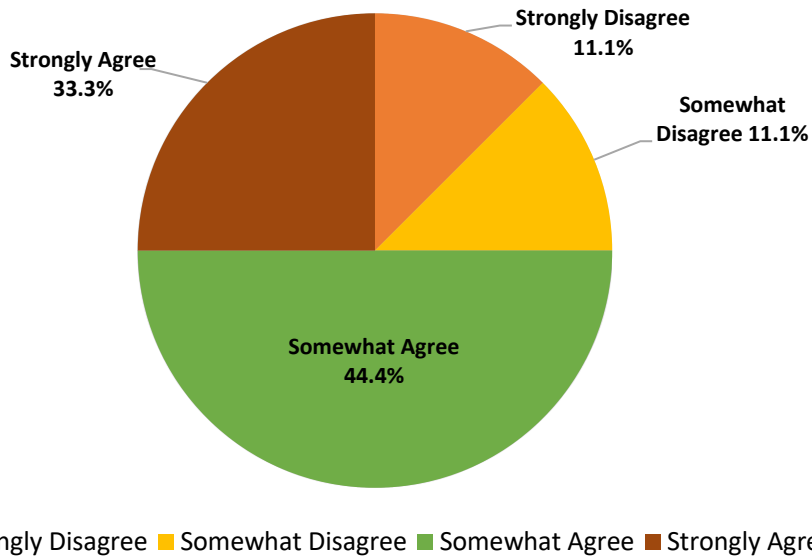


Figure 15. Teacher Survey Question 17 Responses: teacher agreement levels with the idea that PBL lessons that integrate multiple content areas to create a solution or product increase academic achievement indirectly in other areas. (n=9)

Teacher Survey Questions 18 - 19: Qualitative Data. In response to teacher open-ended survey question #18, which asked teachers what are the greatest challenges with the STEM programs of Engineering, Biomedical Science, and Computer Game Design? The data showed 7 out of 9 teachers responded. The most frequently reported theme was given by three teachers who indicated that time, resources, and funding was one of the greatest challenges with the STEM programs. The next most frequent response of two teachers reported that student preparation from the elementary and middle school levels with the necessary STEM related skills was a challenge. This contributed to the attrition within each program to include the underrepresented student groups in STEM. Another idea reported by one teacher was the challenge presented with the lack of student focus. One other data point reported by one teacher was the challenge of preparing students who lack certain basic STEM skills to attain the industry certifications within each program. These data findings indicate that teachers perceive the lack of funding

within a STEM program as a challenge, which limits the resources and can impact the time needed to complete the STEM lessons with efficacy. Another finding from these data indicate that the lack of student preparation vertically from the elementary to middle school can be a challenge to retaining students as well as negatively impacting their ability to complete the industry certifications associated with the programs.

In response to teacher open-ended survey question #19, which asked teachers what are some ways to improve the STEM programs of Engineering, Biomedical Science, and Computer Game Design? The data showed 7 out of 9 teachers responded. The most frequently reported theme was tied three ways. The first most frequent theme reported by 2 teachers to improve the STEM programs was student problem solving skill preparation vertically from the elementary level to middle and high school level. Another next most frequent response by 2 teachers to improve the program reported that more resources and equipment for hands-on experiences supported with quality professional development would improve the STEM programs. One other idea reported by 2 teachers to improve the program was better marketing to incoming freshman highlighting work products of students that tie to authentic projects that meet local community needs. These opportunities can organically drive community mentorship opportunities. One teacher reported the question was not applicable. These data findings indicate that teachers perceive the preparation of student's impacts their problem-solving skillset needed to improve their success in the STEM programs. One final data finding to improve the program was the need to improve the marketing of each program utilizing the community-based project work to improve the community involvement in mentoring the students.

Teacher Survey Questions 20-21: Quantitative Data. Teacher Survey

Questions 20. has multiple parts. In response to teacher survey question #20, part a., requesting teachers to respond to the statement about having enough instructional time for students to process material in their STEM program utilizing PBL in their lessons, the category with the highest response was *somewhat agrees* by 4 teachers (50.0%). The category with the next highest response rate, *strongly disagrees*, was 3 teachers (37.5%). The category with the least high response rated somewhat disagrees with 1 teacher (12.5%) each. The category with a response rate of 0 teachers was strongly disagrees. I interpret these data to mean that most teachers agree that they do not have enough instructional time to allow students to process material in their STEM-PBL implementation. These data lead to the need to consider a structural change to improve teacher-planning time to allow teachers to collaborate on a PBL project.

Teacher survey question #20, part b., asks about the challenge of obtaining materials needed for STEM-PBL lessons. The *somewhat agrees* category had the highest response with 4 teachers (50.0%). The category with the next highest response was *strongly disagrees* with 3 teachers (37.5%). The *somewhat disagrees* category had the least responses with only 1 teacher (12.5%). The *strongly disagrees* category had a response rate of 0 teachers. I interpret these data to mean that teachers have a mixed experience with obtaining necessary materials for STEM-PBL implementation with many (50%) feeling as if supplies are an issue. The finding that 37.5 % *strongly disagrees* that materials are a great need is concerning to me as an administrator. This indicates that many of the teachers experience a roadblock to STEM-PBL implementation in the form of necessary materials. These data may be explained by the fact that materials in the

Engineering and Biomedical Technology program are consumables and need to be replenished continuously; whereas the Game Design programs are usually software driven and do not have the need of consumable supplies for the classroom.

In response to teacher survey question #20, part c., which asks teachers whether they agreed or disagreed with the challenge of professional development or support on PBL implementation in their STEM program, the categories tied with the highest response rate were *strongly agree* and *somewhat agrees* with 3 teachers (37.5%) each. The category with the next highest response rate was *somewhat disagrees* with 2 teachers (25.0%). The category *strongly disagrees* had a response rate of 0 teachers. I interpret these data to mean that by the number of teachers' responses of *somewhat agrees* (75%) there are deficiencies in professional development or support for teachers in STEM-PBL programming. This seems to indicate an important area for growth and improvement. There is a need for all the STEM programs to embed training and support structures within the school academic culture across content areas as a method for increasing the probability that STEM-PBL will affect positive gains in student achievement.

Teacher survey question #20, part d., concerns the challenge of the academic aptitude of the students in STEM-PBL programs. The *somewhat agrees* category had the highest responses with 3 teachers (37.5%). The categories tied with the next highest levels of responses were *strongly agrees* and *somewhat disagrees* with 2 teachers each (25.0%). The *somewhat disagrees* category was selected by 2 teachers (22.2%). The category with the least was *strongly disagrees* with 1 teacher (12.5%). I interpret these data to mean that over half of the teachers' responses, 62.5%, range from *strongly agrees* to *somewhat agrees* that indicates that the academic aptitude of students is challenged by

STEM-PBL. This could be a result of students' reading and mathematics aptitude as well as their technological ability. This is a topic for a deeper investigation.

In response to teacher survey question #20, part e., which asked teachers whether they agreed or disagreed with the challenge of finding high quality projects that exist in their STEM program, the category with the highest response rate was *strongly agrees* with 3 teachers (37.5%). The categories tied with the next highest rate were *somewhat agrees* and *somewhat disagrees* with 2 teachers (25.0%) each. The *strongly disagrees* category was selected by 1 teacher (12.5%). I interpret these data to mean that most teachers (62.5%) agree that there is a lack of available high-quality STEM-PBL project curriculum or project plans. This implies that the current science curriculum does not clearly tie the standards to related projects. These data suggest that some attention to a curricular shift that includes PBL as a cross- curricular application of the standards to encourage teachers to provide these opportunities that will improve student's ability to think critically.

Teacher survey question #20, part f., asks teachers about the challenge of having adequate planning time with other teachers in their STEM program. The category with the highest responses was *somewhat agrees* with 3 teachers (37.5%). The categories tied at the next highest rate were *strongly agrees* and *somewhat disagrees* with 2 teachers (25.0%) each. The category with the least responses were *strongly disagrees* with 1 teacher (12.5%). I interpret these data to mean that most teachers (62.5%) agree that there is a deficit in adequate planning time with other teachers. This is an interesting finding considering that this school has an alternating block schedule that provides 90-minute blocks of class time with built-in professional learning community time in addition to

teacher planning time. Adequate planning time is another implementation concern requiring further consideration program improvement.

In response to teacher survey question #20, part g., which asked teachers whether they agreed or disagreed with the challenge of managing student work and maintaining accountability with group activities, there are tied response rates for *strongly agrees* and *somewhat agrees* with 3 teachers (37.5%) each. The categories tied with the next level of responses were *strongly disagrees* and *somewhat disagrees* with 1 teacher (12.5%) each. I interpret these data to mean that most teachers (75%) agree that managing student work and maintaining accountability with group activities is a challenge. This finding is interesting considering the nature of STEM content activities. Accountability issues can be a part of any classroom culture and depend on many other variables. STEM-PBL assessment issues may have additional variables with which teachers struggle. Accountability issues are of concern for PBL implementation and require further investigation.

Teacher survey question #20, part h., concerns the challenge of assessing students' work within group activities in their STEM program using PBL. The *somewhat agrees* and *somewhat disagrees* categories are tied with the highest rate of responses with 3 teachers (37.5%) each. Interestingly, the categories *strongly agree* and *strongly disagrees* tied for the next highest rate and cancel one another out with 1 teacher (12.5%) each. I interpret these data to mean that teachers have contradictory perceptions concerning the challenges they face in assessing students' work within group activities. I feel that this is an interesting finding in that it reviews teachers differing experiences and abilities with PBL implementation. Some teachers are very comfortable with group

activity implementation and others are not as experienced or lack the instructional skills to efficiently manage assessment for group work. This issue is a topic reflecting teacher instructional capacity and training. It is part of a larger professional issue pertaining to general instructional practices within any classroom environment.

In response to teacher survey question #20, part i., which asked teachers whether they agreed or disagreed with the challenge of meeting state or district standards using PBL lessons in their STEM program, the highest rate of response was *strongly disagrees* with 3 teachers (37.5%). The categories tied with the next highest rates of response were *somewhat agrees* and *somewhat disagrees* with 2 teachers (25.0%) each. The category with the least responses was *strongly agrees* with 1 teacher (12.5%). I interpret these data to mean that the majority of teachers disagree that there is a challenge concerning meeting state or district standards using PBL lessons within STEM programs. These data are yet another piece of evidence suggesting that much can be lost with student learning due to the issue of state mandated standardized testing. The pressure of raising scores and teacher VAM outweighs the exponential potential that STEM-PBL lessons with collaboration can provide.

Teacher survey question #20, part j., concerns assessing individual student's mastery of the content in STEM-PBL instruction. The highest response rate was *strongly disagrees* with 3 teachers (37.5%). The categories tied with the next highest response rate were *strongly agrees* and *somewhat disagrees* with 2 teachers (25.0%) for each. The category with the least high responses was *somewhat agrees* with 1 teacher (12.5%). I interpret these data to mean that the majority of teachers disagree that there are challenged by assessing individual student's mastery of the content in their STEM

programs using PBL. This is an expected result based on previous data that indicated teachers in the STEM programs are using many different forms of assessment for student performance.

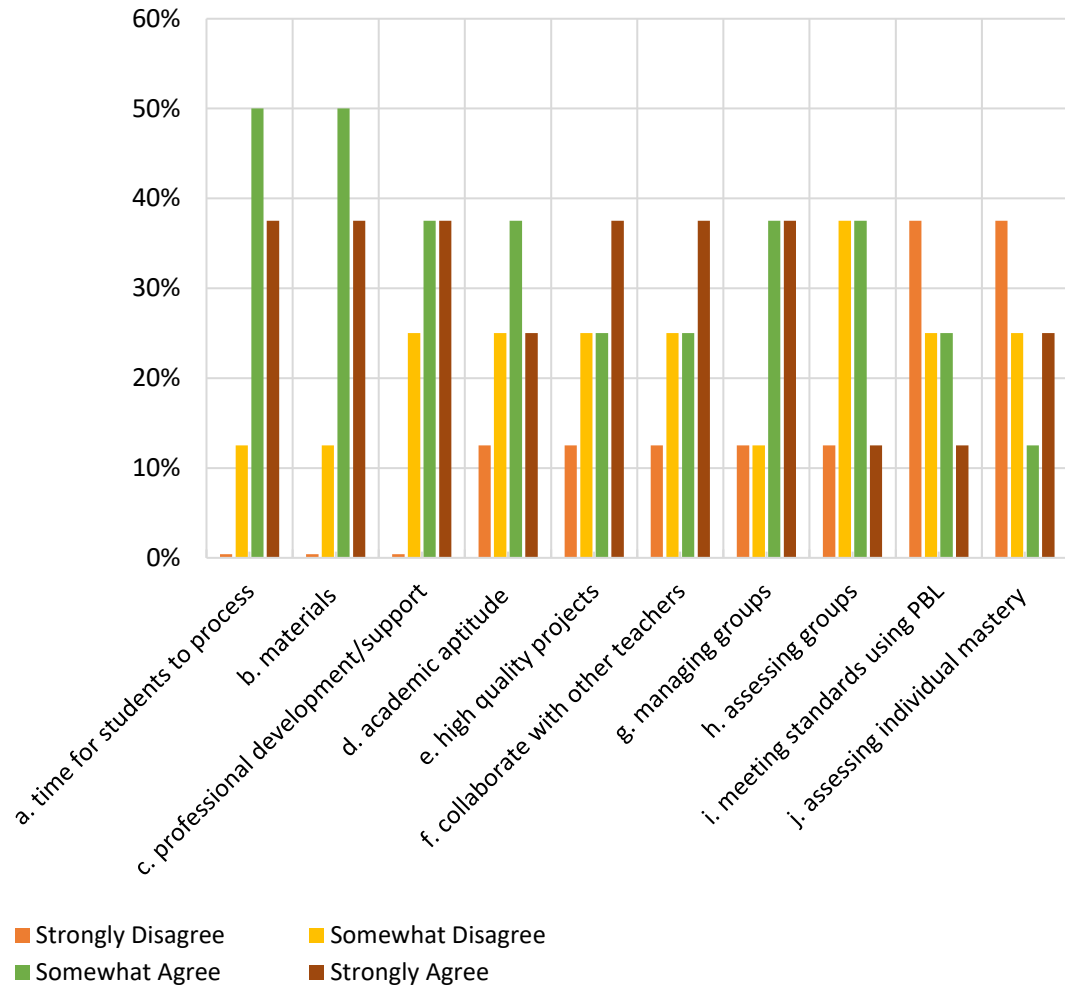


Figure 16. Teacher Survey Question 20 Responses: the extent to which teachers agree or disagree concerning challenges they feel exist in implementing lessons in their STEM program that utilizes PBL as an instructional method in any content area in the current standards-based climate: a. having enough instructional time for students to process; b. materials needed for lessons; c. professional development/support on PBL implementation; d. academic aptitude of students; e. finding high quality projects that exist; f. planning time to collaborate with other teachers; g. managing students work and accountability in groups; h. assessing students work in groups; i. meeting state or district standards using PBL; j. assessing individual student’s mastery of the content. (n=8)

Teacher survey question #21, asks teachers if they present PBL lessons that integrate cross-curricular concepts, increase rigor, and promote student inquiry. Four

teachers (44.4%) responded by selecting *strongly agrees*. The categories with the next highest response rates, *somewhat agrees* and *somewhat disagrees*, were selected by 3 teachers (33.3%) each. The categories tied with the least highest response rate were *somewhat* and *strongly disagrees* with 1 teacher (11.1%) each. I interpret these data to mean that most teachers (77.7%) implement STEM-PBL lessons that integrate cross-curricular concepts, increase rigor, and promote student inquiry. I expected the percentage to be even higher due to the interdisciplinary nature of STEM coursework; therefore, I see this as an area of concern in need of further exploration and possibly in need of remediation.

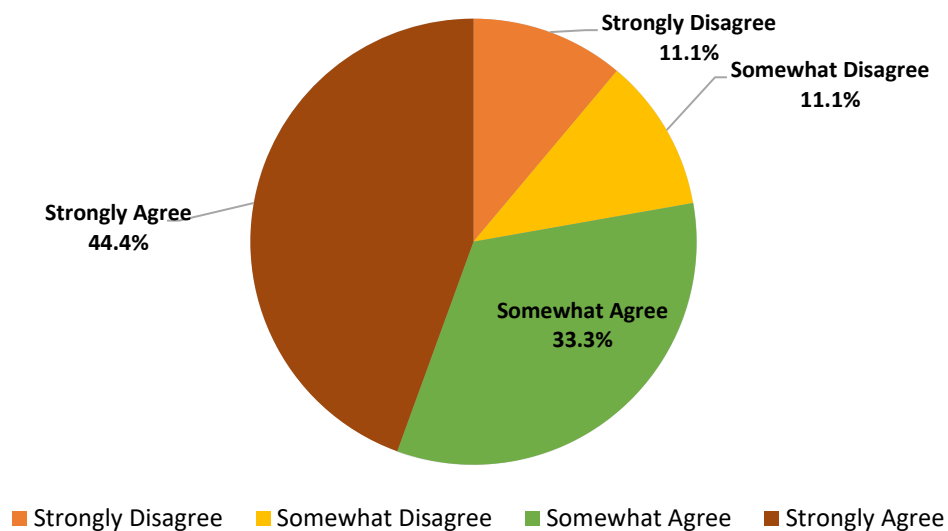


Figure 17. Teacher Survey Question 21 Responses: teacher agreement levels with the idea that PBL lessons that integrate cross-curricular concepts increase the rigor of the lesson for students promoting inquiry. (n=9)

Teacher Survey Question 22: Qualitative Data. In response to teacher open-ended survey question #22, which asked teachers how project-based learning increases the overall rigor of the curriculum to promote high levels of student achievement in the areas of science and mathematics? The data showed 5 out of 9 teachers responded. The first

most frequent theme reported by 3 teachers who indicated that project-based learning in science and mathematics increases the overall rigor promoting student achievement in the STEM programs by giving students opportunities to solve real-world problems by doing applying science and math which results in increased engagement and improved academic achievement. Another idea by 1 teacher indicated that the rigor of the curriculum is increased because project-based lessons take student learning from base knowledge to higher-order thinking that require application and evaluation of the content. Another idea by 1 teacher indicated within a project-based lesson, students learn more by tutoring each other. These data findings indicate that teachers perceive project-based learning increases the rigor in math and science classes because it promotes higher-order thinking and allows students to apply those content skills with the environment of solving a problem showing the relevance of the concepts.

Teacher Survey Question 23: Quantitative Data. Quantitative data teacher survey question 23. has multiple components. In response to teacher survey question #23, part a., about the potential STEM program benefit of pushing student thinking beyond the academic requirements, the category with the highest response rate was *strongly agrees* with 7 teachers (77.7%). The categories with the least high rates were *somewhat* and *strongly disagrees* selected by 1 teacher (11.1%) each. The *strongly disagrees* category had a 0-response rate. I interpret these data to mean that most teachers' responses (77.7%) indicate that they strongly believe that STEM-PBL results in pushing student thinking beyond academic requirements. This finding suggests that teachers see the value of STEM-PBL evidenced within student work products combined with the student behaviors that occur during the work, which is at a high taxonomy of learning.

In response to teacher survey question #23, part b., asks teachers whether they agreed or disagreed that there is a benefit of creating connections across multiple disciplines in the STEM-PBL classroom. The *strongly agrees* category had the highest response rate with selection by 7 teachers (77.7%). The category with the next highest response rate was *somewhat agrees* with 2 teachers (22.2%). The *somewhat disagrees* and *strongly disagrees* categories both had a response rate of 0 teachers. I interpret this significant data to mean that all the teachers (100.0%) agree that STEM-PBL benefits students by creating connections across multiple disciplines. Importantly, 77.7% are in strong agreement that the benefit exists. This demonstrates to me that teachers are cognizant of the underlying principle of cross-curricular interconnections in STEM instruction and are aware of these connections within their own instructional practice.

Teacher survey question #23, part c., concerns STEM-PBL's provision of student time to practice in-depth inquiry. Seven teachers (77.7%) selected *strongly agrees* as their response. The categories with the least highest response rates were *somewhat* and *strongly disagrees* with 1 teacher (11.1%) each. The category *strongly disagrees* had a response rate of 0. I interpret these data to mean that most teachers' responses (88.1%) indicate that teachers perceive that STEM-PBL benefits students by allowing them time to practice in-depth inquiry. It concerns me that even one teacher selected *strongly disagrees* in response to this prompt in that best practices in STEM-PBL aims in theory to provide time to practice in-depth inquiry as a means for the stimulation of student development of deeper levels of conceptual knowledge and connections in learning as well as stimulating additional interest and inquiry.

In response to teacher survey question #23, part d., which asked teachers whether they agreed or disagreed that there is a benefit of teaching multiple ways to accomplish a solution in a STEM program that uses PBL in the classroom, 7 teachers (77.7%) selected *strongly agrees*. The categories *somewhat disagrees* and *strongly disagrees* were selected by 1 teacher (11.1%) each. The *strongly disagrees* category response rate was 0. I interpret these data to mean (77.7%) have a strong belief in the efficacy of STEM-PBL to introduce the essential STEM practice of approaching problems in multiple ways to accomplish a solution. Again, I was disappointed that 2 teachers had disagreement with this statement as I see problem-solving strategy development as a central benefit of STEM educational practice.

In response to teacher survey question #23, part e., asking teachers whether they agreed or disagreed that there is a benefit of increasing student voice to elicit inquiry in a STEM-PBL classroom instruction, 6 teachers (66.6%) selected *strongly agrees*. The category with the next highest response rate was *somewhat agrees* with 2 teachers (22.2%). The category with the least number was *somewhat disagrees* with 1 teacher (11.1%). The category *strongly disagrees* had a response rate of 0 teachers. I interpret these data to demonstrate that the majority of teachers (88.8%) see the benefit of STEM-PBL in increasing student voice to elicit inquiry. This confirms for me that an important practice of STEM-PBL is understood by most teachers and that they see it at work in their classrooms. PBL is fostering student voice in the furtherance of additional inquiry-based learning.

