

CONSIDERATIONS IN BUILDING AN ELEMENTARY MAKERSPACE LAB

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### ABSTRACT

Globalization and technology have placed a recognizable pressure on both employers and educational institutions. Entry-level employees must be adaptive, innovative, collaborative, and have strong problem-solving and communication skills. To prepare students for the future workforce, schools must revisit existing practices and find new ways to foster innovation as the gap between the new skills students need versus what is being taught in public schools continues to grow (Bybee et al, 2006; Wagner, 2012). One way to increase students' interest and skills in STEM education is by incorporating makerspaces into schools. Makerspaces are physical spaces where people have opportunities to build and construct objects based on their own personal interests. Makerspaces foster the innovative ideas and skills students need upon graduation. This qualitative case study investigates why educational leaders decided to launch a makerspace lab and how school leaders established a model makerspace lab at an elementary school. The purpose of this study was to document and describe the change process connected with the implementation of the makerspace lab, how leaders navigated various obstacles, perceptions of the change process, and lessons learned from educators. The findings show that school leaders experienced a novel concept after visiting an extraordinary model makerspace program which demonstrated a unique approach to developing the innovative capacity of young learners. These experiences created a transformational moment in school leaders that motivated them to be change agents and launch their own makerspace lab. School leaders developed community partnerships with an engineering university, a Fortune 500 company, an education community foundation, and a large school district to make this work possible. Together, these educational and business collaborators created a model elementary makerspace model that is one of the first of its kind on the east coast and currently services students from other schools in the region. The findings further discuss the importance of community partnerships, inviting other schools to participate, having a model program to emulate, having the right people, and how a school initiative became a district opportunity.

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### GENERAL AUDIENCE ABSTRACT

Globalization and technology have pressured both employers and educational institutions to change. Entry-level employees must be adaptive, innovative, collaborative, and have strong problem-solving and communication skills. To prepare students for the future workforce, schools must revisit existing practices and find new ways to foster innovation as the gap between the new skills students need versus what is being taught in public schools continues to grow (Bybee et al, 2006; Wagner, 2012). One way to increase students' interest and skills in STEM education is by incorporating makerspaces into schools. Makerspaces are physical spaces where people have opportunities to build and construct objects based on their own personal interests. Makerspaces foster the innovative ideas and skills students need upon graduation. This qualitative case study investigates why educational leaders decided to launch a makerspace lab and how school leaders established a model makerspace lab at an elementary school. The purpose of this study was to document and describe the change process connected with the implementation of the makerspace lab, how leaders navigated various obstacles, perceptions of the change process, and lessons learned from educators. The findings show that school leaders experienced a novel concept after visiting an extraordinary model makerspace program which demonstrated a unique approach to developing the innovative capacity of young learners. These experiences created a transformational moment in school leaders that motivated them to be change agents and launch their own makerspace lab. School leaders developed community partnerships with an engineering university, a Fortune 500 company, an education community foundation, and a large school district to make this work possible. Together, these educational and business leaders created a model elementary makerspace model that is one of the first of its kind on the east coast and currently services students from other schools in the region. The findings further discuss the importance of community partnerships, inviting other schools to participate, having a model program to emulate, having the right people, and how a school initiative became a district opportunity.

## DEDICATION

This dissertation is dedicated to the memory of my dad. Dad, I am so thankful for your strong work ethic, sense of humor, and adventurous spirit. I will never forget working with you into the early mornings installing telephone systems for local businesses. You modeled for me the importance of rising early to work, staying up late until the job is finished, taking time to play, and how to enjoy this journey called life. I love you and miss you greatly.

I also dedicate this dissertation to my mom. I aspire to one day be like you. Your faith, smile, and zeal for life are unmatched! Thank you for being a champion and allowing your life and light to do the talking for you. You have inspired more people than you will ever know! Thank you for your faith and we give praise to Him for our many blessings, including this degree! You have shown me the importance of education. Going to college was not optional for me and you were a large reason I started this journey at Virginia Tech! Thank you, Mom! Thank you being a constant cheerleader and friend. I look forward to our conversations each day and future celebrations! I love you, Mom!

This dissertation is also dedicated to my children, Alyssa, Isabelle, and Josiah. I am so proud of each of you! Alyssa, thank you for leading the way for your brother and sister. Your courage and work ethic are admirable. Isabelle, thank you for our frequent conversations and making your dad smile often. Josiah, you are my Mighty Warrior and my hero! You overcome adversity every day with ease. You rise above all challenges and soar! You have quickly become a young man and I look forward to what is to come. Maybe, one day, you will be able to beat me in basketball!

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## CHAPTER ONE: INTRODUCTION

The health and prosperity of the United States is dependent upon the continuous development of innovative ideas and skills of its citizens (Holdren, 2010). According to the President's Council of Advisors on Science and Technology, these ideas and skills remain the country's most precious assets. Many leaders agree the long-term health of our economy is dependent upon creating far more innovative thinking (Wagner, 2012).

Twenty-first century skills are needed for employees to be competitive in the workforce and prosper in a time of unprecedented global economic competition (Bybee et al, 2006). To be successful and thrive today, people are required to demonstrate high levels of creativity, imagination, and innovative thinking if they are going to invent better services and products for the global marketplace (Trilling & Fadel, 2009). Employees must now be adaptive, innovative, collaborative, and have strong problem-solving and communication skills (Wagner, 2012).

The need for developing twenty-first century skills and mindsets in students and educational leaders has never been more important. As students enter the workforce, they will need to have a diverse and adaptive skill set to meet the demands of the global marketplace (Brophy et al, 2008). The global economy demands that the attributes of the American workforce must be much different from earlier times (Fleming, 2015; Brophy et al, 2008). The rapid development of technology has placed a mandate on industries to become much more adaptive and flexible to remain competitive. Industries now require a workforce that can adapt to these constantly changing conditions and emerging technologies (Brophy et al, 2008). Business leaders are looking for creative, independent, problem solvers in every field, yet employers are reporting that current graduates lack creativity and the necessary innovative and adaptive skills to be successful (Wagner, 2012; Martinez & Stager, 2013). To meet these

growing demands, a renewed focus on Science, Technology, Engineering, and Math (STEM) education is necessary (National Research Council, 2011). STEM education equips students with skills, knowledge, and attitudes necessary to respond to complex challenges in areas such as energy, health, environmental protection, and national security (Holdren, 2010).

One very new and creative approach to increasing student interest and engagement in STEM education is incorporating makerspaces in schools. Arising from these global market demands and technological advances, we see the creation and implementation of makerspaces as one of the most exciting movements in education today (Fleming, 2015). Makerspaces are places where people have opportunities to build and construct objects based on their own personal interests. Makerspaces foster the innovative ideas and skills students will need upon graduation. When all students have access and opportunities to “make,” they can construct their own knowledge about the world around them. Making has the strong potential to engage a diverse body of students in conceptual and experimental learning (Vossoughi & Bevan, 2014).

President Obama demonstrated his vision and passion for STEM education when he said:

I want us all to think about new and creative ways to engage young people in science and engineering, whether it’s science festivals, robotics competitions, fairs that encourage young people to create and build and invent---to be makers of things, not just consumers of things (Obama, 2009, p.13).

This study challenges educational and political leaders’ traditional thinking and encourages educators to find new and innovative ways to promote STEM education with students as early as elementary school. It focuses on the steps transformational leaders took when launching a makerspace lab. By creating makerspaces, or spaces where students can use

their imaginations, students can engage in self-directed activities guided by their personal interests and further develop their innovative skills (Wyld, 2014; Wagner, 2012). This study also explores the change process transformational leaders encountered when launching a makerspace lab.

### **Statement of the Problem**

The gap between the new skills students need to have upon graduation versus what is being taught in public schools today continues to grow (Wagner, 2012). The future development of STEM fields is dependent upon a consistent workforce of diverse and talented individuals. However, the K-12 educational system is failing to equip students with the skills they need to enter careers of their choice (National Research Council, 2011).

Elementary and secondary students in the United States demonstrate lower proficiency scores in math and science when compared to peers worldwide. Recent studies show less than one-third of U.S. eighth graders show proficiency in math and science (Holdron, 2010). In the Framework for K-12 Science Education, the National Research Council reports that too few U.S. citizens have strong STEM backgrounds. Many workers do not have the necessary foundational knowledge or skills to be competitive in the workplace (National Research Council, 2011).

Fewer people are graduating from colleges and universities in STEM related fields, so employees who lack the skills needed to prosper are having difficulty competing for jobs in the high-tech workforce (Basham & Marino, 2013). STEM jobs are currently in high demand. Projections forecast that there will be millions of unfilled positions due to an insufficient amount of technically skilled individuals in the U.S. workforce (Rothwell, 2013; Craig et al, 2011). The Bureau of Labor and Statistics and the U.S. Department of Labor found there is an inadequate

supply of workers with degrees in engineering and science fields through the 2026 projections (Sargent, 2014).

Equity and diversity concerns regarding the current STEM workforce must be addressed as well. African Americans, Hispanics, Native Americans, and women are underrepresented in the STEM fields (Yoder, 2014). Large gaps in achievement and interest in STEM fields exist between African Americans and Latino youth when compared to White and Asian students. Only 4% of African Americans are earning bachelor's degrees in engineering (Yoder, 2014). Just 7% of the total STEM workforce are African Americans, Latinos, and Native Americans combined, even though they represent over one-fourth of the U.S. population (National Science Foundation, 2014; Yoder, 2014). This lack of representation of these groups contributes to fewer participants entering high-growth and well-paid positions and limits diverse talents and perspectives needed in STEM fields (Holdren, 2010).

Many factors contribute to these equity and diversity gaps, including inequitable access to resources, quality instruction, role models, cultural differences, and stereotypes (Margolis et al, 2010). America's lack of investment in consistent and effective STEM education has resulted in, not only mediocre test scores, but a shortage of citizens interested in and able to fill critical roles in STEM related fields (Holdren, 2010). Educational leaders and policy makers must actively pursue new ways to help all students gain access to STEM education and capture students interests early in their educational careers. The future of our nation depends on it (Holdren, 2010).

## Study Background

Globalization and technology have placed a tremendous amount of pressure on educational institutions and businesses to change. Technology has revolutionized the way organizations are being operated, creating a greater need for efficiency, and streamlining of processes and structures (Hechanova et al, 2013). The United States must once again launch a major effort to improve STEM education as our nation is in danger of losing its competitive edge in our global economy (Bybee & Fuchs, 2006). To prepare students for the future, schools must revisit existing practices and find new ways to foster innovation in all students through STEM education.

Research shows that educational institutions must capture students' interests in STEM education early because students begin to lose interest in STEM by middle school, especially young women and minorities (Brophy et al, 2008). Many students, who might normally thrive in STEM related careers, are not even aware of what engineers do and have not had STEM experiences or opportunities (Banks-Hunt et al, 2016).

“The future can and must be different” (Honey & Kanter, 2013, p.2). Schools must look for systematic solutions to meet the STEM education demands (National Research Council, 2011; Holdron, 2010). Our educational system must find new and innovative ways to promote STEM education and foster 21<sup>st</sup> century learning for all students. Educational institutions, namely public schools, and educational leaders must revisit existing practices and programs to meet these growing business, industry, and employer demands (National Research Council, 2011). For the United States to thrive in the future, a true shift is needed today in both the programs being offered to students and in educational leaders' and students' mindsets about what constitutes quality STEM education (Dougherty, 2013).

Educational leaders and policy makers must begin asking how can all students be given access to a quality STEM education. In today's constantly changing technology and global economy, educators must remember that students in school today will enter jobs that have technologies yet to be invented (Hlubinka et al, 2013; Martinez & Stager, 2013). By seeking out new ways to allow all students access to tinker, explore, play, and problem-solve, a new way of educating students to be "future ready" will emerge (Martinez & Stager, 2013).

Educators must find new ways to capture children's interest in STEM education when students are in elementary school and take advantage of students' curiosity about the world. While new STEM initiatives have targeted middle and high school students, fewer opportunities exist for elementary students and their teachers (DeJarnette, 2012). Giving students early exposure to STEM activities and initiatives positively impacts elementary students' perceptions about STEM education and promotes considerations of pursuing STEM related careers (DeJarnette, 2012; Bagiati et al, 2010).

We already know what works for children. Perhaps the greatest asset is to leverage children's innate curiosity about the world around them. Children are born curious and come equipped with a desire to learn. This curiosity rivals that of even the most determined scientist. Early in school, however, this spark- what psychologists have dubbed intrinsic motivation- is all too frequently extinguished by the extrinsic goals and expectations of school (Honey & Kanter, 2013, p. 2).

Elementary students have the cognitive abilities to engage in STEM activities and problem-solving skills. Engaging students in their primary years of schooling in STEM education also builds self-efficacy, reinforces students' confidence in their own abilities and captures their interests in pursuing advanced courses in STEM fields. Students need to be

allowed to construct their own knowledge and gain insights by being given opportunities to explore and inquire about the world around them (DeJarnette, 2012). Engineering concepts, advanced science inquiry, and math concepts are being incorporated at much earlier stages of the elementary school curriculum. (Dejarnette, 2012).

### **Purpose of the Study**

I used a case study methodology to focus on *why* school leaders launched a makerspace program and *how* educational and business leaders implemented the makerspace lab initiative at one elementary school. The *why* question is important to describe the motivation of the leaders, but emphasis was placed on how the implementation occurred. The purpose of this qualitative study was to document and describe the change process connected with the implementation of the makerspace lab, how leaders navigated various obstacles, perceptions of the change process, and the lessons learned from educators.

This research required the approval of key stakeholders and involved overcoming multiple challenges that will be further explored. Transformational leaders partnered with a local state university, a Fortune 500 business corporation, a large school district, and an elementary school to educate students on STEM careers and gave students opportunities to build and create. The experiences and lessons learned in the implementation process will serve as a model for others considering launching a makerspace lab.

### **Research Questions**

This study investigates the process school leaders followed when adopting an elementary school makerspace lab. The following research questions will guide the study.

1. Why did the school leaders decide to implement the makerspace lab?

2. How did the school leaders obtain the resources to launch the makerspace lab?
3. What factors (supports and obstacles) influenced the implementation of the makerspace lab?
4. What are the lessons learned from the leaders and school personnel who were involved in launching the makerspace lab initiative?

### **Definition of Terms**

***Innovation-*** An introduction of a new idea, method, or device.

***Makerspaces-*** Places or physical spaces where young people come together to explore their own interests; learn how to use tools and materials, both physical and virtual; and develop innovative projects. (Fleming, 2015).

***STEM Education-*** The acronym STEM stands for Science, Technology, Engineering, and Mathematics education. STEM education represents a relationship between these four interwoven fields (Basham & Marino, 2013).

***The Maker Movement-*** An adult movement of hobbyists, tinkerers, engineers, artists and hackers who creatively design and build objects for playful and purposeful means (Martin, 2015). Dale Dougherty described the Maker Movement in education as an approach to problem-based and project-based learning that relies on hands-on, collaborative experiences to solve problems (Dougherty, 2013).

***Transformational Leadership-*** A leadership approach that causes change in individuals and/or social systems. In transformational leadership, the leader creates a vision of what the future should look like, aligns people with this vision, and empowers others to fulfill the vision despite the presence of obstacles (Kotter & Cohen, 2008; Kotter, 1995).

***Twenty-First Century Skills-*** Skills people need in order to be successful in the twenty-first century. Some skills include communication skills, creativity, problem-solving skills, adaptive skills, collaborative skills, and technology skills.

## **Limitations and Delimitations of the Study**

### **Limitations**

Limitations are influences and factors the researcher cannot control. This qualitative case study occurred in its natural setting and would be difficult to replicate. Case studies provide an analysis of a specific organization, group, or company and limit the ability to generalize the findings to other groups (Merriam & Tisdell, 2016). In this study, a Mid-Atlantic school was selected where I was both the building principal and the researcher for this research project. Reflexivity is needed to explain my biases, dispositions, and assumptions regarding this makerspace lab initiative. My overlapping role of principal, researcher, and participant was the biggest challenge in this study. The results of this study may not be generalizable to all schools launching a makerspace lab; however, it will be generalizable to schools like the school in this case study.

### **Delimitations**

Delimitations are choices made by the researcher which need to be disclosed. School leaders, central office staff, university personnel, and business leaders, who experienced the makerspace lab at one elementary school were selected for this research study. The selected school is a Mid-Atlantic elementary school that focused on providing STEM educational opportunities to students throughout the region. The selected school did not have a STEM makerspace lab before this study began. This study primarily focuses on the process adult

leaders went through launching the elementary makerspace lab. Educational and business leaders were selected because they played a role in launching the makerspace lab. The Superintendent, central office staff, school personnel, and business leaders that worked to create change at one elementary school were selected for this study.

### **Chapter Outline**

This study is presented in five chapters. The current chapter provides a rationale and purpose of this study. Additionally, it provides an overview of the research questions, definition of terms, limitations and delimitations of the study. Finally, this chapter reviews the way the overall study is organized. Chapter 2 consists of a comprehensive review of literature regarding the maker movement, makerspaces, and transformational leadership. Chapter 3 explains the research method. In this chapter, the research design and data collection processes are discussed. Chapter 4 presents the results from this study and data analysis. This chapter describes the ways in which participants' responses address each of the four research questions that guided this research study. Chapter 5 provides the summary, conclusions, and recommendations based on this research.

## CHAPTER TWO: LITERATURE REVIEW

Finding systemic solutions to the challenges and promoting a “maker mindset” through STEM education may not be as daunting as it might sound (Martin, 2015). Programs and ways of creating innovators occurred (perhaps unintentionally) in our country through a movement called the Maker Movement. To understand how to develop makerspaces in elementary schools, this review will discuss the maker movement, makerspaces, and transformational leadership.

### **The Maker Movement**

The Maker Movement represents a growing movement of tinkerers, engineers, hackers, and artists who use creativity and design to build things for enjoyment and useful purposes (Martin, 2015). The Maker Movement incorporates a do-it-yourself mentality in which adults come together to share the wonders of making (Papavlasopoulou et al, 2017). As part of the Maker Movement, individuals (or creators) share their processes and products with others (Halverson & Sheridan, 2014). The Maker Movement can be traced back to 2005 with the founding of Make Magazine and the first Maker Faire in 2006 (Martin, 2015).

Individuals that create and make objects are considered “makers.” We are all makers of things. Making things and then finding ways to make them better is at the core of humanity (Martinez & Stager, 2013). Makers believe that if you can imagine it, you can make it. As part of the maker movement, makers continually seek out opportunities to tinker and learn how to do new things by engaging in hands-on learning experiences. The Makerspace Playbook highlights how makers enjoy coming together to highlight their work and to celebrate the work of others (Hlubinka et al, 2013).

The Maker Movement offers great insights into what learning may look like in the future. While the Maker Movement has been initiated in spaces that are not in schools and involves mostly adult participants, there is a growing interest among educators to bring making into schools to help promote STEM education (Martin, 2015). The Maker Movement has provided a model for moving students from being consumers of knowledge to being creators of knowledge (Fleming, 2015). By giving students opportunities to make, students are turning knowledge into action (Fleming, 2015). From the Maker Movement, specific spaces called *makerspaces* have emerged offering solutions to reach all students with STEM education.

### **Makerspaces**

Makerspaces offer a possible solution to the growing concerns pertaining to STEM education. Makerspaces are places where young people can have access to materials and explore their own interests; learn how to use tools and materials, both physical and virtual; and develop creative and innovative projects (Fleming, 2015). Students are considered “makers” as they explore, play, tinker, and learn in makerspace locations. Tools do not define a makerspace but the act of making does (Hlubinkai et al, 2013). Makerspaces come in a variety of sizes and shapes and serve as a gathering point for tools, projects, mentors, and expertise.

One way educators and policy makers can leverage children’s curiosity about the world around them is by providing students with makerspaces where students have access to tools, technology, and supplies. In makerspaces, students are given opportunities to come together to share the magic that occurs with creating, tinkering, and reusing materials and technology (Honey & Kanter, 2013). Makerspaces are places where students can turn their ideas into products and become entrepreneurs (Anderson, 2012). Makerspaces encourage risk-taking, revision, and opportunities for students to reflect (Bonagura, 2017). Makerspaces hold

tremendous potential for instilling essential skills students will need to be properly equipped for the future (Han et al, 2017; Hlubinka et al, 2013).

Makerspaces can happen in a living room, garage, community center or the library at school. Makerspaces are informal spaces located in educational and community settings where individuals immerse themselves in creative making (Han et al, 2017). Makerspaces allow makers to seek out opportunities through hands-on, do-it-yourself opportunities. (Hlubinka et al, 2013). Makerspaces have the potential to empower students to believe they can imagine and design anything (Hlubinka et al, 2013).

Makerspaces can take on many different forms but typically involve taking on a physical space with resources available to pursue technical projects of personal interest and have the support of the maker community (Oliver, 2016). Makerspaces facilitate learning, which moves people from being users of knowledge to being consumers of knowledge (Han et al, 2017).

Makerspaces have experienced a tremendous rise in popularity in recent years, which is starting to gain momentum in public schools. There is a growing interest in schools about bringing making into K-12 education to enhance learning opportunities for students and engage them in engineering and design practices (Martin, 2015). Makerspaces have incredible potential to foster the essential skills needed for the future and they are growing in popularity around the world (Han et al, 2017). Educators must pay close attention to these trends as they could transform our mindsets and shift our approaches to promoting STEM education. Makerspaces offer new possibilities to learning and ways to expand our understanding of how children learn best.

When considering STEM education and launching a makerspace, it is vital to incorporate several key ingredients. These ingredients include self-guided learning based on the students' interests (Oliver, 2016), learning through play (Britton, 2012), incorporating the engineer design process through a design-make-play model (Honey & Kanter, 2013), tolerance for failure and retrieval (Britton, 2012), encouraging peer collaboration and peer sharing between experts and novices (Britton, 2012), and blending digital and physical technologies (Fleming, 2015).