Question #23, part f., has to do with students evaluating and analyzing evidence as a benefit occurring in the STEM-PBL classroom. The *strongly agrees* category had the

highest response rate of 6 (66.6%). The category with the next highest response rate was *somewhat agrees* was 3 teachers (33.3%). The category tied with a response rate of 0 teachers was *somewhat disagrees* and *strongly disagrees*. I interpret these data to mean that all of the teachers (100.0%) agree that STEM-PBL benefits students by engaging them in evaluating and analyzing evidence. This is as I would have anticipated as fitting for an effective STEM-PBL classroom, so I feel that the teachers understand the evidential learning context of STEM-PBL.

Teacher survey question #23, part g., asks teachers whether they agreed or disagreed that there is a STEM-PBL benefit of students taking ownership of their learning. The category with the highest response rate was *strongly agrees* with 6 teachers (66.6%). The category with the next highest response rate was *somewhat agrees* with 2 teachers (22.2%). The category with the least highest response rate was *somewhat agrees* with 1 teacher (11.1%). The *strongly disagrees* category had a 0-response rate. I interpret these data to mean that most teachers (88.8%) agree that STEM-PBL benefits student learning in that they take ownership of their learning. It is important to note that the findings indicate that no teachers disagreed that student ownership was occurring in their classrooms. Again, I anticipated this finding in that student ownership of learning is an important outcome of STEM-PBL practices.

Question #23, part h., concerns fostering collaboration and teamwork, 6 teachers (66.6%) rated this as *strongly agrees*. The category with the next highest rating was *somewhat agrees* with 2 teachers (22.2%). The category with the least high rate of response was *somewhat disagrees* by 1 teacher (11.1%). The *strongly disagrees* category had a 0-response rate. I interpret the data to mean that most teachers (88.8%) agree that

there is a benefit to students in terms of gaining the skill of fostering collaboration and teamwork in a STEM program that uses PBL in the classroom. Again, PBL has collaboration and teamwork as a core practice so I anticipated that most of the teachers would find this a characteristic of their classroom practice. I am concerned that one teacher selected *somewhat disagrees*.

In response to teacher survey question #23, part i., which asked teachers whether they agreed or disagreed that there is a benefit of increasing students' ability to critically think through possible outcomes, 6 teachers (66.6%) selected the response *strongly agrees*. The category with the next highest response rate was *somewhat agrees* with 3 teachers (33.3%). The category tied with a response rate of 0 teachers was *somewhat disagrees* and *strongly disagrees*. I interpret the data to mean that all of the teachers (100.0%) agree that building the skill of increasing students' ability to critically think through possible outcomes is a strong benefit of a STEM program that uses PBL in the classroom. I anticipated this outcome as critical thinking applied to possible outcomes in applied STEM learning especially in the PBL classroom is foundational to best practices instruction in STEM-PBL.

Teacher survey question #23, part j., is concerned with the instance of the STEM-PBL classroom allowing students opportunities to hear other views. The category with the highest response rate was *strongly agrees* with 6 teachers (66.6%). The category with the next highest response rate was *somewhat agrees* with 2 teachers (22.2%). The category with the least highest response rate was *somewhat disagrees* with 1 teacher (11.1%). The category with a response rate of 0 teachers was the option *strongly disagrees*. I interpret these data to mean that most teachers (88.8%) agree that there is a

benefit to allowing students the opportunities to hear others views in a STEM program that uses PBL in the classroom and promote student engagement in this practice in their classrooms. I anticipated a positive response from all teachers, so I am concerned that one teacher selected the response *somewhat disagrees*.

In response to teacher survey question #23, part k., which asks teachers whether they agreed or disagreed that there is a benefit of fostering time-management in a STEM-PBL classroom, 6 teachers (66.6%), the highest response rate, selected *strongly agrees*. The category with the next highest response rate by the teachers was *somewhat agrees* with 2 teachers (22.2%). The category with the least response rate was *somewhat agrees* with 1 teacher (11.1%). The *strongly disagrees* category had a response rate of 0 teachers. I interpret the data to mean that most of the teachers (88.8%) agree that students are learning the skill of time-management in the STEM-PBL classroom. The data suggests that there is a built-in aspect to this methodology that requires planning and forethought. This leads to students developing time-management skills that translate well in preparing them for future academic, and career demands.

Teacher survey question #23, part l., asks teachers whether they agreed or disagreed that there is a beneficial result from STEM-PBL of promoting student reflection and focus. The category with the highest response rate was *strongly agrees* with 6 teachers (66.6%). The category with the next highest response rate was *somewhat agrees* with 2 teachers (22.2%). The category with the least highest response rate was *somewhat disagrees* with 1 teacher (11.1%). The category with a response rate of 0 teachers was *strongly disagrees*. I interpret these data to mean that most teachers (88.8%) agree that STEM-PBL promotes student reflection and focus; however, as in prior

findings, I am concerned that one teacher selected the response *somewhat disagrees*. This may require further study as student reflection and focus are strongly tied to PBL instructional practices.

In response to teacher survey question #23, part m., teachers rated the benefit of a STEM program that uses PBL in the classroom for nurturing student innovation. The category with the highest response rate was *strongly agrees* with 5 teachers (55.5%). The category with the next highest response rate was *somewhat agrees* from 3 teachers (33.3%). The category with the least highest response rate was *somewhat disagrees* with 1 teacher (11.1%). The *strongly disagrees* category was selected by 0 teachers. I interpret these data to mean that most teachers agree that they are nurturing student innovation in their STEM-PBL classroom. The data clearly suggest that the STEM-PBL classroom environment inspires students to think critically and find innovative ways to solve problems.

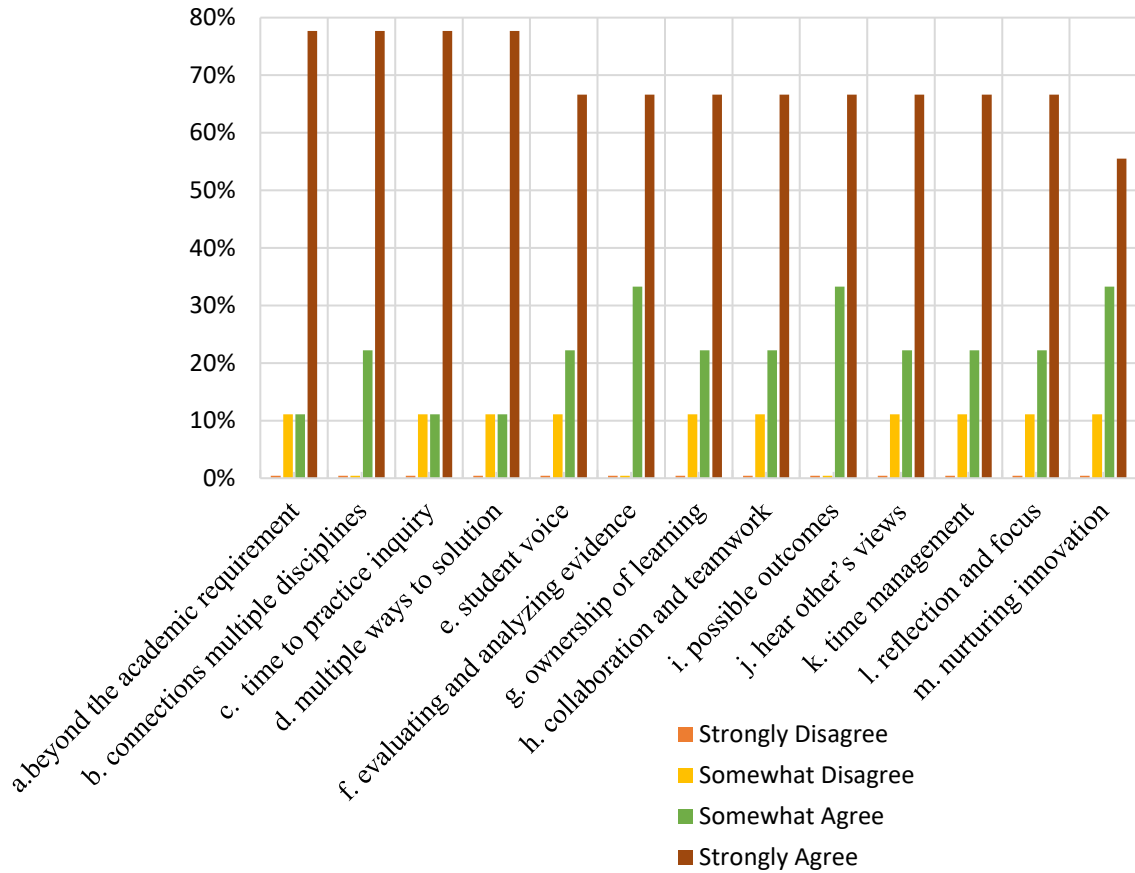


Figure 18. Teacher Survey Question 23 Responses: the extent to which a STEM program using PBL benefits student learning by the following means: a. pushing student thinking beyond the academic requirement; b. creating connections across multiple disciplines; c. allowing students time to practice in-depth inquiry; d. teaching multiple ways to accomplish a solution; e. increasing student voice to elicit inquiry; f. evaluating and analyzing evidence; g. students taking ownership of learning; h. fostering collaboration and teamwork; i. increasing student's ability to critically think through possible outcomes; j. allowing for opportunities to hear other's views; k. fostering time management; l. promoting student reflection and focus; m. nurturing innovation. (n=9)

Teacher Survey Question 24: Qualitative Data. In response to teacher open-ended survey question #24, which asked teachers how student technological aptitude limits or increases the level of academic achievement with project-based learning? The data showed 5 out of 9 teachers responded. The first most frequent theme reported by 3 teachers regarding technological aptitude limiting or increasing academic achievement in the STEM programs reported technology increased achievement because it required students to gather, analyze, and explain their findings accurately and at a faster rate. Another next most frequent response reported by 2 teachers in the STEM programs regarding technological aptitude limiting academic achievement reported students' aptitude increased by doing and explaining their findings and technological knowledge was irrelevant to increasing the academic achievement. The data findings indicate that most of the teachers perceive that generally technological aptitude does increase the level of academic achievement because it promotes the higher order functions of learning and critical thinking to be problem-solvers. However, some teachers perceived that it was the processing of knowledge and its findings that increased academic achievement rather than the technological aptitude.

Teacher Survey Question 25: Quantitative Data. In response to teacher survey question #25, teachers selected responses that rated whether they agreed or disagreed with the statement that STEM-PBL methods should be a component of future educational reform integrating cross-curricular standards to prepare students with the 21st century skills necessary for future careers. The category with the highest response rate was *strongly agrees* with 5 teachers (55.6%). The category with the next highest response rate was *strongly disagrees* with 2 teachers (22.2%) each. The categories with the least

highest response rates were *somewhat agrees* and *somewhat disagrees* with 1 teacher (11.1%) each. I interpret these data to mean that the majority of teachers (66.7%) agree that STEM-PBL methodology should be a component of future educational reform for integrating cross-curricular standards into classroom practice to prepare students with the 21st century skills necessary for future careers.

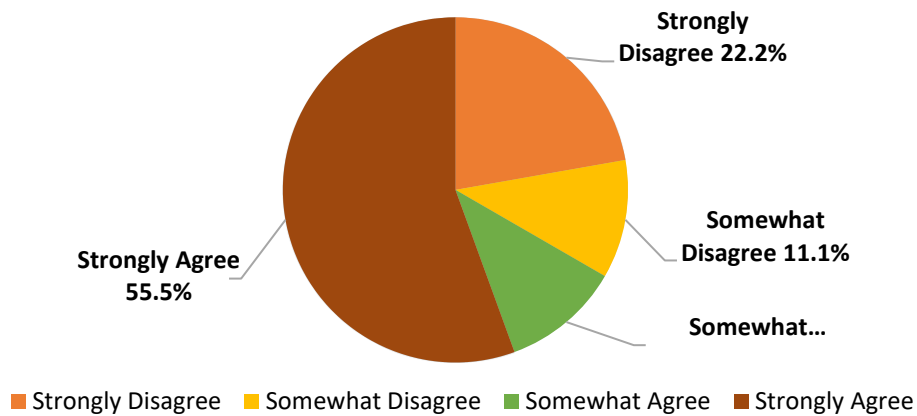


Figure 19. Teacher Survey Question 25 Responses: teacher agreement levels with the idea that STEM-PBL methods should be a component of future educational reform integrating cross-curricular standards to prepare students with the 21st century skills necessary for future careers. (n=9)

Student Data

Additional school level data sets provide a broader context for my inquiry. The pertinent data selected include student GPAs, graduation rates, industry certifications earned, and Title I low income student percentages over time. The data are analyzed in the next section and displayed in Table 1.

GPA Earnings. Data demonstrates that student achievement, as measured in GPA earnings, is positively impacted by PBL methodology environments over time as indicated in Table 1 data. The data indicate that non-magnet programs had maintained gains over time vacillated with a demonstrated .06 gain from 2014-2015 school year to the 2017-2018 school year. Magnet programming in Biotechnology steadily gained in

GPA averages over time from 3.29 to 3.55, a .26 gain; in Engineering Technology, there was a .17 gain in GPA. Computer Game Design had a .15 gain over time and is the only program that is a state curriculum as opposed to a national curriculum from Project Lead the Way. The findings may be influenced by the selection of students into magnet programs based on choice and a high level of interest in the content area, giving students greater learning motivation in addition to the PBL methodology-based instructional environments. One additional point worth noting is the increase in enrollment within each program over time. This finding indicates that the student outcomes and opportunities are sustaining the programs.

Table 1

Aggregated GPA Averages for 9-12 Graders per Year in Non-Magnet and Magnet Programs

	2014-2015		2015-2016		2016-2017		2017-2018	
	#	Average GPA	#	Average GPA	#	Average GPA	#	Average GPA
Non-magnet	889	2.27	947	2.24	1009	2.29	919	2.33
Biotechnology	123	3.29	154	3.35	175	3.45	206	3.55
Computer Game Design	122	3.00	145	3.07	154	3.14	167	3.15
Engineering Technology	180	3.16	204	3.23	211	3.33	220	3.33

Graduation Rates. Student cohort graduation rates over time at the school level provide an indicator for student performance trends for the high school. According to five years of school cohort graduation data, the school's graduation rates have consistently risen from the 2012-2013 school year (47.90%) to the 2016-2017 school year (80.5%). As the rate has increased, the school has also narrowed its school to district graduation rate achievement gap from 26.2% in 2012-2013 to 2.4% gap in 2016-2017, as depicted in

Figure 20. This trend may suggest that the STEM-PBL programs have indirectly contributed positively to increasing the overall growth in the graduation rates perhaps attributed to students' choice to attend these programs.

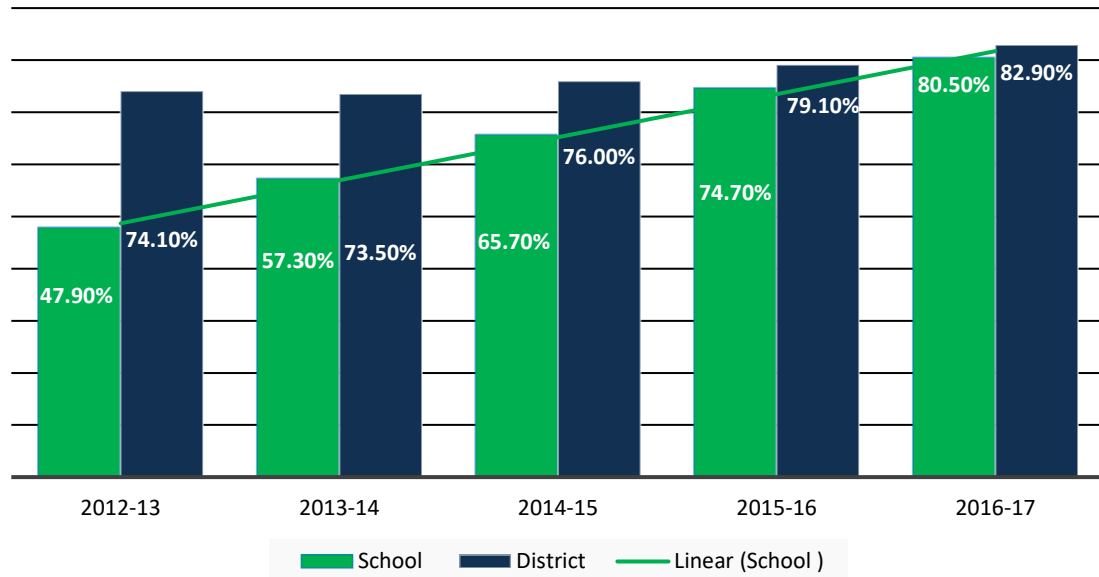


Figure 20. School and District Cohort Graduation Rates: Florida Department of Education, fldoe.org PK-12 Portal, High School Graduation Rates, retrieved from <https://edstats.fldoe.org/>

This improvement trend is also apparent in the percentages attributed to different types of graduation obtainments as presented in Figure 21. As the graduation rate has increased, the rate of cohort members who continued in school after their classmates graduated has decreased significantly from 28.2% in 2012-2013 to only 9.8% in 2016-2017. Alternative graduation pathways (special diplomas, GED or GED-based diplomas, and certificates of completion) have steadily decreased over a five-year period as well, though not as significantly. The data suggest that there is a positive trend producing more regular diploma options over the five-year period and further implies that students are more successful in meeting the state graduation requirements within these programs of choice.

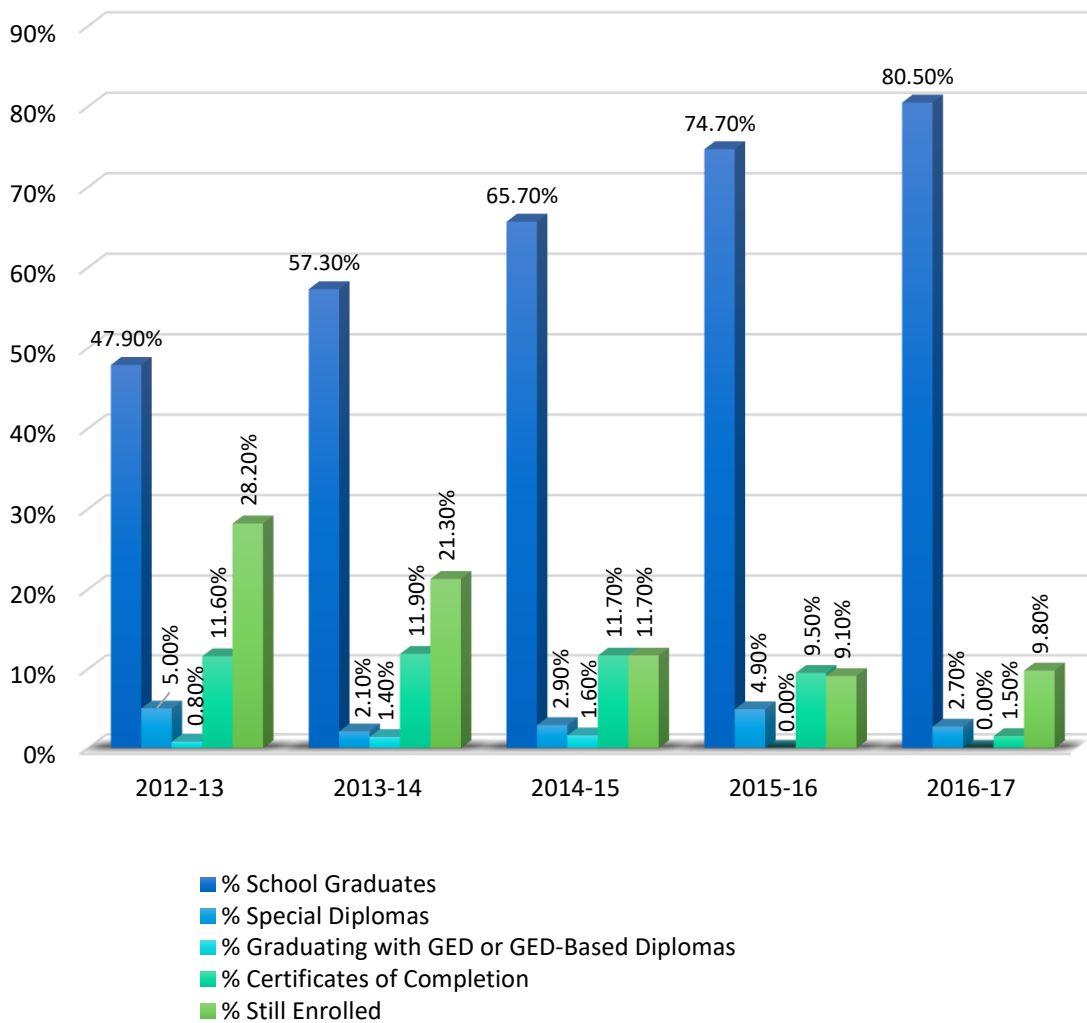


Figure 21. School Cohort Graduation Rates by type of Graduate or School leaver: Florida Department of Education, fldoe.org PK-12 Portal, High School Graduation Rates, retrieved from <https://edstats.fldoe.org/>

Industry Certifications. The emphasis on STEM education at the school may have contributed to a rapid rise in the number of Industry Certifications Passed over a three-year time frame. The positive trend line for the high school’s completed Industry Certifications shows the strength of the Industry Certification program. The discrepancy between Passed and Attempted has been significantly narrowed by 2016-2017. As an administrator at the school I can attest to a concerted effort on the part of industry

program instructors to support student completion of Industry Certifications. The increasing data trend clearly suggests that these STEM programs give students multiple opportunities to acquire industry certifications that improve their resumes for future college and career readiness.

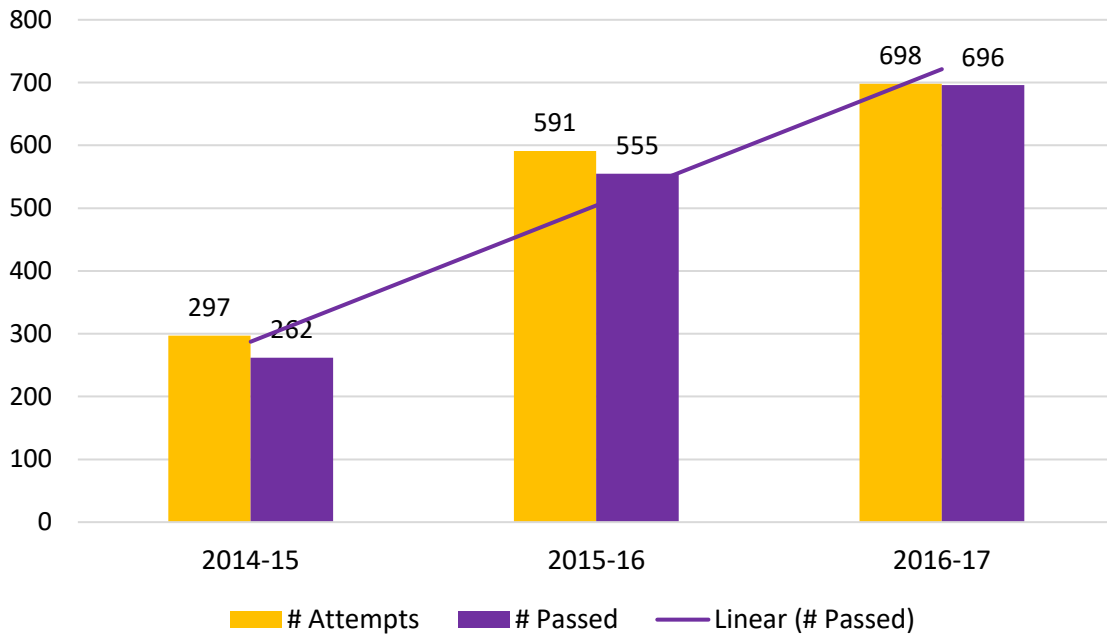


Figure 22. Industry Certification Attempts and Passed with trend line for the high school. Retrieved from school district evaluation department, October 11, 2017.

These positive trends in graduation rates and industry certifications may be attributable, in part, to the investment of the school in STEM programming, STEM and PBL instructional strategies implementation, and the additional teacher development training available at the school site as part of the Title I funding as well as magnet program status. Title I, Part A, provides local educational agencies (LEA) resources that help children gain a high-quality education and the skills to master the Florida Standards. Title I identification provides additional resources to schools with economically disadvantaged students. These resources provide additional teachers, professional

development, extra time for teaching, parent involvement activities, and other activities designed to raise student achievement.

Low Income Student Percentages. To provide a fuller context for my research, I have considered student poverty data as a possible influential variable. The school has remained a Title I identified school over a six-year period. A decrease in the percentage of low-income student levels over the period may be a contributing factor to the positive performance trends. The school's six-year trend demonstrates a decrease in the percentage of low-income students from 88.8% to 68%. The reason for Title I designation and the additional resources provided to Title I schools is based on correlation between the lack of resources and other characteristics of low-income students with decreased school performance levels in comparison with higher income students. Therefore, it seems pertinent to acknowledge the 20.8% decrease in low-income students over a six-year period as a factor contributing to performance increases.

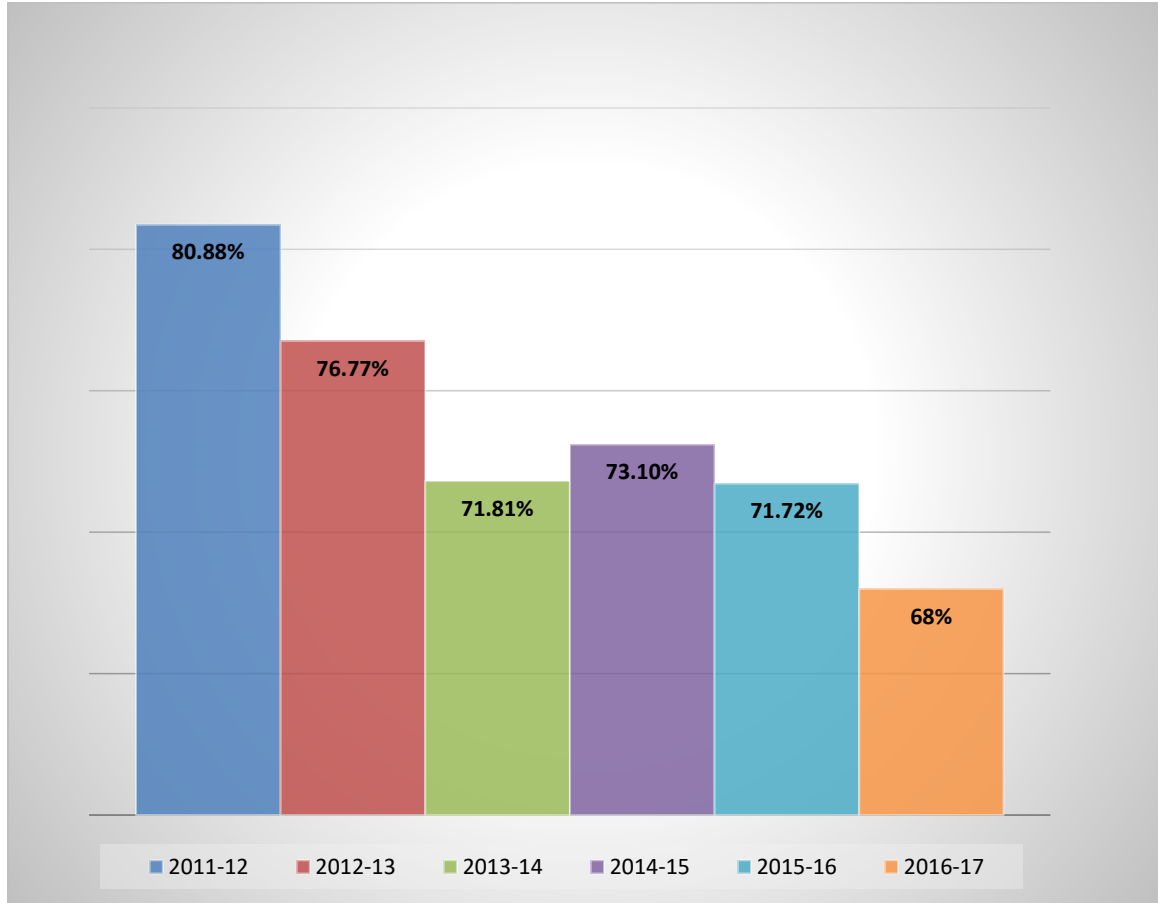


Figure 23. School level low-income percentage reported as Title I qualification by the Florida Department of Education Bureau of Federal Educational Programs Final Title I Schools List. Retrieved from Title I, Part A: Improving the Academic Achievement of the Disadvantaged, <http://www.fl DOE.org/policy/federal-edu-programs/title-i-part-a-improving-the-academic-/>

Interviews

As a part of my data collection, I scheduled interviews with various program related populations to give triangulation of the data with different perspectives of the stakeholders related to the topic of my STEM-PBL study. I interviewed school administrators (Appendix B), school guidance counselors (Appendix C), district directors (Appendix D) in STEM and CTE, parents (Appendix E), and a stem teacher-focus group (Appendix F) representing each program. The goal was to obtain up to 3 interviews from

each population and up to 6 teachers with the stem teachers focus group interview. I was able to obtain 2 interviews across all groups mentioned above and 4 teachers to participate in the stem teacher focus group representing all programs within the study.

Administrator Interviews. In reference to the administrator interviews, I intended to obtain 3 interviews from the school site. At the conclusion of my data collection, I was able to attain 2 administrator interviews with a range of 45-60 minutes lasting an average length of 50 minutes, representing 66.6% response rate of the projected interviews planned. I was able to get the perspectives of the principal and the assistant principal for magnet curriculum to give insight to each of the programs of Engineering, Biomedical Technology and Game Design.

In response to question #1, which inquired into their perception on how they would define STEM education, both administrators identified the general common language being able to define STEM is an acronym representing science, technology, engineering and mathematics and were able to add other key points. The emergent theme of the responses expressed that these content areas are components of skills aligned to jobs in today's workforce. The overall understanding of the data suggest that STEM education prepares students for future career fields in which STEM thinking applications are central.

In response to question #2, concerning perceived STEM, project-based learning effectiveness as a method of instruction that increases academic achievement, the common response was clear agreement that the STEM-PBL instructional methods are effective and increase academic achievement for students. The common themes in the responses were that direct, hands-on application of theory prepares students with skills to

compete in a global society and that hands-on activities increased retention, which leads to self-motivation and deeper learning. The perceptions expressed clearly suggests that administrators perceive the STEM-PBL method of instruction provides a means for transferring student learning of concept knowledge into applied knowledge leading to greater preparation as critical thinkers and problem solvers.

In response to question #3, concerning perceptions about what is working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, responses demonstrated that they felt these programs give students opportunities to actively think through real-world applications within STEM fields while attaining industry certifications. They explained that students can practice 21st century skillsets required for success as workers in a global economy. The response data collected suggests that what is working well within these programs is two-fold: students are attaining the 21st century skills and more particularly, are becoming problem solvers within these fields. The perception is that students are being prepared as knowledgeable, critical thinkers who are challenged to apply their knowledge during their acquisition of industry certifications. The responders affirmed their perception of the value of industry certifications as preparation directly associated with the demands of the job market.

Question #4 elicits responses about what is not working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design. The responses do not share any one dominant similar theme. The singular responses however make some interesting observations. One administrator feels that the programming was not keeping up with current technology and that resource support is not adequate. The administrator feels that the lack of funding has contributed to the inability of the school to

recruit and retain specialized teachers who hold credentials in STEM instructional pedagogy and who have industry field experience. Another administrator holds the perspective that there is a lack gender balance in the programs; more specifically, the programs are unable to attract and retain girls. The findings for question #4 suggest that STEM programs are underfunded and have difficulty keeping current with the technology. An additional finding is the perception among administration that insufficient funding levels contributes to difficulty in placing qualified instructors in the programs. In addition, there seems to be a continuing problem in recruiting members from the underrepresented STEM group of female students into the programs.

In response to question #5, concerning the greatest challenges in the STEM programs of Engineering, Biomedical Science and Game Design, the most common response indicated the challenge of keeping the programs current with industry and attracting qualified teachers who hold the needed skillsets. Another challenge they noted, as in question #4, was the ability of the programs to retain female STEM students. In addition, there is a challenge with students wanting to change programs after concluding that their program choice was not what they expected. The findings suggest that a great challenge exists to these STEM programs in terms of funding needs and finding the qualified instructors to lead STEM education. In addition, there seems to be a need for clearer exposure and better pre-enrollment communication with students in terms of the STEM program expectations and requirements.

In response to question #6, about STEM program improvement suggestions, the most common response indicated by administrators is their perception that the programs could be improved by proactively examining future trends in STEM fields and student

preparation needs for future job demands, many of which jobs do not yet exist. They also agree that coordination with community stakeholders, such as the YMCA, to create STEM programs that teach STEM skills such as those involved in robotics activities would be an avenue for providing students with resources and learning opportunities. Another improvement suggestion was to enhance program rigor by adopting nationally recognized standards and curriculum, such as adding Project Lead the Way Computer Science program. The findings suggest that the essence of improving these programs relies on finding a means to drive STEM program enhancement using rigorous curricular alignment with future trends. This is related to a previous concern of keeping the programs current with industry expectations.

In response to question #7, which inquired into the efficacy of project-based learning in increasing the overall rigor of the curriculum and in promoting higher levels of student achievement in the content areas of science and math, the responders agreed that PBL increased the rigor of the curriculum and enhanced student achievement levels. The administrators mentioned project-based learning hands-on applications and reinforcement of theoretical concepts in these content areas as well as PBL linking these applications to relevant to real-world issues. The findings here suggest that PBL is positively perceived as furthering science and math standards obtainment and in helping students make conceptual learning connections with real-world application. Real world applications provide students with the context of authentic learning situations in which to think through solutions applying learning at various levels and in various ways.

Question #8 inquired about the relationship between technological ability to STEM-PBL program success. The most common perspective was that the greater the

technological background the better the students were able to process and understand the STEM concepts and navigate the computer programs integrated into the curriculum. The findings here suggest administrators see technological aptitude as an aid to student STEM program success. This implies their support of student exposure to technology before entering these high school programs. Perhaps this may be accomplished through the suggestion of a prerequisite course or by enhancing first level coursework in the programs with intentional technology readiness instructional components.

Question #9 concerns the relationship of STEM project-based learning to standards-driven curriculum to student achievement levels. The most common response indicates that they felt standards-based curriculum and PBL are aligned and connected. They explained that students must master the standards to be able to apply that knowledge to STEM-PBL lessons. They also made another key point, the STEM-PBL process teaches students to learn from their mistakes in order to make improvements. Students are using their conceptual knowledge in practical ways; the standards are reinforced through PBL. The findings suggest that administrators acknowledge the alignment between the Florida state standards and STEM-PBL educational practices; and that they further see STEM-PBL as a means to greater levels of standards mastery.

In response to question #10, which asked what they thought about the future of STEM in educational reform, the most common response here was that they perceived that STEM education would drive educational reform because it is applicable to all content areas and prepares students with the 21st century skills for future career demands. The data suggests that the perception among STEM administrators is that STEM

education will be prominent in educational reform as it aligns to the demands and requirements of the future job force.

Guidance Counselor Interviews. In reference to the guidance counselor interviews, I intended to obtain 3 interviews from the school site. At the conclusion of my data collection I was able to attain 2 guidance counselor interviews, with a range of 45-60 minutes lasting an average length of 45 minutes, representing 66.6% response rate of the projected interviews planned. I was able to get the perspectives of the guidance counselors within the magnet programs to gain insight into each of the programs of Engineering, Biomedical Technology and Game Design from their perspectives in working with the students.

In response to question #1, which asked the guidance counselors their perception on how they would define STEM education, the most common emergent theme communicated by the guidance counselors indicated that STEM education is defined as science, technology, engineering and mathematics, but includes a more rigorous technical program that fosters higher level thinking as compared to a traditional curriculum. The findings suggest that these guidance counselors perceive STEM education as a program that allows students to pursue a highly technical program that pushes their thinking.

In response to question #2, which asked if they perceived STEM, project-based learning was an effective method of instruction that increases academic achievement, the common theme was that they agree that STEM-PBL is an effective method of instruction that increases academic achievement because students have a special interest in these programs; this special interest increases student motivation to learn and do well. In addition, they noted that hands-on work enhances students' ability to manipulate and use

their knowledge leading to higher levels of achievement. The data suggests that the guidance counselor's perception, based on their interactions and feedback from students, was that STEM-PBL is an effective method of instruction that appeals to students' interests as motivating factor in learning that improves achievement.

In response to question #3, concerning what was working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, the most common theme was the opportunity for students to acquire industry certifications and the school's achievement of the highest levels of completion of industry certifications in the district. They further indicated that the industry certifications contribute to student resume building for college or for use as a credential directly transferable to workforce placement. The data suggests that the guidance counselors felt industry certifications were working well as a component of the STEM programs with their alignment to industry and workforce expectations.

In response to question #4, which asked what was not working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, the common response was the lack of funding for meeting the needs for updated technology for the programs in terms of both hardware and software. To continue to meet the needs of students, STEM programs need technological updates to keep current with industry expectations. The data suggests that the lack of funding and resources for technology upgrades in these programs is not working well. Funding for technology upgrades to meet ever-changing industry expectations to remain relevant to students' workforce preparation needs has been a continuing battle for our school.

In response to question #5, inquiring into perceptions about the greatest challenges in the STEM Engineering, Biomedical Science and Game Design programs, the common response from both guidance counselors was similar to the previous question response, lack of funding. In addition, they pointed out another challenge of reaching under-represented groups to enter the STEM programs and the lack of tutorial programs to support students who do not have critical thinking skills to be successful. The data here supports the lack of funding as a perceived continuing challenge to STEM program ability to support student success.

Question #6 is an inquiry into ways for improving the STEM programs. The common theme shared by both counselors involved the need for increased funding and local business support. Business relationships are a means for increasing apprenticeship opportunities for students leading to better preparation for, and better understanding of the workplace. The data here suggests that the involvement of local business partnerships could improve and expand the overall STEM experience to promote career readiness and to prepare students for future careers.

In response to question #7, concerning how project-based learning increases science and math rigor to promote high levels of student achievement, the most common theme indicates that teachers may not be making clear concept learning connections for students within the projects. However, they did perceive that the science and math knowledge is integrated within the STEM-PBL lessons and that the projects fostered an environment of collaboration. The data suggests that science and math are clearly connected but they are unclear as to whether the connections are being made within the STEM-PBL lessons.

In response to question #8, which asks about the relationship between technological ability and STEM-PBL program success, the clear response was that there is a strong thematic relationship between technological ability and success in STEM programs. They feel that the more technology background the students have, the better they can navigate the program content and challenging projects and so increasing their success. They felt the students could better focus on the rigorous applied content topics rather than struggling with technology tools inherent in the project-based learning applications. The data suggests that technological background increases the rate of student learning because students are able to focus on the problem-solving content as opposed to the technology tools used to master the problem at hand.

In response to question #9, concerning the relationship of STEM project-based learning and standards-driven curriculum to student achievement, the emergent theme from the guidance counselors was that they perceived the standards corroborate what industry demands and is doing. The example given was robotics content allowing students to apply skills linked to multiple standards. The data suggests that the guidance counselors perceive that content standards are clearly embedded within STEM-PBL lessons and support content across all curricula, which is a means for increasing overall student achievement.

In response to question #10, which asked what they thought about the future of STEM in educational reform, the emerging theme was that STEM is at the forefront of educational reform. Industry demands will push high schools to include STEM programs and school to work apprenticeships. The data suggests that guidance counselors perceive STEM will drive future educational reform.

District Directors in STEM and CTE Interviews. In reference to the district directors in STEM and CTE interviews, I intended to obtain 3 interviews from the school site. At the end of my data collection I was able to attain 2 district director's interviews, with a range of 45-60 minutes lasting an average length of 60 minutes, representing 66.6% response rate of the projected interviews planned. To gain a global lens view for each of STEM programs under consideration (Engineering, Biomedical Technology and Game Design), I was able to collect the perspectives of the district directors working to support STEM and CTE programs on a local and state level.

Question #1 asked the district directors about their perception on how they would define STEM education. The most emergent theme communicated by both directors was similar with their use of the terms associated with the components of science, technology, engineering, and mathematics as a basis for educational programming integrating student application of their learning. Another considered answer included the concept that STEM is about innovation, creativity, problem solving, and connecting learning to authentic workforce contexts. The data suggests that these leaders have a common language for defining STEM as an educational practice involving the process of applying science, technology, engineering and mathematics learning by creating a space where students are inspired to create and innovate to solve problems.

In response to question #2, concerning STEM, project-based learning as an effective method of instruction that increases academic achievement, both district directors thematically affirmed that project-based learning is a model that manages constructively the integration of multiple content areas. The cross-curricular instruction increases learning and engagement giving students multiple experiences with content

concepts driving a deeper level of understanding and greater levels of achievement. Another thematic affirmation mentioned is that PBL promotes the connection of knowledge learning by helping students understand how STEM area concepts fit together as a means of problem solving during an activity. The data suggests that STEM PBL is effective because it encompasses cross-curricular standards and creates a collaborative environment of meaningful discourse that is essential to solving problems, which is engineering.

In response to question #3, which asked what was working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, the emergent theme was that they both perceived that the STEM programs encompass high rigor and scaffolds learning within the projects to challenge students; and that in this way, the programs are preparing students to pursue an Engineering program or transition directly into the workforce. Another aspect of the responses is that the programs can attract a very diverse student population. Lastly, the responders mentioned their assessment of the Project Lead the Way curriculum as a rigorous, nationally recognized curriculum that focuses on collaboration and innovation. The data suggest that the district directors' perception of what is working well is the program curriculum of Project Lead The Way. This is a national curriculum that is highly rigorous and assessed with industry certifications that prepares students for career and college readiness. The directors affirmed the positive attributes of the program as providing scaffolds of learning for a diverse population of students and as a means for student preparation for the field of engineering.

In response to question #4, which asked what was not working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, the emerging theme from both district directors was in the area of recruiting the underrepresented groups of minorities and females. Another idea mentioned is that the district lacks a clearly defined vertical pathway for preparing students for STEM programs and getting them interested in STEM. Lastly, there is a lack of support in terms of professional development for instructors consisting of technological updates to keep them current with the continual dynamic changes in the technology within each program. The data suggests that from the district directors' perspective, what is not working well is recruiting underrepresented groups to the STEM programs. This could be connected to the lack of a clear vertical STEM pathway within the district. This gives thought to the idea that STEM curricula could be integrated throughout the district in the elementary and middle schools to better expose and prepare students for STEM at the high school and beyond.

In response to question #5, which asked what the greatest challenges in the STEM programs, the emerging theme from the district directors reflects a strong need for finding qualified talent to teach the specialized courses. Another idea that was strongly communicated is the challenge of the lack of funding for these STEM programs. The data clearly suggests that funding and finding qualified teachers are some of the greatest challenges in STEM education.

In response to question #6, which asked what were ways to improve the STEM program? The most common theme reported to improving the STEM program is to increase the emergence of digital literacy and computational thinking by increasing the

opportunity for all students to learn computer science. Another idea to improve the program is the alignment of the STEM pathway from the lower elementary to middle and high school levels. They indicated that presently only silo STEM programs exist at the elementary and middle levels and some only contain a component of STEM. The data suggests that a vertical articulation of STEM programs would improve the STEM program, as students would be exposed to these skills earlier better preparing them for the highly rigorous project lead the way curriculum at the high school.