**Self-guided learning based on students' interests.** Makerspaces are based on sound developmental principles. Piaget (1976) said that "to understand is to invent" (Piaget, 1976, p.11). Piaget formulated the theory of constructivism, which believes that knowledge does not result from receiving information given by someone else, without the learner first going through an internal process of making sense. (Martinez & Stager, 2013). Papert found that students' learning potential could be unleashed by providing them with environments where their interests and passions thrive (Papert, 1980). Papert's *constructionism theory* showed students can learn by creating and discovering knowledge, rather than receiving it passively (Papavlasopoulou et al, 2017). According to Papert, learning occurs when students construct knowledge by building, making, and sharing objects they have created. Papert felt products need to be displayed, discussed, examined, explored, and admired. Papert's theory is at the core of the maker movement in education. Making gives students self-guided opportunities and offers all students the potential to excel!

**Learning through play.** Playful learning environments encourage students to experiment, which can lead to increased conceptual knowledge (Hatano & Inagaki, 1986). Research shows that humans are born with an innate desire to experiment, explore and imagine new possibilities and be innovative (Wagner, 2012). Fun and playful activities are intrinsically

motivating (Vansteenkiste et al, 2004). This motivation can have several educational benefits including persistence when being faced with a challenge. Makers tinker and learn through creative play. These ingredients foster inspired and passionate STEM learners.

Learning through play and building is not a new concept. It has long been debated that children can learn by play and can learn by building and using interesting tools and materials (Montessori, 1912). Papert (1980), who is known by some as the father of the maker movement, believed the way individuals learn primarily depends on the models the learner has available (Papert, 1980).

### **Incorporating the engineer design process through a Design-Make-Play model.**

Honey and Kanter (2013) reinforced not only the importance of play but also the importance of the engineering process through a Design-Make-Play model. The very ingredients that allow makers to thrive in makerspaces are the “deep engagement that occurs with content, experimentation, exploration, problem-solving, collaboration, and learning to learn” (Honey & Kanter, 2013, p. 4). A Design-Make-Play model highlights how the next generation of science inventors can be developed and offers engineering design opportunities for students. (National Research Council, 2011; Honey & Kanter, 2013).

*Design* is a critical component to the engineering process which serves as a powerful tool to teach science, technology, engineering, and math (STEM) education. Through the *design* process, students can learn how to identify a problem or area of need, and learn how to plan, test, model, and solve the existing challenge. This process promotes higher-order thinking skills. Design-based learning provides students with engaging opportunities and promotes critical thinking and problem-solving skills. The skills incorporated in the design process help solve some of the most pressing challenges in the world today (Honey & Kanter, 2013).

*Making* incorporates building and adjusting objects by hand in order to figure out how things work. This process can be used for pure pleasure or to accomplish a specific task. The *Maker Movement* encourages others to come together with their passions for making unique objects. There are no failures, no right or wrong ways of doing things. It is all about figuring out how things work and reworking them. At the core of “making” is deep engagement, experimentation, problem-solving, collaboration, and exploration of content. These are the essential STEM ingredients that promote both passionate and inspired entrepreneurs (Honey & Kanter, 2013).

*Play* is a vital facet of the Maker Movement and makers. Play is a voluntary activity that can incorporate make-believe and invention. There are strong parallels between the learning of science and children’s natural desire to play, explore and invent (Honey & Kanter, 2013). Play encourages students to be experimental and curious which are vital to be a scientist. The common theme is that exploration and invention, without pressure, lead to new innovations and opportunities! Fun and playful activities are intrinsically motivating and can have a variety of educational benefits, including being persistent when faced with challenges (Vansteenkiste et al, 2004).

**Tolerance for failure and retrial.** One critical component of the engineering process is teaching students how to fail and learn from their initial design flaws. Martin (2015) reported there is a “maker mindset” that represents critical attributes in the Maker Movement. Martin found that failure is part of the educational experience. Often, failure is not promoted in educational circles, particularly when associated with schools, students, or initiative. In a maker mindset, failure is celebrated and is considered the new way of winning (Mohannadi, 2011).

At the heart of innovation is failure. Failure can be defined as something that is not working out as expected (Maltese et al, 2018). While failing in schools may seem counterintuitive, it is a necessary component to a quality education. Learning must be challenging for students and educational institutions must encourage students to be persistent when initial attempts are unsuccessful. At the heart of tinkering is a process of being stuck and then unstuck (Petrich et al, 2013). Failures in a school setting can be just as productive if students are supported to better understand the problem (Kapur, 2008). Students need to have productive struggles while in school (Warshauer, 2015) and educators need to help support students through these challenges without letting them become stopping points (Kapur, 2016).

**Opportunities for peer collaboration and peer sharing.** Our world is changing such that our citizens must develop and enhance their collaborative skills. The ability to work collaboratively in a variety of environments and with a variety of different people, is a key skill for the success of the 21<sup>st</sup> century (Suarez-Orozco & Sattin, 2007). Students need opportunities to collaborate and makerspaces provide a natural platform to promote such behavior. The word collaboration is derived from Latin roots *com* and *laborare*, which means to *work together*. When individuals practice collaboration, they create a shared vision with united strategies when solving a problem or addressing an issue. Collaboration occurs when a group of people work toward a common goal (Chrislip & Larson, 1994.)

Collaboration can be defined as a process where different individuals have unique perspectives and see different components to a problem or issue and then can explore solutions that go beyond their limited individual vision of what is possible (Gray, 1989). Collaboration has stakeholder independence. Solutions emerge by constructively working through differences,

having shared ownership, and joint responsibility of results. Collaboration is a continuous and emergent process and skill (Gray, 1989).

**Blending digital and physical technologies.** Makerspaces blend digital and physical technologies to explore ideas, develop students' technical skills and create new products (Sheridan et al, 2014). Makerspaces promote technology, innovation, and entrepreneurship (Hatch, 2013). Makerspaces' primary role is a technical workshop (Hlubinka, 2013). Technical support for makerspaces involve giving the students access to tools, materials, physical space, and support as students pursue projects (Han et al, 2017). Properly equipped makerspaces should have low-cost, sufficient technology available to students. Equipment in makerspace locations might include 3D printers, laser cutters, robotics kits, crafts, computers, and low-cost technology (Martin, 2015, Martinez & Stager, 2013).

The emergence of recent low-cost technologies has allowed makerspaces to thrive in public and private settings. A microcontroller, which is a small, programmable computer on a chip, can process input like sensors, switches, and data. Arduinos are one example of low-cost, student friendly microcontrollers whereas Beagle Bone, and Raspberry Pi are mini computers that students can utilize and manipulate (Martin, 2015). The possibilities and potential of microcontrollers and mini computers in schools are endless.

### **Transformational Leadership in Building Makerspaces**

Globalization, technology, and a new economy have ushered in great opportunities for organizations along with great turmoil (Hechanova & Cementina-Olpoc, 2013; Beer & Nohria, 2000). The stakes of dealing with change have not been this high since the Industrial

Revolution. Most traditional organizations have accepted that they must either continue to change or die (Beer & Nohria, 2000).

Transformational leadership plays an instrumental role in launching a makerspace. Leading change is difficult as 70% of all change initiatives fail (Beer & Nohria, 2000). When launching a makerspace, it is essential to have the right people leading the change effort (Kotter, 1995). This may look different depending on the school district, school system, and culture of the school and school district (Bonagura, 2017, Fleming, 2015).

Transformational leaders of any change effort in education may include the building principal, a STEM teacher, central office staff, local school board, business leaders, or even the students themselves (Bonagura, 2017; Fleming, 2015). Transformational leadership entails challenging the status quo (Hechanova & Cementina-Olpoc, 2013). Change is difficult because most people are reluctant to alter their habits. Employees will maintain the status quo and keep doing what they have always done unless there is a substantial threat to change (Garvin & Roberta, 2005).

Transformational leadership defines what the future should look like, aligns people with that vision, and motivates people to create change even when obstacles are present (Kotter, 1995). Leaders must learn how to make the most of their makerspace by leveraging the resources around them to create their own unique makerspace (Fleming, 2015). Most of the research on transformational leadership involves the change process in businesses. I will discuss this research first, then discuss the work related to transformational leaders in STEM education.

There are many steps to creating change that leaders must go through in launching a makerspace. Laying a solid foundation and preparing the organization's soil for key

stakeholders months before the change initiative starts, is essential to sustain change (Garvin & Roberto, 2005). Kotter & Cohen have established eight steps transformational leaders must go through when creating change that apply to all change initiatives (Kotter & Cohen, 2008; Kotter 1995).

- 1) *Establishing a Sense of Urgency*- During this stage, it is imperative to identify and discuss crises, potential crises, or major opportunities. Over 50% of the business companies Kotter studied failed to establish a sense of urgency because they underestimated how difficult it can be to get people out of their comfort zones. In unsuccessful change attempts, the people became paralyzed by risks (Kotter & Cohen 2008). Most successful change efforts begin when some individuals come up with a concept and try to communicate their idea broadly and dramatically to core stakeholders. During this stage, transformational leaders need to convince at least 75% of the managers that the status quo will be more dangerous than attempting the new change (Kotter & Cohen, 2008).
- 2) *Forming a powerful guiding coalition*- Major renewal programs often begin with just one or two people. During successful transformation efforts, the leadership team continues to grow over time. During this step, it is important to assemble a team of people with enough influence to lead the change effort. When a minimum amount of people is not achieved early in the change effort, nothing significant will happen (Kotter & Cohen, 2008; Kotter 1995).
- 3) *Creating a vision*- The vision helps direct the change effort and is one of the most essential parts of the process. During this step, the leader creates a picture of what the new change will look like and the likely benefits of this change effort. For a leader to

effectively motivate and inspire others to action, a great leader must collectively paint a picture of what future success might look like (Kotter & Cohen, 2008; Kotter 1995).

Every team needs a strong vision to give it direction and purpose (Maxwell, 2001). The leader should dedicate time to make sure the vision is aligned with others on the team who are assisting with the change effort. Transformational leaders create a vision or ideal goal for others to work toward (Bryman, 1992). Kotter's rule of thumb is that if the transformational leader is unable to communicate the vision in five minutes or less and get a reaction that shows understanding and interest, the leader has not fully developed the vision and been able to clearly articulate it (Kotter & Cohen, 2008).

- 4) *Communicating that vision*- Transformational leaders develop an image of the future for their organization and communicate this vision to the people they are leading. By communicating the vision, the leader conveys a set of values which guides and motivates his/her people. A vision provides a common purpose for employees to work towards and promotes individual behavior which aligns with the leaders' values for the organization (Kouzes & Posner, 2007; Bass, 1985). Transformational leaders need to use every vehicle possible to communicate the new vision to all stakeholders involved (Kotter, 1995). Communication increases the commitment and connection of the members of the team (Maxwell, 2001). Collaboration and networking are key to implementing successful change (Fleming, 2015).
- 5) *Empowering others to act on the vision*- Transformational leaders involve team members in decision making. Such leaders share power and information with their staff and encourage autonomy (Kouzes & Posner, 2007; Nadler & Tushman, 1990). Leaders set up policies and procedures which allow the staff to be part of the problem-solving and

decision making. Empowerment involves creating a climate of establishing trust, respect, and open communication with constituents. When creating change, getting buy-in from other key stakeholders, and empowering them to act on the vision is imperative.

Transformation is not going to happen unless most people in the organization are willing to help and make short-term sacrifices to carry out the vision. Employees will not make sacrifices even when they are not happy with the status quo, unless they feel that the change is possible (Kotter & Cohen, 2008; Kotter, 1995).

- 6) *Planning for and creating short-term wins and removing obstacles to the new vision-* It is vital that leaders support their staff when challenging and difficult goals are set (Nadler & Tushman, 1990). Successful leaders acknowledge individuals, but also recognize team achievements and successes (Kouzes, and Posner, 2007). When leaders recognize the team, it provides proof of the leader's values and reinforces the efforts being undertaken. It builds an ongoing commitment to the vision of the leader (Carless et al, 2000). Transformational leaders need to spend time talking to key stakeholders and plan for unexpected challenges to arise (Fleming, 2015). Having an understanding of the needs and desires of the community where the transformational leader is initiating change is a vital part of the planning process (Fleming, 2015).

Obstacles will arise in any change process. Transformational leaders need to confront barriers which may include attitudes, old procedures, or lack of resources. Expect them to be a natural part of the change process. During transformational change, no organization can eliminate all the obstacles, but the big ones must be addressed and removed (Kotter & Cohen, 2008). Sometimes the obstacle is the organizational structure (Kotter & Cohen, 2008). Narrow job categories can make it very difficult to increase

productivity and create change. Other obstacles may include getting support from the supervisors of the organization. Kotter's research found that bosses who refuse to change or who make demands that are inconsistent with the overall effort, may be the most difficult challenge to overcome in the overall change effort (Kotter & Cohen, 2008).

When a supervisor does not support the change effort or does not understand or encourage the change, the entire change effort may be thwarted (Kotter & Cohen, 2008).

Transformational leaders find ways to gain needed support and buy-in from senior leadership when creating systematic change.

- 7) *Consolidating improvements and producing still more change*- Real transformation takes time. The change effort must include short term goals and ways to meet and celebrate these goals (Kotter & Cohen, 2008, Kotter, 1995). Change efforts can take years to truly be a part of the culture in the organization (Kotter & Cohen, 2008). Transformational leaders are active in looking for ways to celebrate clear performance improvements, set goals, and reward the people involved in accomplishing these goals. Commitments to creating short-term wins help keep the sense of urgency levels high, which can allow for analytical thinking and the opportunity to revise and clarify the vision (Kotter & Cohen, 2008). Transformational leadership entails challenging the status quo (Hechanova & Cementina-Olpoc, 2013).

All too often, transformational leaders declare victory too soon (Kotter & Cohen, 2008; Kotter, 1995). After a few years of hard work, leaders may be tempted to celebrate the victory with the first measurable performance goal. Declaring the war has been won based on the first year of performance can be catastrophic to the change effort. Changes must become deeply embedded into the organization's culture for the change to be

transformational. This process can take five to ten years (Kotter & Cohen, 2008, Kotter, 1995).

- 8) *Institutionalize new approaches and anchor change in the corporation's culture*- When transformational change has taken root, it will be embedded in the culture and be the way things are carried out daily within the organization. The new behavior or concept is part of the social norms and shared values of the organization (Kotter & Cohen, 2008, Kotter, 1995). Leaders often use innovative and unconventional approaches to achieve their goals (Kouzes & Posner, 2007; Bass, 1985). Transformational leaders encourage their staff to think creatively, take risks, and encourage innovative thinking (Carless, 2000).

Kouzes and Posner (2007) describe the change process for transformational leadership in terms of five sets of behaviors. When creating organizational change, Kouzes and Posner contend that leadership is all about relationships. This approach differs from the work of Kotter, as Kouzes and Posner prioritize relationships in every facet of transformational leadership. Kouzes and Posner found every leader modeled these five critical steps to promote collaboration and build systematic change: 1) Model the way 2) Inspire a shared vision 3) Challenge the process 4) Enable others to act, and 5) Encourage the heart (Kouzes & Posner, 2007).

1. *Model the way*. Kouzes and Posner (2007) claim that outstanding leaders must model the way and be an example of the expectations they place upon the people they supervise. Leaders must understand that if they want to establish momentum within the organization, gain commitments from the team members, and achieve the highest standards, they must be an example and model the behavior they expect from the people they lead. Transformational leaders must be clear about their guiding principles and clarify their values. When leaders model the way, they earn the respect of the people

they lead. People follow the person first, then they will follow their specific game plan to success (Kouzes & Posner, 2007).

2. *Inspire a shared vision.* One of the most important things any leader can do is to create a common vision. According to Kouzes and Posner (2007), leaders enlist others in a common vision. They must develop strong relationships with their people and know their team members' hopes, dreams, and aspirations. To build strong collaborative teams, leaders need to personally know the members they are leading. Transformational leaders give their constituents a sense of purpose (Kouzes and Posner, 2007). This stage is similar to Kotter's *Create a vision and Communicate the vision* (Kotter, 2007). The best leaders inspire others and take them to places they would not have gone on their own. One of the most essential skills a leader possesses is casting a vision. For a leader to effectively motivate and inspire others to action, a great leader must collectively paint a picture of what future success might look like (Kotter & Cohen, 2008; Fleming, 2015; Maxwell, 2001).
3. *Challenge the process.* Leaders must spend time answering the why change question? Every single case that Kouzes and Posner studied involved some type of challenge. The challenge involved a change from the status quo. (Kouzes and Posner, 2007). No case that demonstrated leadership involved keeping things the same. Leaders are considered pioneers and they search for ways to innovate, grow, and improve (Kouzes and Posner, 2007). Kotter & Cohen (2008) had somewhat similar findings as transformational leaders had to establish a sense of urgency when creating change and had to anticipate removing obstacles when trying to accomplish the new vision.

Successful leaders cannot afford to sit and allow the challenges they may face to overtake them. Leaders must venture out and search for ways to innovate, grow, and improve their collaborative teams and organizations. Leaders must be willing to take risks and sometimes fail (Kouzes & Posner, 2007).

4. *Enable others to act.* One cannot do it alone. A single person cannot accomplish anything of great significance. According to Kouzes and Posner (2007), to get extraordinary things accomplished in teams and in organizations, leaders must enable others to act. Their research found that transformational change requires developing a team. Kotter had almost identical findings as he called this stage, empower others to act on the vision (Kotter & Cohen, 2008; Kotter, 1995). The team must be taught the importance of trusting each team member. Kouzes and Posner found strong relationships must exist between the various team members. Great teams have strong collaboration between members and individual accountability. To accomplish extraordinary change, leaders have to empower others toward action (Kotter & Cohen, 2008; Kouzes & Posner, 2007). A shift must occur from “I” to “we” as STEM leaders inspire others to act. By spending time on the research about STEM and jointly working with administration on providing the necessary staff development to increase student and staff awareness, the makerspace movement can thrive!
5. *Encourage the heart.* While collaborative teams grow and work toward achieving the desired goal, team members can become frustrated and disgruntled. At times they may even be tempted to give up and try to remove themselves from the team. According to Kouzes and Posner (2007), leaders must encourage their teams to carry on by

encouraging the heart. Genuine acts of caring can encourage others to move forward with the change effort (Kouzes and Posner, 2007).

Employees should be recognized for their efforts as the transformational leader's job is to create a culture that celebrates victories (Kouzes and Posner, 2007). Kotter found that transformational leaders need to be intentional in planning for and creating short term wins (Kotter & Cohen, 2008; Kotter, 1995). A culture that celebrates team victories and values is essential for collaborative success!

**Application to leading STEM Education.** While there is a tremendous amount of research on transformational leadership in the business sector, there is little to no research on transformational leadership in STEM education, particularly at the elementary level and with regard to makerspaces. The limited research that does exist tends to focus on *why* makerspaces are important, but rarely focuses on *how* to launch a makerspace at the elementary level. However, the research evidence provides some guidance to school leaders, so I will synthesize what is known in this field.

All leaders, according to the research from Kouzes and Posner (2007), have encountered some kind of challenge. Creating makerspace labs will have challenges during the launching and implementation process. Adding makerspaces to the elementary school curriculum represents a major change in the way schools operate. As in any field, changing systems, structures, and policies that don't fit the traditional way of doing things will present challenges (Kotter, 1995). During the initial steps of the change process, expect people to be reluctant to change.

Leading a makerspace movement requires leaders to collectively share a vision of what the makerspace will look like before construction and creation of the space begins. When launching makerspaces, know that any change process will take time. As the educational leader

creates change in launching a makerspace, there will be people who will be resistant to change. One needs to plan for such obstacles and challenges as they are a common component of the change process. By inviting a wide variety of potential stakeholders and getting school board members, central administration, teachers, parents, and students on board with the makerspace concept, others can add value to the implementation project (Bonagura, 2017).

All too often, this is glossed over without spending the necessary time to promote sustainable change. The STEM leaders and administration must spend time with staff and the community educating others about the importance of building a makerspace. This may include using all forms of social media to convey the makerspace vision. Leading a makerspace movement requires leaders collectively sharing a vision of what the makerspace will look like before construction and creation of the space begins.

Education is a people business, so finding the right people is crucial to the success of any educational innovation. The success of the makerspace will hinge on selecting the right leaders and team members to facilitate change (Kotter & Cohen, 2008). In creating a makerspace lab, leadership may come from administration, the STEM teacher, central office staff and school board members (Bonagura, 2017). When relationships are strong between team members, the team will be more willing to make difficult and bold decisions. When relationships within the team are weak, teams will avoid making the difficult, but necessary, decisions to maximize performance (McLain Smith, 2008).

The leader of the makerspace lab must find ways to encourage staff and students. Creating and sustaining positive change is not an easy task. The makerspace leaders, staff, and students will experience some challenges along their way. Continuing to promote STEM and the deep understanding of content through the engineering process remains paramount, even though

it may not be easy. “Challenging the process” is when the leader finds innovative ways to help grow the organization and promote necessary improvements to the overall system. Leaders need to be able to take risks and be open to learn from their mistakes (Hechanova et al, 2013; Kouzes & Posner, 2007). “Inspiring a shared vision” describes a leader who creates a vision that is full of potential and seeks out followers to support the vision (Hechanova et al, 2013; Kouzes & Posner, 2007). “Enabling others to act” are leadership behaviors that empower followers to take action by giving them autonomy to make decisions (Hechanova et al, 2013; Kouzes and Posner, 2007). “Modeling the way” demonstrates the importance of leading by example. The leader must live out the values and visions articulated. “Encourage the heart” occurs when the leader recognizes the individual and team contributions and celebrates their victories during the change process (Hechanova et al, 2013; Kouzes & Posner, 2007). By taking risks and searching for creative ways to grow their makerspace, the lab has a much higher probability of succeeding!

This research study adds to the research literature by addressing the gap in our knowledge regarding the implementation of elementary school makerspaces. The purpose of this study is to analyze how school leaders launched a makerspace at a Mid-Atlantic elementary school, the processes they endured in launching the makerspace lab, and the critical partnerships they formed in this case study research.

## CHAPTER THREE: RESEARCH METHOD

In the last few years, makerspaces have experienced a tremendous rise in popularity and are starting to gain momentum in public schools. While most literature on makerspaces focuses on *why* makerspaces are important, little research exists regarding *how* to create makerspace labs in public elementary schools (Oliver, 2016). This study analyzed issues related to implementing a makerspace lab at King Elementary School (all names of people and organizational entities involved in this study are pseudonyms). This chapter describes the methodology that was used for this research study. Included in this chapter are the reasons why a case study approach is the research methodology, the research design, research questions, role of the researcher, setting, participants, instrumentation, data collection, data organization, data analysis, issues of trustworthiness, and ethical procedures.