Question #7, which asked how project-based learning increases the overall rigor of the curriculum, the common theme from the district directors was affirmative. They perceived PBL as adding depth to understanding math and science concepts by adding rigor in a natural integration within the higher-level activities. Their responses suggest that the PBL model allows students to apply the learned concepts in science and math to different situations or problems.

In response to question #8, which asked what the relationship was of technological ability to being successful in a STEM-PBL program, the most common theme was affirmative. They perceived technological ability as important for enhancing a student's ability to be successful in STEM or in any school curriculum. The idea of technological ability is no longer an option but a requirement in the digital age for all students. The data suggests that technology is an important part of any student's success whether they are in a STEM program or not. The key take-away was twofold, not only do students need to know the technology, but also students need to know how to use it to solve problems and conduct activities in a wide variety of contexts and fields of study.

In response to question #9, asking about the relationship of STEM project-based learning and standards-driven curriculum to student achievement, the responses indicate that the district directors thematically agree that mastery of the standards is the main objective of education. They perceived that there is alignment between the standards and the construction of project-based lessons. They explained that the project is the mechanism that drives the mastery of the standards within the lesson. The data suggests that there is alignment between the state standards and STEM education to support future organizational change that connects these science and math curricular standards.

In response to question #10, which asked what they thought about the future of STEM in educational reform, the response from one of the directors was that STEM would be a huge part of reform because of the push from industry to meet the needs of the future workforce from the public schools. Another concern mentioned was the need for state and national support through policy change and proper funding. The data suggests that STEM will be a part of future educational reform, but that STEM programs have many challenges. These challenges include adequate funding and the support required depends on state-level policy change.

Parent Interviews. In reference to the parent interviews, I intended to obtain 3 interviews from parents of students who completed and graduated from these STEM programs. At the end of my data collection I was able to attain 2 parent interviews, with a range of 45-60 minutes lasting an average length of 40 minutes, representing 66.6% response rate of the projected interviews planned. I was able to get the perspectives of the parents of students within the Engineering and Biomedical magnet programs. These data allowed me to gain insight into the overall thematic perception of the quality and level of

instruction within these programs that prepared them for a college level program in these fields.

In response to question #1, which asked the parents their perception on how they would define STEM education, both parents articulated the perception that STEM is defined as being an environment that connects all subjects with hands-on activities and leverages student interest to advance learning. Clearly, the theme was both parents perceive STEM learning environments as beneficial as a means of appealing to student's interests and as a means of integrating cross-curricular learning opportunities for advancing achievement of standards across multiple content areas.

Question #2 investigates parent perceptions of STEM project-based learning as an effective method of instruction that increases academic achievement. The most common theme from parents considers project-based learning as an effective method of instruction that increases academic achievement because of the hands-on application of learning. One parent indicated that her daughter, who is in the Biomedical Program, learns and retains the learning because she is doing. Her son graduated from the Engineering program and is thriving in college level Engineering program. The data suggests that from a parental perspective, the STEM-PBL method of instruction is effective because of the key element of application integrating hands-on experiences.

In response to question #3, which asked what was working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, the thematic response was again the application of learning and student interest for the program. The parents shared that their son has had a smooth transition into an Engineering program in college and is better prepared having been in this program. It was noted that a project that

his college classmates struggled with he had done in high school. Another idea was that the traditional teachers were not as connected to the STEM programs. The data suggest the take-away of what is working well in these STEM programs is the hands-on application aspect that increases learning. This learning serves students as a toolbox to problem solving preparing them for the next level.

In response to question #4, which asked which asked what was not working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, the most common response from the parents was that the volume of work was not working well in these programs. It was shared that students have a difficult time balancing the workload and the extracurricular activities, which include career organizations (Career, Technical, Student Organizations or CTSO's) that allow students to compete across the state. Some examples shared referred to the Robotics team for Engineering and HOSA for biomedical, and Skills USA for Game Design. The data suggests that time-management and organization are key elements to be addressed by the curriculum to ensure that the students can balance program expectations and opportunities. These data bring me to consider the need for a pacing analysis that gathers the timelines and expectations of all these organizations as part of the curriculum. In this way, a better-aligned pacing load may be maintained to allow more students to be involved in CTSO's and provide adequate time for students to accomplish coursework expectations.

In response to question #5, which queries about the greatest challenges in the STEM programs of Engineering, Biomedical Science and Game Design, the concerns expressed were again the lack of funding. They described the fact that the programs are

expensive to sustain and have many project-related classroom materials that are consumables that must be replaced every year. Furthermore, they felt that there was the lack of qualified teachers who have the skill level to teach in these programs. In addition, they felt that the expenses were very high for the students to compete in the organizations outside the classroom that apply the learning such as, TSA, Robotics, FBLA, and HOSA. They further explained that these competitions have fees and require materials to practice the skills necessary to compete so fundraising events are necessary to support the students. The data suggests that the lack of qualified teachers and funding is the greatest challenge. These concerns relate to student equity and can be a contributor to the underrepresented subgroups in STEM programs. Underrepresented student groups, especially lower income youth, do not have the financial ability to participate and in addition, do not have the technological background to compete at this level. This is an issue to be considered in the organizational change plan.

Question #6, concerns ways to improve the STEM program. The most common response was clear that increasing the time to accomplish the curriculum was needed. Another concern was the need to increase funding and to recruit more qualified teachers. In addition, improvement suggestions included the addition of a program for Project Lead the Way for Computer Science. The data suggests that funding is key and a competitive salary that could possibly attract more highly qualified teachers is needed. The funding increase would supplement or enhance programs to be sustained and upgraded to become current with technology as demanded by business and the manufacturing industry.

In response to question #7, which concerns project-based learning promoting the overall rigor of the curriculum to promote high levels of student achievement, the

common response from parents was they felt PBL in math and science more clearly presents concepts and differentiates learning for student needs. PBL allows the teacher to move about the classroom and facilitate learning as it unfolds. In addition, responses affirmed that students are more involved in the learning and the understanding is reinforced because they are doing something with the concepts. The data suggests that STEM-PBL lessons promote high levels of understanding in math and science curriculum because it allows students to connect the concepts as they conduct a project to solve a larger problem. This method gives purpose to why students learn the math and science.

In response to question #8, which considers the relationship of technological ability to being successful in a STEM-PBL program, parents felt that technological ability is very important, but not necessary because students will learn as they go. They shared that students who have the base knowledge have an easier time and tend to help their peers, so therefore, it all equals out in the end. Overall, the consensus is having technological ability is needed but can be learned. The data suggests that students who have the technological background are better prepared to handle programmatic expectations. However, students in these programs assist their peers learning from each other, which mirrors the collaboration found in industry on project teams. This is an excellent reaffirmation that STEM programs are integrating 21st century skills.

In response to question #9, which asked what the relationship of STEM project-based learning and standards-driven curriculum was to student achievement, the most common theme from parents was that PBL was connected to standards. They felt that this STEM-PBL environment takes the standards every student should learn and makes it adaptable and exciting to learn. The data suggests that parents feel the STEM-PBL

environment makes learning interesting because it connects the learning with a purpose and the standards are the skills needed to problem solve through the issues. The thought here is that learning is building the tools and these tools evolve with higher-level expectation and are reusable in many situations.

In response to question #10, which asked what they thought about the future of STEM in educational reform, parents felt STEM reform will be evolving and will eventually be infused in every public school because it is related to future jobs. They felt the expansion of education should be at the vocational level giving students the skills they need. These programs prepared my son to think and that it takes hard work. The Project Lead the Way curriculum prepared him to be successful in college. The data here suggests that the parent perspective shares in the feeling that STEM will be a part of future educational reform and should be infused in all schools and at all levels.

STEM Teacher Focus Group. About the STEM Teacher Focus Group interviews, I intended to obtain 6 teachers representing each of the programs from the school site. At the end of my data collection I was able to attain 4 teachers to participate in the focus-group interview, with a range of 45-60 minutes lasting an average length of 60 minutes, representing 66.6% response rate of the projected interviews planned. I was able to get the perspectives of teachers in the Engineering, Biomedical Science, and Game Design programs to gain deep insight from the instructor's perspectives that teach each of these specialized programs.

In response to question #1, which asked the STEM teachers how they would define STEM education, the most common response communicated by the teachers was that STEM was an interdisciplinary curriculum that applied science, technology,

engineering and math concepts. Another idea is they felt STEM was any form of education that focused on one of the four principles of STEM and involved hand-on inquiry-based learning where kids are fully immersed in and doing something. The data suggests that the teachers agree that STEM integrates multiple content areas and is a hands-on application of learning that takes the learning deeper than reading a passage or text and learning information. This demonstrates a shared understanding among the teachers of the application-rich emphasis in STEM.

In response to question #2, which asked if they perceived project-based learning in STEM as an effective method of instruction that increases academic achievement, the most common response from teachers was in the affirmative. They stated that STEM-PBL was an effective method of instruction because it allows for a deeper exploration with real-world connections to material. Another strong idea expressed concerned students having hands-on experiences leading to better understanding of concepts at higher levels. They felt that allowing students to have the time for applications to practice and solve problems in real life leads to greater learning of the connections between content areas and concepts. The data suggests that teacher's feel that the STEM-PBL method is an effective method of teaching which promotes student learning by the real-world application. This method of learning may be applied in all content areas. A part of my proposed change to be considered is to initiate PBL in other content areas provided that teachers have the time to collaborate on project topics and implementation plans.

In response to question #3, which asked what was working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, the common response was that teachers felt that teacher collaboration, structure, and time management

are working well. Another idea that was articulated was the specialized curriculum within a cohort structure provides an effective learning environment for students. In addition, some mentioned clubs such as Robotics as positive support to classroom learning, and which also increase student buy-in to the program. The content applications integrated into the curriculum supports student success in local, state, and national CTSO competitions. The data suggests the application of learning that is tied to a competitive arena increases the student engagement and interest in learning. Students seem to have a vested interest thereby motivating their desire to have a high-quality level of understanding.

In response to question #4, concerning was not working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design, the most common response from teachers is the lack of funding for consumables and updated technology. Another aspect articulated is the lack of time to complete the curriculum and time needed for students to complete their projects. It was shared that many students stay afterschool to complete assignments. The data clearly suggests that a lack of time for both teachers and students as well money for the programs are roadblocks for implementing with fidelity. These roadblocks are out of the teachers' control and are therefore, considerations for administrative change.

In response to question #5, about the greatest challenges in the STEM programs of Engineering, Biomedical Science and Game Design, most of the teachers agreed that the greatest challenge was the pacing of the curriculum and the lack of enough time for students to engage in the project learning cycles including enough time for trials, reflection, learning from their mistakes, and discovering alternative solutions to

problems. Another idea that was challenging was student's lack of adequate background knowledge leaving them unprepared for the program expectations. One final idea was the challenge of having the time to collaborate with other content area teachers on the traditional side to improve continuity for students. The data suggests that students would benefit from some STEM skill preparation in the elementary and middle school levels along with structural changes to the schedule to give teachers more time to collaborate. This will be a focal point of my organizational change plan as students' level of preparation is variable across the feeder schools producing additional strain on curriculum pacing.

Question #6 investigates perceptions about ways to improve the STEM program; the common response from teachers was to foster more parent, faculty, and industry involvement in the integration of the STEM theme for all students. This would provide opportunities to expose all students to STEM thereby eliciting their interest in the potential high paying careers. Another idea mentioned was having proper fundraising opportunities or grants to supplement the programs. The data suggest that the lack of funding is a deep concern that could improve many levels of the programs from the classroom needs to the competitions. This aspect must be explored as part of the proposed changes to support the transition while sustaining the integrity of the programs

Question #7 concerns how project-based learning increases the overall rigor of the science and math content area curriculum to promote high levels of student achievement. The most common response from teachers was the STEM-PBL environment introduces real-world scenarios that reinforce math and science concepts to go beyond the standard for complex learning. The data suggests that math and science concepts are pillars in

STEM-PBL lessons and projects. The thought here is that perhaps this PBL model can include other subjects to collaborate and compliment learning across all disciplines. Learning is truly a compilation of all subjects, as the knowledge is never applied in isolation. This idea will be a component within my change proposal and can be applied at all levels.

In response to question #8, which asked what the relationship was of technological ability to being successful in a STEM-PBL program, the response of two teachers felt that technological ability was important and had a great impact on being successful in a STEM program. They further explained that students without the technological background struggle with learning the technology and the concepts. The other two teachers felt that the motivation and desire to learn was more important and would drive a student to learn the technology. The data suggests that motivation combined with technological background would both have a positive impact on student success within the STEM programs.

In response to question #9, which concerns the relationship of STEM project-based learning and standards-driven curriculum to student achievement, the most common response was that comparatively they viewed the STEM-PBL environment as a more highly engaged classroom that culminated the standards. They further explained having taught in the traditional classroom the collaborative aspect of PBL assists students in remembering what is taught for future learning. The data suggests that teachers feel they have more success in a PBL classroom environment and students gain deeper knowledge of the standards working in connection as opposed to subjects taught in isolation. This is additional evidence that reinforces the need for change to include more

collaborative creative learning spaces for students to learn how to think and process solutions.

In response to question #10, concerning the future of STEM in educational reform, the teachers agreed that STEM will be a part of educational reform but will first have to overcome the barrier of funding. Another key idea was that the structure should change to include STEM skills at all levels. The data suggests that STEM educational reform is greatly needed but must overcome the lack of funding and structural planning changes at all levels to create tomorrow's problem solvers.

Organizational Changes

In my analysis of the data provided by the stakeholders in my study, I see a clear basis for areas of organizational change that may positively influence STEM program and STEM education progress and student achievement within the district. I will focus my work around the organizational change to implement a district-wide system that will infuse STEM content and project-based experiential learning vertically from the elementary level to middle and high school. This STEM change initiative is a needed process to prepare students with the skills to compete globally with the demands of current and future industry. The change will include two key focus areas to include student preparation and teacher professional development. The first focus is the goal of aligning the standards in science curriculum to engage students in STEM-related problems that encompass all content areas in a concerted effort utilizing the construct of science, technology, engineering and mathematics to become problem-solvers. The second focus is to create collaborative professional development around this evolution of

STEM change that serves as a district incubator to promote and sustain the integration of current STEM topics and technology.

The first step towards this movement will be to propose a purpose of STEM education that is rooted in a common language. This purpose will clearly define the understanding that STEM education has many faces, but all have common threads including human base knowledge, inquiry, and design (Bybee, 2013, p. 5). The organizational change will consider the representative context, culture, conditions and competencies that must be addressed within the district and the classroom to implement this transformation with efficacy.

I selected my organizational change focused on the topic of STEM education with an emphasis of the PBL methodology of instruction because of the global demand for the 21st century. There has been a purposeful national educational movement towards academic equity while the global achievement gap continues to widen. In my professional experience, I believe the topic of STEM and PBL can be utilized in tandem to address both concerns at the classroom level. The national, state, and district prioritization of this method being integrated at all levels will exponentially improve critical thinking skills across all content areas. This initiative will also bring awareness and understanding that a PBL lesson brings application of multiple content-based standards that culminate into a student-driven problem-solving network. The findings in my study indicate a lack of vertical alignment with the skills and concepts that would improve student's ability to problem solve.

I have identified my complete baseline AS-IS chart (Appendix N) utilizing Wagner's (2006) 4 C's model for change that represents Context, Culture, Conditions,

and Competencies. This visual shows a graphical picture of my analysis for An Evaluation of a Magnet Program that Utilizes Project-Based Learning to Improve Student Achievement. The AS-IS diagnostic chart (Appendix N) is comprised of my STEM program evaluation that outlines specific context, culture, conditions, and competencies related to the topic of my organizational change. The details of each of these categories previously referenced center on the focal point addressing the lack of vertical integration of STEM-PBL skills in science curriculum and instruction.

Context

The relevant and interconnected context (Appendix N) factors of my STEM study as depicted in my “AS IS” visualization include historical perspectives, school community needs, economic outcomes, and, ultimately, global competitiveness. According to Wagner, the context of a study gives a perspective that orients the reader to community, social, historical, economic, or global factors that relate to the topic, (Wagner, 2006). I will explore these aspects with the lens of creating academic opportunity for all students with the end goal of preparing students for future college and career readiness.

Historically, science education has been limited in the lower elementary levels and the idea of STEM integration has only recently been considered. This barrier will be considered within the landscape of the organizational change to create policies and procedures that align through all levels of learning. This process change will include a vertical and horizontal shift including input from stakeholders of all content areas of science, technology, engineering, mathematics, as well as the social sciences and English areas.

School and community needs are changing with the shifts in the skillset needed to prepare our students for these academic challenges. The opportunity for students to achieve these skills with an addition of an industry certification gives students a foundation to a career. These opportunities serve as a pathway building their resume to compete in the job market. The major difficulty associated with achieving a STEM curriculum that meets students' future needs is in being able to anticipate how these needs will evolve in the future.

Economic needs of industry have changed drastically calling for 21st century skills such as collaboration, problem-solving, and critical thinking. In my professional experience, as a science teacher and administrator, I can see the need for change to include a science vertically integrated curricular shift as a priority. This topic focus will drive the community awareness and truly inform teachers and district leaders on the relevance, value and importance of this methodology as a tool to address problems related to our economy and workforce needs. This process will organically assist with changing teacher mindsets that oppose the STEM-PBL implementation.

Culture

According to Wagner (2006), the culture of a study provides a perspective on an organization's shared beliefs, values, behaviors, mindsets, and process expectations throughout the system. One of the cultural barriers includes the mindset of teachers towards cross-curricular collaboration on STEM-PBL lessons. Teachers have reported that they work in isolation and the reality is they do not have enough time to plan and collaborate with teachers in other content areas.

Another cultural barrier is the pressure imposed on teachers with a standards-driven end-of-course exam. Teachers feel that there is not enough time to cover the standards and fear that these additional lessons would impact the assessment outcomes. This mindset limits the opportunity for teachers to integrate the rigorous STEM-PBL lessons that include a culminating application of multiple standards.

A final cultural barrier is the lack of community business involvement allowing for the provision of hands-on experiences for students. The teachers felt that giving the students more opportunities for an apprenticeship or internship in a STEM field would expose them to many career options. This exposure would also lead to business partnerships allowing the external stakeholders to influence driving the instructional shifts needed to meet industry demands.

Conditions

According to Wagner (2006), the conditions of a study give a perspective that may limit the outcomes based on an organization's constraints on time, space, resources, policies or structures. One condition in my study is the lack of district funding for STEM education. This directly affects the ability to engage in projects that require usable resources. Another condition is that this is a Title 1 high school, which is already dealing with limited resources for the general academic programs required by the state. Another important condition is the lack of the support structure to improve STEM-strategy implementation district-wide. This condition is also related to the lack of state and federal funding. A final condition is the lack of planning time for cross-curricular collaboration.

Competencies

According to Wagner (2006), the competencies of a study give a perspective on the skills and knowledge of the stakeholders that influence student learning such as teachers or administrators. In my study one competency that impacts the promotion of STEM education is the lack of a common district understanding and language on what it clearly is defined to mean. The topic can take on many different interpretations therefore giving uneven lesson results in certain classroom environments. This can be a deterrent to embracing the effort and validates the concern of the time it takes to plan.

Another competency is the lack of understanding about STEM among teachers at the instructional classroom level. Teachers sometimes may not truly trust or understand the interconnected aspect of multiple standards being addressed within a STEM-PBL lesson. This competency will also deter a teacher from taking instructional time away from standards that are directly tested on state standardized assessments. An additional concern is that teachers may be able to identify what STEM means but that it is not truly understood and has never been culturally embedded as a way of work and learning. These issues are addressed by the competency of a true understanding about what STEM education means in practice.

Unanswered Questions

In my study, some unanswered questions reference the lack of national, state, and local prioritization of STEM education. How can we overcome the barrier of a lack of funding for STEM education? How can we build teacher capacity in the areas of STEM education, STEM expertise, and immersing STEM technology applications? How can the district address the lack of structure that provides the pacing time needed to encourage

teachers to integrate a methodology that includes STEM-PBL lessons? What would be the best way to address the vertical alignment of science-STEM education from our lower elementary level to the secondary high school level? How can we build relationships with external community business partners to collaborate in shifting the learning process to include real-world opportunities?

Next Steps

The organizational change would involve several next steps to communicate the purpose and execute the plan intentionally. The plan will have many stages but will begin with creating a clear district vision around STEM education for all students. The mission of implementation would include embracing a common language. Secondly, I would collaboratively create a framework that is developed with a task force comprised of all content area supervisors and teachers ensuring alignment of the FSA Standards. Thirdly, the plan will provide a district professional development for all teachers to educate the instructional staff on the district meaning of the STEM process. This training will embed the standards culminating all content areas within an application-based environment to include pacing and collaboration time. Finally, there should be a communication plan to include the internal and external stakeholders and serves as a marketing theme to promote this STEM movement. This plan will provide a research-based rationale that supports creating the 21st century skills allowing student to collaborate, and problem solve in an educational environment preparing them for life and success.

Community Member Collaboration

To include the perspectives of stakeholders in the STEM community about the relevant information to the change plan I will collaborate and convene with a local STEM

advisory board within the current educational, technological, and industrial arenas. Bybee (2018), explained clearly in his connection of the STEM movement to citizenship. He makes the point that the true purpose of public education is to produce citizens that will sustain the needs of the future while maintaining social order. Therefore, creating a community culture around the 21st century skills needed for future demands is a pillar on which our county was built. These organizations will serve as the incubator driving the demand of this content yielding the skillset for the 21st century labor force. I will include educational, technological and industrial manufacturing organizations as the key stakeholders around this issue. These organizations employ high-level technological automation in their daily operations and can initiate business-educational partnerships providing students real-world application to these concepts.

Interpretation

The results of my findings within my STEM project study framed some key aspects that suggest both positive and negative focal points to drive my proposal for change. I have found the quantitative and qualitative data collected provides perceptions and feedback from all stakeholders that have value to inform change internally with structure and culture to embrace a STEM-centric way of work that leverages all content area standards. The data shows a common theme across the differing populations associated with the topics explored within each of the STEM programs of Engineering, Biomedical Science, and Game Design. The data collected gave further evidence as to the relevance and benefits that a STEM education provides students and the barriers that are impacting these programs from reaching more of the underrepresented groups at all

levels. A final point that adds validity to my results is the impact that this topic will have on future educational reform to prepare our students for the challenges ahead.

The specific significance of the results showed some very positive outcomes within these STEM programs. There are positive successes to celebrate that translate to the application of learning into industry certifications. These students lead the district in this effort. Another point to celebrate is the application of the learning within the classroom and external organizations that allow students to compete with their learned skills at the local, state, and national levels in areas such as Robotics. In these extensions of the learning process students become a part of a community of learners who collaborate as a cohort to push their learning with a purpose. On the negative side, the stakeholders gave through survey feedback and interview the growing concerns about the lack of time to collaborate, cover material and funding to support these programs. The culminating conclusion of all the reported data will serve as my driving force for organizational change both at the school level and district-wide as the feeder schools for this program come from all over the district.

The findings within my STEM project study turned out this way because STEM education is on the national stage and the competition to meet the needs of the global economy looms within the educational community. Thus, I feel that the topic is relevant in today's educational arena and proactively explores future challenges. Another reason that contributed to the study outcomes was the integrity of my results was protected. I delivered my data collection in a safe, and confidential manner with full disclosure for all the participants. Lastly, I ensured that my data questions across all populations were

aligned to give a clear triangulation of the perception data increasing the reliability of its significance.

Judgments

The overall objective of the project study was to evaluate three STEM programs at a STEM High School that utilized project-based learning as a method of instruction. I analyzed five populations of stakeholders utilizing both quantitative and qualitative methods of data collection aligned to four exploratory questions and two secondary questions to delve deeper into the programs. The primary exploratory questions examined 1) what is working well within each STEM program, 2) what is not working well within each STEM programs, 3) what are the greatest challenges within the STEM programs, and 4) what are some ways to improve the STEM programs. The secondary questions examined 1) how project-based learning increased the overall rigor in the areas of science and math, 2) how does student technological ability relate to the level of academic achievement and success in STEM-PBL programs.

In responses by most stakeholders there were four key findings that I thought were significant in analyzing what was working well across all the STEM programs. All of the data collected in the survey and within the interviews and focus-group interview shared these topics from their perspective. The key topics related to what is working well with the programs utilizing STEM-PBL were the opportunities students had for hands-on experiences, problem solving real-world scenarios, acquisition of industry certifications, and clubs and organizations that allow students to compete with their learned skills.

In responses by most stakeholders there were seven key findings that I thought were significant in analyzing what was not working well across all the STEM programs.

The key topics related to what is not working well with the programs utilizing STEM-PBL were the lack of funding, retaining qualified teachers, attracting and retaining the underrepresented groups of students, keeping the technology current, lack of vertical alignment of Stem curricular topics from elementary to middle and high school, lack of adequate time and pacing, and stem professional development and support for teachers.

In responses by most stakeholders there were five key findings that I thought were significant in analyzing what the greatest challenges were across all the STEM programs. These findings were like what is not working well above. The key topics related to what the key challenges are with the programs utilizing STEM-PBL were lack of funding and resources, lack of adequate time to complete curriculum, lack of qualified specialized teacher talent, lack of students being prepared from the middle schools, attrition of underrepresented student groups such as females.

In responses by most stakeholders there were nine key findings that I thought were significant in analyzing the ways to improve all the STEM programs. These findings were increasing funding, ensuring proper equipment, current technology and resources, stem professional development for teachers and time to collaborate with content area teachers. In addition, the data suggests that better student preparation with digital literacy at the lower levels, STEM vertical alignment will improve student success. Finally, increasing community and business partners and forming mentorships will provide students enhancements that relate to industry requirements in these fields.

In responses by most stakeholders there were two key findings that I thought were significant in analyzing what how project-based learning increased the overall rigor in the areas of science and math. These findings were students retained more knowledge

because of the hands-on application of the project-based learning environment. The activities include the math and science connections, which allow students to apply their knowledge to solving problems.

In responses by most stakeholders there were three key findings that I thought were significant in analyzing how students' technological ability relates to their level of academic achievement and success in STEM-PBL programs. These findings suggest that technological ability increases the student's academic achievement because it allows them access to understanding how the programs work and increases their ability to access information. Another finding suggests that the technological ability increases achievement through fostering the organization and analysis of information provided through the computer programs.

The findings of my study suggest that there are many benefits that are positive within the STEM programs of Engineering, Biomedical Science, and Game Design. Some positive factors are the hand-on application of the concepts that embed the standards of math and science leading to problem solving of real-world issues. Another factor is the culmination of the STEM learning in the acquisition of industry certifications and competitions. Conversely, some negative challenges that impact these programs are the lack of funding, resources, pacing time to complete curriculum and professional development for the STEM teachers.

Recommendations

In my analysis of the findings of my project evaluation I have uncovered some issues to address. There are some overarching concerns that are prominent as resonated throughout the data such as lack of funding for STEM, which is beyond our control.

Some topics that may be addressed internally are creating a structural environment that fosters collaboration and professional development support for teachers and the community. Another change at the district level suggested by the data is better student preparation with digital literacy at the lower levels providing a STEM vertical alignment pathway that will improve student success at the high school within these programs. Finally, a third part of the change is increasing community and business partners and forming mentorships to provide student educational enhancements that translate to industry job requirements in these fields.

In my professional experience, these structural changes will allow time for teachers to collaborate with each other complimenting the content area standards giving purpose to the learning. The STEM professional development can unite the instructional force to increase continuity across disciplines. The community involvement mentoring students can improve the attrition of the underrepresented students improving equity for all students to have access to these programs.

The organizational change will include structural changes within the school that allows for cross-curricular collaboration of STEM teachers with the traditional teachers. This collaborative structure will promote a joint effort to engage in projects that apply all the content standards in a space where students collaborate as a team and problem solve the issues of their community. In addition, a structural change that creates a vertical alignment of teacher collaboration promoting a STEM pathway from the elementary, middle and high school to better prepare students to succeed in these programs.

I selected the structural alignment within the school to improve the cross-curricular collaboration because the data suggests when the standards are culminated and

applied in a PBL environment the outcomes are increased student interest, engagement, and ultimately improved academic achievement. These projects require that the content skills work in connection to the problem being solved. In terms of improving student preparedness with digital literacy I will propose the vertical alignment of STEM pathways across the district. This system will improve the skills needed to succeed in a STEM program at the secondary level.

CHAPTER FIVE: TO-BE FRAMEWORK

Introduction

In my program evaluation, I have diagnostically identified areas for potential improvement within the STEM programs of Engineering, Biomedical Science, and Game Design. The national attention to this topic provides the platform and timing to be able to engage all stakeholders around the urgency for the change. The STEM movement has started to be integrated at local, state, and national levels but not yet structurally organized at all levels. There is a tremendous amount of research that provides insight into this topic and its place in future educational reform. In my previous chapter, I outlined the process given by Wagner et al. (2006), who would describe the “As-Is” within the STEM programs organization as indicated in the data collection within my study. This process gave me insight into the current system at Avatar Technical High School highlighting the needed areas requiring change that could leverage the maximum yield with STEM academic achievement. In this current chapter, I will envision the next steps as outlined within Wagner’s et al. (2006), “To-Be” plan that will structure the organizational change to improve the STEM programs. I will address my proposed plan to combine the collaborative efforts of teachers, school leadership, district, and local business partners to work in tandem toward a combined effort of creating a shift towards a STEM-centric culture and environment. The ultimate impact of this change will be linked to solving internal and external community issues.

Review of Literature Related to Change

The topic of STEM education has been at the forefront of educational conversations as we strive to prepare our students to compete in a global economy. My

study of the Engineering, Biomedical Science, and Game Design STEM programs at Avatar Technological High School serves as an example of a specialized program that requires resources and specialized training to sustain the efficacy of each area of study. The results of my study highlighted the need for change at the school, district, and state level in reference to STEM priorities, culture, structure, and procedures that will inform some potential policy changes for the future. As an instructional leader, it is important to be mindful that change has to be inclusive of all stakeholders to build trust and buy-in for the initiative. In this literature, I will methodically show the established research that supports my proposed change of creating a STEM shift cultivating innovators, developing STEM capacity, fostering teamwork and trust, creating a stem pathway, creating a community and business network of support and leading the stem change.

Creating a Foundation for a Cultural STEM Shift. In leading this organizational change, I must first consider the barriers to shifting the school towards a STEM-centric philosophy. There are many elements that must be addressed to clear the path or as Reeves (2009) analogizes as, pulling the weeds. I will consider the anxiety associated with the cultural mindset that there is not enough time to integrate PBL with the plethora of standards within each content area. This begins by establishing the purpose urgency and need for the change as it related to preparing our students for the future. According to Wagner, “Research shows as human beings we are all born with the innate desire to explore, experiment, and innovate” (Wagner, 2012, p. 26). The idea of STEM education engages all students at all levels and is more than just a program. The ultimate goal of education, as stated by Myers and Berkowicz, “Education should be in the business of developing independent thinkers prepared to face challenges yet

unknown” (Myers & Berkowicz, 2015, p. 11). Another point to leverage the resounding purpose and why STEM is an important foundational part of education is our growing economy that demands workers be equipped with the skills for future STEM careers. The next step is to build the STEM capacity at all levels to implement the change.

Developing STEM Capacity with Professional Development. The first point to be considered within my organizational change is the common language of STEM and its impact on student achievement within all content areas. The ideology of STEM education as a movement to improving student achievement must be established collaboratively with all stakeholders within the work. There should be a shift in the processes and procedures of how teachers collaborate for the shared purpose of contributing to a STEM–PBL lesson environment that incorporates multiple standards across several disciplines of study. A critical part of the change will be job-embedded professional development that provides support and resources to teachers to incorporate STEM-PBL lessons with cross- curricular collaboration. Research from Desimone, (2009) indicates that effective STEM professional development consists of five areas of focus that include collective teamwork, active participation, program coherence, learning new skills, and extended time combined to build content specific knowledge. The basis of the professional development that supports this is given by Myers and Berkowicz who suggest, “Professional development includes a cycle of reflect, refine, and revise, as part of a curriculum development process of the STEM shift” (Myers & Berkowicz, 2015, p. 93). The vision of change would ensure that teams of teachers would collaborate each nine week quarter on a cross-curricular project inclusive of multiple standards incorporating these attributes.

Fostering Teamwork and Trust among Stakeholders. The organizational change will only be possible if I first establish a common goal that inspires trust among the stakeholders of teachers and school leaders to promote an environment of teamwork. Teachers must feel this initiative is a valid and beneficial change to improve their students overall academic achievement. As Fullan (2001) suggests, a leader should establish a central moral purpose around the change that will become the social glue that ensures implementation. In addition, in order to maximize the internal capacity of this transformation we will see the natural by-product of sharing strategies and partnering on a common project theme. This will come with the relationships and trust among the stakeholders within the systemic change. This is a cultural shift that will take time to occur as the relationships are built in forming the STEM teams. This systemic shift will model the change as students develop the skills to work in a team to problem solve.

Creating a STEM Pathway Internally and Externally – Structural Change.

The organizational change will require the internal structural change that will allow teachers the planning time to collaborate on STEM-PBL lessons within the school. The data indicated that there is no clear vertical alignment of the standards that assist in preparing students for the STEM topics in each of the programs of Engineering, Biomedical Science, and Game Design. This change will be collaboratively organized by the administration to be mindful of the schedule and time constraints that exist within the alternating block classroom periods. As an intentional resonant leader, I will follow the advice of Boyatzis and Mckee (2005) to choose the steps that lead to resonance over dissonance. As a resonant leader, I will combine the attributes they give of “knowledge of resources, human, and intellectual, environmental and social capital to maximize STEM

performance” (Boyatzis & McKee, 2005, p. 5). The change would involve vertical alignment between teachers within the same discipline on the skills that prepare our students for the STEM college programs and careers. In addition, the structure would allow planning time for cross-curricular planning across content areas to collaborate on a STEM-PBL lesson.

The second tier of structural change needed is the district external change to support STEM educational alignment vertically from elementary to middle and high school levels. The data indicated that students enter the high school lacking the preparation for the expectations required in a rigorous STEM program. This is supported by research that, as of 2017, “Thirty-five percent of the states have adopted the new NGSS standards that include math, science, and computational thinking as a science and engineering practice” (Bybee, 2018, p. 24). Interestingly, the state of Florida has not yet revised or adopted the new NGSS science standards. I will propose that STEM education alignment be integrated into elementary and middle school levels to begin the process of creating young innovators that have the critical thinking skills to be dynamic problem solvers.

Community and Business Partnerships. The organizational change will include the connection to community and business partners to further support the STEM movement in providing avenues that will give all students the opportunity to be exposed to STEM topics and technology. The data indicate that many of our underrepresented groups of students do not have the same base knowledge due to lack of opportunity or exposure. As Jeff Weld (2017) indicated the marriage of career and technical education (CTE) and the business community are the core that gives STEM relevance. A key point

worth noting is, “STEM brings school to business partnerships to promote lateral connections across disciplines and vertically kindergarten through twelfth grade”, (Weld, 2017, p. 47). The involvement of local community business partners and universities can support this initiative, which will assist in addressing the issue of equity and providing opportunity to students who are underrepresented in these programs as indicated within the teacher feedback of my study. The idea here is to compliment the work in schools with outside resources that promote technological access and aptitude.

Creating a Cohesive Process for Change. For any organizational change to be successful there must be a methodical process to anticipate the barriers and plan for it. I will follow the steps in Kotter’s (2012) eight-stage process to plan the steps for change. As an instructional leader, I will establish a sense of urgency around the STEM shift while ensuring the right team leaders are a part of the planning of the organizational change. The vision should be clearly communicated and collaboratively developed to include a representative of all content areas and each STEM program. This organizational plan should also be inclusive of the school and district leadership to ensure support and sustainability. Ultimately, as the STEM culture shift begins it will become institutionalized within the school culture to include cross-curricular collaboration teaching 21st century skills as a way of work.

Envisioning the Success TO-BE

After analyzing my program evaluation of the STEM programs of Engineering, Biomedical Science, and Game Design based on the data, there were several areas of potential change that surfaced as avenues through which to improve academic achievement. The overall goal is to have students enter the programs with the skills

necessary to be successful and to be prepared for post-secondary STEM-related programs or technical careers. The steps to achieving this goal as mentioned previously, clearly identified by data analysis and supported by the literature review. I utilized the tools from Wagner et al. (2006) outlined in his 4C's (Appendix O) to envision the systemic change representing the future contexts, conditions, competencies, and culture of my plan engendered with fidelity and with support at all levels.

Context

In terms of the ideal context related to my potential change there are two points to consider. First, the context would foster and support an organizational system that will prioritize 21st century skills into the science curriculum strengthening a STEM skillset. This movement will frame the STEM shift as a new way of thinking about teaching and learning to promote the skills students will need to be successful with future career demands.

Secondly, the context would serve in framing the current need for state advocacy to inspire future policy change that will prioritize science by integrating STEM education changes and adopting the new next generation NGSS standards. The next generation NGSS standards integrate mathematics and computational thinking related to the engineering process as a working part of science that promotes inquiry. Bybee (2018) tells us that Florida is one of only 10 states not yet to have embraced this shift in science curricular standards. Integration of STEM education and adopting next generation NGSS standards promise to contribute to closing the global achievement gap and preparing students to think critically, anticipate, and solve future real-world issues.

Culture

In terms of the ideal culture related to my potential change there are four key points to consider. First, the change will cultivate a STEM culture shift within the school that fosters cross-curricular collaboration towards innovation. The mindset of an innovator can occur at all levels within the building from student to teacher to administrator. The idea of STEM as the process but innovation as the mechanism that makes it happen would be embraced to overcome obstacles and figure out new ways of accomplishing things. As Couros (2015) explains, administrators deal with budget barriers in a school system that sets higher expectations with decreased funding sources. In an arena where more is expected with less funding, this idea of innovation is a mindset or a different approach to thinking that will support my organizational change.

Secondly, my change will enhance a cultural partnership with local businesses and the community that includes hands-on STEM activities for all students. The idea here will be to broaden the connection to business partners such as the YMCA to include resources that increase student to STEM skills. These organizations can provide outside programs to compliment STEM such as robotics and provide access to technology such as computers. In addition to these ideas other organizations within industry can partner with the school to provide mentorships to further enhance student learning improving academic achievement.

Thirdly, the context will foster a culture that correlates and leverages state science standards to promote alignment to STEM skills and activities. The thought here is to provide clarity for teachers to understand the relevance and connection of all content standards to the success of a strong STEM-centric school community. This cultural mind-

set shift will build the trust needed to promote cross-curricular collaboration that leverages standards in multiple content areas.

Finally, the context will cultivate a cultural STEM-centric shift fostering teamwork among teachers of all content areas to solve community issues. This teaming philosophy within my proposed change will mirror the expectations for students while promoting multiple standards working together towards a goal or outcome. I envision teachers working as partners on projects with relevant content to both disciplines creating a STEM-centric way of work school-wide.

For the STEM-shift to occur there must be a culture that supports the vision at all levels. Underscoring Weld (2017) who clearly accentuated the national STEM prioritization as incorporated in the federally mandated Every Students Succeeds Act (ESSA) outlining the importance of supporting and providing pathways for STEM teaching and learning. The purpose of this mandate was to increase exposure of STEM education to underrepresented students and to include opportunities for collaboration and hands-on activities. Thus, my process for change will build on this foundation to be collaborative including all stakeholders of school administration and STEM program lead teachers and staff to ensure alignment of the goals. The pulse of the cultural health will be continually monitored to provide support for its implementation, as the change is occurring to account for barriers to its success.

The school will have a STEM task force that will oversee the professional development and ensure that a positive coalition of the willing is promoting the process down to each department and PLC level. There will be continuous follow-up on the teachers that are collaborating as a team on these projects. Also, there will be a system in

place to elicit teacher feedback on the process and what they see could create improvements as we integrate this change.

Conditions

In terms of the ideal conditions related to my proposed organizational change there are only a few items to mention some of which are fixed and may be barriers to consider. The first item addresses the STEM funding issue to consider different avenues and resources. The STEM school programs can enhance efforts to secure additional grants and organizations that will assist with STEM funding to provide the consumable resources and equipment to keep the curriculum current within each of these programs.

A second condition that will remain as a fixed component of the environment is the status of being a Title1 school site. This school continues to serve a diverse population with a high level of students with a lower socio-economic background. This condition cannot be controlled or changed and therefore must be considered as a fixed component to plan for within the change.

A third idea to improve the quality of the specialized instructional talent needed to teach is a proposed stipend attached to these positions. The data suggested the additional extracurricular hours associated with these programs and outside organizations that allow students to showcase and compete within the state. Additionally, these teachers are highly specialized required to keep their skills current and up to date with industry. An additional stipend may attract this talent to the STEM school.

A fourth idea within my proposed change to address student preparation is the suggestion to include a change within the district-wide science curricular alignment to support STEM education at all levels to directly improve student's readiness for these

programs at the high school level. This would expose students to STEM related skills at the elementary and more so at the middle school creating equity. These foundational layers will scaffold STEM skills throughout their education producing the critical thinkers prepared to solve the problems of tomorrow.

A final idea to address the concern of planning time will be a proposed shift in the structure to better support cross-curricular planning time between all content areas. This change will allow teachers the time to plan STEM-PBL lessons that are relevant in promoting both curricular standards. This process will foster a team approach to teaching and learning STEM, which will also institutionalize this way of work into the school culture to benefit academic achievement for all students again improving equity.

Competencies

In terms of the ideal competencies that will address the common understanding of STEM education I will propose a vision to infuse STEM literacy school-wide. This vision will be communicated with clarity to all teachers showing the relevance and importance of its impact on student learning. As teachers begin to embrace the understanding and process of integrating the STEM-PBL philosophy into their classrooms, their competency will increase the willingness to embrace a STEM-centric identity.

A second critical component to ensure the vision is embraced with fidelity is to provide professional development to promote the skills in STEM-PBL. The school administration and academic coaches will collaborate to create a series of professional development that supports teachers and builds the instructional capacity at the professional learning community level in each content area. This will support STEM-

PBL implementation across all content areas to engage in the collaboration needed to partner with these activities.

Conclusion

As I execute my plan to create and lead my organizational change I have reflected on the current scholarly research that have provided guidance to assist me in attaining a positive outcome. In considering the data that clearly defined the current state of these programs identifying the context, culture, conditions, and competencies to be addressed within the STEM programs I can address the systemic shift to improve student achievement. This process has highlighted a need for change in several specific areas to be realized in my “To-Be” analysis that addresses my change systematically with strategies and actions to accomplish this transition.

CHAPTER SIX: STRATEGIES AND ACTIONS

Introduction

The strategy provided by Wagner et al (2006) has guided my vision of STEM organizational change from the current state denoted by the “As-Is” (Appendix N) to the transition I envision the school to become outlined in the “To Be” (Appendix O). This process had guided me to assess seven objective areas for organizational change to improve the STEM programs and student academic achievement. My plan of action collaboratively addresses the needs indicated by the data to work together in improving the level of STEM skills for students and provide teachers the support and professional development to improve their instructional craft with STEM-PBL. In each of the seven-targeted objectives outlining my strategies and actions for the STEM change (Appendix P) there is a clear alignment to the “To Be” prescribed needs with action steps to achieve it. The overarching goal of this STEM shift is to improve stem skills for all students while leveraging cross-curricular emphasis to improve student achievement in multiple content areas.