King ES launched a makerspace lab in the 2017-2018 school year in a partnership with Computers Inc. and Champion University. The makerspace lab serviced over 1,000 students from King ES and other schools within Caesar School District. During the initial implementation year, King ES had over 1,000 visitors attend the makerspace lab. School leaders, central office leaders and local university leaders who played a role in implementing the makerspace lab were interviewed individually regarding the makerspace lab implementation process.

I used a case study methodology to focus on *why* school leaders launched a makerspace program and *how* educational and business leaders implemented the makerspace lab initiative. The why question is important to describe the motivation of the leaders, but emphasis was placed on how the implementation occurred. The purpose of this qualitative study was to document and describe the change process connected with the implementation of the makerspace lab, how

leaders navigated various obstacles, perceptions of the change process, and the lessons learned from educators.

### **Research Design**

Case studies ask how and why questions and allow the researcher to provide a holistic study of real life events (Yin, 2003). Case studies take a detailed look at the phenomenon, or the case, in its natural context and gain a perspective from the participants involved in this phenomenon (Yin, 2003). Case studies are an “in-depth description and analysis of a bounded system” (Merriam & Tisdell, 2016, p.37). Case study research contributes to the field of knowledge for the individual, group, and organization (Yin, 2003).

In this study, I specifically looked at *why* school leaders decided to launch a makerspace lab and *how* the makerspace lab has been implemented at King ES. I utilized an exploratory case study approach by building common understandings throughout the entire research process, including the collection and analysis of data (Yin, 2003). Exploratory models are beneficial in areas where previous research is not abundant (Yin, 2003). The implementation process, as perceived by school leaders, central office staff, local university staff, and business leaders at King ES, was examined with the hope of adding to the existing body of knowledge on the makerspace lab implementation process.

### **IRB Approval**

To protect the identities of the school district, King Elementary School, Computers Inc., Champion University, and the individuals in this research, pseudonyms were used for all people, places, committee names and organizations. Since this research study involved people, a submission to the Institutional Review Board (IRB) at Virginia Tech and the Western IRB was

required. An informed consent form was signed by all parties involved prior to any interviews taking place.

### **Research Questions**

This study investigates the process school leaders followed when adopting an elementary school makerspace lab. The following research questions will guide the study.

1. Why did the school leaders decide to implement the makerspace lab?
2. How did the school leaders obtain the resources to launch the makerspace lab?
3. What factors (supports and obstacles) influenced the implementation of the makerspace lab?
4. What are the lessons learned from the leaders and school personnel who were involved in launching the makerspace lab initiative?

### **Role of the Researcher**

The role of the researcher is significant in qualitative research, as there is a need to reduce possible bias. Research stances can range from that of a complete participant to that of being a spectator (Merriam & Tisdell, 2016; Creswell, 2003). My positioning in this study is important because I served multiple roles. I currently serve as the building principal at King Elementary School, the primary researcher, and have been an active participant and leader in launching the makerspace lab. In my role as building principal, I was responsible for helping lead the makerspace lab implementation at my school. Analytical reflexivity is needed to explain my biases, dispositions, and assumptions regarding this makerspace lab initiative. My overlapping role of principal, researcher, and participant was the biggest challenge in this study. As the principal of King Elementary School, I was motivated to seek out key stakeholders to

consider launching this makerspace initiative. In my role as principal, I had to be a change agent and determine who would help further promote the makerspace lab. I also needed to help create a sense of urgency with key stakeholders and challenge traditional practices regarding STEM education. It should be noted that the makerspace lab was launched independently from any research study. It should also be noted that I elected to write the results section of Chapter 4 and the introduction of Chapter 5 in the third person to separate myself from the findings and because it is easier for the reader to follow.

### **Setting**

This study took place at King Elementary School (King ES) which is a Mid-Atlantic School that serves approximately 600 students in grades K-5. King ES has a diverse student population of over 10% Hispanic, over 10% African American, and over 50% White. The elementary makerspace lab was launched to reach all students at King ES, with additional outreach opportunities being extended to students in the surrounding region within Caesar School District. Students from other schools within the district attended the makerspace lab at King as a one-day field trip experience. The makerspace lab accommodates one classroom of up to 30 students per day. King ES did not have a makerspace lab before this pilot initiative started. Every student from King ES visited the makerspace lab a minimum of two times during the initial implementation year. During the first year of implementation, over 1,500 students, 100 parents, 127 classrooms, 10 elementary schools, and 5 principals from neighboring schools visited the King ES makerspace lab. The makerspace lab at King ES was considered a hub, or extension of the makerspace lab at Champion University. The elementary makerspace lab at King ES served as a model initiative for Caesar School District highlighting the partnership that was formed between Champion University, Computers Inc., King ES, LIGHT, and Caesar

School District. LIGHT is an educational community foundation that Caesar School District has established to help create partnerships between the school system and other business partners.

### **Participants**

Purposeful sampling was used to select the participants in this case study research (Merriam & Tisdell, 2016). Purposeful sampling occurs when the investigator determines what selection criteria is necessary and then selects a sample from which the most can be learned (Merriam & Tisdell, 2016). Participants in this study were purposefully selected to collect the richest data possible in relation to the phenomenon being studied. To gain an in-depth understanding of the change process, interviews of various stakeholders related to the implementation of the makerspace lab were conducted.

Specific criteria were used to select potential participants. King ES was selected as the site because its recent implementation of the makerspace lab aligns with my interest in studying the implementation of such labs. Specific school personnel were selected to participate in this study to better understand the change process educational leaders went through when launching the lab. These leaders and staff were selected because they had some role in the implementation process and could provide input regarding the change process.

At the school level, Mary, the full time STEM teacher, was selected as she played an important role in the implementation process. As the current principal at King ES, I was directly involved in the implementation process of the makerspace lab. While being the principal, participant, and researcher of this project, it was necessary to conduct an interview on myself. A teacher focus group consisting of six staff members from King ES, was selected to gain a better

understanding of the staff reaction to the lab initiative and to gather feedback on ways the process could have been improved.

Participants who do not work at King ES were selected if they either played a role in the implementation process or were impacted by the lab in some fashion. Central office personnel at Caesar School District, professors at Champion University, and a senior executive from Computers Inc. were interviewed because of their role in the lab implementation process. Individual interviews occurred with selected participants from these organizations who played an active role in the implementation process. The purpose of these interviews was to gather data to gain a comprehensive overview and picture of the lab implementation process.

At the district level, four central office personnel from Caesar District were selected to participate in this study. These participants included the Caesar District's Superintendent, Samson; the Associate Superintendent, Esther; the Director of Finance, David; and the Director of LIGHT, Eve.

Champion University professors that played a role in supporting the makerspace implementation process at King ES were participants in this study. These participants include the lab director from Champion University's Makerspace Lab, Luke and a professor at Champion University, Peter who introduced me to the makerspace lab at Champion University.

A business leader from Computers Inc. was selected for this study as well. One of the founders of the makerspace programs, and Computers Inc. Executive, Rachel, was a participant in this research project. Rachel played a vital role in providing the initial vision for the makerspace labs throughout the country. Rachel was responsible for building the infrastructure

for the community partnerships and was pivotal in uniting business partners with universities and local school districts.

A total of nine individual interviews occurred independently at a time and location that was convenient for the participants. Informed consent was signed before any interviews occurred. In addition to these individual interviews, a teacher focus group of six teachers from King ES was conducted to gain additional insights on the implementation process of the makerspace lab at King ES.

### **Data Collection**

Case study research requires the investigator to explore a bounded system, or case, over time through detailed and in-depth data collection, involving multiple sources of evidence. (Creswell, 2003; Merriam & Tisdell, 2016). In this research, I used interviews and documents as my primary sources of data because they provide the greatest insight into the perceptions of the values, beliefs, and challenges leaders experienced during this pilot elementary makerspace initiative. Individual interviews allowed me to gain multiple perspectives that most closely align with each individual experience. The interview questions and protocols were developed using guidelines for effective interviews (Merriam & Tisdell, 2016). A document review allowed me to chronologically analyze significant moments in the change and makerspace implementation process. Documents included, but were not limited to, makerspace lab emails, field notes, school programs, school agendas, and the principal's reflection journal.

To ensure reliability, I compared and cross-checked data and converged all these data sources together through triangulation (Creswell, 2003). By merging all these data sources together, I examined evidence from multiple sources and used it to create a justification for

specific themes that emerged from the research. (Creswell, 2003). Specific protocols were followed for data collection to enhance credibility, dependability, and transferability in this study.

## **Interviews**

I contacted potential participants about the interviews to explain the purpose of the study and invited them to sign a letter of consent. I scheduled personal interviews that were held at a time and location that was convenient for each individual participant in this study. Interviews were conducted with nine key leaders, including interviewing myself as the principal of King ES. The purpose of the interviews was to gain an in-depth understanding of the educational leaders' perceptions, beliefs, and factors they feel impacted the implementation process of the makerspace lab. I used a semi-structured interview process, so I had both established questions and the opportunity to ask more specific questions as needed. When interviewing those most closely connected with the implementation of the lab, I focused my questions on those aspects of the implementation process with which they were most familiar. For example, the lead teacher in the makerspace lab discussed day-to-day operations in the lab, while central office personnel were questioned about issues such as providing resources to support the lab. Each interview lasted no longer than an hour in duration.

At the conclusion of each interview, I recorded my significant observations and reflections in the principal's journal. I personally transcribed each interview and asked each participant to review my notes for accuracy. I also noted any modifications that needed to be made in subsequent interviews. Table 1 displays the alignment between the research questions and interview questions. Table 2 displays the probing questions that were used to follow-up on the interview questions.

Table 1 *Alignment of Initial Interview Questions with Research Questions*

Research Questions	Initial Interview Questions
Why did the school leaders decide to implement the elementary makerspace lab?	What do you see as the benefits to an elementary makerspace lab?
How did the school leaders obtain the resources to launch the elementary makerspace lab?	<p>What was your role in the process?</p> <p>How did school leaders interact with central office and other agencies in moving this initiative forward?</p> <p>What did school leaders do to influence the decision to fund the makerspace lab?</p>
What factors (supports and obstacles) influenced the implementation of the elementary makerspace lab?	<p>What factors were required for this elementary makerspace lab to be successful?</p> <p>What process was used to finalize the decision to move forward at central office?</p> <p>What were your concerns with this initiative?</p>
What are the lessons learned from the leaders and school personnel that were involved in launching the elementary makerspace lab initiative?	What did you learn from this initiative?

Table 2 *Alignment of Initial Interview Questions with Probing Interview Questions*

Initial Interview Questions	Probing Interview Questions
What do you see as the benefits to an elementary makerspace lab?	Why was the lab a priority?
Tell me the story of how this elementary makerspace lab came into existence.	How did this happen?
What was your role in this process?	What specific actions did you take to make this happen?
How did school leaders interact with central office and other outside agencies to help move this initiative forward?	What resources did school leaders secure from central office that were essential in this initiative?  What role did these outside agencies play in the implementation process?
What factors were required for this elementary makerspace lab to be successful?	Which of these really stand out?  How important were the community partners in this initiative? Why?
What process was used to finalize the decision to move forward at central office?	Who played an instrumental role at central office in this process in securing necessary resources? Why?  How was it decided that the makerspace lab at King ES would receive additional funding?
What were your concerns regarding this initiative?	How were these concerns addressed to move forward with this initiative?
What did you learn from this initiative?	What makes the elementary makerspace lab unique?

## **Documents**

Ensuring the credibility of case study research requires the collection of data from multiple sources of evidence (Merriam & Tisdell, 2016; Creswell, 2003; Yin, 2003). Case documentation for this study was valuable in examining themes in educational leaders' beliefs, perceptions and understandings regarding the implementation process. Documents included transcriptions, emails, agendas, and the principal's journal entries. Since these documents were produced for reasons other than the study at hand, some purposeful sampling was needed to locate pertinent documents that focus on the research question (Merriam & Tisdell, 2016).

During the implementation of the makerspace lab, emails regarding the makerspace lab implementation were chronologically studied. Emails that offer data and insights to the makerspace implementation process were analyzed. I was open to any possibility that could lead to new discoveries and themes. I collected data until I felt no new discoveries were being revealed through the interview process and document review.

## **Data Organization**

A plan for data organization was necessary to prepare the data for analysis. I used a password-protected laptop to contain my dissertation, my notes, and digital files. I kept my computer back-up file in a locked cabinet, to which I have sole access. A secured location, separate from the computer back up, contained all paper documents, records, and transcriptions. Data will be stored securely for a minimum of three years after the completion of the study.

I will maintain a key that contains the original names of the participants and organizations along with the pseudonyms used in this research project in a separate locked

location to which I have sole access. The key will be stored in a secured location that is separate from the data.

### **Data Analysis: Level 1**

In case study research, the researcher collects and analyzes data simultaneously (Cousin, 2005; Merriam & Tisdell, 2016). The qualitative data analysis of this case study involved a description of the setting and individuals, “followed by analysis of the data for themes or issues” (Creswell, 2003, p. 191).

Data analysis involves making meaning out of the data and requires moving back and forth between concrete data and abstract concepts (Merriam & Tisdell, 2016). Data analysis is the process used to answer the research questions. To answer my research questions, I used a constant comparative method (Merriam & Tisdell, 2016). I personally transcribed each interview to gain a deep understanding of my data.

After each individual interview was transcribed, I utilized a line-by-line coding process of coding and category construction on each interview transcript (Creswell, 2003). Each code was analyzed to determine what specific categories emerged from the individual interviews. After various codes were analyzed, I color coded individual codes and grouped the individual codes into clusters. The process was the same for the teacher focus group. I cross checked these findings to see how they compared to my overall impression in my principal’s journal.

To ensure credibility, I conducted member checks or respondent validation by soliciting feedback from the people I interviewed (Merriam & Tisdell, 2016). I had each participant review my notes for accuracy. This helped rule out the possibility of misinterpreting my preliminary or

emerging findings. When necessary, I went back and recoded the interview findings to create more specific and detailed categories to reflect what the interviewee was trying to communicate.

I examined the specific email documents, educational programs, and agendas involving the makerspace initiative. I searched for data from these documents and artifacts. The documents that were pivotal in the implementation phase of the makerspace lab were analyzed in relation to the research question.

### **Data Analysis: Level 2**

After the individual interview transcripts were coded and categorized, the second phase consisted of examining the coded and categorized data for patterns, themes, and relationships. Next, I grouped the codes into categories and began to identify specific themes that emerged when studying the entire body of data. I analyzed what relationships and themes existed when combining the data sources together. These themes were color coded, clustered, and matched to the specific research question.

I looked for specific themes that emerged from educational leaders regarding their perceptions, values, and beliefs about the implementation of an elementary makerspace program. I used my research question as a framework for this document analysis. Data were coded and categorized based on output from individual interviews, the teacher focus group interview, and the document reviews.

### **Issues of Trustworthiness**

One goal of this research was to add to the existing literature regarding the implementation of elementary school makerspaces. In qualitative research, trustworthy results rely on the ethical behaviors of the researcher. Considerable attention was given to the research

design, analysis, and interpretation of the findings. Specific implementation strategies were used to increase credibility, dependability, transferability, and confirmability of this qualitative study.

### **Credibility**

Credibility of a study determines how the research findings match reality (Merriam & Tisdell, 2016). For a design to be credible, triangulation, respondent validation, adequate engagement in data collection, and researcher's position must be utilized. By making use of multiple sources of data to include educational leader interviews, a teacher focus-group interview, and document reviews, triangulation increased the internal validity of my research. I utilized respondent validation, or member checks, to seek feedback from the participants to verify that the interview analysis was an accurate assessment of what participants in this study were trying to communicate during the interview. When there were discrepancies, I adjusted the findings to better capture their perspectives. Adequate engagement in data collection was used to get as close as possible to the participant's perceptions, values, and beliefs regarding implementation of the makerspace lab pilot initiative (Merriam & Tisdell, 2016). I continued to collect data on the implementation process until the emerging findings felt saturated. I used researcher's position, or reflexivity, by continually reflecting on my biases, and perspectives, and explained how these values and expectations may have impacted this study. Finally, I utilized a peer review strategy by discussing my emerging findings with colleagues from my doctoral cohort.

### **Dependability**

Dependability or reliability refers to if the research findings can be replicated (Merriam & Tisdell, 2016). If the study were to be replicated, would it yield the same results?

Dependability is problematic because human behavior is never static, nor is what many people

experience more reliable than what one person experiences (Merriam & Tisdell, 2016).

Replication of a qualitative study will not yield identical results. In case study research, what is critical is whether the results are consistent with the data collected. (Merriam & Tisdell, 2016).

In this study, I used triangulation, respondent validation, data collection, and researcher's position to help ensure the findings were dependable. In addition to these strategies, I used an audit trail to increase dependability in this study. An audit trail gave a detailed account of the methods, procedures, and decision points when carrying out this study (Merriam & Tisdell, 2016).

### **Transferability**

Transferability, or external validity, determines if the findings of one study can be applied to other situations (Merriam & Tisdell, 2016). Transferability seeks to understand how generalizable the results of the research study are to other settings. For the reader to determine whether the results from the context of this study would transfer to the context in which they work, the researcher must supply detailed descriptions of the context and the phenomena being studied.

For the transferability of the study, I developed what Merriam and Tisdell (2016) described as "rich, thick descriptions" of the data collection and data analysis process which would allow readers to assess the similarities between their current situation and this specific study (Merriam & Tisdell, 2016, p.256). I provided enough data, so the reader was able to determine how similar their situation is to this case study research. The more similar the reader's situation is to this research project, the more likely they can transfer the results to their specific situation.

## **Confirmability**

Qualitative studies rely on the integrity of the researcher. Researchers must be aware and reflect on their own biases, beliefs, perceptions, and values. Reflexivity, or researcher's position, is how the researcher impacts and is impacted by the research process (Merriam and Tisdell, 2016). Researchers need to explain their biases, dispositions, and assumptions about the research project.

As the principal at King ES and researcher of this project, I reflected on my biases, dispositions, and assumptions about this project and examined the data from alternative perspectives. To minimize these biases, I kept a reflexivity journal to articulate my assumptions, experiences, and world view regarding makerspace lab initiatives. The purpose of this journal was to clarify how I interpreted the data from this initiative, record my interpretations from the individual and team interviews, and summarize key points from the interview.

## **Ethical Procedures**

The trustworthiness of a study depends on the ethics of the researcher. The credibility of the researcher and the rigorous methods used are vital components to the process. The training, experience, and rigor of the researcher determines the credibility of the qualitative research study (Patton, 2015). As this research project occurred in a natural setting, ethical dilemmas could have been encountered and confidentiality could have inadvertently been compromised. The working relationships between myself, as the researcher, and the participants in this study could have unforeseen consequences. Each participant was provided with the purpose of the research study, gave informed consent, and was involved in member checks to ensure credibility, transferability, and dependability in this qualitative study.

The necessary safeguards were put in place by seeking approval and informed consent from all participants in this study. Approval from the Institutional Review Board (IRB) at Virginia Tech and the Western IRB were necessary to help prevent unethical behaviors. Permission to conduct the study was obtained by Caesar School District.

### **Summary**

Chapter 3 included a description of the research design, research questions, role of the researcher, setting, participants, instrumentation, data collection, data organization, data analysis, issues of trustworthiness, ethical procedures, and the reasons why a case study approach was the research methodology. An exploratory case study approach was utilized as I built common understandings through the entire research process, including the collection and analysis of data (Yin, 2003). The implementation process of a makerspace lab at one elementary school, as perceived by school leaders, central office staff, university staff, and business leaders was examined with the goal of adding to the existing body of knowledge regarding STEM education.

## CHAPTER FOUR: RESULTS

Globalization and technological advances have pressured employers and educational institutions to change. To prepare students for the future workforce, schools must revisit existing practices and find new ways to foster innovative ideas and skills in all students through STEM education. An interesting change being adopted in some elementary schools involves adding makerspaces, which can provide new and innovative ways to promote STEM educational opportunities and promote needed skills, ideas, and mindsets students should possess upon graduation. The purpose of this case study was to describe why and how school leaders implemented a makerspace lab in an elementary school.

To accomplish this purpose, the researcher examined the change process connected with the implementation of the makerspace lab at a Mid-Atlantic elementary school (King ES), how leaders navigated through various obstacles, perceptions of the change process, and the lessons learned from educators. The research yielded several key findings regarding what leaders determined to be significant when launching the elementary makerspace. From these key findings, themes were developed based on data from school and business leader interviews, along with a document review of the entire implementation process.

This study investigated the process school leaders followed when adopting an elementary makerspace lab. The following research questions guided this study.

1. Why did school leaders decide to implement an elementary makerspace lab?
2. How did school leaders obtain the resources to launch an elementary makerspace lab?
3. What factors (supports and obstacles) influenced the implementation of the makerspace lab?

4. What are the lessons learned from the leaders and school personnel who were involved in launching the elementary makerspace lab initiative?

### **Participant Demographics**

The participants in this study included primarily school leaders from King ES along with central office personnel within Caesar School District. Participants also included university personnel from Champion University and a senior business leader from Computers Inc. that partnered with King ES during this initiative. Table 3 highlights participant demographics.

*Table 3 Participant Demographics*

Participant(s)	Experience	Position
<b>King Elementary School</b>		
Mark	22 years	Principal
Mary	17 years	STEM teacher
Teacher Focus Group	20 years to 36 years	K-5 Teachers
<b>Caesar School District</b>		
Samson	40 years	Superintendent
Esther	36 years	Associate Superintendent
David	29 years	Director of Finance
Eve	15 years	Director of LIGHT
<b>Champion University</b>		
Luke	21 years	Director of Champion Lab
Peter	14 years	Professor
<b>Computers Inc.</b>		
Rachel	36 years	Vice President

Each participant in this study had over 10 years of experience in their respective fields. Purposeful sampling was used to select these participants who played a role in the implementation of the makerspace lab at King ES.

### **Data Collection**

Data were collected from multiple sources of evidence. Interviews and documents served as the primary sources of data, as they provided the greatest insights into the perceptions of the values, beliefs, and challenges leaders experienced during this elementary makerspace initiative. Individual interviews were conducted using a semi-structured interview format. This allowed the researcher to customize each individual interview and gain insights that most closely matched the participant's area of expertise. A document review was conducted to chronologically capture and analyze significant moments in the change and makerspace implementation process.

### **Interview Data**

Individual interviews began on October 10, 2018 and concluded on November 27, 2018. Individual participants were asked questions pertaining to the process school leaders experienced when launching the makerspace lab at King ES during the 2017-2018 school year. A focus group, consisting of six teachers from King ES were interviewed on November 5, 2018 regarding their perceptions with the makerspace initiative and the impact the makerspace lab had on them professionally. The teacher cohort specifically answered questions pertaining to their perceptions about how the makerspace lab was launched at King ES and discussed what could

have been changed to make the implementation process better. They reflected on the impact the makerspace lab at King ES had on their instructional practices.

Interviews took place at multiple locations, including King Elementary School, Caesar School District's Central Office Building, and Champion University. Each interview lasted no longer than an hour in duration. On October 10, 2018, the King Elementary School principal began individual interviews by conducting a self-guided personal interview before interviewing other participants. This was done at the onset of the interview process as the researcher did not want to be influenced by other participants' responses, and to demonstrate analytic reflexivity. All interviews were conducted in person, with the exception of two interviews that were conducted over the phone due to travel considerations. The researcher conducted a total of nine individual interviews to gain an in-depth understanding of the educational and business leaders' attitudes, beliefs, and perceptions of factors they felt impacted the implementation process of the makerspace lab. Interviews were recorded with multiple digital audio recorders and were personally transcribed by the researcher to gain a deep and rich understanding of the data.

## **Documents**

Case documents for this study were valuable to examine events, patterns, and themes in educational leaders' beliefs, perceptions, and understandings regarding the implementation process. The researcher used purposeful sampling to locate pertinent documents that focused on the research questions. Purposeful sampling occurs when the investigator determines what selection criteria is necessary and then selects from the sample from which the most can be learned (Merriam & Tisdell, 2016). To gain an in-depth understanding of the change process, documents related to the implementation of the makerspace lab were collected. Documents

included transcriptions, emails, artifacts, agendas, and the principal's journal entries regarding the makerspace lab initiative at King ES.

Specific criteria were used to select the documents for this study. King ES was selected as the site because of its recent implementation of the makerspace lab aligns with the researcher's interest in studying the implementation of such labs. Specific documents were selected to better understand the change process educational leaders went through when launching the lab. Documents were selected because they had valuable information regarding the change process when implementing the makerspace lab at King ES.

The document review was beneficial to construct a timeline of significant events in the implementation process, study emerging themes, and it confirmed many of the findings from the individual interviews. The document review also captured important data regarding the total number of visitors that attended the lab during the initial implementation year.

### **Organization of Data**

Electronic data to include interview transcripts and MP3 audio recordings were organized by each participant's name, stored on a computer hard drive, and saved using a portable flash drive. Paper copies of the individual transcripts were identified by each individual leader's name and stored in a locked file cabinet. Pseudonyms were created for all participants to ensure anonymity. The key to the pseudonyms was filed in a separate locked cabinet to ensure confidentiality.

### **Data Analysis: Level 1 Coding and Category Construction**

Data analysis involves making meaning out of data and required moving back and forth from concrete data to abstract data (Merriam & Tisdell, 2016). After each individual interview,

the researcher personally transcribed each interview to gain a deeper understanding of the data. After the transcription was complete, a process of line-by-line coding and category construction was utilized (Creswell, 2003). Each code was analyzed to determine what specific clusters or categories emerged from the individual interviews. The process was the same for the teacher cohort interview. The findings were cross-checked and compared with the researcher's overall impression in his principal's journal.

Each individual's coded transcripts were manipulated and clustered using a color-coded system. Each individual code was analyzed and manually clustered by physically placing the color-coded paper strips into similar groups. For, example, all of Mary's coded responses were copied on blue paper. Mary's coded responses were then individually separated, being identifiable by its blue color, and individually grouped into the appropriate cluster. During this initial process, specific categories began to emerge. While this process was initially cumbersome, it allowed the researcher to get as close to the data as possible. This process allowed the researcher to make meaning out of the data, moving from concrete data (color coded data strips) to more abstract concepts (emerging categories). Table 4 highlights the emerging categories from this data analysis.

Table 4 *Emerging Categories from Interview Data*

Category	Description
Transformational moment	Experience a new concept that challenges traditional educational practices
Vision	Develop a concept design that inspires others
Community partnerships	Champion University- leading engineering university  Computers Inc.- Fortune 500 Company  LIGHT- Educational Community Foundation
Model program and mentors	Model Program- Champion University's Makerspace Lab  Mentor- Luke, Lab Director of Champion University's Makerspace Lab  Peter- Professor and mentor at Champion University
Transformational leadership	Leaders navigate change during this initiative
Inspire others	Students, staff, educational and business leaders are motivated to promote STEM educational opportunities

### **Data Analysis: Level 2**

After this process, the researcher listened to each individual interview again to gain a holistic perspective on the data. The researcher recorded notes and identified themes in his principal's journal that began to emerge from the audio recorded interviews. The goal was to synthesize clusters and move from categories to emerging themes.

The researcher revisited the existing categories and tried to develop common strands between the data. The researcher clustered, organized, and cross-checked the categories. Titles

were given to categories and emerging themes. The researcher cross-checked initial findings, reviewed individual transcripts and recoded the data. Cross-checking ensured the findings accurately reflected the data from the individual interviews and document review.

After categories were established and emerging themes were determined, the emerging findings were linked to the research questions. A color-coded system was created and assigned to each research question. For example, “Why did school leaders decide to implement a makerspace lab?” was assigned a pink code. “How did school leaders obtain the resources to launch a makerspace lab?” was assigned a yellow code. The researcher went back to the original individual interview transcripts and highlighted pertinent data corresponding to this question in the appropriate color. From this data analysis, specific categories were clustered under the corresponding question and themes were reinforced.

Data were coded and categorized based on output from individual interviews, the teacher focus group interview, and the document review. A case analysis using inductive and comparative method was utilized across all sources of evidence, searching for similarities and differences. From this analysis, Table 5 and 6 highlight seven themes that emerged from the data regarding educational leaders’ perceptions, values, and beliefs about the implementation of an elementary makerspace lab.

Table 5 *Key Findings for Research Questions*

Research Question	Theme	Key Findings
Why did school leaders decide to implement a makerspace lab?	1: Adults recognize the untapped potential of young learners	Experience a novel concept
		Transformational moment
		Inspire adults to action
		Early exposure
How did school leaders obtain resources to launch a makerspace lab?	2: Passionate leaders as change agents	Passion
		Drive
		Formulate an innovative idea
		Form a guiding coalition of leaders
		Create a shared vision that can be operationalized
		Construct the makerspace lab
	3: Cast a wide net	Empower others to act on vision
		Establish Community Partnerships
		Involve the superintendent, school board, and central office
		Invite other schools
		Recruit other principals
		Conduct a grand opening ceremony
4: Exhaust all options	Site-based management	
	Community Partnerships influence funding	
	School initiative became a District opportunity	

Table 6 *Key Findings for Research Questions*

Research Question	Theme	Key Findings
What factors (supports and obstacles) influenced the implementation of the makerspace lab?	5: Have the right people	Have the right STEM teacher (Qualities of the right STEM teacher)
		Have the right principal leader
		Secure strong mentors
	6: Have a strong model to emulate but make it your own	Enlist support staff
		Find a strong model program Model makerspace components
	7: Overcoming obstacles	Reluctance to change
		Encourage Equity
Promote Diversity		
Secure Funding		
What are lessons learned from the leaders and school personnel that are involved in launching this makerspace lab initiative?	8: A model makerspace can shift mindsets and inspire others.	Inspire students Inspire teachers Inspire parents

## Research Question 1

The first research question asked, “Why did the school leaders decide to implement a makerspace lab?” Four categories emerged from an analysis of the interview transcripts and document reviews. The categories explain the reasons *why* school leaders embarked on this journey: adults experienced a novel concept, underwent a transformational moment, were inspired to action as a result of their STEM experiences and promoted STEM resilience through early exposure. These four categories combine to form the first theme.

**Theme 1: Adults recognize the untapped potential of young learners.** In each of the individual interviews, school leaders, university personnel, and business leaders recognized the untapped potential in young students. Most participants in this study shared some type of experience in which a child exceeded the adult’s expectations and demonstrated potential that exceeded initial adult determinations.

Several adult participants discussed how STEM educational opportunities should be started early to challenge students’ interest and imagination in elementary school. Many participants noted how students demonstrated exceptional and/or unanticipated levels creativity and potential that schools often fail to elicit or nurture. After personally witnessing elementary students’ STEM abilities that exceeded their personal expectations, school leaders experienced a sense of urgency to act and promote needed change. The leaders worked in their sphere of influence to foster student growth and encourage more STEM educational opportunities for elementary-aged students.

***Experience a novel concept.*** School leaders decided to implement an elementary makerspace lab because they directly experienced a novel concept themselves. Data analysis

revealed both the school principal (Mark) and school STEM teacher (Mary) each went on a field trip to Champion University's makerspace lab (Mary was a fourth grade teacher at the time of the field trip). These experiences were their first exposure to a STEM makerspace lab. Mark experienced a cutting-edge STEM model when visiting the makerspace lab at Champion University and Computers Inc.

Champion University and Computers Inc. were launching a new innovative makerspace lab located on Champion University's campus. My professor, Peter, wanted to give us a special opportunity to experience it. We went to the makerspace lab at Champion University, instead of going to my doctoral class, one evening. I have never laughed so hard. We engaged in hands-on learning and built something using servo motors. I had never experienced anything like it! We really had to think outside the box.

Mary described the change she experienced when visiting Champion University's Lab.

It started with a field trip to Champion University and Computers Inc. Makerspace Lab. I took a group of fourth grade students there. At that time, I was a fourth grade teacher. It was magical, in the sense that it was a difficult day for them intellectually. But watching them work, and fail, and survive, and move forward was absolutely amazing! I have always tried to teach standing back a bit and frontloading. Letting kids explore and figure it out. But in that moment at the lab, it was, "Wow! What a great way of learning!" I saw it work. In four short hours, I saw kids who knew absolutely nothing about a subject matter become masters, within four short hours!

Central office staff members experienced an innovative concept when they attended a makerspace lab at King ES. The experience helped provide motivation for them to support the

school leaders in this endeavor. Esther, the Associate Superintendent in Caesar School District described her first experience with an atypical initiative, when attending the makerspace lab at King ES. “Learning is experiencing. This opportunity, at the makerspace lab at King ES, gave kids, I believe, an experience of a lifetime. I would compare it to a Disney World experience!”

Dr. Samson, Superintendent of Caesar School District, shared a similar experience when visiting the makerspace lab at King ES.

All you have to do is watch the kids working in the makerspace lab at King ES. You can see how they are making connections and how they are working with other kids and engaging in their learning. The students are coming up with outcomes and are coming out with things they were actually able to create. They are having programming opportunities and moving from an idea to a finished product. All of those things were demonstrated at the makerspace lab at King ES. To me, all of that was very exciting!

***Transformational moment.*** A second reason school leaders launched a makerspace lab was because the school leaders at King ES and other leaders experienced a transformational moment.

Mary, the STEM teacher at King ES, said she underwent a life-changing experience.

I felt like I came back changed from that field trip. The transformational moment for me was watching my students struggle and having the struggle be a stepping stone to learning. Another transformational moment was seeing kids who really struggle in the mainstream class just shine. Two of my boys, who were stronger in math, really struggled with communication. As they worked together in the makerspace lab, they were able to communicate this idea of an elevator and then build it! It was so cool! So much

happened when we visited the Champion University's Makerspace Lab. It really was transformational!

Luke, the Lab Director of the Champion University's Makerspace Lab, described his new way of thinking.

That was transformative for me, back in October 2016. It reinforced some things that I witnessed, in happenstance, when groups visited the lab at Champion University. I just said, "I am not intimidated by reaching out younger now."

Mark, the building principal at King ES, described his epiphany.

That evening, I remember going home and waking up in the middle of the night thinking, "That was an incredible experience!" It revolutionized the way I thought about education. I realized that I needed to do something differently as an educator.

***Inspire adults to action.*** The third reason why school leaders decided to implement the makerspace lab was their STEM experiences inspired them to act. In multiple interviews, adult participants expressed how they needed to do something in response to what they witnessed in the makerspace lab. Multiple examples and testimonies were given by adults who were introduced to some exemplar makerspace opportunity, experienced a provoking moment, and were energized to respond.

Luke, the Director of the Champion University Makerspace Lab, experienced this phenomenon with adult leaders.

I can tell you this is the first time I can remember in just about anything I have done, where people walk in (to the makerspace lab at Champion University) and say, "I want

this!” King ES was among the very first. King ES leaders were also the first to actually do something about it.

Peter, a professor at Champion University, explained how the makerspace lab at Champion University helped galvanize other adults. “To me, the big thing about Champion University’s makerspace lab, more than inspiring the kids, it is inspiring the adults to do something, like you guys were doing.”

Eve, the Director of Light, which promotes collaboration between the district and businesses, was determined to reach out to other central office staff members and potential business partners after visiting the makerspace lab at King ES.

After experiencing your lab, we went to every single supervisor. We brokered a deal with the Director of Finance. We did all that we could. We wanted to support your passion. We wanted to support what the right thing was for kids.

Mary, the STEM Teacher at King ES, was motivated to change but managed her emotions and behavior in a different fashion.

I was upset because I knew the field trip to the makerspace lab was over. I knew it was over and we would never be able to go back. I got a little angry. I was literally in a bad mood for four solid days. That’s when I had a conversation with my husband. I thought if other locations can create a field trip experience at their school, we could too! I was like, this is happening. And if it doesn’t happen here, I am going to make it happen somewhere else. It was a call to action. It became a passion project.

***Early Exposure.*** The fourth reason why school leaders decided to implement a makerspace lab was they saw the need to build STEM resilience through early exposure. The

participants in this study emphasized the importance of prioritizing STEM educational opportunities for students when they are in elementary school.

Luke, the Lab Director, shared his feelings about starting STEM education early.

I still think and firmly believe that a critical component to building STEM resilience is early exposure. Certainly, I have taught myself things in my thirties, forties, and fifties. I think most adults will tell you that the later you wait to start something, the harder it is to do. Whether it is for kinesthetic reasons, whether it's because our hearing is worse, or our eyesight is worse. You name it. Perhaps we just have a lot of other stuff crowding our memory. I think that early exposures prime kids.

David, Director of Finance, shared the importance of providing students with STEM opportunities when they are young.

“When kids in the makerspace lab get an opportunity to play and see that it is fun and enjoyable, it is amazing what they can do and it is amazing what they can learn.”

Peter, a professor at Champion University, expressed his beliefs on when to begin STEM education.

I think the key is to get kids when they are young. If we can get kids interested when they are really, really young, you can get that enthusiasm. For me, elementary is definitely the place to start STEM education. If you think about what kids are doing, they are just exploring, especially in Kindergarten. STEM really is a more formal way of investigating the world around you and building things to do stuff. I think elementary school is the perfect age to reach them and capture their enthusiasm. You know if they are getting enthusiastic about sports or drama or whatever they are interested in, well

STEM is just another experience. Some kids will take to it and others will not. If you don't give young students the opportunity, then they, of course, will not take to it.

When kids can have exposure to STEM education over several years, that is how you build engineers. Kids that are in Kindergarten right now, they are building through first grade, second grade, all the way through fifth grade. It gets well beyond what the fifth graders now will be able to do when they leave the lab, because they will have several years to engage in STEM educational opportunities.

The Superintendent of Caesar School District summarized these findings.

I think we are turning the corner in this country in terms of recognizing that very amazing ideas come from very young people. In fact, I would make the argument that at the elementary level, creativity is soaring. Elementary makerspace labs are unleashing creativity and thought processes and working in collaboration with other students in a guided kind of atmosphere where they are actually engaging in learning.

**Summary.** The participants in this study first experienced a novel concept which resulted in a transformational moment and a call to action. For most, maintaining the status quo was no longer an acceptable response when preparing students for the future. The leaders at King ES sought to inspire central office staff, university personnel, and business leaders with a shared elementary makerspace vision to build STEM resilience and foster the innovative skills students will need when entering the workforce. Adult leaders recognized the potential elementary students harnessed and worked to find ways to provide additional opportunities to develop these skills and creative thinking through makerspace experiences.

## Research Question 2

The second research question asked, “How did school leaders obtain resources to launch a makerspace lab? Fifteen findings emerged from the analysis of interview transcripts and document review. The findings were grouped into three themes (Themes 2 - 4). Seven of the findings combined to produce Theme 2: passion, drive, formulate an innovative idea, form a guiding coalition of leaders, create a shared vision that can be operationalized, construct the makerspace lab, and empower others to act on the vision. Five findings combined to form Theme 3: establish community partnerships; involve the superintendent, school board and central office leaders; invite other schools, recruit other principals, and conduct a grand opening ceremony. The remaining three findings formed Theme 4: site-based management, community partnerships influence funding, and school initiative became a district opportunity.

**Theme 2: Passionate leaders as change agents.** Mark, the building principal and Mary, the STEM teacher at King ES were transformational leaders in this makerspace initiative. They inspired and navigated change throughout the implementation process. Several participants in this study discussed how the school leaders’ passion influenced and inspired them to support their vision to establish an elementary makerspace lab. Participants noted how they were persuaded with Mark and Mary’s drive and commitment to ensure the makerspace lab experience was successful.

Mark and Mary were change agents. The makerspace lab originated with an innovative idea and blossomed to be one of the first elementary makerspace labs on the east coast to partner with a Fortune 500 Company and a leading engineering university. Mark and Mary worked collectively with other leaders to form a strong partnership to navigate change. Together, they collected adequate resources to launch and sustain their elementary makerspace lab.

***Passion.*** Educational leaders obtained the resources to launch the makerspace lab resulting from Mark and Mary’s passion for this initiative. Passion, according to Kouzes and Posner, is all about what gets people up each morning and what will not let them sleep at night (Kouzes & Posner, 2007). Data analysis revealed how Mark and Mary’s enthusiasm toward launching an elementary makerspace influenced and inspired several participants. For example, Luke, Lab Director from Champion University, noted the importance of having leaders who were enthusiastic about their project. “I think the enthusiasm that [Mark] and Mary had to bring the makerspace to your school is really what got the ball rolling. It may have carried [him] through the ups and downs of the whole process.”

Mary discussed her zeal for the makerspace initiative.

It was a passion project for me, so we spent all summer building it. I spent the summer writing lesson plans for the field trip and all the other things we do at school. I spent time writing STEM lesson plans for different grade levels, writing grants, and teaching myself STEM content. We also spent a lot of time getting buy-in. The buy-in was hard but I think it is starting to happen. It has been really, really, hard but it is so rewarding when the kids come in.

David discussed how he was impressed by the devotion of Mark and Mary.

I think there are probably several things that are of value in making the decision to fund the lab. As much as anything else, is seeing the passion and drive that you and Mary had to do this. Not just strictly in the sense of what is happening with the kids, but the level of extra effort that you and Mary were making to make sure your students were successful.

*Drive.* The second finding that emerged from data analysis when studying how school leaders obtained the necessary resources to launch a makerspace lab was the importance of the King Elementary leaders' drive. Drive is defined by how leaders set the example by their daily actions and demonstrate how committed they are to their beliefs by the deeds they perform (Kouzes and Posner, 2007). Drive is the level of commitment and determination leaders showed in this initiative. Several participants noted how they were impacted by the school leaders' drive and determination. Mark and Mary demonstrated their commitment by working diligently to overcome challenges that arose during this project.

Mary discussed Mark's leadership and commitment to this initiative.

[Mark was] relentless. [He] were not afraid to pick up the phone and have a conversation. It would have never, ever happened without leadership, meaning you. I would have never picked up the phone. You know, every time you made a call, what did I do? I doodled. I just drew on a piece of paper. I was thinking, but I would have never been able to take that initiative and ask, "How do you think that meeting went?" You were always the person who pushed forward and made it happen. It would not have happened. Especially since we were getting push back from central office. You could have said, "O.K. We won't do it." Then the lab would have become an empty room and we would have used it for storage. But look at it today!

Peter expressed the importance of having committed leaders.

It is your determination, enthusiasm, and commitment to the project that helped make this initiative successful. You had a principal that was willing to do it and a leader who was willing to butt heads with the people to get things done and fight for it. You also had a

teacher who was not only super enthusiastic but was very capable. It was a great combination.

David discussed how drive can be a key determinant in any new initiative's success or failure.

I think there are a lot of individual programs and I would say even for specialty programs at the high school. The ones that are successes verses the ones that are not as successful are often determined by who is driving the program there. How committed are they? How excited are they? How much care and commitment and love do they put into the program?

In this study, participants noted the importance of passion and drive to the overall success of this initiative. Both factors are intrinsic reward components that motivated change during this entire process. Transformational leaders, in this case study, found that change first happened within before it could be spread to inspire others!

***Formulate an innovative idea.*** The third finding that emerged from the data analysis when studying how school leaders obtained the necessary resources to launch a makerspace lab, was the importance of formulating an innovative idea. During this makerspace initiative, Mary, the STEM teacher at King ES, devised an unusual notion. She wanted her school to have its own elementary school makerspace lab on its campus. Mary had a conversation with Peter, the university professor. Mary recalled the original idea.

On the field trip to Champion University, I remember talking to Peter. It was when the kids were eating pizza. Peter said, "This is what we want. We want other schools to do this." That probably got me to think, "Okay, well, we want this at our school." That is

when I went to you (the building principal) and discussed the idea of having our own makerspace lab at King ES that would serve other fourth grade students at Caesar School District.

The building principal, Mark, had a similar idea. Mark wanted to find a way to have the students at King ES exposed to the makerspace experiences and STEM education more frequently in elementary school. After Mary's classroom visited the makerspace lab at Champion University, Mary requested a meeting with Mark to discuss the potential of starting a makerspace lab at King Elementary School. Mark recalled the initial meeting where the elementary makerspace concept was shared.

I had a note under my office door that said, "Can we talk?" Mary had the same vision. When we met later that morning, Mary said, "I would really like to bring a makerspace lab like the one at Champion University to King ES!" My eyes lit up as I had the same vision. We worked together to discuss how we could make it happen on our elementary campus.