Strategies and Actions

Objective 1: Planning for the STEM Mindset Shift

Initiating this STEM mindset shift school-wide first begins with planning for the change. First, to infuse a STEM culture, I will establish a high expectation for all staff and faculty to be a part of this initiative school-wide and collaborate on a common vision and mission. Teachers often work in silos with very limited time to collaborate with teachers in their own similar content area much less those outside of their field. The goal of this initiative is to foster collaboration among teachers across the STEM school while

broadening their skills in STEM-PBL lesson design and implementation. This begins with a common language of understanding what STEM truly means and establish a school STEM literacy vision and mission. The goal is to collaboratively develop this vision and mission with all stakeholders represented to include teachers, students, administration, and academic coaches in science, math and reading.

The next step is to create a governing coalition to assist with the STEM initiative planning, support, and implementation to ensure its success. This STEM Team would consist of representative teacher leaders from each core area and CTE to include science, mathematics, English, social studies, and each of the programs of engineering, biomedical science and game design. The expertise of these teachers will come together to create a STEM culture by creating project opportunities that are relevant to all content areas. These experts will train teachers on how to team with another content teacher at least 2 to 4 times a year on a project that fosters student collaboration across disciplines making the connections to solve real world issues related to the community.

The STEM Team will develop rubrics that assess the level of student competency as a measure of mastery. These instruments will allow students to work in a team within a safe environment that allows students to take academic risks, fail, and revise their plan to reach the expected outcome. The STEM activities will provide an environment that fosters critical thinking, collaboration, and problem solving as a mechanism of creating student driven solutions.

To address some of the funding issues the school leaders and STEM team will collaborate and broaden the purpose of the STEM boosters to support the STEM programs school-wide. The STEM boosters entity is constituted by parents, STEM

teachers, and administrative representatives and is an internal school organization that seeks out, organizes, and provides funding and support for the extra-curricular competitions and field trips for students within all STEM programs. In my professional experience, I have observed there is a larger amount of resources and parental support for certain programs such as Engineering than others, which creates an inequitable source of support across all extracurricular CTSO's. This extra support could assist students from lower socio-economic backgrounds with travel expenses for competitions, as well as supplementing materials for projects. I will share that the parents within Engineering are very conscious of this and have created opportunities for students to earn scholarships depending on their financial need as long as they meet the project criteria and participate.

Objective 2: Communicating and Marketing the STEM Initiative

To ensure a strong foundation the purpose of this STEM initiative and shift in mindset must be clearly communicated to all stakeholders. This is key to ensuring that all teachers and school leadership are working toward the same goal with efficacy. The goals and objectives will be clearly outlined and placed on the school website, in marketing materials presented at district events, and sent to parents through parent links and other district modes of communication. This effort will be combined with the schools marketing opportunities inviting the community to an interactive event that is students driven showcasing each of the STEM programs aligned to future career opportunities.

Objective 3: STEM Curricular Shift

The executive board will assist in developing some guiding resources to establish relevance and value building trust with the instructional staff. A flowchart that correlated the STEM Math and Science standards to STEM related activities would help bridge the

gap. This bridge will then assist teachers with their content standard translation to the STEM-PBL activities into the classroom. These activities will include multiple content standards to reach the outcome or project product. This step will serve as the glue that connects all disciplines giving the why as to its relevance and benefit to both teachers and students to improve academic achievement school-wide.

Objective 4: STEM School-wide Professional Development

The STEM initiative will require support for teachers to build the STEM instructional capacity school-wide. In my professional opinion as an Assistant Principal for Curriculum, I have observed teachers are sometimes placed in a specialized STEM position with very little training on how to effectively communicate the material and implement a hands-on activity to leverage learning of multiple standards. Therefore, academic coaches and administration will collaborate to build STEM capacity throughout the school on a professional development plan promoting the design and implementation of STEM-PBL lessons that incorporated multiple standards with fidelity.

All PLC teacher leaders within each content area will be trained with this series of professional development modules. The goal will be for these PLC facilitators to then train all teachers within their department the benefits to infusing the STEM teaching methodology and design. Teachers will then be encouraged to choose any teacher of a different content area in which to partner with hopefully at a frequency of once per nine weeks or a minimum of once per semester. This frequency will be decided collaboratively with teacher input in conjunction with their colleagues within each department.

Objective 5: Structural Changes

In order to address the lack of planning opportunities for teachers during the school day I must consider a structural adjustment in the schedule. The schedule will shift to allow for dedicated teacher planning time that aligns with other departments to assist with increased teacher collaboration. This logistical adjustment will allow teachers to engage in cross-curricular planning and partnering that brings their students together to work collaboratively to problem solve. This process would organically increase curricular rigor that allows students the time to grapple with the concepts and create a solution related to a community issue jointly. This process simulates the expectation set force by industry.

Objective 6: Building Community and Business Partnerships

For this initiative to be successful we will need to elicit support from local business partnerships, universities, and the local community that the Avatar Technical High School serves. In my professional experience, the community support has been a body of advisors rather than functioning as mentors to our STEM programs. We will strive to enhance the current STEM advisory board to include a function of direct involvement that brings opportunities for students to engage in real-world experiences within the STEM industry of local businesses. These experiences will include mentorships, apprenticeships, and shadow opportunities provided by these manufacturing business partners to show the pathway to future career opportunities.

In addition, we will establish student driven community outreach within each of the programs to give exposure to this knowledge and skillset. In my professional

experience the outreach has been concentrated in the robotics area sponsored predominantly by the Engineering students. This has proven to be a highly effective approach to reaching the community students at the elementary and middle school levels providing exposure to robotics. I will build on this to expand the schools summer outreach program to showcase all the STEM programs to include Biomedical Science and Game Design. This student driven process will further the STEM exposure giving access to all students within the lower levels to increase the vertical preparation needed to be successful at the high school level.

Objective 7: Assessment of STEM Initiative

To ensure continuous improvement of this STEM-centered shift the process will be assessed, and progress monitored to provide teacher support and resources to ensure success. In my professional experience, the greatest concerns from teachers are how to assess these projects to effectively monitor the mastery of the concepts. These activities have often been criticized for the lack of these objective assessments aligned to the content standards. The progress of these outcomes can be measured with clearly defined rubrics aligned to the content standards. This project measure combined with student progress on quarter grades and nationally normed standardized assessments such as the SAT and ACT will provide a more complete scope of student ability and skill. The hope is that these activities that foster student collaboration and critical thinking will positively reflect in all these indicators. The overall goal of which is to impact student equity, providing opportunity towards the acquisition of industry certifications to improve academic achievement and ultimately raise the graduation rate for all students.

Conclusion

The seven objectives addressing the needs of these programs are clearly outlined identifying the priorities within the goals, strategies, and actions to accomplish the change. These objectives will serve as the foundational pillars that will work in tandem to create a STEM culture school-wide. Each of the seven objectives has been aligned to the context, culture, and competencies needed within each program of Engineering, Biomedical Science, and Game Design. My deep analysis of the data collected by all related stakeholders driven by this process has identified a clear pathway to change from my vision of the current state of these programs to the improved transformation of change I would envision it to be. These changes inform on the direction for future policies that consider a thorough analysis of the program needs related to the educational, economic, social, political, legal, moral and ethical implications of this suggested STEM shift. These areas must be considered and synthesized to ensure sustainability of this change for future district policies and procedures.

CHAPTER SEVEN: IMPLICATIONS AND POLICY RECOMMENDATIONS

Introduction

The policy issue related to my program evaluation of STEM education with the emersion of PBL suggested by my findings are embedded within the 7 objectives previously identified. In the analysis of my findings I must consider the stakeholders that would be impacted by any policy change. I recognize the need for clarity of the policy purpose and outcome driving the change to form a common accepted definition of STEM education. This common understanding will solidify its meaning universally within the district to impact potential change. The data from my study indicated a lack of prioritization and funding to support STEM-PBL awareness as a vision and the clear application of its relevance across disciplines. Additionally, there is a need within my policy for professional development to overcome the teacher mindset barriers to this change. The ultimate organizational change would include a fluent STEM pathway connecting science curricular standards at all levels from elementary to middle and high school education. This pathway will provide students with the 21st century skillset to think critically and meet the demands of industry.

Currently in the district and state there is no clear policy, practice, or bylaw in place promoting STEM education. There is a district initiative in place promoting computer science as a course at the middle and high school levels. This was started because of the *Computer Science for All* initiative towards the end of President Obama's administration. This computer science initiative was implemented district-wide in 2018. The focus of my policy will go deeper into the application of STEM within schools giving a clear definition of what STEM means as it relates to my project evaluation.

Therefore, I will define STEM education, for the purpose of this study, as the teaching of science and mathematics applied within technology and engineering (Johnson, Peters-Burton and Moore, 2016). This will serve as the common language of STEM to address the need for a curricular shift that engages students with STEM PBL activities across all disciplines.

I propose a policy at both the state and local district levels that are in alignment and support STEM throughout all grades. A suggested State STEM policy would promote a STEM initiative that includes schools at all levels to have a plan that will provide equitable access and opportunity for all students. These projects will outline collaborative experiences with problem solving activities that include the innovative application of Florida standards from multiple content areas with a foundation in math and science. My suggested policy will foster a framework where content areas converge to build a literacy of computational skills. In addition, I suggest a local district policy and procedural framework entitled: *STEM-Shift School-Based Incubator Initiative*. This school-based incubator will give every school the autonomy to form a central STEM incubator whereby teachers collaborate creating cross-curricular problem-solving activities allowing students to work on teams to critically think through and address the school community real-world issues. These incubators will be student-driven think tanks of inspired innovation. This focus is related to my findings that address the issues of teachers working in isolation lacking inter-disciplinary collaboration.

My proposed policies and procedures will address the problem of assessment and have a structure that is transparent with common accountability metrics connected to the learning standards as an extension to the application of the skills. The structural barriers

are also addressed where every teacher will have common planning time every morning before school to collaborate on cross- curricular activities. Teachers will have autonomy to team around real-world relevant issues with a minimum frequency of one major culminating project a year applying multiple standards to the solution.

My proposed STEM policy relates to my program evaluation by fostering the infusion of cross-curricular activities that align to the current math and science standards at all levels elementary through high school promoting vertical articulation of critical thinking skills. This process will include the immersion of a collaborative PBL process which culminates standards in a problem-solving activity. This vertically articulated curricular shift is at the core of my program evaluation and organizational change plan. The integration of these activities will strive to promote student and teacher collaboration, teamwork, and critical thinking around community issues. Ultimately, the culmination of all content areas will be used to problem solve through these issues posed reinforcing skills and utilizing peer to peer self-correction throughout the process. This shift will bring creativity and relevance to learning which will reinforce the application of skills yielding increased student achievement.

Policy Statement

The rationale supporting my recommended STEM policy is to provide a framework of reform that will build a needed bridge from the district foundation of providing opportunity and access for students with computer science courses to the application of these skills to real-world community issues. I believe a STEM policy that provides the next steps within the district would provide awareness that shows the content interconnectedness to the existing standards while simultaneously creating

computational literacy. As Myers and Berkowicz (2015) indicated, “Schools undergoing a STEM-centric shift develop teachers that grow creating skilled content-based learning opportunities for all children” (Myers & Berkowicz, 2015, p. 88). This shift would not be overwhelming as a change, but rather would provide a layer on the existing standards utilizing those learned skills to solve problems putting the knowledge to work. I envision the policy as being effective in addressing the issues outlined within the competencies, culture, context, and conditions of my program evaluation.

Analysis of Needs

The policy recommendation above is driven by many issues and concerns indicated by the findings within this study. The section below explains in more detail, the analysis of needs within this study on STEM education, as it is related to various aspects of the educational arena. I took an introspective look at the educational, economic, social, political, legal, moral and ethical needs related to the topic of STEM education. These topics give a global perspective of STEM education outlining the educational responsibility and lens from each vantage point to inform on the potential impact to enhance learning for all students preparing them for college and future careers.

Educational Analysis

The Educational Analysis of my STEM policy problem context implications outlines the need for STEM infusion at all levels, local, state and national to provide our students with the 21st century skills to complete in a global economy. The first point to analyze is the stakeholder alignment with the common language and understanding of the need for STEM education by our current educational workforce, and its connection to industry demands. An important thought reminded by Myers and Berkowicz (2015) is to

consider the STEM vision collectively as a systemic change inviting as many stakeholders and partners into the process as possible. The policy will then address the barrier of teachers working in silos by showing the interconnected component of all content areas within STEM PBL activities. If teachers see the relevance and ease of transition with little or no additional tasks added to their already full plates the collaboration component will be seen as a positive that could compliment the total educational output with greater yields with student academic achievement.

Economic Analysis

The Economic Analysis of my STEM policy problem context implications must consider two issues. The first is the local economic impact of a generation of students who are not equipped with the skills to meet the future need of industry within our country. The second is the federal investment that impacts local funding for the curricular changes, materials, equipment and technology to sustain future STEM educational needs and growth. There is a published national inventory of funding from various federal agencies. This funding was earmarked to targeted STEM workforce needs and at first glance seemed like a substantial amount. To clarify the true amount Bybee (2013) explained that out of the \$1.1 trillion dollars spent on education in the United States each year, less than 1% was slated to fund STEM education. This was a startling realization and did not seem to support the priority of STEM as a national push. This also explains the findings within my study citing funding issues as a top issue each year to sustain the functioning of these programs.

Social Analysis

The Social Analysis of my STEM policy problem context implications links directly to the core of educational equity and opportunity for all students. The analysis is defined best by Johnson, Peters-Burton & Moore (2016), STEM education is socially transformative teaching science and mathematics with the integration of technology and engineering. This transformation of information makes content learning relevant to all students both socially and culturally. Therefore, my proposed STEM policy will promote educational inclusion in STEM infusing a universal methodology that promotes activities with a focus on community issues anchored in student interests.

Political Analysis

The Political Analysis of my STEM policy problem implications context involves many facets and barriers. The topic of STEM had gained national awareness and has produced many national initiatives, but none have yet to become a national policy. The issue should be a bipartisan topic as it directly concerns the welfare of our national economy and security. As indicated by Bybee (2013), in 2010 there was a mandate that federal agencies were to collaborate to provide a five-year strategic plan for STEM education. This suggests the political implication of what role the federal government should have in designing national reform and improvements for promoting STEM education as a priority. Also, how does this then impact the political arena of each state and their educational STEM policies and initiatives to unify us on a national stage to be globally competitive.

Legal Analysis

The Legal Analysis of my STEM policy problem implications context involves inclusion and is related to equity. I can see that any policy regarding STEM education may alienate a certain subgroup or impact students in poverty areas. This unintended consequence can lead to legal opposition of the policy reform. It is conceivable that these students could have less access to technology at home to promote their computational literacy and involvement in group projects. I can also consider school financial systems having funding issues to promote a STEM initiative to assist these concerns, which can lead to legal educational issues. As Fowler (2013) explained, financial systems that question constitutionality can be challenged in state courts and stimulate legislation across the country to follow suit. This issue could potentially influence community support of the policy and produce some input as to how the policy would ensure an equitable playing field when determining access to these programs. Further consideration could be given to providing access within community centers to allow all students to develop these skills from the elementary to high school levels.

Moral and Ethical Analysis

The Moral and Ethical Analysis of my STEM policy problem implications context involves the argument that STEM education will prepare all students for the challenges of the future is both a moral and ethical responsibility of public education as outlined by our constitution. Fowler (2013) indicates that, “The moralistic political culture has been the fuel supporting government reforms for the good of society” (p. 83). I believe that my STEM educational policy will lead to greater reform to better prepare our students for college and technical career readiness. This movement will guide the

educational instructional shift to embed the creative critical thinking skills that will cultivate problem solvers needed to sustain our economic viability into uncharted future demands.

Implications for Staff and Community Relationships

The policy implications for staff relationships between the faculty members within each department would be positive by fostering the need for collaboration. This process would build the internal instructional capacity within the school and district organization. In my own experience as a school leader facilitating a stem robotics competition, I have witnessed the interactions of teachers and outside community staff who work in tandem with student STEM groups on projects within the engineering program. The outcomes these challenges produced were inspiring to witness as student problem solve with each other to accomplish the ultimate project objective with adult facilitation. The students worked together as a team to continue to improve the mechanics of the robot to move to the next level of competition and competed against students of other countries achieving success. This methodology of STEM-PBL contributed to their academic achievement both in the classroom and within the competitions that allowed them the opportunity to apply their critical thinking skills.

The policy implications for community relationships as a stakeholder would greatly improve by the nature of STEM ecosystems building business partners as a means to bridge the gap and garner apprenticeships and mentorships for students. The very nature of building a STEM-centric school environment will require the assistance of local businesses and community outreach to create a network of support for these programs. In my professional experience, as an educator, I have facilitated community relationships

that have provided mentorship opportunities with local hospitals for the biomedical students. These opportunities allowed students to shadow medical professionals within their chosen field of study as a future career. The results began the process of building the students resume to foster a pathway into a future medical profession, which is symbiotic to the current needs of industry.

The policy implications for other stakeholders such as parents would be positive, as they would have renewed trust in the product of our educational system giving purpose to their students learning that can be applied to the future workforce. I believe the STEM movement will get students back to the basics of learning with relevance. STEM education using a PBL methodology allows for reflection, and refinement of a product, which teaches self-regulation, introspection, and teamwork. In my professional experiences as an educator spanning 27 years working in the area of science I have seen the possibilities that STEM-PBL activities can provide with real-world applications. One specific example in the area of engineering is the ability of students to create solutions that can be marketable products. In my time as a school leader there were student designs that addressed a real-world issue and was eventually became a patented product.

Conclusion

In conclusion of my proposed STEM policy there is much to consider in addressing the issues of funding supporting the curricular shift to STEM teaching and learning to promote 21st century skills. These efforts towards reform are the first steps to the STEM socio-transformative work that will address student need as well as provide cultural relevance to appeal to student academic interest that also align to future career demands from industry. This leads us to the conclusion of my program evaluation and the

potential that STEM-PBL educational reform can have on student interest leading to potential improved academic achievement.

CHAPTER EIGHT: CONCLUSION

Introduction

The current challenges within our educational arena align greatly with my STEM-PBL program evaluation within the areas of engineering, biomedical science, and computer game design. The topic of STEM is a prominent subject on the national and state stage with respect to educational reform towards preparing students for future careers while increasing student achievement and promoting the 21st century skills necessary for the future workforce. The idea of STEM brings relevance to the learning, integrates multiple content standards into the curricula, and fosters collaboration with a team mindset.

In the state of Florida, currently computer science has been integrated in all middle and high schools as of July 1, 2018, according to state statute HB 495-K-12 Public Education. This trend seems to support growth in the area of STEM education as it applies to real-world problem solving of community issues, which is the focus for this project. The purpose of this program evaluation analyzes the efficacy of the curricula within these magnet programs to inform on what is working well along with the challenges that can lead to change for improvement of STEM education.

Discussion

The STEM-PBL program evaluation of engineering, biomedical science and computer game design was received well and acknowledged as a viable topic for change within the STEM community and district. The methodology within the IRRB process provided by National-Louis University and my school district required a thorough planning and implementation of a program evaluation. This process sequentially outlined

the methodologies and legal requirements protecting confidentiality while informing on my topic with efficacy and anonymity. In my evaluation, I collected data of the perceptions from multiple stakeholder groups for a full triangulation to include teachers, administrators, district directors, and parents through a survey and interview process. The data was analyzed with a mixed methodology to include both quantitative and qualitative paradigms.

The purpose of my evaluation was to analyze STEM-PBL learning methodology within the programs of engineering, biomedical science, and game design to inform on the relationship to student achievement. In my study, I examined what aspects were working well, what aspects were not working well, greatest challenges, and ways to improve the STEM program. In addition, I explored the relationship that science and math and technological skill level had on student achievement and success within these programs.

This process addressed my initial goals within the findings indicating what was working well within these programs relates to students being given the opportunity to get hands-on learning experiences with real-world relevant instruction. The findings also indicated that some of the greatest challenges presented could be a lack of planning time, funding, professional development, and finding qualified teachers with industry background. An additional overarching finding was the lack of prioritization of STEM-PBL lessons at state and local levels due to a curriculum that was driven by an end of course assessment and the need for community and business partners. These indicators also contributed to the barrier of cross-curricular planning time where secondary teachers often work in isolation.

The next steps that followed the implementation of my program evaluation were the proposed strategy of organizational change addressing the issues mentioned above within the findings. I identified several components to address the issues within my findings presented as change objectives. These objectives outlined a plan for a school-wide stem-centric shift change initiative, a communication plan to promote the initiative, cross-curricular collaboration shift, STEM-PBL professional development across all content areas, structural changes to increase planning time, and enhance community and business partnerships. Finally, these steps towards organizational change will be assessed for effectiveness to continually improve the impact of the initiative to ensure equity of opportunity to STEM-PBL activities for all students.

The suggested policy I am advocating address the issues by implementing a district-wide STEM policy that would be a catalyst driving a STEM-centric shift both horizontally and vertically for all schools preparing students with these skills starting with elementary to middle and high school levels. This STEM policy would provide the awareness and support needed to increase the opportunities for all students to be exposed the hands-on activities that foster the needed 21st century skills to meet industry demands. This policy will promote cross-curricular collaboration integrating multiple content standards to drive students to critically think through problems. This STEM-centric project-based learning environment is collaborative and would not require additional competencies. This approach would provide a platform for application of the current standards to work in tandem to solve real world problems while enhancing computational literacy. Ultimately, I envision the STEM policy addressing the issues outlined within the

competencies, culture, context and conditions of my program evaluation that truly prepare students for life

Leadership Lessons

The leadership lessons I have learned through this process resonate throughout my role as a school administrator within the area of instructional leadership with an emphasis on achievement focused learning environments. In my experience, as an Assistant Principal for Magnet Curriculum at a STEM magnet high school I have observed first-hand the value that STEM-PBL can add to teaching and learning for all students. This methodology allows students the opportunities to collaborate and create their own solutions to real-world community issues. This process becomes the fluid that feeds a fountain of untapped potential within each student. The journey of STEM exploration that resulted from this process has broadened my lens to consider all aspects of creating change on the ground that will be sustainable. The study has taught me the value of triangulating the data and getting many perspectives to address the proposed issues. The work has stretched my leadership lens through a detailed investigative system analyzing a relevant educational topic of STEM-PBL synthesizing the input and perspectives of many stakeholders to generate a plan of action driving true organizational change.