The makerspace lab at King ES, started with an innovative idea that focused on launching an elementary makerspace lab. Mark and Mary shared how they were inspired by their visit from Champion University's Makerspace Lab which generated a tremendous amount of enthusiasm and passion by both leaders to carry out this initiative. They became relentless and sought additional ways to obtain the necessary resources to launch and sustain a makerspace lab at King ES. Mark and Mary developed their vision together. They formed a leadership team, or guiding coalition, to fulfill this initiative.

***Form a guiding coalition of leaders.*** The fourth finding that emerged from the data analysis was Mark and Mary formed a guiding coalition of leaders to help inspire and navigate change during this makerspace initiative. This leadership unit started with just two leaders and grew significantly during this initiative. Participants discussed the importance of Mark and Mary's leadership tandem in the overall success of this initiative. David discussed the significance of having a leadership squad.

I think it was interesting and valuable for me to see what was happening from the perspective of what you and the STEM teacher were doing. I think you latched on to a teacher there (Mary) that wanted to make this a mission. She helped take those ideas and vision that you were putting forward and worked with you to be on the ground, making it happen. The extent to which this is something you (and Mary) took on and became passionate about and the level of extra effort and work. I mean, you are doing your day job, and this is obviously above and beyond to make all of this happen.

Together, Mark and Mary supported one another, inspired one another, and complemented one another when initiating change and launching the makerspace lab. The school leaders at King ES, aligned their personal visions and developed a program that would inspire elementary aged students. For example, Dr. Samson noted the importance of having an aligned vision. "Mary has a passion about this program, and she had a vision for the makerspace. It wasn't just the principal's vision. She shared a vision."

***Create a shared vision that can be operationalized.*** The fifth finding that emerged from the data was creating a shared vision that could be operationalized. The building principal, Mark, and the STEM teacher, Mary, developed a conceptual model that would give elementary students the opportunity to be exposed to the engineering design process and have opportunities

to play, imagine, create, design, and build. To carry out this initiative, specific and targeted strategies to get potential stakeholders involved in the process were necessary. Dr. Samson, Superintendent of Schools, noted that it took more than just a vision. “When you are going to implement something big and especially if it goes beyond your school, and it involves other outside businesses, you have to have a vision you can operationalize.”

To operationalize the vision, significant planning and development occurred from the onset of this initiative. Purposeful planning of curriculum, resources, logistics, target audiences, cost for visitors, and a communication plan occurred before potential stakeholders were approached regarding funding and support.

*Curriculum development.* Planning the makerspace lab required developing a curriculum for all the students to engage in. Peter noted the importance of having a highly engaging curriculum. Peter stated, “With the right teaching and enough time, every kid would likely be able to learn.” Mary also shared the importance of having a strong educational program.

Everything you do in that lab has to have a purpose. I spent the summer writing lesson plans for the field trip. I wrote lesson plans for all those different grade levels and was teaching myself during this journey.

*Resources and logistics.* Building a makerspace lab required developing a plan for several logistical items pertaining to resources. There was a need for a highly engaging teacher, space, a strong curriculum, technological resources to include laptops for students and servo motors, furnishings, and consumable materials. Luke, a lab director, disclosed what he felt were essential start-up items in makerspace labs.

The highly engaged teacher is critical. Ideally, there is a designated space or space that exists for similar purposes. It could be a science lab, which would be a comfortable implementation area to put these kinds of resources, materials, and laptops. That is the other big thing. Another important things is having some sort of desktop or laptop computers that makes these electronic or digital makerspace opportunities more feasible.

*Target Audiences. Outreach.* The makerspace lab was created to reach students not only at King ES, but specifically reach students from other schools. Mark and Mary established a model makerspace lab that serviced fourth grade students from other schools within Caesar School District. The goal of the makerspace lab was to be an extension, or hub, to the Champion University’s Makerspace Lab. The makerspace lab at King ES was designed to be a field trip destination for other schools to visit. Dr. Samson noted, “Your plan was unique in that you wanted to bring other students from other schools in to your makerspace lab.”

The leaders at King ES offered this makerspace experience to visitors at no cost. To allow students from underserved and underrepresented areas to have equal access to this unique field trip experience, visitors were not charged to visit the makerspace lab. Rachel, the Senior Vice President for Computers Inc., shared the importance of having this makerspace opportunity be free to visitors.

I think it is imperative for the makerspace experience to be free to others! I think there are a lot of good STEM programs out there that charge a fee . But if you are going to charge somebody for it, you are going to weed out some of the underrepresented groups.

Due to the overwhelmingly high demands from other schools to attend the makerspace lab, priority was given to Title I Schools to reach underrepresented and underserved students.

Teachers from non-Title I schools experienced some frustration with limited availability due to popular demand. One teacher from King ES noted the frustration her husband experienced when trying to sign up to visit King's Makerspace Lab.

Actually, my husband teaches at another school in Caesar School District. He said, "How come you can never get in to that place? It is always booked!" He kept saying, "I can't even get in over there." The makerspace lab has become popular and people want to come. It is known in our community and outside of our school. It is a place that kids really want to go to.

*Targeted Audience. In-Reach.* The second targeted audience reached all students and teachers at King ES. All students from Kindergarten through fifth grade students at King ES, including students with special needs and ESOL students, attended the makerspace lab on at least two occasions during the 2017-2018 school year. This was the "in-reach" target audience of the makerspace lab initiative. Mark stated, "The makerspace lab was built for students at our school and students from other schools too! We built a powerful model here."

*Communication Plan.* After forming a vision that could be operationalized, it was important to communicate the vision with others. The school leaders updated central office leaders with the developments of the makerspace lab on a periodic basis and often reached out to members at central office to gain support for this initiative. Esther spoke of the importance of having a communication plan.

Normally there is a process when you have a great idea that requires money and other resources. This process involves a communication plan. I did my best to circumvent the bureaucracy, but I could not win it all because we would have asked for more funding.

We probably would have done some things a little bit sooner. There were constraints with funding, yet we had a great idea and energy that came with launching the lab. As a result of these, we were able to expand the lab beyond your school to include others.

***Construct the makerspace lab.*** The sixth finding that emerged from the data analysis was the importance of constructing the makerspace lab. While participants noted the importance of having a solid plan to carry out the makerspace lab, participants were significantly influenced by seeing the lab in action. To launch this makerspace lab at King ES, school leaders built the makerspace lab before securing all the funding to sustain the makerspace lab. Caesar School District operates under a site-based management funding system, which allowed school leaders funding flexibility. To launch this initiative, the building principal allocated resources and personnel to cover start-up expenses when launching the makerspace lab. The school leaders at King ES (Mark and Mary) moved quickly from concept development to construction of the lab. Mary summarized these findings. “We believed if you build it, they will come. Mark said, ‘Go for it!’ and we started building.”

What the school leaders did not understand at the time was the huge influence constructing the makerspace lab, and witnessing it in action, had on others. Many participants in this study disclosed how important it was to have potential stakeholders personally observe the makerspace lab.

Eve, the LIGHT Director, had similar perceptions regarding the importance of seeing the makerspace lab in action.

We are trying to figure out ways to make the awareness level (of the makerspace lab) known. If they hear about it, that's one thing. If they read about it, that's another thing. If they see it, that's a very different thing.

Dr. Samson was impacted by observing students working in the makerspace lab.

You know the old adage, "Seeing is Believing." Watching those students, under the direction of the teacher, and the kinds of things the students were demonstrating to all the stakeholders. You know, that makes a believer out of you. You are seeing what you were told was going to happen, happening! It is exciting to see ideas and a vision of something translate into action and reality. It is a very exciting and motivational experience to go through.

David discussed how the actual construction of the makerspace lab impacted his understanding of the makerspace initiative at King ES.

We can talk about it on the phone and we can talk about funding and all, but there is certainly tremendous value in coming out to the makerspace lab and showcasing it. This is really what you see. Here is a hands-on opportunity and you are making it real for stakeholders and potential donors.

*Makerspace lab video.* After the lab was constructed, school and central office leaders showcased the makerspace lab by using other forms of media. Leaders marketed the makerspace lab to potential stakeholders by creating a makerspace video that captured some of the learning that was happening at King ES. This tool was pivotal in persuading other principals in Caesar School District to attend the makerspace lab at King ES.

Esther highlighted the importance of using the makerspace lab video to reach a wider audience.

I think the piece that really sold folks is not only did we talk about the lab, but you were actually able to show the video. The experiences that teachers and students were having as a result of their visit to your lab was instrumental. Anyone who saw that video wanted to be a part of it!

***Empower others to act on the vision.*** The seventh finding of how school leaders obtained the resources to launch a makerspace lab was by empowering others to act on the vision. The leaders at King ES were change agents who understood the importance of motivating others to act. Several participants discussed how they were personally convinced to take steps to help move this initiative forward. When launching this initiative, educational and business leaders showed support by first working in their sphere of influence to promote the elementary makerspace lab and then encouraged others to be a part of the makerspace journey at King ES. For example, Eve was convinced to reach out to other central office staff members and potential business partners after visiting the makerspace lab at King ES.

After experiencing your lab, we went to every single supervisor. We brokered a deal with the Director of Finance. We did all that we could. We wanted to support your passion. We wanted to support what the right thing was for kids.

David discussed how Esther was motivated to act on the vision.

Esther certainly did a good job of trying to keep your makerspace lab at King ES and make people aware of it. She highlighted the fact that we are trying to do something new and different here. The effort and passion on the part of you and your staff there were

making it successful. That alone does not mean that it is going to be sustainable in the longer term. Esther had some discussions with the other Associates about how we can look at making this something that would be more of a district resource. If we really are going to look at wanting to put resources into it, then in all likelihood, it probably is going to have some kind of attraction and feasibility to a wider range of students than just King ES. Esther also did well by talking to the Superintendent in trying to get his interest and attention. Here is what is happening. Here is what is working. Here is how it is coming along.

Five categories combined to form the third theme: establish community partnerships, involve the superintendent, school board and central office leaders, invite other schools, recruit other principals, and conduct a grand opening ceremony.

**Theme 3: Cast a wide net.** The leaders at King ES realized the importance of inviting others to participate in this initiative. School leaders at King ES utilized other experts in the field to help launch this initiation. Mark and Mary worked relentlessly to create partnerships and build momentum. Potential donors, stakeholders, business leaders, university leaders, educational leaders, and students from other schools were invited to experience the new makerspace lab at King ES and join forces in this initiative.

***Establish Community Partnerships.*** The eighth finding that emerged from the data analysis involved the importance of establishing community partnerships. For this makerspace lab to be successful, school leaders at King ES realized they needed support from other community agencies. To launch and sustain a makerspace lab, the school leaders at King ES needed other experts in the field to provide support and serve as an example. Champion University and Computers Inc. had a preexisting program that was operational at the onset of

King's makerspace lab initiative. Champion University had partnered with Computers Inc. and built a model makerspace program for elementary, middle, and high school students located at Champion University's Mid-Atlantic Campus. This model makerspace served as an excellent resource and example for the leaders at King ES.

The school leaders from King ES approached Champion University and Computers Inc. about forming a partnership between the three entities. Mark, the building principal at King ES, recalled the initial attempt to form a partnership with Computers Inc. and Champion University.

We arranged a meeting with Champion University and Computers Inc. regarding a potential partnership. We were very nervous about this opportunity. I will never forget walking in to the meeting and Rachel, the Vice President of Computers Inc., was sitting there. We were not expecting her to be there, along with Luke, the Director of Champion University's Makerspace Lab. At our meeting, Rachel and Luke asked us if we would be interested in forming a partnership! Champion University and Computers Inc. were looking for a partnering school too! A perfect marriage occurred as a result of this.

Mary's recollection varied slightly regarding the initial meeting with Champion University, Computers Inc., and King ES.

The first meeting we had was with Champion University and Computers Inc. Rachel, the Vice President from Computers Inc. was there! It literally was like coming at a Shark Tank. I remember us walking down that long hallway after the meeting. They (Rachel and Luke) were so excited, they asked us for a timeline. They asked our school to be the hub! We walked out of there thinking, "We've got this. This is going to be amazing!"

*LIGHT*. After forming a partnership with Champion University and Computers Inc., school leaders at King ES reached out to another community partner within Caesar School District, known as LIGHT to secure funding for this makerspace initiative. LIGHT is part of the Community Foundations Board and is an organization that helps engage business partners and brings resources to schools within Caesar School District. LIGHT's role, led by Eve, is to generate funding to help support new initiatives. Eve worked diligently with the school leadership team at King ES and helped them share their vision with others. Eve summarized LIGHT's role in Caesar School District, "LIGHT is part of that process to help open doors of schools. Our goal is to get businesses into our schools. We open doors. Amassing resources, connecting dots, supporting partnerships and resources for kids, that's what we do."

***Involve the superintendent, school board, and central office staff.*** The ninth finding that emerged from the data analysis was the importance of enlisting the support of the Superintendent, school board, and central office staff. After school leaders at King ES entered into community partnerships with Champion University, Computers Inc., and LIGHT, school leaders at King ES invited and enlisted the support of the superintendent, school board, and essential central office staff to participate in the makerspace lab experience at King ES. At the onset of this initiative, Mark, the building principal at King ES, reached out to Dr. Samson, the Superintendent of Caesar School District, to gain his support.

I remember meeting with the Superintendent, which was another key piece in building momentum with this initiative. I pulled him aside and said, "We have an opportunity to really have this perfect marriage where you have business, college, and an elementary school coming together. Would you support something like this?"

The Superintendent, Dr. Samson, was extremely supportive of this initiative from the beginning. Dr. Samson recalled this conversation.

I remember one time coming out to your school and you talked with me about this idea that you had and the concept of it. I thought it was an innovative concept. Those are the things that a School Superintendent is looking for. Innovative and exciting ways to engage kids in STEM. All of those things were factors when I first started hearing about your concept.

Esther, the Associate Superintendent understood the importance of having the Superintendent being familiar with any new initiative. “The key stakeholder is always, in a school system, the Superintendent. He’s always the key stakeholder.”

Mark and Mary involved the school board at the onset of this project. The Superintendent shared his views on involving school board members from the inception of any new initiative.

Involving the school board is important because once I recommend the budget, the school board looks at the budget and it becomes the school board’s budget. Ultimately, any new program that involves dollars has got to be approved by the school board. When you involve school board members in the conceptual pieces, include them in the kickoff, and bring them in to actually see the makerspace lab in action, these actions help pave the way for it to go forward.

Central office leadership played a major role in supporting and sustaining this initiative. Key central office personnel including the Superintendent from Caesar School District, the Director of Finance, the Director of LIGHT, and the Associate Superintendent each worked

proactively to support this makerspace initiative. Involving these leaders early in this initiative and having them provide their insights into how to enhance the program was pivotal in the long-term success of this program.

Esther encouraged school leaders at King ES to invite other key stakeholders from central office. Esther urged the building principal to invite every content supervisor from central office to attend the makerspace lab at King ES.

This is not an opportunity for students and teachers that is in isolation. The term STEAM or STEM by itself is about collaboration. Planning for it involved having those folks (key stakeholders) be at the table, and having those folks adding their expertise and their suggestions not only on how this could be launched, but also sustained.

You had a great idea that you shared with me. I understand that when we talk about something as complex as STEAM or STEM, it involves several key stakeholders. We engaged the Supervisor of Science, the Supervisor of Technology, the Supervisor of Mathematics, the Supervisor of the Arts. These folks had to come together so they could support each component of STEM.

Mark noted the importance of inviting key supervisors from central office as well. Mark invited the Supervisor of Science, the Supervisor of Technology, the Supervisor of Math, the Supervisor of the Arts, and the Supervisor of Learning to attend the makerspace lab at King ES. After inviting the central office supervisors, Mark noticed a trend.

They all started coming to visit the lab. This started building momentum toward our program. Just inviting them. You know what I found interesting is there are a lot of folks at central office that don't often get an invitation. When they get that invitation,

they are excited to come down and check out the new makerspace initiative. They become not only receptive but wanted to help!

Peter, a Champion University Professor, noted the way Mark and Mary worked with other leaders.

I learned the importance of your people skills or political skills. I come at things from a perspective of, I want to do it, so let's just do it. You came from the perspective of, let's work with this group. Let's meet with that group. Let's sell it to them. You did a really good job of getting people on board. Some of them were very enthusiastic and some of them were very opposed. The way you guys worked with people, pro, con, and neutral, to make it happen was a very important lesson.

***Invite other schools.*** The tenth finding from the data analysis was the importance of inviting other schools to attend the makerspace lab at King ES. One of the most impactful factors that participants noted was the influence inviting students from surrounding schools had on their decision to support and fund the lab. This was a critical finding. The makerspace lab at King ES was built to service students from other schools. This revolutionary concept proved to be a compelling selling point to stakeholders when choosing to get behind this initiative. Dr. Samson, Superintendent of Caesar School District, commented on the importance of including other schools.

Your plan was unique in that you also wanted to bring other students from other schools into it. But if you are really wanting to launch into something bigger, you have got to have more financial support. Well ultimately, I am the person who makes the final recommendations on anything new in that budget. Even if it might be something that

costs two or three million dollars, to something like this, that might fund a position that costs 100,000 dollars. When it came budget time, there were some challenges trying to make sure that this thing was going to move past the initial start-up money. The fact that other kids were going to be invited and other kids were going to have an opportunity that they would have missed out on, because you can't put this together in every school.

Ultimately, I gave the green light to dedicate some funding for it.

Similarly, the Director of Finance discussed how this initiative reached a wider range of students and worked with students outside of just King ES.

If we are going to put resources into it, then in all likelihood, the makerspace program at King ES, is going to have to have some kind of attraction and feasibility to a wider range of students than just to King ES. In addition to launching this initiative for your own school, you have gone out and worked with 10-15 additional schools. From a funding perspective, it is reaching a wider range of students.

***Recruit other principals.*** The eleventh finding from the data analysis was the importance of recruiting other principals to participate in this initiative. Esther noted the importance of encouraging principals to visit the lab at King ES.

The process of rolling out the lab changed when we involved other schools and other students. I think the best way we can build momentum is for you to come and share at our level meeting. When I say level meeting, it is a principals' meeting of 60 other principals in which you had the opportunity to share the concept coupled with your long-term vision.

At one of the principals' meetings, Mark and Mary shared their vision of the makerspace lab and showed the video marketing their program. As a result of this video and makerspace

presentation, over 70 school principals signed their school up to visit the makerspace lab at King ES in the future!

Peter shared his feeling on the importance involving the principals in initial process. “I think who really needs to get involved is the principals. If the principal is interested, then they will bring the makerspace concepts to their school. They will support the teacher who is interested and so forth.”

***Conduct a grand opening ceremony. Bring partners together to celebrate success and build momentum.*** The twelfth finding from the data analysis was the importance of conducting a grand opening ceremony. Several participants emphasized the importance of bringing partners together to celebrate success and build momentum. The school and central office leaders understood the importance of motivating others. At the beginning of the makerspace lab initiative, school leaders from King ES and central office leaders held a grand opening ceremony that was monumental to celebrate the official launching of the makerspace lab. The open house celebration gave other potential stakeholders an opportunity to experience the makerspace lab and see it in action.

Multiple participants discussed the significance of bringing all the change agents together for a special event and how this created momentum and brought additional credibility to the makerspace program. Esther and Eve recommended an official kickoff celebration to launch the makerspace lab at King ES. Every participant noted the importance of conducting such an event. Dr. Samson, Superintendent of Caesar School District, captured the importance of having a commencement event.

You brought partners together. You had Champion University. You had Computers Inc. and you had the school district. You had the key partners. You had the Head of Finance, who prepares the Superintendent's budget. You had parents. You had students actually demonstrating STEM concepts. You had the high-flying person (Mary) who runs the program.

By having this (grand opening) event, you are demonstrating to people that this is more than a vision, this is more than a project that we have submitted a paper for, or asked money for, or asked for help with. Here is what the kids are going to know and be able to do and seeing it in action! I think the grand opening event is something that demonstrates to all stakeholders, "Wow!" It had a "Wow" factor to it.

Along with Dr. Samson, Eve identified the importance of the open house and having David, the Director of Finance, attend and experience the makerspace lab at King ES.

I think the open house really did open the eyes of a lot of our leadership. Let's face it, Mark. You don't have the money in your budget to support a staff member (Full-time STEM teacher). We are trying to figure out ways to raise the awareness level. If you hear about it, that's one thing. If they read about it, that's another thing. If they see it, that's a very different thing. We brought those Associates together. We had five Associate Superintendents attend that night and the Assistant Superintendent, along with the Superintendent. They all saw what was going on. We got kids there. We got parents there. They were all excited about it. That really is where the rubber meets the road. And then we bring in other large businesses to see the kind of work that is going on there.

Getting David, the Director of Finance, there that evening was of utmost importance.

And that was Esther, Associate Superintendent of Caesar School District, going into his office and saying, you have got to go and see this thing. You have never seen anything like it. He was blown away!

Esther found the grand opening, or open house, was a significant event during the launching of this makerspace initiative.

I think your willingness to have an open house, if you will, or grand opening of the makerspace lab at King ES, was an opportunity for us to invite key stakeholders into your school and into the lab, so they could hear the theory and the research behind the lab. But more importantly so they could actually see and experience the lab. You had stakeholders pretty much at every level of the organization (school district) and in the communities.

Specifically, you had school board members. You had the County Supervisors and folks from Champion University. You had Computers Inc. and the Superintendent there. Teachers, parents, and students were there. All the folks that would be involved in launching, to include some of your donors or funders. The open house allowed folks to experience the lab and its real-time sense. It was not a thing out there, it was something that we discussed and were able to see.

**Theme 4: Exhaust all options.** Three categories combine to form the fourth theme: site-based management, community partners influence funding, and a school initiative became a district opportunity. The school leaders at King ES worked diligently to exhaust all their options when launching this makerspace lab. Mark and Mary utilized site-based management,

established community partnerships, and took calculated risks. While school leaders were able to successfully get the makerspace lab off the ground, sustainability challenges remained. In this study, key central office staff noted the importance of having a leading engineering university and large business corporation support the makerspace lab independently from and prior to the school district's decision to get behind this initiative. Both the Superintendent and the Director of Finance discussed how community partnerships and having a higher education partner and business partner influenced their decision to eventually support the makerspace lab.

*Site-based management provides flexibility.* The thirteenth finding that data analysis revealed was that site-based management's budgeting framework in Caesar School District allowed the school principal to reallocate resources to create a full time STEM position for the 2017-2018 school year. Caesar School District operates under a site-based management system. Resources and funding allocations are managed at the school level by each principal of the designated building. The principal at each school in Caesar School District is the designated school budget holder and is responsible for properly managing appropriated funds. The financial management system that Caesar School District operates under allows school principals to customize their individual school budgets to create programs and provide resources that best meets the needs of their individual building. In this initiative, Mark discussed how he reallocated resources which gave him the necessary seed money to cover the initial costs to launch the makerspace lab.

As a principal, we had to dedicate some money from our site-based budget. We needed to prioritize different things. Instead of saying, we are going to hire a new custodian, we waited to see if we needed one. Staffing wise, we are going to reallocate some funds. We needed a cafeteria hostess, but we waited to hire her. This was going to be our

second cafeteria hostess, but let's wait. There were some personnel moves that we needed to reprioritize. We chose to have a full time STEM teacher over some of these other positions.

***Community partners influence on funding.*** The fourteenth data finding was that the data analysis revealed that Community Partners influenced the Superintendent's and Director of Finance's decision regarding funding for the makerspace lab. What was fascinating to note was the power the collaborative partners had on the final decision by Caesar School District to eventually fund the makerspace lab. Having a leading engineering university, in Champion University, and a Fortune 500 Company, in Computers Inc. support the makerspace initiative independently from Caesar School District made an impression on key central office leaders.

School leaders at King ES first reached out to Champion University and Computers Inc. to form a partnership between them and the King ES. Community partnerships were a determining factor in Caesar School District funding the initiative. The Superintendent and the Director of Finance both described the influence community partnerships had on their decision to fund the makerspace lab. Dr. Samson, Superintendent of Caesar, commented on the influence of the university and business partners.

We have people that are looking at innovation and innovation grants and ways to help people with great ideas for kids. Those partnerships with kids are something we hold in high regard because a lot of times those universities or businesses, they are always doing research and cutting edge-kinds of technology and endeavors. That was another strong part of it that was very appealing.

The Director of Finance, David, commented on the impact the community partners had on his decision to potentially fund the makerspace lab at King ES.

The fact that you tied in both a higher ed partner and a business partner. Again, it highlights the interest and desire on their part. The fact that they are looking at you totally independent. They are seeing the value and the opportunity to create something and make something happen that otherwise wouldn't be happening and would definitely be improving instruction and would be good for kids. All of those things tend to highlight it to say these things go above and beyond the normal effort. Therefore, at some point, we kind of need to see (as a school district) what we can do to help support this.

*Take calculated risks when considering funding for new programs.* When making school district determinations about which programs will be funded and which ones will not, there are several important considerations Dr. Samson, the Superintendent, must make. Many of these decisions involve weighing risk and the implications of using appropriated funds for new projects.

There's always a certain amount of risk when you are a school Superintendent. When you are dealing with lots of competing needs. "Well, I would like a position at my school that wants to do X" or "We have had these trailers and I'd like to have a new addition that is multi-million dollars." We have staffing needs. "I want to get a step and cost of living increase and a COLA. I want my salary to increase as I can't live off this. When you have all of those competing needs, there is a lot of contemplation about if you are going to support something new, with new money. When you have all these other things that still need the money. We are trying to get back to 2007 budgetary levels. When you are going to step out there as the School Superintendent and give somebody new money for a

new project, you have got to be able to take calculated risks with that. When I get behind a project like this makerspace lab, I took a calculated risk. But all my indicators, based on my many years of experience, this is a risk worth taking! The value of the money going in is much smaller than the value of the payoff of this educational opportunity.

***School initiative became a district opportunity.*** As a result of these factors, Caesar School District showed their support of this initiative by funding a majority of makerspace lab expenses for the 2018-2019 school year and are making considerations to cover the makerspace expenses at King ES by making it a budget priority and funding the lab in future years.

Dr. Samson, Superintendent of Caesar School District, noted what persuaded him most in supporting this initiative.

The fact that kids from other schools were going to be invited and other kids were going to have an opportunity that they would have missed out on because you can't put this together in every school. Ultimately, I gave the green light to dedicate some funding for it.

David, the Director of Finance, expressed how the leaders' commitment to exhaust all options eventually persuaded Caesar School District to fund the makerspace lab at King ES.

I think there are probably several things that are of value in making the decision (to fund the makerspace lab). Coming out and seeing what you are doing is important but as much as anything else, is seeing the passion and drive you and Mary had to do it. Not just strictly in the sense of what's happening with the kids but the level of extra effort that you and Mary were making to be successful. What can we find for traditional business partners? How can we pursue other options and other funding mechanisms, etc.? By the

time you had gone through and exhausted those other avenues, then certainly you get credit for due diligence and extreme effort. Then maybe at this point, there comes a point at which well, it looks like it is very worthwhile. We (Caesar School District) need to step up and help the process as well.

You have worked with 10 or 15 other schools. I know you had a whole series of students come visit your lab. It highlights the fact that this is more than just a King ES program. It is literally becoming a district opportunity!

**Summary.** In this study, two school leaders were transformational leaders that initiated change. The guiding coalition of two leaders from King ES grew to include other key educational leaders that promoted change. These two school leaders had passion for this initiative and were driven to find a way to make it work. Participants discussed how Mark and Mary were relentless in creating and navigating change. What started as an innovative idea blossomed from a school initiative to a becoming a district opportunity.

### **Research Question 3**

The third research question asked, “What factors (supports and obstacles) influenced the implementation of the makerspace lab?” Nine categories emerged from the analysis of the interview transcripts and document review. The categories explain what factors influenced the implementation of the makerspace lab: have the right STEM teacher, have the right principal leader, secure strong mentors, enlist support staff, find a strong model program, model makerspace components, reluctance to change, equity, diversity, and funding.

**Theme 5: Have the right people.** Four categories combine to form the fifth theme: have the right STEM teacher, have the right principal leader, secure strong mentors, and enlist support

staff. Having the right people was essential to the overall success of this initiative. Several participants discussed how having the right teacher, and having the right principal, who could lead and navigate change was vital.

This makerspace initiative also required help and support from other leaders as well. Participants discussed how the Superintendent, the Associate Superintendent, the Director of Finance, and Director of LIGHT, all had important roles in supporting this initiative. If any of these individuals had opposed the makerspace lab, it would have been very difficult, if not impossible to achieve. Participants noted other people that were instrumental in this initiative included the Director of the Champion University Makerspace Lab, the Vice President from Computers Inc., and a professor from Champion University.

***Have the right STEM teacher.*** The first factor that influenced the implementation of the makerspace lab was having the right STEM teacher. Several participants emphasized how selecting the right teacher was one of the most important factors of this entire initiative. Participants discussed the significance of having a superb STEM teacher run the day-to-day operation of the makerspace lab. Luke, the Director of the Makerspace lab at Champion University shared his stance on this topic. “Having a highly engaged teacher is just critical.”

Mark, the principal at King ES, realized the importance of matching a teacher to this unique makerspace program. He reallocated and reprioritized resources and personnel to ensure he had the proper leader for the makerspace lab.

My goal was to make sure we had the right teacher in place. I had to move one of my master teachers out of the classroom. We moved the fourth grade teacher into the full-time STEM teacher position. It was challenging doing that and finding the just right

match for our new makerspace program. In the end, it really was worth losing a great fourth grade teacher, when you think about the impact the STEM teacher can have on the whole school and students in this region.

Peter, a professor at Champion University, highlighted his views on staffing for the makerspace lab. “The key more than anything else is that you have the right teacher.”

Participants stressed that hiring the right teacher was essential in this initiative. Selecting a consummate teacher varies depending on the needs of each unique makerspace location. Participants elaborated on the characteristics Mary possesses that made her an exemplary employee and STEM teacher. There were several different responses by participants that often focused Mary’s growth mindset and her strong people skills. Luke, the Director of Champion University, reported he looks for specific commonalities when selecting a match for new makerspace labs.

Your STEM teacher is unique. She does have traits in common with other teachers I work with. What are those unique traits that will take me in new directions I did not anticipate? Some of those traits are being a lifelong learner. Even if somewhat intimidated by learning something brand new, they look forward to immersing themselves in that kind of experience. In other words, they are comfortable with what we euphemistically call a steep learning curve. A second would be that they have a genuine love for kids. That translates into inspiring kids to become lifelong learners themselves.

The right teacher also needs to, as Luke described, “Let kids be kids. Young people are unlikely to remember every line of code I taught them, but they will remember how I made them feel and how they felt in my lab.”

Peter, a professor at Champion University, discussed the importance of having the right teacher and discussed qualities found in Mary, the full-time STEM teacher at King ES. His perspective closely aligned with Luke's perspective.

Mary is passionate and interested in her own growth. This makerspace initiative definitely took her out of her comfort zone. She definitely cares about kids. She did things that some teachers might not be willing to do. She went to LIGHT's board meeting and the types of grants she wrote. She went above and beyond. She is a great communicator and is very committed to makerspace initiative. She empowers her students and makes learning fun for kids.

The teacher cohort from King ES stressed the importance of having a teacher with strong coaching and collaboration skills.

I think it was important when Mary came to our grade level and looked at our curriculum. She asked for our input. She asked what units we wanted her to come up with for (an engaging) activity. When Mary created those activities and ran them by us, it was very helpful.

Esther shared the importance of selecting a teacher who is an exact match for the school and community.

I like to use a quarterback analogy. The quarterback is responsible for getting the ball in the right person's hands, so he can score. As the leader of King ES, you had the wisdom to identify Mary as the person who would score. You were spot on. She is the perfect person to do this work. She's a risk-taker. She's a do whatever it takes person. She has a family that supported this endeavor. She is making real time adjustments throughout

the year about how to make things better, right down to the furniture, the displays, and the pieces of equipment needed. Her heart was in this work. So it was easy to support her and follow her. It is all about having the right people. You can have a great idea, but not having the right leader, and not having the right implementer, will not help that idea come to its fruition.

Mark highlighted the importance of having a dedicated STEM teacher by budgeting a full-time position to run the makerspace lab. Many existing makerspaces are furnished with materials and technology but often do not have a devoted staff person.

You have to have someone who can lead the makerspace initiative and work with students and staff on a daily basis. We demonstrated our commitment to this makerspace lab program when we added and funded a full time STEM teacher position to our school budget.

Rachel, the Vice President from Computers Inc., also spoke to the importance of dedicating a committed teacher to the program.

You took Mary out of the classroom and dedicated her to the makerspace program. She is an essential piece to the makerspace lab. A dedicated director and teacher. If the makerspace lab is just a space, it will have a limited use. But to have somebody in the lab who can help teachers, as I am sure Mary has, is just critical. Mary can help your teachers at the ground level and show them how they can use the lab. When Computers Inc. looks at other schools who want to launch a makerspace lab, I ask, “Who is going to teach?”

Eve, the Director of LIGHT, took the importance of a dedicated teacher further when she discussed the possibility of opening a second similar makerspace lab.

I am in the process of creating a second lab and I have some concerns. Unless you have a dedicated staff member (teacher) and a back-up, the child's experience is not going to be what it should be. I have concerns with just having one dedicated person. It needs to be more than just one person. It is not something one person can do.

***Have the right principal leader.*** The second factor that influenced the implementation of the makerspace lab was having the right principal. Participants discussed how enlisting a devoted principal to lead the initiative was instrumental. The success of any initiative depends on leadership. Several participants in this study discussed the importance of having a leader or director of the makerspace lab, who can provide the vision and navigate change. Mary, reflected on the importance of having an excellent principal and the impact Mark, the building principal, had on the overall success of the makerspace lab.

You were willing to take a chance. And take a beating at some points. You were not afraid to pick up the phone and have a conversation. It would have never happened without your leadership. Meaning you!

I would have never picked up the phone. I can't pick up the phone. You know, every time you made a call, what did I do? I doodled. I just drew on a piece of paper. I was thinking but would have never been able to take that initiative and ask, "How do you think that meeting went?" You were always the person who pushed forward and made it happen. Especially when we were getting push back from central office. You could have

said, “We won’t do it!” and then the lab would have become an empty room and we would have used it for storage. But look at it today! You were RELENTLESS!

Mark reflected on the importance of being devoted to this initiative.

I see myself as a change agent. As the principal of a school, you have to be a visionary. You have got to know where you are leading your people. I asked, “Who are the key people that need to be on this team? Who are the difference makers that can bring this project to fruition?” You have to navigate change. You have to be able to facilitate change. It can’t be something that is not familiar to you. Expect some barriers and pitfalls along the way.

Esther, the Associate Superintendent of Caesar School District, recognized the importance of have a principal leading the makerspace initiative.

The makerspace lab came into existence because the principal, Mark, had a vision and continues to have a vision for 21<sup>st</sup> century learning and innovation. He presented this initiative to the superintendent staff which resulted in the superintendent supporting this program.

Eve, the Director of LIGHT, shared the importance of the principal’s leadership in this initiative.

The makerspace lab at King ES came into existence because of the vision Mark had after he had the opportunity to see the lab at Champion University. He realized after visiting Champion University’s makerspace lab, that there was an awesome opportunity for students, yet it was far away. He wanted to put a makerspace lab on his own campus. He

wanted to create the first elementary makerspace lab in Caesar School District that would partner with Champion University and Computers Inc.

Peter, a professor from Champion University, noted the importance of having both a dedicated teacher and an inspired leader. Peter expressed the importance of having the right people in place when leading change.

I think you have to have both a principal and a teacher who are willing to do it (and launch a makerspace lab.) There were a lot of things you had to do in terms of resources, in terms of persuading people, trying to get grant money, and trying to get computers that were less expensive or free. I think the people leading the change effort are the most important part.

The Superintendent of Schools, Dr. Samson, summarized the importance of having a devoted teacher and an enthusiastic principal during this initiative. He believes there has to be three key elements to have a successful makerspace initiative pertaining to leadership.

One is you absolutely have to have the principal as the champion. He or she has to know enough about the initiative, be involved enough with the components and parts. Are there external players? They have to have a good sense that people are going to come through with what they said they are going to come through with and do what they said they are going to do. Whether it is staffing, money, or research. Whatever that might be. You have to have the knowledge that there are going to be contributing players, not just a flash in the pan or public relations event when you kick something off.

The second thing that you have to have is a person who is actually going to be leading the day-to-day work. The teacher or teaching assistant, whoever is responsible for carrying

out the day-to-day operation has to be a high flier. They have to be dedicated. They have to have the type of personality that doesn't have to be told every step and everything to do. They don't wait to be told and are self-initiating. You need that type of highly competent person in the makerspace lab.

The final thing is you have got to have traction with other people. You can't really bring in something that not only goes throughout the building but involves people in other buildings, if you don't think there are other people who believe it is a good idea and who buy into the thing.

***Secure strong mentors.*** The third factor that influenced the implementation of the makerspace lab was securing brilliant mentors. This makerspace program would not have been possible if it were not for the support of Luke, a professor at Champion University, and Peter, a professor at Champion University. During this makerspace initiative, Luke and Peter served as critical resources to the leaders at King ES. Luke and Peter helped with developing start-up supply lists and developed a highly engaging curriculum that inspired children. They advised Mark and Mary on innovative ways to raise funds for the makerspace lab. They assisted with professional development offerings and were a constant source of on-going support. Mary shared how vital Luke and Peter were to her as instructional and supportive coaches.

Luke provided emotional and technical support. It was great to be able to talk to him and have him come up with some really neat ideas. He would say, "Well, we could look at it this way," when I was totally freaking out! He was a mentor to us. He helped give us what we wanted. He would say, "Here, take this sign. Do this. Do that." Champion University Rocks!

Mark discussed the importance of having mentors during this initiative. “I think having Luke and Peter available to help guide us through the initial implementation stages was instrumental to the overall success of this initiative. We could not have done it without them.”

Having these mentors, which were backed by Champion University, helped build credibility to the makerspace program. When King ES partnered with Champion University’s model program, a partnership with the leaders of these organizations also occurred. Champion University’s faculty provided a framework for school leaders at King ES to emulate and provided on-going assistance when technical and instructional questions arose. During this makerspace initiative, leaders at King ES faced obstacles and worked with people who were reluctant to change existing practices. The mentors from Champion University served as a support system and helped strategize next steps in the implementation process.

***Enlist support staff.*** The fourth factor that influenced the implementation of the makerspace lab was enlisting support staff. The central office staff at Caesar School District were instrumental and provided the funding to make this initiative possible. The Superintendent of Caesar School District, the Associate Superintendent, the Director of Finance, and the Director of Light, played a role in bringing this makerspace lab to fruition. Any one of these central office staff members could have thwarted this initiative, but key leaders from central office were supportive of this innovative concept.

Volunteers were another important factor that participants in this study mentioned when considering support staff. Peter discussed how Mary was resourceful when recruiting volunteers.

Mary went above and beyond to recruit others. She had her husband, who conveniently is a pilot, come in and volunteer. It is really hard to run a lab with just one person. You were able to recruit a variety of parent volunteers in the lab.

Luke, Lab Director at Champion University, discussed how Mary enlisted volunteers.

Mary was able to tap into volunteer resources that I would not have known to look for. Some of which were friends and family. Others were just people that she knew who would be intrigued and interested. It only took her a few minutes of conversation before they were ready to come in and help. Sometimes, this requires familiarity with the community.

**Theme 6: Have a strong model to emulate and make it your own.** Two categories combined to form a sixth theme: find a model makerspace to emulate and model makerspace components. The school leaders in this study stressed the importance of having a model program to emulate, especially during the initial launching stages of this initiative. The leaders at King ES, did not attempt to invent something from scratch. The leaders at King ES utilized Champion University's Makerspace Lab as an instructional model. While the makerspace lab at Champion University was intended to reach middle and high school students, Mark and Mary customized the program at King ES toward elementary-aged students.

***Find a strong model program.*** The fifth factor that influenced the implementation of the makerspace lab was finding a strong model to emulate. Both Mark and Mary fashioned their makerspace lab at King ES with certain core components from the model program at Champion University's Makerspace Lab. Mary shared the importance of having a model program to emulate.

Champion University gave me all the supply orders and they gave me all their excel spreadsheets. It was such a nice model to follow. I was in uncharted territory. I love History. I didn't know anything about Science and Technology and Engineering. Champion's guidance in building the lab and in professional development was amazing! Mark stressed how significant an exemplary program was in this initiative.

I think there are certain factors that have to fall into place for a makerspace initiative to be successful. First, you have to have a vision. What is the makerspace lab going to look like? What are the components? What will make the makerspace lab magical? To answer these questions, it helps to have a model school or model program in existence to help be an example and mentor to you as you launch. This is really important.

***Model makerspace components.*** The makerspace lab at Champion University had certain characteristics that made the experience for many students and staff members magical. Several participants described certain components that made their makerspace lab experience memorable and magical: failure, play, collaboration, free, noncompetitive, and no prescribed outcome.

*Embrace failure.* Mary, the STEM teacher at King ES, shared certain core components to a magical program. Failure is a core ingredient to innovation. Giving students the opportunity to fail and work through those initial unsuccessful attempts was vital. "Watching them work, and fail, and survive that, and move forward was absolutely amazing! Watching the struggle and having that struggle be a stepping stone for learning."

Esther, Associate Superintendent at Caesar School District, discussed the importance of failure and taking risks.

The makerspace lab helps kids take risks. It helps them learn that trial and error have a place in their lives for learning and for life. That everything won't work the first time, but you need perseverance. Tweak it here and try something else there. There are life lessons that come through the lab.

Similarly, Mark commented on the importance of having failure incorporated into learning.

We need to prepare kids differently. I feel the makerspace lab gives kids an understanding of the engineering process. It teaches them to work through failure. When you think about significant things in your life, usually there are some pitfalls. There are some challenges and you have to rise up above that. When you get knocked down, you have to get back up. We are purposefully teaching kids to work through initial failures and they are thriving! When it doesn't work well the first time, the culture in the makerspace lab is, "Keep trying!"

*Encourage play.* Peter shared the importance of having kids playing and exploring.

To me, education is about having kids exploring and being creative. When you combine science and art, who knows where you guys will take it. Having games where kids can come in and play. Parents could play the games and kids would be interacting with the world. I am a constructivist, so I like this kind of approach.

Eve, the LIGHT Director, also believed in play and hands-on learning opportunities.

"Kids learn by using their hands. They are functional learners, collaborative, and problem-solvers. There are things that students do when they build, something that is going to be retained in a different way."

*Foster collaboration.* Mary commented on the power of collaboration in the makerspace lab.

Seeing the kids who really struggle in the mainstream classroom just shine, like the two boys who made the elevator. Two boys, stronger in math, that really struggled with communicating, especially in writing. But working together in the makerspace lab, they were able to communicate this idea of an elevator and then build it.

*No cost to participants* Rachel, the Vice President from Computers Inc., was adamant that there were certain factors that were essential to reach underserved and unrepresented student groups. The makerspace opportunity needed to be extended to others at no cost to visitors.

There are a couple of things that are imperative. I think the biggest one is it has to be free! I think there are a lot of good STEM programs out there that you have to pay for. But if you are going to charge somebody for it, you are going to weed out some of the underrepresented groups.

Mary also shared the importance of offering this to students at no cost. “We had the backing of LIGHT with transportation and the timing was amazing. We offered this opportunity to students at no cost!”

*Create a noncompetitive environment.* Rachel, the Vice President from Computers Inc., found there were other critical components to a model makerspace. Rachel discussed that students should engage in STEM related activities that do not involve competition. There should be celebrations of each group’s work, but no winners and losers!

One of my biggest takeaways was it cannot be competitive! While I love a good competition, but I do not encourage it when introducing something new. We participate

in First Robotics. When you are trying to weed people in, you don't want to weed kids out! You want to pull them in. If you are trying to engage students in potential careers and projects and there is competition, they just shut down. They will have a bad experience and they will say, "These careers are not for us!" Being non-competitive, everyone gets the same applause and they get the same "Ooohs and Aahhhs!"

*Avoid prescribed outcomes.* A fascinating finding from this research is this notion of allowing kids to tinker, design, and play with no prescribed or predetermined outcome. So often in educational systems, the goal of the lesson is to regurgitate the objective in the same fashion it was delivered to the recipient. In makerspaces, students have the freedom to create, design, and build objects that are totally unique. Rachel, the Vice President from Computers Inc., elaborated on this point.