Another key leadership lesson learned is within the process to creating success within a change process. The change process if successfully thought out and planned could inform and culminate to a suggested policy supporting full implementation of the STEM-PBL methodology of learning into schools at all levels. I was informed through this process all the aspects that were working well and barriers that existed at the

classroom level. The leadership lesson revealed here reiterated the value of inclusion of stakeholders when creating the plan for change to ensure buy-in of its implementation. This process has allowed me to take a deep introspective look at the area of study of STEM-PBL and its possibilities to address current educational challenges.

The experience of going through a methodical process of analyzing the data from multiple stakeholders that yielded viable findings related to my initial exploratory questions informing on my topic has reinforced its purpose for me as an administrator. This process has significantly highlighted its potential relevance to educational reform. I learned that teachers and all stakeholders are equally passionate about providing the best hands-on experience for their students and are vested in their learning to promote the skills students need to be successful with future career preparation. I feel this process has enhanced my leadership skills and lens in developing a sound plan to creating cultural change in my own school or as a future principal. I also have grown as a leader within my own mindset of considering the stakeholder's position, power and the role that politics and policy can have on change.

Conclusion

The proposed STEM policy as a focus of organizational change both horizontally within each school and vertically from elementary to middle and high school levels could be a viable learning method to reinforcing critical thinking within current content standards. There is a current call to action by policymakers and educational leaders arguing that improving STEM teaching and learning opportunities for children is key to their future prosperity. (Johnson, Peters-Burton & Moore, 2016, p. 3). This call is anchored in two key educational realities. One reality is that future jobs will have a

related STEM component requiring proficiency of these skills and these jobs are linked to economic prosperity as mentioned above.

In the words of Dewey, “We only think when confronted with problems, which is equivalent to the element of our connected experience” (1938). This methodology unifies educational communities to promote critical thinking and problem solving around real-world issues. As Myers and Berkowicz explains, “A STEM Shift dismantles subject silos, breaks impenetrable walls, and invites collaborative conversations locally and globally”, (2015, Myers and Berkowicz, p. 74). The idea behind this STEM shift is to provide an educational vehicle that can establish a system to create a cross curricular collaborative environment that organically fosters problem solving of these current issues that are relevant to students and their community. In the larger context, we as educators must consider the urgency and the need for this STEM organizational change. The current industry demands drive the skills that should be taught and cultivated within our schools. In closing, the educational reform efforts should prioritize the need for change that addresses the global achievement gap to prepare students for future careers. This STEM-centric shift should include the integration of 21st century skills into the science curriculum to increase computational literacy for all students and be applied across all content areas to produce successful future innovators.

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Appendix A: Teacher Survey

Teacher Survey Questions on STEM and Project-Based Learning at the High School Level

Instructions: This survey is designed to provide valuable information about teacher perceptions on how project-based learning techniques are being used in STEM education and how teachers can be better supported to integrate PBL into standards-based lessons that connect all content areas. Please answer all questions to the best of your knowledge and experience. There are no correct or incorrect answers or responses and all results will be kept confidential.

Baseline Participant Information

1. How many years have you been a high school classroom teacher?

- a. 0-5
- b. 5-10
- c. 10-20
- d. 20+

2. How many years have you been teaching at your present school?

- a. 0-5
- b. 5-10
- c. 10-20
- d. 20+

3. Do your teaching responsibilities include standards in Math, Science, Engineering, Game Design, Biotechnology?

- a. Yes
- b. No

4. What area of concentration are you certified to teach? Please mark all that apply.

- a. Mathematics
- b. Science
- c. Engineering
- d. Business or /Technology
- e. Biotechnology
- f. Game Design

Teaching Responsibilities

5. How often do you teach any of these subjects: Math, Science, Engineering, Business, Technology, Biotechnology, Game Design?

	Never	Sometimes	Frequently	Always
a. As a single subject, standards-based course, lessons, or projects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. As an interdisciplinary project with other subjects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. Do you also teach or integrate any of these subjects into your instruction? Check all that apply.

- a. Computers/Technology, Multi- Media Arts
- b. Career-Technical course standards
- c. Art/Music/Drama
- d. Internships, community/service-based learning
- e. Capstone, Senior Projects, Extra-curricular project/outcome-based products.

Teacher Support and Professional Development

Never Sometimes Frequently Always

7. Teachers in the STEM program...

- a. have regularly scheduled professional learning community meetings that focused on PBL instructional practice and student learning.
- b. have received PBL instructional coaching/mentoring formally and from peers.
- c. collaborated with school leadership in addressing teacher and student needs to improve achievement.
- d. collaborated with school leadership to set policies and procedures in decision making for the STEM program.

Student Focus – *Your Students*

8. How often have you observed your STEM students in the following capacity:

	Never	Sometimes	Frequently	Always
a. Inquiring on their progress to receive academic support.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Reflecting or refining their work.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Inquiring to demonstrate they are striving for deep knowledge.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Initiating student driven decisions about what to learn.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Initiating student driven decisions about how to problem-solve.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9. How often do you use the following methods to assess student performance in your STEM program?

	Never	Sometimes	Frequently	Always
a. Multiple choice or short answer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Open-Ended questions/problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Portfolios of student work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Group Projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Individual Projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Projects that yield a product	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Hands-on demonstrations, exhibitions or oral presentations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. How often do most of your STEM students do the following?

	Never	Sometimes	Frequently	Always
My students...				
a. collect, organize and analyze information and data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. solve real-world problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. decide how to present their learning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. orally present their work to peers, staff, parents or others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. research content deeply to become experts on the topic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. evaluate and defended their ideas and views	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. work on multi-disciplinary projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. participate in community projects/ internships/apprenticeships	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. participate in competitive organizations that applied learned skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Project Based Learning

This survey defines Project Based Learning (PBL) as an instructional approach to instruction that includes all of the following:

- a. engages student in an extended investigation
- b. requires student inquiry into a topic in depth
- c. includes some student self-direction/choice/collaboration
- d. requires students to think critically and problem solve
- e. end-product includes a presentation of findings, results and conclusions

Please respond to the following PBL specific questions as it relates to your classroom experience and practice.

11. Indicate which of the following kinds of projects or activities your STEM-PBL lessons would include from the following:

- | | Yes | No |
|---|-----------------------|-----------------------|
| a. Researching competing views on an issue and holding a Socratic debate. | <input type="radio"/> | <input type="radio"/> |
| b. Creating a presentation describing a product. | <input type="radio"/> | <input type="radio"/> |
| c. Researching a community issue to offer a solution. | <input type="radio"/> | <input type="radio"/> |
| d. Constructing simulations, models (e.g., physical or computerized models of bridges, buildings, robotics, 3D products). | <input type="radio"/> | <input type="radio"/> |
| e. Developing artistic products or performances. | <input type="radio"/> | <input type="radio"/> |
| f. Role-playing as stakeholders to solve simulated problems | <input type="radio"/> | <input type="radio"/> |
| g. Creating a working version of a physical product, device etc. | <input type="radio"/> | <input type="radio"/> |
| h. Creating a computer-based product or program (e.g., web page, blog, video game). | <input type="radio"/> | <input type="radio"/> |

12. Rate each of the following reasons for integrating PBL into your STEM curricular instruction. I use PBL in my STEM lessons.....

- | | Not
Important | Somewhat
Important | Very
Important |
|--|-----------------------|-----------------------|-----------------------|
| a. to make teaching and learning rigorous | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. to effectively teach standards-driven content | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. to personalize and tailor learning to student interest and needs | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. to teach critical thinking skills beyond academic content (21 st century skills) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

- e. to promote team-mindedness and collaboration
- f. to promote students' global perspective
- g. to show cross-curricular connections
- h. to foster problem solving and
promote a culture of student inquiry

13. To what extent do you agree or disagree concerning the impact of a STEM program using PBL as an effective teaching strategy for the following groups of students? STEM-PBL is especially effective for...

	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
a. high achieving students	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. average achieving students	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. low achieving students	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. students who lack academic motivation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. students who struggle with limited English language proficiency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. students who struggle with math aptitude	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. students with strong technology skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. students with high reading and math ability.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

14. What is working well in the STEM programs of Engineering, Biomedical Science and Computer Game Design? Please explain briefly

15. Lessons that involve STEM-PBL are effective in increasing student motivation and interest.

Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

16. What is not working well in the STEM programs of Engineering, Biomedical Science and Computer Game Design? Please explain briefly

17. PBL lessons that integrate multiple content areas to create a solution or end product increase academic achievement indirectly in other areas.

Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

18. What are the greatest challenges in the STEM programs of Engineering, Biomedical Science, and Computer Game Design? Please explain briefly

19. What are ways to improve the STEM program? Please explain briefly:

20. In your opinion, which of the following challenges do you feel exist in implementing lessons in your STEM program that utilizes PBL as an instructional method in any content area in the current standards –based climate?

I have experienced challenges with...

	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	
a. having enough instructional time for students to process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. materials needed for lessons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. professional development/ support on PBL implementation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. academic aptitude of students'	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. finding high quality projects that exist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. planning time to collaborate with other teachers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. managing students work and accountability in groups	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. assessing students work in groups	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. meeting state or district standards using PBL	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
j. assessing individual students mastery of the content	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

21. PBL lessons that integrate cross-curricular concepts increases the rigor of the lesson for students promoting inquiry.

Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

22. In the content areas of science and mathematics how does project-based learning increase the overall rigor of the curriculum to promote high levels of student achievement? Please explain briefly:

23. In your professional opinion, do you feel there are benefits to a STEM program using PBL in the classroom? I feel STEM and PBL benefits student learning by...

Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

- | | | | | |
|---|-----------------------|-----------------------|-----------------------|-----------------------|
| a. pushing student thinking beyond the academic requirement | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. creating connections across multiple disciplines | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. allowing students time to practice in-depth inquiry | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. teaching multiple ways to accomplish a solution | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. increasing student voice to elicit inquiry | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. evaluating and analyzing evidence | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. students taking ownership of learning | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. fostering collaboration and teamwork | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. increasing students' ability to critically think through possible outcomes | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

- | | | | | |
|---|-----------------------|-----------------------|-----------------------|-----------------------|
| j. allowing for opportunities to hear other views | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| k. fostering time management | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| l. promoting student reflection and focus | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| m. nurturing innovation | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

24. How does technological aptitude limit or increase the level of academic achievement with project-based learning? Please explain briefly

25. STEM-PBL methods should be a component of future educational reform integrating cross-curricular standards to prepare students with the 21st century skills necessary for future careers?

- | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|
| Strongly Disagree | Somewhat Disagree | Somewhat Agree | Strongly Agree |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Thank you for your participation on this survey!

Appendix B: Administrator Interviews

Principal/Assistant Principal for Curriculum Interview Questions – STEM –PBL

Directions: Please answer the following questions using your own opinions, perceptions and experiences.

1. In your opinion how would you define STEM education? (Define it in your own words.)
2. Do you feel STEM project-based learning is an effective method of instruction that increases academic achievement? If so, explain why?
3. What is working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
4. What is not working well in the STEM programs of Engineering, Biomedical Science and Computer Game Design?
5. What are the greatest challenges in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
6. What are ways to improve the STEM program?
7. In the content areas of math and science how does project-based learning increase the overall rigor of the curriculum to promote high levels of student achievement?
8. In your educational professional opinion, what is the relationship of a student's technological ability to being successful in a STEM-PBL program at your school?
9. What is the relationship in your opinion of STEM, inquiry-based learning and standards driven curriculum as related to student academic achievement?
10. As an educational leader, what do you think the future of STEM is in educational reform?

Appendix C: Guidance Counselor Interviews

Guidance Counselor Interview Questions

Directions: Please answer the following questions using your own opinions, perceptions and experiences.

1. In your opinion how would you define STEM education? (Define it in your own words.)
2. Do you feel STEM project-based learning is an effective method of instruction that increases academic achievement? If so, explain why?
3. What is working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
4. What is not working well in the STEM programs of Engineering, Biomedical Science and Computer Game Design?
5. What are the greatest challenges in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
6. What are ways to improve the STEM program?
7. In the content areas of math and science how does project-based learning increase the overall rigor of the curriculum to promote high levels of student achievement?
8. In your educational professional opinion, what is the relationship of a student's technological ability to being successful in a STEM-PBL program at your school?
9. What is the relationship in your opinion of STEM, inquiry-based learning and standards driven curriculum as related to student academic achievement?
10. As an educational leader, what do you think the future of STEM is in educational reform?

Appendix D: District Personnel Interviews

District Director of STEM/ CTE Interview Questions

Directions: Please answer the following questions using your own opinions, perceptions and experiences.

1. In your opinion how would you define STEM education? (Define it in your own words.)
2. Do you feel STEM project-based learning is an effective method of instruction that increases academic achievement? If so, explain why?
3. What is working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
4. What is not working well in the STEM programs of Engineering, Biomedical Science and Computer Game Design?
5. What are the greatest challenges in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
6. What are ways to improve the STEM program?
7. In the content areas of math and science how does project-based learning increase the overall rigor of the curriculum to promote high levels of student achievement?
8. In your educational professional opinion, what is the relationship of a student's technological ability to being successful in a STEM-PBL program at your school?
9. What is the relationship in your opinion of STEM, inquiry-based learning and standards driven curriculum as related to student academic achievement?
10. As an educational leader, what do you think the future of STEM is in educational reform?

Appendix E: Parent Interviews

Parent STEM/ PBL Interview Questions

Directions: Please answer the following questions using your own opinions, perceptions and experiences.

1. In your opinion how would you define STEM education? (Define it in your own words.)
2. Do you feel STEM project-based learning is an effective method of instruction that increases academic achievement? If so, explain why?
3. What is working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
4. What is not working well in the STEM programs of Engineering, Biomedical Science and Computer Game Design?
5. What are the greatest challenges in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
6. What are ways to improve the STEM program?
7. In the content areas of math and science how does project-based learning increase the overall rigor of the curriculum to promote high levels of student achievement?
8. In your educational professional opinion, what is the relationship of a student's technological ability to being successful in a STEM-PBL program at your school?
9. What is the relationship in your opinion of STEM, inquiry-based learning and standards driven curriculum as related to student academic achievement?
10. As a parent, what do you think the future of STEM is in educational reform?

Appendix F: Teachers in STEM Focus groups

Focus Group Interview Questions-Teacher (STEM and PBL)– Engineering, Game Design, Biotechnology

Directions: Please answer the following questions using your own opinions, perceptions and experiences.

1. In your opinion how would you define STEM education? (Define it in your own words.)
2. Do you feel STEM project-based learning is an effective method of instruction that increases academic achievement? If so, explain why?
3. What is working well in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
4. What is not working well in the STEM programs of Engineering, Biomedical Science and Computer Game Design?
5. What are the greatest challenges in the STEM programs of Engineering, Biomedical Science, and Computer Game Design?
6. What are ways to improve the STEM program?
7. In the content areas of math and science how does project-based learning increase the overall rigor of the curriculum to promote high levels of student achievement?
8. In your educational professional opinion, what is the relationship of a student's technological ability to being successful in a STEM-PBL program at your school?
9. What is the relationship in your opinion of STEM, inquiry-based learning and standards driven curriculum as related to student academic achievement?
10. As a parent, what do you think the future of STEM is in educational reform?

Appendix G: Informed Consent-Adult Participation Survey-Teacher

My name is LeShea Serrano, and I am a doctoral student at National Louis University, Tampa, Florida. I am asking for your consent to voluntarily participate in my dissertation project. The study is entitled: “AN EVALUATION OF A STEM MAGNET PROGRAM UTILIZING PROJECT-BASED LEARNING TO IMPROVE ACHIEVEMENT”. The purpose of the study is to understand how STEM project-based learning is implemented at your school. The study will also examine how the efficacy of the STEM programs and how project-based learning might impact motivation and student achievement.

My project will address the effectiveness of the STEM program and project based learning at your school. I will use the data I collect to understand the process and changes that may possibly need to be made regarding the STEM programs at your school. I would like to survey you in regards to your thoughts on the implementation of the STEM program at your school.

You may participate in this study by clicking the link below signing this consent form indicating that you understand the purpose of the study and agree to participate in an online survey. It should take approximately 20 minutes for you to complete the online survey. All information collected in the survey reflects your experience and opinion regarding the STEM program and project-based learning.

Your participation is voluntary and you may discontinue your participation at any time with absolutely no negative effects. I will keep the identity of you, the school, the district, and all participants confidential, as it will not be attached to the data and I will use pseudonyms for all participants in the report. Only I will have access to all of the survey data, which I will keep in a locked cabinet at my home or on a password protected hard drive for up to 5 years after the completion of this study, at which time I will shred all survey data. Participation in this study does not involve any physical or emotional risk beyond that of everyday life. While you are likely to not have any direct benefit from being in this research study, taking part in this study may contribute to our better understanding of the implementation process of the STEM programs at your school and what changes, if any, need to be made.

While the results of this study may be published or otherwise reported to scientific bodies, your identity will in no way be revealed. You may request a copy of this completed study by contacting me at lserrano1@my.nl.edu

In the event you have questions or require additional information, you may contact me at: email lserrano1@my.nl.edu. If you have any concerns of questions before or during participation that you feel I have not addressed, you may contact my dissertation chair, Dr. Carol Burg, cburg@nl.edu, ; or EDL Program Chair, Dr. Stuart Carrier, scarrier@nl.edu; 847-947-5017; or the NLU’s Institutional Research Review Board: Dr. Shaunti Knauth, NLU IRRB Chair, shaunti.knauth@nl.edu, 312.261.3526, National Louis University IRRB Board, 122 South Michigan Avenue, Chicago, IL 60603.

Thank you for your participation.

Please click on this link to signify your acceptance of this informed consent and to take the survey: <https://tinyurl.com/STEM-and-PBL>

Participant Name (Please Print)

Participant Signature Date

LeShea Serrano
Researcher Name (Please Print)

Researcher Signature Date

**Appendix H: Informed Consent-Adult Participation Interview-Administrator,
District
Personnel, Guidance Counselor**

My name is LeShea Serrano, and I am a doctoral student at National Louis University, Tampa, Florida. I am asking for your consent to voluntarily participate in my dissertation project. The study is entitled: "AN EVALUATION OF A STEM MAGNET PROGRAM UTILIZING PROJECT-BASED LEARNING TO IMPROVE ACHIEVEMENT". The purpose of the study is to understand how STEM project-based learning is implemented at your school. The study will also examine the efficacy of the STEM programs and how project-based learning might impact motivation and student achievement

My project will address the effectiveness of the STEM program and project-based learning at your school. I will use the data I collect to understand the process and changes that may possibly need to be made regarding the STEM programs at your school. I would like to interview you in regards to your thoughts on the implementation of the STEM program at your school.

You may participate in this study by signing this consent form indicating that you understand the purpose of the interviews and agree to participate in one 45-60 minute interviews, with possibly up to 5 email exchanges in order clarify any questions I may have regarding your interview data. I will audio tape and transcribe the interviews. All information collected in the interviews reflects your experience and opinion regarding the STEM programs and project-based learning at your school.

Your participation is voluntary and you may discontinue your participation at any time with absolutely no negative effects. I will keep the identity of the school and all participants confidential, as it will not be attached to the data and I will use pseudonyms for all participants. Only I will have access to all of the interview tapes and transcripts, and field notes, which I will keep in a locked cabinet at my home or on a password protected hard drive for up to 5 years after the completion of this study, at which time I will shred all interview transcripts, tapes, and notes. Participation in this study does not involve any physical or emotional risk beyond that of everyday life. While you are likely to not have any direct benefit from being in this research study, taking part in this study may contribute to our better understanding of the implementation process of STEM programs and project-based learning at your school and what changes, if any, need to be made.

While the results of this study may be published or otherwise reported to scientific bodies, your identity will in no way be revealed. You may request a copy of this completed study by contacting me at lserrano1@my.nl.edu.

In the event you have questions or require additional information, you may contact me at; email lserrano1@my.nl.edu. If you have any concerns of questions before or during participation that you feel I have not addressed, you may contact my dissertation chair, Dr. Carol Burg, cburg@nl.edu, or EDL Program Chair, Dr. Stuart Carrier, -scarrier@nl.edu; 847-947-5017; or the National-Louis Institutional Research Review Board: Dr. Shaunti-Knauth, NLU IRRB Chair, shaunti.knauth@nl.edu, 312.261.3526, National Louis University IRRB Board, 122 South Michigan Avenue, Chicago, IL 60603.

Thank you for your participation.

Participant Name (Please Print)

Participant Signature Date

LeShea Serrano
Researcher Name (Please Print)

Researcher Signature Date

Appendix I: Informed Consent-Adult Participation Interview-Parent

My name is LeShea Serrano, and I am a doctoral student at National Louis University, Tampa, Florida. I am asking for your consent to voluntarily participate in my dissertation project. The study is entitled: “AN EVALUATION OF A STEM MAGNET PROGRAM UTILIZING PROJECT-BASED LEARNING TO IMPROVE ACHIEVEMENT”. The purpose of the study is to understand how STEM project-based learning is implemented at your school. The study will also examine the efficacy of the STEM programs and how project-based learning might impact motivation and student achievement

My project will address the effectiveness of the STEM program and project-based learning at your school. I will use the data I collect to understand the process and changes that may possibly need to be made regarding the STEM programs at your school. I would like to interview you in regards to your thoughts on the implementation of the STEM program at your school.