It is not a prescribed outcome! That is really important! It is not a kit that you have to put together and make it work. It is not a kit with a prescribed outcome. It is not a test. Your machine doesn't have to work in a prescribed way. We want our kids to come up with their own invention and that nonprescribed outcome is really important.

**Theme 7: Overcoming Obstacles.** Four categories combined to form the seventh theme: resistance to change, equity, diversity, and funding. There were various obstacles that the leaders at King ES navigated through when launching this initiative. School leaders anticipated and navigated through these obstacles to achieve success. Failure to address any of these issues properly would have thwarted the entire initiative.

*Expect reluctance when creating chang.* With any new initiative, interrupting the status quo is a significant challenge that leaders must overcome. In this makerspace initiative, some

staff members and members from central office reported they did not want to change the status quo. Participants discussed possible reasons as a lack of communication with King ES leadership to staff and central office, a lack of a clear vision presented by the leaders at King ES, or limited familiarity with the subject matter.

Mark shared how he navigated central office's reluctance to change.

There were many meetings with central office. Initially, there was some hesitancy. Any time we are talking about a new program, and a new way of doing things, and there are dollar signs attached to it, there is going to be some reluctant individuals. I think that happens initially.

You have to navigate change. You have to be able to facilitate and lead change. It can't be something that is not familiar to you. There will be some barriers and some pitfalls. I think with innovation, there comes a natural reluctance to change. With innovation, we are thinking about things differently and challenging the status quo.

When we talked about it to central office, we shared that we wanted to build this field trip experience. We wanted to encourage engineering and bring other schools in. Initially, central office was hesitant. It was something new and different. I kept hearing, "Nobody has done this before. Nobody has done anything like this before!" and I took it as a compliment. I took it as a hint that maybe we were moving in the right direction. You have to be very delicate with implementing change. You have to stretch others you are leading right where they are. You have to grow them, but you can't stretch them too far too quickly. It is like a rubber band. If you stretch it too far too quickly, it might snap. It is a process of helping those people and growing them. Once central office began to get

an understanding of what this new initiative would look like, and we invited them out, they began to really buy in.

The school leaders at King ES were familiar with the change process as they had led other initiatives in different leadership capacities. Their experience, passion to be change agents, and convictions that what they were doing was in the long-term best interest of students helped sustain this initiative. School leaders at King ES created a shared vision and enlisted others help who had expertise in this process. Once the school leaders clearly articulated a shared vision to central office, many key stakeholders supported this initiative! The makerspace lab at King ES became a centerpiece for Caesar School District!

***Encourage equity.*** Equity concerns presented a large obstacle for the school leaders at King ES. Why would one school get a special makerspace lab, while others would not? This presented a very serious obstacle for the leaders at King ES to overcome.

David, the Director of Finance, shared his concerns on equity. “My biggest concern regarding this initiative was equity. Why would our school district have such a unique program at one school and not be funded at another school?”

Similarly, Peter shared his concerns pertaining to equity.

I wondered if there would be an issue with people questioning how does something this nice (like the makerspace lab at King ES) go in a school with that population? Does this look like another time where a middle class gets favoritism? There are advantages to this school (having a makerspace lab) because their academic achievement scores are so high. You don't have to worry about passing the state tests, so you can try new things. On the

other hand, I sort of worry about why are they getting this (makerspace lab) versus somebody else.

***Promote diversity.*** The leaders at King ES addressed these diversity concerns by extending the makerspace lab experience to students outside of King ES. By extending the invitation to other fourth grade students in the surrounding area and giving priority to schools with large free and reduced lunch populations, equity and diversity concerns were minimized. The field trip was offered at no cost to all visitors. This was done to ensure that underserved and underrepresented students would have an equal opportunity to experience the makerspace lab at King ES. School leaders also prioritized Title I Schools when scheduling other school visits.

***Secure funding.*** Perhaps the largest obstacle with any makerspace lab is funding. It is imperative to exhaust all options when trying to generate enough money to support a makerspace initiative. Peter shared his concerns regarding funding.

It takes a teacher to run a makerspace lab, so that is a big piece of the budget. As we know, personnel is over 90% of a school budget. That is a big chunk of money to have or move somebody into that position.

Mark, the building principal, commented on the importance of funding and viewed it as one of his largest obstacles to overcome in this initiative.

How do we pay for this makerspace lab? There was a lot of time and energy going into answering this question. Going door-to-door, asking businesses for money, buy-in, and support for a program that we had not yet launched.

Eve, the LIGHT Director, spoke directly about her concerns with funding the makerspace lab. “Let’s face it, Mark. You don’t have the money in your budget to support a staff member. We are trying to figure out ways to make the awareness level known.”

The school leaders at King ES overcame equity and diversity concerns by inviting students from other schools into the lab with priority being given to underserved students. Allowing visitors to attend the makerspace lab for free allowed all students, regardless of socioeconomic backgrounds to attend. School leaders had to be relentless in pursuing potential donors.

Dr. Samson, Superintendent of Caesar School District, noted what persuaded him most in supporting this initiative.

The fact that kids from other schools were going to be invited and other kids were going to have an opportunity that they would have missed out on because you can’t put this together in every school. Ultimately, I gave the green light to dedicate some funding for it.

David, the Director of Finance, expressed how the leaders’ commitment to the success of this initiative persuaded Caesar School District to fund the makerspace lab at King ES.

I think there are probably several things that are of value in making the decision (to fund the makerspace lab). Coming out and seeing what you are doing is important but as much as anything else, is seeing the passion and drive you and the members of your staff (Mary) have to do it. Not just strictly in the sense of what’s happening with the kids but the level of extra effort that you and the staff (Mary) were making to be successful. What can we find for traditional business partners? How can we pursue other options and other

funding mechanisms, etc.? By the time you had gone through and exhausted those other avenues, then certainly you get credit for due diligence and extreme effort. Then maybe at this point, there comes a point at which well, it looks like it is very worthwhile. We (Caesar School District) need to step up and help the process as well.

You have worked with 10 or 15 other schools. I know you had a whole series of students come visit your lab. It highlights the fact that this is more than just a King ES program. It is literally becoming a district opportunity!

Caesar School District showed their support of this initiative by funding a majority of makerspace lab expenses for the 2018-2019 school year and are making considerations to fund the makerspace expenses at King ES by making it a budget priority moving forward.

**Summary.** Having the right people was one of the most significant factors in influencing this makerspace lab initiative. Most participants found that having the right teacher that served as a full-time STEM teacher was imperative. Having the right principal, who could lead the daily operations and navigate change at the school and central office level was imperative. People matter. Having strong mentors and gaining central office's support was vital to the overall success of this initiative. Participants discussed the importance of having a model program to help ease initial start-up challenges and obstacles. In this study, these obstacles included reluctance to change, equity and diversity challenges, and funding concerns. School leaders addressed these concerns by focusing on inviting students from other schools and targeting schools with large underserved and underrepresented student populations. This decision resonated in key central office decision makers who eventually decided to fund most of the makerspace lab expenses for King ES.

#### Research Question 4

The fourth research question asked, “What are the lessons learned from the leaders and school personnel that are involved in launching this makerspace lab initiative? Three categories emerged from the analysis of interview transcripts and document review. These categories combine to explain the lessons learned from leaders and school personnel when launching this initiative: Inspire students, inspire teachers, and inspire parents.

**Theme 8: A model makerspace initiative can shift mindsets and inspire others.** The exemplary makerspace model at King ES has inspired students, parents, teachers, administrators, central office staff, university leaders, and business leaders. While educational leaders sought to equip students with the necessary 21<sup>st</sup> century skills, what educational leaders learned from this initiative is that it also inspired students and adults as well. Teachers, students, and parents noted how they have noticed a shift in existing mindsets.

*Inspire students.* The first lesson learned from leaders involved in launching this makerspace lab is that the model makerspace lab at King ES inspired students. Creating a strong makerspace model and dedicating a full-time STEM teacher to work with students in the makerspace lab had a profound influence on students. Document reviews and teacher interview data revealed that students were motivated and influenced in many ways after visiting the makerspace lab at King ES. One student imagined different ways she could help others by creating an invention. “What if I could invent something to help Flint, Michigan. They could have an app (that measures water levels) on their phone.”

Another student's self-image changed regarding her engineering skills and abilities after visiting the makerspace lab. "My day here was awesome! I never thought I had engineering in me. This lab really made my inner engineering come out!"

Similarly, teachers have noted how students have been inspired and impacted by the makerspace lab at King ES.

I think it has helped kids be bigger risk-takers. There are definitely some who can get in there (to the makerspace lab at King ES) and they can't do it right away. It takes them a little bit but they are always able to come back. They get engaged, which is what they don't do in the classroom.

Students were energized by their visits to the lab. One child compared their visit to a similar experience at an amusement park. "Today was amazing and I had a lot of fun. I even thought it was better than Disney World."

Another teacher shared how her students were changed from their visit to the makerspace lab at King ES.

I wanted to take this time to thank you for this amazing opportunity today. We have arrived back at our school and my students are still raving about the time they had today and they would love to go back. Please thank the Caesar School District and your volunteers again for me for allowing my fourth grade class to come and participate in this unforgettable experience. We had an awesome time and learned so much! It was a pleasure to come to your school today! I know my students will remember their time at the makerspace lab at King ES for years to come and their projects they created. They are now making plans to be engineers.

*Inspire teachers.* The second lesson learned from leaders involved in launching this makerspace lab is that this model makerspace lab has inspired teachers. The makerspace lab at King ES had a profound impact on teachers. What school leaders at King ES learned was that classroom teachers who visit the makerspace lab at King ES are being inspired by the STEM teacher and the engaging curricula in the makerspace lab. After visiting the makerspace lab, one teacher discussed how she was galvanized by the visit. “I have been teaching for 15 years. This is by far the BEST field trip I have ever been on. My students thrived, worked together, and created awesome things today.”

After conducting a teacher cohort interview, teachers from King ES were moved by the makerspace lab initiative at King ES and by the STEM Teacher. Several teachers shared how this has impacted their instructional practices and shifted their existing mindsets.

Well, the makerspace lab at King ES, for me, isn't just about the kids. My mindset has totally changed. The things that I do in Kindergarten are a lot different now, because of the makerspace lab at King ES. I have a lot more hands-on. Everything I do, which is terrible sometimes because I am totally Googling everything, is to try to do different activities that are hands-on. More problem-solving, thinking about things. I think that is what they need. I think it is 21<sup>st</sup> century learning. It has impacted me a lot. My mindset has totally changed.

The makerspace lab at King ES and the STEM teacher challenged teachers to consider different pedagogical approaches. One teacher noted the importance of placing more ownership and responsibility on the child for their own learning. “Children are becoming thinkers and problem solvers, where we are not doing so much for them. They are thinking on their own.”

This profound statement is at the heart of this work. STEM education is about self-exploration, tinkering and play. All too often the teacher is the conveyor of wisdom. A shift has occurred in the mindsets of many teachers as children are given freedom to explore the world around them. One teacher discussed how she is taking a different approach to instruction. “You have to let them fail! You have to let them fail!”

Similarly, another teacher realized the importance of giving the children ownership over their learning.

I think this is an opportunity for them to do something where we are not managing them. They spend a lot of time when we are telling them what to do. This is an opportunity for them to just do. Just try it. Well, that didn't work. Try it again. We all just have to stand back and let it happen. And then you get things like boats, that you didn't expect to work, now work. They figure it out!

Teachers, from King ES, shared the impact that the makerspace lab at King ES and having a full-time STEM teacher is having on the entire school. One teacher described how STEM educational experiences and concepts taught in the makerspace lab have become contagious in the building.

I think it is spilling over into our classrooms too! I might do an activity. Now, when we have STEM Fridays, I am trying some of those things in my classroom, which is way out of my comfort zone. We have tried a couple of those. We collaborated with our younger peers (in 1<sup>st</sup> grade), which was really fun. The kids really look forward to it. It is happening everywhere. It is not just in the lab, but it is happening in the classrooms as well. It is kind of just all over King ES!

The makerspace lab at King ES is having a tremendous influence on students and staff. The lab was created to prepare and *equip* students with the needed 21<sup>st</sup> century skills to be better prepared to enter the job market. What leaders learned from this initiative was that the lab not only prepared students with needed skills but *inspired* students to invent, problem-solve, and consider STEM careers while still in elementary school.

***Inspire parents.*** The third lesson learned from leaders involved in launching this makerspace lab is that a model makerspace lab can influence parents. Parents have noticed a change in their children as well. One parent told a Kindergarten teacher at King ES how her younger child is more independent than their older daughter who had the same teacher two years earlier. The parent attributes this change in behavioral patterns to the makerspace lab at King ES and the change in instructional practices the Kindergarten classroom teacher has implemented as a result of the makerspace lab at King ES.

Both of my daughters had Ms. Branch as their Kindergarten teacher. My youngest daughter is different. She looks at things differently and is a much more independent thinker. What you are doing here is working! I see the changes in my younger daughter from the STEM activities. I love what is happening at King ES!

### **Summary**

The case study at King ES provided invaluable data regarding considerations when building a makerspace lab. Data findings revealed that elementary students, beginning in Kindergarten, are ready for STEM educational opportunities. Transformational leaders at King ES demonstrated how their relentless passion and drive to launch an elementary makerspace catalyzed others to action.

Having the right people and a strong makerspace model were critical during this initiative. School leaders, university leaders, and business leaders partnered together to create one of the first elementary school makerspaces on the east coast that served as a hub to Champion University's and Computers Inc.'s model makerspace lab. Data findings revealed that community partnerships and inviting students from other schools to visit the makerspace lab as a field trip experience impacted the school district decision to eventually fund the makerspace lab. After experiencing the makerspace lab and seeing students turn ideas into action, the Superintendent, Director of Finance, and School Board from Caesar School District supported and funded this makerspace project with considerations to expand this model to other schools in the future.

## CHAPTER FIVE: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to provide additional information to the field of STEM research and leadership. In the Framework for K-12 Science Education, the National Research Council reports too few U.S. citizens have strong STEM backgrounds. Many workers do not have the necessary foundational knowledge or skills to be competitive in the workplace (National Research Council, 2011). The gap between the new skills students need to have upon graduation versus what is being taught in public schools today continues to grow (Wagner, 2012).

Arising from global market demands and technological advances, the creation of makerspaces are one important way to foster the innovative thinking and skills needed for the future (Han et al, 2017, Fleming, 2015). When all students have access and opportunities to “make”, they can construct their own knowledge about the world around them. Making has the strong potential to engage a diverse body of students in conceptual and experimental learning (Vossoughi & Bevan, 2014). Makerspaces hold tremendous potential in instilling essential skills students need to be properly equipped for the future (Han et al, 2017: Hlubinka et al, 2013).

To better understand makerspaces and to provide STEM educators with possible solutions to these challenges, this research focused on *why* school leaders launched a makerspace program and *how* educational and business leaders implemented a makerspace lab in an elementary school. The purpose of this qualitative study was to document and describe the change process connected with the implementation of the makerspace lab, how leaders navigated various obstacles, and the lessons learned from educators. Using a case study design, I collected data from multiple sources of evidence including interviews with educational leaders, business leaders, and by conducting a document review from leaders in this initiative.

In this chapter I discuss the findings of the interview questions, school documents, and data analysis findings found in Chapter Four. My discussion highlights findings from these four research questions.

1. Why did the school leaders decide to implement the makerspace lab?
2. How did the school leaders obtain the resources to launch the makerspace lab?
3. What factors (supports and obstacles) influenced the implementation of the makerspace lab?
4. What are the lessons learned from the leaders and school personnel who were involved in launching the makerspace lab initiative?

### **Summary of Findings**

The first research question addressed *why* school leaders decided to implement a makerspace lab. In this study, education leaders experienced a novel concept. This led to a transformational moment for educational leaders that inspired them to action. Maintaining the status quo was no longer an acceptable response for the leaders in this study. The educational leaders recognized the untapped potential of young students and were inspired to create additional STEM opportunities for students. Participants noted that the best way to build STEM resilience is through early exposure.

The second research question addressed how school leaders obtained the resources to launch a makerspace lab. In this study, two school leaders, the building principal and the STEM teacher were transformational leaders that initiated change. These two school leaders had passion for this initiative and were driven to find a way to make it work. Mark, the school principal, and Mary, the STEAM teacher, formulated an innovative idea. The building principal

and STEM teacher formed a guiding coalition of leaders who were committed to be change agents. Together, Mark and Mary created a shared vision that could be operationalized. This guiding coalition of leaders started with a group of two and grew significantly during the makerspace implementation process. The goal of educational leaders in this study was to create a makerspace lab that reached students from other schools along with servicing students at their own school. During this process, school leaders formed community partnerships with a Fortune 500 Company and a leading engineering university. School leaders involved the superintendent, school board, and central office staff. The school leaders took a leap of faith using site-based school funds and constructed the makerspace lab with the belief that it would empower other leaders to support the makerspace lab initiative. The school leaders made this makerspace lab their passion project and were persistent in inspiring a shared vision with others.

The school leaders at King ES understood they could not create a strong makerspace lab without the support from others. The building principal, Mark, and STEM teacher, Mary, cast a wide net and invited students from other schools to experience the makerspace lab as a field trip experience. Extending the invitation to students outside of King ES played a vital role in obtaining additional funds to sustain the makerspace lab.

School leaders at King ES invited and involved others in this initiative. Mark, Mary, and other central office personnel saw the value in bringing potential donors together to celebrate the opening of the makerspace lab. Students, parents, business leaders, central office staff, school board members, the superintendent, university leaders, and business leaders all had the opportunity to visit the makerspace lab in a kick-off ceremony. This celebration ceremony influenced key decision makers about funding and supporting the makerspace lab.

Participants identified the importance of having a site-based management system in place at King ES to launch this initiative. This allowed the building principal to have the resources to start the makerspace lab. Community partnerships also played a pivotal role in influencing Caesar School District. Having established community partnerships with Champion University and Computers Inc. prior to the Caesar School District supporting this initiative was paramount. Caesar School District was influenced by these partnerships and showed their support by funding a majority of makerspace lab expenses for the 2018-2019 school year! Currently Caesar School District is making considerations to assist with makerspace expenses at King ES next year by making it a budget priority moving forward.

The third research question addressed what factors (supports and obstacles) influenced the implementation of the makerspace lab. Having the right people was one of the most crucial factors in influencing this makerspace lab initiative. This research found that having the right teacher that served as a full-time STEM teacher was imperative. Having the right principal, who could lead and navigate the change process was also an essential factor. Securing strong mentors who provided support with this initiative was a significant factor in launching a successful initiative. Other factors that were vital were having the superintendent, school board, and other central office personnel support this initiative.

Finding a strong model program was an imperative factor in the implementation of the makerspace lab. The school leaders at King ES utilized a preexisting makerspace lab model that was located on the campus of Champion University. This model program highlighted the importance of the engineering process, play, and working through failure. The makerspace lab at Champion University was free to visiting students, utilized a noncompetitive design, and had no

prescribed outcomes for students. Mark and Mary incorporated these components into their makerspace lab at King ES.

There were particular obstacles during this makerspace initiative that presented challenges for the leaders at King ES. The first obstacle school leaders faced was many individuals were reluctant to change. Maintaining the status quo is a common challenge leaders face when launching a new and innovative concept. In this case study, school leaders had to be relentless in helping inspire a shared vision with central office staff within Caesar School District. This process took time and was cumbersome. Yet with persistence, and by having central office staff visit the makerspace lab, school leaders were able to inspire, encourage, and motivate central office leaders to get behind this initiative.

Equity and diversity concerns were obstacles that were addressed in this makerspace lab initiative. Why would a makerspace lab be launched and partially funded at King ES, when other schools do not have such a lab? To address these concerns, school leaders designed the makerspace lab to be purposed for outreach. The goal of the lab was to reach all students from other schools in Caesar School District and provide equal access. Schools that had specific demographics that included large populations of underserved and underrepresented groups in STEM education, were given priority to visit the lab.

Funding was the biggest obstacle in this research study. School leaders worked relentlessly to explore multiple avenues to secure funding. Sustainability was a significant concern. Site-based management allowed the school leaders at King ES to launch a unique program and provided flexibility with initial start-up costs but this did not address sustainability concerns. The establishment of community partners influenced the Caesar School District's decision to eventually fund a majority of the makerspace lab initiative. Since a leading

engineering university and Fortune 500 company were willing to partner with King ES independently from Caesar School District, the Superintendent and Director of Finance felt there was minimal risk to invest in this program and that potential gains for this investment far exceeded the risk. This helped address sustainability concerns.

The fourth research question addressed the lessons learned from leaders and school personnel when launching this makerspace lab initiative. Leaders learned that a strong elementary makerspace lab model can shift mindsets, develop needed 21<sup>st</sup> century skills, and inspire others. While educational leaders sought to *equip* students with the necessary 21<sup>st</sup> century skills, what educational leaders learned from this initiative is that it also *inspired* students and adults as well. Multiple participants in this study shared how they were motivated to do things differently and how they experienced a shift in traditional thinking.

### **Discussion of Findings**

To provide an in-depth analysis, the findings were merged from the other four research questions into one comprehensive discussion. This allowed the opportunity to compare and contrast differences between the findings and current research.

Although little current research has investigated the considerations necessary when launching an elementary makerspace lab, the findings of this case study confirm and extend many of the concepts found in the literature. The findings from this study were compared with existing research on leadership theory and STEM educational research.

Kouzes and Posner's research studied thousands of leadership experiences and uncovered five practices that all leaders engage in when creating change: Model the way, Inspire a shared vision, Challenge the process, Engage others to act, and Encourage the heart (Kouzes & Posner,

2007). The discussion of findings is explicitly organized around Kouzes and Posner's five practices of exemplary leadership (Kouzes & Posner, 2007).

**Model the Way.** Kouzes and Posner's research found that leaders must model the behaviors they expect from others. Leaders had an unwavering commitment to a clear set of values and were passionate about their causes. Leaders believed strongly in something and stood up for their beliefs. Leaders modeled the way (Kouzes & Posner, 2007). The major findings of this research compliment the findings of Kouzes and Posner. Findings from this study revealed that school leaders from King ES modeled the way by launching one of the first elementary makerspace labs of its kind on its own campus within Caesar School District. The school leaders at King ES worked with central office staff, university personnel, and business leaders to build a model makerspace lab that serviced over 1,000 students in its first year of implementation.