You may participate in this study by signing this consent form indicating that you understand the purpose of the interviews and agree to participate in one 45-60 minute interviews, with possibly up to 5 email exchanges in order clarify any questions I may have regarding your interview data. I will audio tape and transcribe the interviews. All information collected in the interviews reflects your experience and opinion regarding the STEM programs and project-based learning at your school.

Your participation is voluntary and you may discontinue your participation at any time with absolutely no negative effects. I will keep the identity of the school and all participants confidential, as it will not be attached to the data and I will use pseudonyms for all participants. Only I will have access to all of the interview tapes and transcripts, and field notes, which I will keep in a locked cabinet at my home or on a password protected hard drive for up to 5 years after the completion of this study, at which time I will shred all interview transcripts, tapes, and notes. Participation in this study does not involve any physical or emotional risk beyond that of everyday life. While you are likely to not have any direct benefit from being in this research study, taking part in this study may contribute to our better understanding of the implementation process of STEM programs and project-based learning at your school and what changes, if any, need to be made.

While the results of this study may be published or otherwise reported to scientific bodies, your identity will in no way be revealed. You may request a copy of this completed study by contacting me at lserrano1@my.nl.edu.

In the event you have questions or require additional information, you may contact me at email lserrano1@my.nl.edu. If you have any concerns of questions before or during participation that you feel I have not addressed, you may contact my dissertation chair, Dr. Carol Burg, cburg@nl.edu; or EDL Program Chair, Dr. Stuart Carrier, -scarrier@nl.edu; 847-947-5017; or the National-Louis Institutional Research Review Board: Dr. Shaunti-Knauth, NLU IRRB Chair, shaunti.knauth@nl.edu, 312.261.3526, National Louis University IRRB Board, 122 South Michigan Avenue, Chicago, IL 60603.

Thank you for your participation.

Participant Name (Please Print)

Participant Signature

Date

LeShea Serrano

Researcher Name (Please Print)

Researcher Signature

Date

Appendix J: Informed Consent-Adult Participation Focus Group-Teacher

My name is LeShea Serrano, and I am a doctoral student at National Louis University, Tampa, Florida. I am asking for your consent to voluntarily participate in my dissertation project. The study is entitled: “AN EVALUATION OF A STEM MAGNET PROGRAM UTILIZING PROJECT-BASED LEARNING TO IMPROVE ACHIEVEMENT”. The purpose of the study is to understand how STEM project-based learning is implemented at your school. The study will also examine the efficacy of the STEM programs and how project-based learning might impact motivation and student achievement.

My project will address the effectiveness of the STEM program and project-based learning at your school. I will use the data I collect to understand the process and changes that may possibly need to be made regarding the STEM programs at your school. I would like to interview you in regards to your thoughts on the implementation of the STEM program at your school.

You may participate in this study by signing this consent form indicating that you understand the purpose of the interviews and agree to participate in one 45-60 minute focus group interview, and possibly up to 5 email exchanges in order clarify any questions I may have regarding your interview data. I will audio tape and transcribe the interview. All information collected in the interviews reflects your experience and opinion regarding the STEM programs and project-based learning at your school.

Your participation is voluntary and you may discontinue your participation at any time with absolutely no negative effects. I will keep the identity of the school and all participants confidential, as it will not be attached to the data and I will use pseudonyms for all participants. Only I will have access to all of the interview tapes and transcripts, and field notes, which I will keep in a locked cabinet at my home or on a password protected hard drive for up to 5 years after the completion of this study, at which time I will shred all interview transcripts, tapes, and notes. Participation in this study does not involve any physical or emotional risk beyond that of everyday life. While you are likely to not have any direct benefit from being in this research study, taking part in this study may contribute to our better understanding of the implementation process of STEM programs and project-based learning at your school and what changes, if any, need to be made.

While the results of this study may be published or otherwise reported to scientific bodies, your identity will in no way be revealed. You may request a copy of this completed study by contacting me at lserrano1@my.nl.edu.

In the event you have questions or require additional information, you may contact me at email lserrano1@my.nl.edu. If you have any concerns of questions before or during participation that you feel I have not addressed, you may contact my dissertation chair, Dr. Carol Burg, cburg@nl.edu, or EDL Program Chair, Dr. Stuart Carrier, scarrier@nl.edu; 847-947-5017; or the National-Louis Institutional Research Review Board: Dr. Shaunti-Knauth, NLU IRRB Chair, shaunti.knauth@nl.edu, 312.261.3526, National Louis University IRRB Board, 122 South Michigan Avenue, Chicago, IL 60603.

Thank you for your participation.

Participant Name (Please Print)

Participant Signature

Date

LeShea Serrano

Researcher Name (Please Print)

Researcher Signature

Date

Appendix K: Email Letter for Participation in an Interview

Dear Participant:

I am currently a doctoral student at National-Louis University working on a research study regarding STEM programs at the high school level and I would like to invite you to participate in the study through completion of an interview.

The interview is designed to collect information on the implementation of STEM project-based learning related to student achievement.

For this study, participation is completely voluntary, and you may decline altogether or leave any questions blank if you choose not to answer. There are no known risks to participation beyond those encountered in everyday life. The responses you provide will remain confidential and anonymous. The reported results will be a collective total of all respondents. Only I will have access to all of the survey data, which I will keep in a locked cabinet at my home or on a password protected hard drive for up to 5 years after the completion of the study, at which time I will shred all survey data collected.

If you agree to participate in the study, I will set a time and location that is convenient at your school to conduct the interview, which should take approximately 45-60 minutes. The interview should not impact classroom instructional time.

Please email me a response indicating you are willing to participate and I will then send you the questions in advance and will attain your Informed Consent form at the time of the scheduled interview.

I thank you in advance for your participation in my study towards the advancement of STEM education.

Warm Regards,

LeShea Serrano, M.Ed.
Doctoral Candidate
National-Louis University

Appendix L: Email Letter for Participation in a Focus-Group Interview

Dear Participant:

I am currently a doctoral student at National-Louis University working on a research study regarding STEM programs at the high school level and I would like to invite you to participate in the study through completion of a focus-group interview.

The interview is designed to collect information on the implementation of STEM project-based learning related to student achievement.

For this study, participation is completely voluntary and you may decline altogether or leave any questions blank if you choose not to answer. There are no known risks to participation beyond those encountered in everyday life. The responses you provide will remain confidential and anonymous. The reported results will be a collective total of all respondents. Only I will have access to all of the survey data, which I will keep in a locked cabinet at my home or on a password protected hard drive for up to 5 years after the completion of the study, at which time I will shred all survey data collected.

If you agree to participate in the study, I will set a time and location that is convenient at your school to conduct the focus-group interview, which should take approximately 45-60 minutes. The interview should not impact classroom instructional time.

Please email me a response indicating you are willing to participate and I will then send you the questions in advance and will attain your Informed Consent form at the time of the scheduled interview.

I thank you in advance for your participation in my study towards the advancement of STEM education.

Warm Regards,

LeShea Serrano, M.Ed.
Doctoral Candidate
National-Louis University

Appendix M: INFORMED CONSENT School Site Administrator: Consent to Conduct Research at School Site

My name is LeShea Serrano, and I am a doctoral student at National Louis University, Tampa, Florida. I am asking for your consent for selected staff at your school to voluntarily participate in my dissertation project. The study is entitled: AN EVALUATION OF A STEM MAGNET PROGRAM UTILIZING PROJECT-BASED LEARNING TO IMPROVE INSTRUCTION. The purpose of the study is to understand how STEM project-based learning is implemented at your school. The study will also examine the efficacy of the STEM programs and how project-based learning might impact motivation and student achievement.

My project will address the process of STEM-PBL in your STEM programs and how it impacts those involved at your school. I will use the data I collect to understand the process and changes that may possibly need to be made regarding the STEM programs at your school. I will survey up to 40 teachers, interview up to 1 principal, 2 assistant principals for curriculum, 3 guidance counselors, and do a focus group teacher interview with teachers in regards to their thoughts on the implementation of the STEM programs at your school.

I will give participants who volunteer an online survey to be completed and returned using specific instructions as included, and an Informed Consent form indicating that they understand the purpose of the survey and agree to take the survey. The survey should take approximately 20 minutes to complete. Also, participants may volunteer for 45-minute interviews with possibly up to 5 email exchanges in order to clarify any questions I may have regarding your interview data. I will conduct 45-minute interviews with those participants who have completed an Informed Consent form indicating that they understand the purpose of the interview and agree to be interviewed. I will audiotape the interviews and transcribe the tapes. I will also collect academic achievement student data such as grade point averages, graduation rates, and industry certification data, which the district has informed me they will provide to me. All information collected in the surveys and interviews reflects participants' experience and opinion regarding PBL and the STEM programs at your school.

By signing below, you are giving your consent for me to ask for voluntary participation from selected stakeholders to participate in this research study: to complete an online survey, to participate in interviews and focus-group interviews.

All participation is voluntary and participants may discontinue participation at any time. I will keep the identity of the school and all participants confidential, as it will not be attached to the data and I will use pseudonyms for all participants. Only I will have access to all surveys, interview tapes and transcripts, and field notes, which I will keep in a locked cabinet at my home or on a password protected hard drive for up to 5 years after the completion of this study, at which time I will shred all interview transcripts. Participation in this study does not involve any physical or emotional risk beyond that of everyday life. While participants are likely to not have any direct benefit from being in this research study, taking part in this study may contribute to our better understanding of the implementation process of STEM programs at your school and what changes, if any, need to be made.

While the results of this study may be published or otherwise reported to scientific bodies, your identity will in no way be revealed. Participants may request a copy of this completed study by contacting me at lserrano1@my.nl.edu. In the event you have questions or require additional information, you may contact me at email: lserrano1@my.nl.edu. If you have any concerns of questions before or during participation that you feel I have not addressed, you may contact my dissertation chair, Dr. Carol A. Burg, email: cburg@nl.edu or EDL Program Chair, Dr. Stuart Carrier, scarrier@nl.edu; 847-947-5017; or the NLU's Institutional Research Review Board: Dr. Shaunti-Knauth, NLU IRRB Chair, shaunti.knauth@nl.edu, 312.261.3526, National Louis University IRRB Board, 122 South Michigan Avenue, Chicago, IL 60603.

Thank you for your participation.

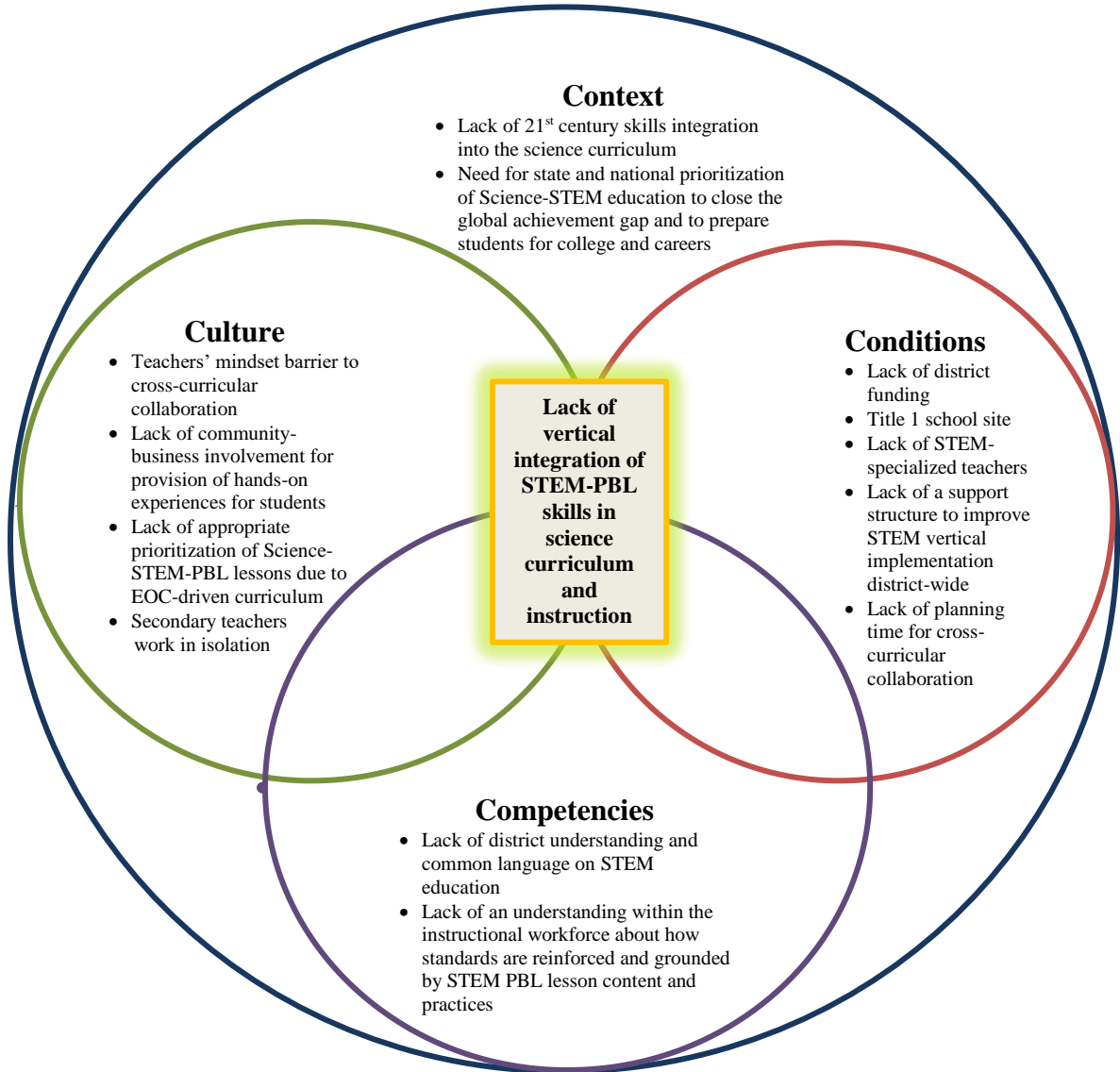
Participant Name (Please Print)

Participant Signature Date

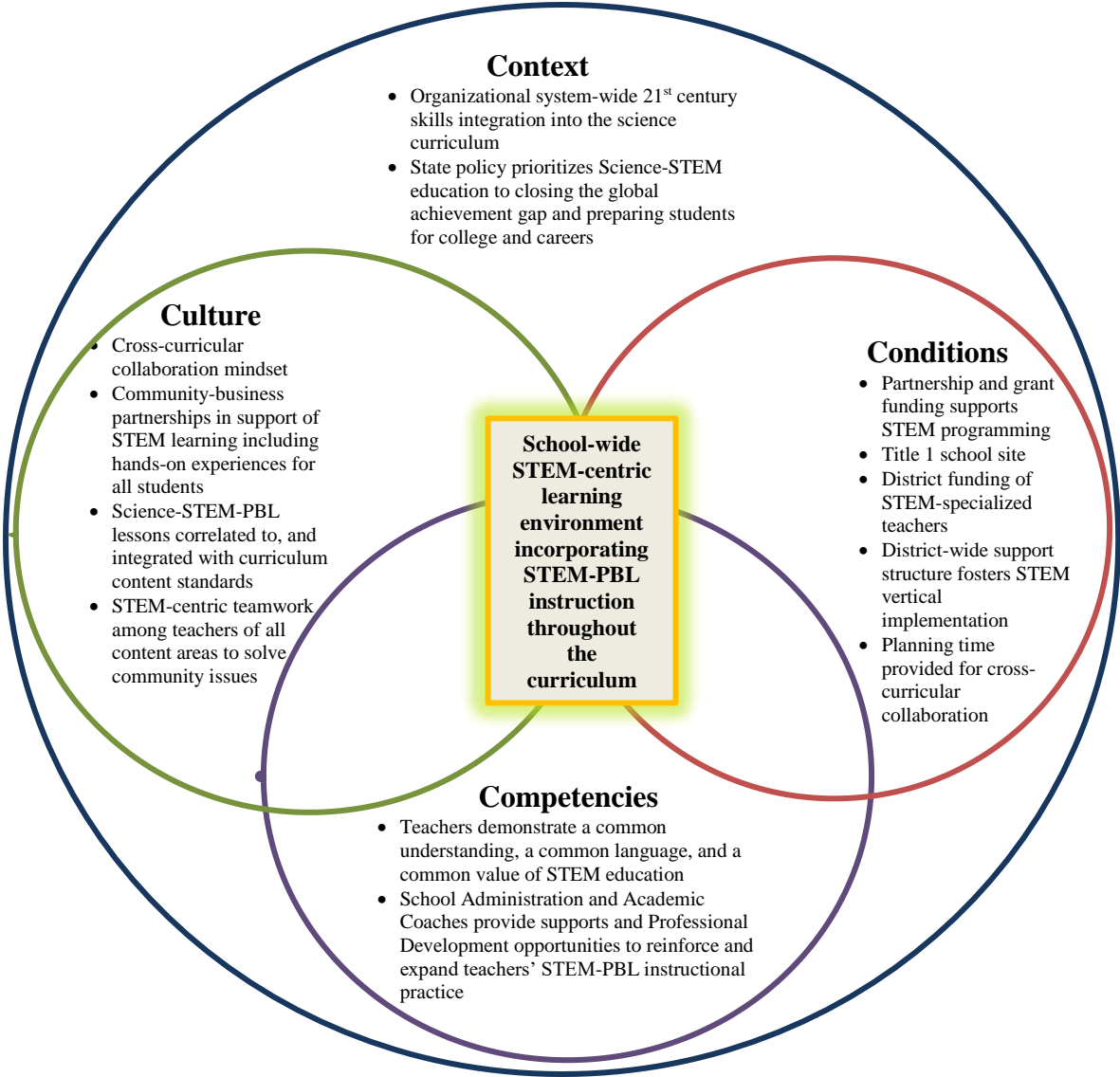
LeShea Serrano
Researcher Name (Please Print)

Researcher Signature Date

Appendix N: Baseline AS IS 4 C's Analysis for An Evaluation of a Magnet Program that Utilizes Project-Based Learning to Improve Student Achievement



Appendix O: TO BE 4 C's Analysis for an Evaluation of a Magnet Program that Utilizes Project-Based Learning to Improve Student Achievement



**Appendix P: Strategies and Action Chart
Seven Objectives of Change Addressing Need with
Goals, Strategies, and Actions**

Objectives and Goals	Strategies	Actions
<p>Objective 1– Context, Culture, Competencies and Conditions Goal: Planning for the STEM-centric shift change initiative school-wide.</p>	<ul style="list-style-type: none"> • Establish a high expectation for STEM alignment for faculty and staff. • Create a governing coalition: Stem Executive Board. • Assess levels of competency with the STEM theme. • Enhance the STEM Boosters purpose for school-wide support and funding. 	<ul style="list-style-type: none"> • Collaboratively develop a STEM literacy vision and mission. • Form a STEM executive board of all stakeholders. • Survey teachers on experience with STEM-PBL lessons. • Collaborate with STEM Boosters, Business Partners and District for funding solutions.
<p>Objective 2–Context and Culture Goal: Create a Communication and Marketing plan to promote the STEM initiative.</p>	<ul style="list-style-type: none"> • Ensure that the faculty and staff have a clear understanding of the purpose and relevance of this initiative. • Market the STEM programs to prospective district families and community rebranding. 	<ul style="list-style-type: none"> • Communicate the purpose of the initiative in a whole group faculty meeting during pre-planning. • Collaborate with the district and coordinate a district-wide interactive vertical articulation event showcasing all STEM programs elementary to high school to show the STEM pathway. • Organize district-wide STEM competitions at all levels.
<p>Objective 3-Culture Goal: Develop a STEM curricular shift both internal and external.</p>	<ul style="list-style-type: none"> • Create a flowchart-correlating STEM to Math and Science content standards. • To Foster a teacher culture of trust and cross-curricular collaboration. 	<ul style="list-style-type: none"> • Teachers collaborate and align STEM standards to their content area. • Teachers collaborate and plan STEM-PBL projects aligned to the standards. • Teachers plan for 1 project every 9 weeks partnered with another content area.

<p>Objective 4- Competencies Goal: Develop a school-wide Professional Development plan to integrate STEM across content areas.</p>	<ul style="list-style-type: none"> • Academic Coaches, CTE Department Head and Assistant Principals for Curriculum collaboratively develop a professional to support the cross curricular STEM collaboration in the classroom. 	<ul style="list-style-type: none"> • Academic Coaches train PLC Facilitators. • Build capacity with PLC Teacher leaders training each department on the cross-curricular initiative. • Two Teachers will team each 9-week period on a collaborative STEM –PBL project aligned to relevant content standards.
<p>Objective 5- Conditions Goal: Create a structural change of logistics to allow for teacher planning and collaboration.</p>	<ul style="list-style-type: none"> • Create an organized structural change to allow for increased planning time for teachers in different content areas. 	<ul style="list-style-type: none"> • Create a schedule of dedicated common planning across content areas to foster collaboration.
<p>Objective 6- Conditions Goal: Establish an incubator of Business, Local University and Community Partnerships</p>	<ul style="list-style-type: none"> • Establish a relationship with local business partners, universities and community leaders to provide technological access and equity to all students in the community. • Collaborate with feeder schools to establish outreach. 	<ul style="list-style-type: none"> • Collaborate with the YMCA, and GIRL Scouts to integrate STEM programs and access to technology for all. • Establish community outreach student driven summer camp programs to give access to robotics and technology elementary - middle.
<p>Objective 7-Culture and Competencies Goal: Assessment of the effectiveness of implementation of the STEM initiative.</p>	<ul style="list-style-type: none"> • Enhance the MTSS/ILT process to include assessment and teacher support for the STEM initiative implementation. • Develop assessment rubrics to analyze the project results. 	<ul style="list-style-type: none"> • Include STEM in the MTSS/ILT – Continuous Improvement rotation monthly. • Analyze student indicators such as project rubrics, grades and standardized test results as a pre- and post-assessment for comparison.