School leaders from King ES experienced a novel concept when they visited the makerspace lab at Champion University. Leaders from King ES witnessed an innovative way of learning that triggered a change in their traditional thinking. A transformational moment occurred as these leaders had a shift in their mindsets. After observing students making, building, designing, failing, and surviving failure to create new learning, school leaders at King ES had a fervent desire to learn more about STEM education and were relentless in creating needed change in educational practices.

This transformational moment inspired school leaders at King ES to be advocates for additional STEM opportunities for young children. Maintaining the status quo was no longer an acceptable response for leaders at King ES and they promoted STEM education through the creation of a makerspace lab and by dedicating a full-time STEM teacher to service students at King ES and the surrounding region. The educational leaders at King ES recognized the

untapped potential of young students and modeled the way by working with central office, university personnel, and business partners to build STEM resiliency through early exposure and makerspace experiences.

Giving elementary students early exposure to STEM activities positively impacts perceptions about STEM education and promotes considerations of pursuing STEM related careers (DeJarnette, 2012; Bagiati et al, 2010). The major findings of this research complement the existing research on makerspaces and suggest STEM educational opportunities should begin as early as Kindergarten.

Engineering concepts, along with inquiry-based student learning opportunities, are being incorporated at much earlier stages of the elementary curriculum (DeJarnette, 2012). Elementary students have the cognitive abilities to engage in STEM activities and problem-solving skills. Engaging elementary students in STEM educational opportunities builds self-confidence and self-efficacy (DeJarnette, 2012). In this study, educational leaders at King ES found that students, beginning in Kindergarten, successfully engaged in STEM educational opportunities, navigated the engineering design process, and experienced success with inquiry-based learning opportunities. Participants discussed how STEM education focuses on exploring the world around them and building things to accomplish tasks. By educating students when they are young, participants discussed how educators at King ES were able to utilize a child's natural enthusiasm for learning, engage them in meaningful play, and further develop needed STEM skills and innovative thinking.

Every leader Kouzes and Posner studied had an unwavering commitment to a clear set of values. Leaders were passionate about their causes and were willing to stand up for their beliefs (Kouzes & Posner, 2007). In this study, participants discussed how the school leaders at King ES

were devoted to ensuring the makerspace lab at King ES was successful. School leaders at King ES were relentless in their commitment to fulfill their vision of a makerspace lab at King ES and stood up for what they believed in. School leaders created community partnerships with Champion University and Computers Inc., worked with university personnel, central office staff, school board members, parents, and students to create a strong model makerspace lab that served as a field trip destination for other students in Caesar School District. The school leaders at King ES developed a team of supporters that made this makerspace journey possible.

The school leaders' passion for this initiative was sparked by others who were modeling the way. School leaders at King ES were influenced by Luke and Peter's passion to promote STEM education. Luke, a lab director at Champion University, and Peter, a professor at Champion University, helped model the way by creating and operating a model makerspace lab located at Champion University, and throughout the region, to emulate. The model makerspace lab gave regional leaders a model to emulate and introduced a new approach to learning and inquiry-based instruction.

The emphasis on standardized testing in American schools has hindered the growth of inquiry-based instruction in schools. Elementary students are often given information about science and have become consumers of knowledge. As a result, students are relying on knowledge, products, and conclusions that others have made rather than experiencing it and constructing knowledge themselves (DeJarnette, 2012). Students can learn by creating and discovering knowledge rather than receiving it passively (Papavlasopoulou, 2014). In this study, the model makerspace labs at King ES and Champion University showcased how students can construct knowledge through play and by engaging in the engineering process. The makerspace lab at King ES and Champion University were created to allow students to discover knowledge

and work through initial failures. These makerspaces have modeled the way and serve as a window into what future educational opportunities may look like.

**Inspire a shared vision.** Kouzes and Posner found that when leaders envision the future, they are expressing their passion. Passion, according to Kouzes and Posner is all about what gets people up each morning and what will not let them sleep at night (Kouzes & Posner, 2007). The findings in this research add to the existing work of Kouzes and Posner. In this study, Mark, the building principal, and Mary, the STEM teacher, had two critical intrinsic characteristics that fueled this whole initiative: passion and drive. These intrinsic motivating factors lead the entire change process. Without these two qualities, the stamina needed to create change would not have been sufficient to bring systemic reform.

In this study, the building principal and STEM teacher, developed strong beliefs about creating an elementary makerspace. School leaders at King ES demonstrated an unwavering determination during this initiative and stood up for their beliefs about STEM education. Participants and key decision makers noted how they were influenced by Mark and Mary's passion to the overall success of this initiative. Many participants shared that it was the passion of the leaders in this initiative that motivated them to work in their sphere of influence to support the makerspace lab. This research found that passion matters when leading change but also must be accompanied with action.

Kouzes and Posner found that change requires more than just being passionate about a cause. A leader's deeds are much more important than their words (Kouzes & Posner, 2007). Exemplary leaders go first and set the example through daily actions that demonstrate they are committed to their beliefs and passions. A critical factor to change is the level of commitment leaders have toward the initiative (Kouzes & Posner, 2007). "Personal values drive

commitment” (Kouzes & Posner, 2007, p. 56). The findings of this research expand the findings of Kouzes and Posner. In this study, the *drive* of the school leaders at King ES was imperative. Passion was not enough. Having a genuine interest and love for STEM education was inadequate to bring change. Participants described how they were influenced by Mark and Mary exhausting all their options when creating change. The school leaders at King ES sought support from community partners, businesses, parents, central office personnel. Together, they built momentum, created systemic change, and inspired a shared vision.

Kouzes and Posner’s research found that every social movement and significant change started with a dream. The dream, or vision, created future opportunities for leaders (Kouzes & Posner, 2007). Change began when leaders had dreams and visions of what could be. Leaders had personal beliefs in their dreams and were confident they could make it happen (Kouzes & Posner, 2007). Kouzes and Posner found that leaders had strong beliefs about what they were leading and demonstrated an unyielding commitment to a clear set of values. This requires studying how the leaders are intrinsically or extrinsically motivated to bring about change (Kouzes & Posner, 2007). The findings in this research compliment the findings of Kouzes & Posner. In this study, the building principal and the STEM teacher experienced a transformational moment that forced them to rethink and revisit their own personal educational philosophies. Mark and Mary reflected on their current educational practices and decided to be agents of change. Mark and Mary formulated an innovative idea of creating an elementary makerspace lab on their own campus and formed a guiding coalition of leaders that initiated the change process.

Kotter (1995) describes a sequence of steps that transformational leaders go through when creating change in an organization. The first step is to establish a sense of urgency,

followed by forming a powerful guiding coalition (Kotter, 1995). In contrast, Kotter's research does not focus on the what is happening within each leader that is motivating the change. Most of Kotter's transformational change research focuses on the work that transformational leaders do. Kotter discusses how leaders must establish a sense of urgency, form a powerful guiding coalition, create a vision, communicate that vision, and empower others to act on that vision. In this study, participants noted the importance of intrinsic factors that led to a transformational moment that drove the entire change process. Transformational leaders in this case study found that change first happened within before it could be spread to inspire others.

After leaders reflected on personal practices and forming a guiding coalition, the school leaders at King ES created a shared vision. Mark and Mary aligned their visions of what an elementary makerspace would look like and created a shared vision that could be operationalized. School leaders at King ES considered needed resources, logistics, target audiences, curriculum, and a communication plan. Their goal was to create a makerspace lab that reached students from other schools in addition to servicing students at King ES. To accomplish this goal, Mark and Mary understood they would need to enlist the help from others.

Leaders must enlist others in the common vision. Kouzes and Posner found that leaders must know their targeted audience and be able to speak their language to enlist others' support. Leaders must know the hopes, dreams, aspirations, visions, and values of the people they are leading (Kouzes & Posner, 2007). The findings of this research compliment the work of Kouzes and Posner. In this study, education leaders enlisted the support from others at the onset of this initiative. The school leaders, Mark and Mary, cast a wide net and invited key stakeholders to participate at the inception of this initiative. The superintendent, school board members, central

office staff, school principals, business leaders, university leaders, parents, and students were invited to visit and support the makerspace lab at King ES.

In this study, inviting students from other schools to attend the makerspace lab at King ES was a key finding that helped move this initiative forward. One of the most impactful factors that participants noted was the influence inviting students from surrounding schools had on their decision to support and fund the lab. This was a critical finding. The makerspace lab at King ES was built to service students from other schools. This revolutionary concept proved to be a compelling selling point to stakeholders when choosing to get behind this initiative. Creating a makerspace lab that served as a field trip destination for other schools in the district was not only novel but may have been the single most important decision to help sustain the makerspace lab. Each participant in this study noted how the lab serviced other students and how that was a compelling reason to support the makerspace lab.

The data analysis from this study found that casting a wide net and enlisting others included not only people, but also incorporated agencies and organizations too. The findings from this study found community partnerships and outside agencies were significant factors in creating and sustaining change with key stakeholders. When creating an elementary makerspace lab, participants in this study noted the importance of not only inviting educational leaders but in forming community partnerships. Leaders at King ES shared the significance community partnerships played during this initiative. Leaders from King ES formed a partnership with a Fortune 500 business company and a leading engineering university. Participants in this study discussed how the partnerships with a higher education university, and a business partner working independently with the school influenced central office staff to fund and support this initiative. The Superintendent and Director of Finance both agreed that having the community

partners be invested in the initiative prior to the school district financially supporting it was very influential to move this initiative forward with needed funding from Caesar School District.

**Challenge the process.** Kouzes and Posner found that every leadership case they studied involved a challenge (Kouzes & Posner, 2007). Leaders are pioneers and must be willing to step out into the unknown. Innovation requires searching for new opportunities to grow and improve. Innovation requires experimenting, making mistakes, and taking risks (Kouzes & Posner, 2007). The findings of this research compliment the findings of Kouzes and Posner. Participants described how the school leaders at King ES continuously challenged the process and traditional norms within Caesar School District. Mark and Mary discussed how their desire to create one of the first makerspace labs of its kind, on the east coast, was met with initial reluctance. Creating a makerspace lab at King ES, that served as a field trip destination for other fourth grade students, was a new concept that was not part of customary practices. Leadership involves challenging the status quo (Hechanova et al, 2012). There was initial reluctance from central office because a novel makerspace lab represented a change from the status quo. Mark and Mary overcame challenges that included reluctance to change, equity concerns, diversity concerns, and funding obstacles.

Challenging the process involves searching for new opportunities (Kouzes & Posner, 2007). African Americans, Hispanics, Native Americans, and women are underrepresented in the STEM fields (Yoder, 2014). Just 7% of the total STEM workforce are African Americans, Latinos, and Native Americans combined. Makerspaces offer one solution to build STEM resiliency with underserved and underrepresented groups. In this study, the leaders at King ES emphasized the importance of providing all students will equal access and created a makerspace lab to reach every child. By welcoming students from other schools, offering the makerspace

experience at no charge to visiting schools, and prioritizing schools who have large populations of underserved and underrepresented groups, leaders from King ES found creative ways to address equity and diversity concerns. Having King ES serve as a field trip destination was a novel concept and many participants in this study noted this was a determining factor in this initiative's success.

Kouzes and Posner describe the importance of taking risks. Innovation requires experimenting, making mistakes, and taking risks (Kouzes and Posner, 2007). Participants in this study described how Mark, Mary, and other educational leaders in this study consistently challenged the process by taking calculated risks during this initiative. The building principal and STEM teacher took a risk by building the makerspace lab. Site-based funding allowed the principal the necessary start up money to launch this initiative. Mark reallocated school funds to create a full-time STEM position. Participants noted how this required a step of faith by building the makerspace lab with the hopes of raising funds to maintain the program.

Finding funding for the makerspace lab was the largest challenge leaders at King ES overcame in this initiative. School leaders had to be relentless in pursuing potential donors and exhaust all options. The data analysis revealed that the partnership formed independently with a Fortune 500 company and a leading engineering university, coupled with the way school leaders at King ES exhausted all options, influenced key decision makers in Caesar School District to support the makerspace lab. This resulted in a school initiative becoming a district opportunity where Caesar School District funded a majority of the makerspace lab expenses for the 2018-2019 school year and are considering funding the program for years to come.

**Enable others to act.** Significant dreams do not become reality through just one person. It requires a team effort to accomplish anything of significance. To get incredible things done in

any organization, leaders have to enable others to act (Kouzes and Posner, 2007). The findings of this study compliment the work of Kouzes and Posner. Participants and educational leaders in this study discussed how they understood that they would not be able to launch the makerspace lab based on one individual's effort. Participants reported they understood the importance of needing a team of people and entities to support this endeavor. Several participants noted the importance educational and business leaders played in making this initiative successful. The Superintendent, Director of Finance, School Board Members, Associate Superintendent, Director of LIGHT, university personnel, and business leaders were invited to participate in this initiative at its inception. The findings of this study revealed that each leader from this study worked in their sphere of influence to bring about systemic change. Mark and Mary enabled others to act and empowered them to find creative ways to support the makerspace lab at King ES. In this study, Mark and Mary's leadership team grew as they empowered others to act by first bringing visitors into the makerspace lab to experience and see the lab in action. After visitors attend the makerspace lab, several participants reported they were motivated by their visit and wanted to inspire others. These potential donors and stakeholders were empowered to act and worked in their sphere of influence to impact others.

*Have the right people.* Kotter and Cohen found that at the heart of change is having the right people (Kotter & Cohen, 2008). Kotter and Cohen noted that you have to build a guiding team that has the right people who are committed to working together (Kotter & Cohen, 2008). In this study, having the right people involved in this makerspace initiative was according to many, the most important factor in the overall success of this initiative. People matter. In this initiative, having the right people involved in the project determined its overall success. Participants in this study shared their impressions that the makerspace initiative was successful

because it had the right teacher, the right administrator, strong mentors, and the right supportive staff to lead and navigate change.

**Encourage the heart.** Kouzes and Posner found that leaders understand the importance of encouraging others when leading and navigating change. Change can take time and be exhausting. Leaders encourage and celebrate victories, along with small wins during the journey (Kouzes & Posner, 2007). The findings from this research compliment the work of Kouzes and Posner. In this study, leaders at King ES encouraged the heart in a unique way. The King ES leaders invited all potential donors, central office staff, teaching staff, business partners, parents, and students to celebrate the opening the makerspace lab at King ES via a grand opening ceremony. Every participant in this study noted the importance of conducting a grand opening ceremony. After constructing the makerspace lab at King ES using site-based funding, the findings revealed that bringing all the parties and partners together had a significant influence on key stakeholders. Each participant in this study who attended the grand opening ceremony discussed how the makerspace lab kickoff event built momentum in this initiative. The purpose of the grand opening makerspace ceremony at King ES was to celebrate with the leaders involved with this process, inspire others, and build credibility for the program. The leaders at King ES thanked people for being a part of this initiative, which built momentum moving forward. The leaders at King ES encouraged the heart of others by inviting them to be a part of this makerspace initiative.

### **Personal reflections**

As the researcher in this study, I did not understand the impact that my personal passion and drive to successfully launch this initiative had on others. When you are the one leading change, it is important to reflect on why are you doing it. What motivated me to create such change? Why

would I work relentlessly to overcome obstacles and challenges? The simple answer is because I believed it was what was best for kids. After experiencing the makerspace lab at Champion University, I could no longer ‘principal’ the way I once did. Fortunately, I was not alone in this quest. As shared in our story, I was accompanied by another leader in Mary who also experienced a similar transformational moment. Together, we formed a powerful guiding coalition that influenced others to bring needed change to our school and our school district.

I did not understand the power of inviting other schools to our program until the conclusion of this research project. The simple decision to invite other schools to our makerspace lab as a field trip destination had tremendous traction with all the key stakeholders in this initiative. Each participant noted that by reaching out to others and not being focused solely on our school, equity and diversity concerns were minimized. Welcoming other schools also reached a wider audience which was recognized and appreciated by donors and supporters.

In reflecting on this makerspace initiative, I now realize the power of community partners. The partnership King ES formed with a Fortune 500 company, and a leading engineering university made a huge difference in the eventual success of this program. The Director of Finance and the Superintendent from Caesar School District noted that having two large business and university partners support our makerspace program independently was significant to them. This independent support, separate from any school district support, eventually persuaded these key decision makers in Caesar School District to fund the makerspace initiative moving forward.

This journey reiterated to me the importance of having the right people on board with you. In this initiative, I had the right teacher leader who was instrumental in launching this elementary makerspace lab. She truly was the difference maker and I am confident the initiative would not have been as successful had it not been for her leadership and pedagogical skill set leading the way

at the ground level. I am truly thankful for her and look forward to expanding this initiative to launch makerspace labs in other elementary schools.

### **Conclusions**

This study recognized that one way to reach the untapped potential of young students is by creating makerspaces in elementary school! Early exposure is critical! By giving students an opportunity to play, tinker, design, and create in a makerspace lab forum, the innovative capacity of students, staff, and educational leaders has flourished. By releasing teacher control, and allowing students to own their own learning, we have started down an incredible road full of potential, enthusiasm and opportunity. The collective work and partnerships between a leading engineering university, a Fortune 500 Company, a School District, and a local school have demonstrated that sustainable change is possible. This elementary makerspace initiative started with an idea that grew from an initial party of two. A guiding coalition of transformational leaders created a vision that could be operationalized, and navigated change at the school and central office level. By forming powerful community partnerships and working closely with central office leaders, school board members, and university personnel, an exemplar makerspace model was created to serve as hub to a preexisting makerspace model at Champion University. School leaders were able to develop a concept and model, in conjunction with a local university, that has the potential to revolutionize elementary schools across this nation and change instructional practices forevermore. These daring leaders realized that to make such systemic sweeping changes, they would need to enlist the help, support, and backing of others. By empowering others to act on this vision, a powerful makerspace lab is impacting young students throughout Caesar School District with possibilities of future expansion.

Educational leaders in this study recognized the untapped potential of young learners after experiencing a novel concept. As a result of this transformational experience, the educational leaders, in this study were called to action. In this study, a guiding coalition of transformational school leaders formed community partnerships with a leading engineering university and a Fortune 500 company. This partnership gained enough momentum to motivate central office leaders within a Mid-Atlantic School District and inspired them to find solutions to the growing gap in needed technology skills for students. Transformational leaders empowered and inspired core decision makers and stakeholders to launch one of the first elementary makerspaces of its kind on the east coast! By using an existing model program and establishing mentors to help navigate the change process and challenge traditional practices, new innovative practices have emerged. Through this process, the innovative capacity of students, staff, administrators, and community leaders have grown exponentially. It is the hope of these transformational leaders that these research findings found in this study would serve as a guide to others who are contemplating engaging in a similar initiative.

### **Implications**

Although this study looked specifically at one school, the process educational leaders went through and the lessons learned from leaders in this initiative can assist other schools and leaders who are considering launching a makerspace lab.

Based on the findings from this research and the literature review, schools should consider the following:

1. Begin STEM education early to unleash creativity in young learners. Start STEM education in Kindergarten. Too often, STEM education does not begin until middle and

high school. This research and field work have demonstrated that Kindergarten students are capable and ready for STEM educational opportunities.

2. Hire the right STEM teacher. Commit to having a full-time STEM teacher to run the daily operations of the makerspace lab. This teacher should have a passion for learning and be willing to step outside of their comfort zone. The teacher will need to have leadership qualities and be resilient when navigating change. Educational leaders must consider providing needed resources and most importantly personnel to work with students and teachers in providing purposeful STEM activities.
3. Seek community partnerships. Find a local college that would be willing to work with you in establishing a makerspace for students. Find a local business that would be willing to support your makerspace as well. Exhaust all your options understanding that these partnerships build momentum and can influence central office personnel on funding decisions.
4. Find a strong model program and a mentor. This journey will be more manageable if you are able to find a model makerspace that has already been established. A strong model program will empower students to design and create inventions. Mentors who have previously launched a makerspace lab are an invaluable resource during the initial launching stages too. Mentors can help with ordering necessary supplies, set up costs, and help with finding needed resources. Mentors also provide support to you when you encounter obstacles.
5. Take a leap of faith and build your makerspace lab. Build the makerspace lab with existing resources. Many participants in this study said, “Seeing is believing.” Discussing the concept of the lab was not enough to persuade potential donors and

stakeholders. When they could see the makerspace lab in action and watch students turn ideas into products, they were sold and wanted to do what they could to support the new initiative.

6. Invite teachers and students from other schools. This is not a journey to be taken alone. Invite students from other schools to attend your lab as a field trip experience. If funds permit, offer this to visitors for free. Target schools that have large numbers of underserved and underrepresented students.
7. Invite other leaders. Invite the superintendent, school board, and central office personnel. Invite business owners, parents, and students. Have other principals come to your school to visit the lab. Promote the lab to others whenever possible.
8. Enthusiasm and persistence matter. Make this initiative your passion project. Participants in this study were most influenced by the relentless drive and commitment of the school leaders in this program. There were obstacles and challenges. The transformational leaders were relentless and passionate about doing what was best for kids in providing quality STEM education on their elementary campus. If you don't have the passion, grit, and determination to make this happen, it won't.
9. Inspire students and staff. Let your enthusiasm and energy catalyze others. Develop a passion for STEM education and understand the importance of equipping students when they are young to consider STEM careers. The leaders in this study were motivated to *equip* students with 21<sup>st</sup> century skills. Leaders in this study found that this makerspace initiative not only prepared kids with needed innovative skills, but also *inspired* them to be innovators and future engineers.

10. Step back and let your students lead. Empower your students by giving them opportunities to make. Set a purposeful environment and give them the freedom to build, design, and explore without having a prescribed outcome. Students thrive in this environment. Less of you, and more of them. Step back and watch!

### **Recommendations for Future Studies**

This case study suggests several opportunities for further research in the implementation of other elementary makerspace labs. These would be excellent additions to the burgeoning body of knowledge on this topic.

**Site based management vs. traditional budgetary systems.** Research projects might explore how a site-based management initiative compares with a traditional budget system. Is it easier to launch a new initiative in a site-based management fiscal system than in a traditional budget system? How important is it to have seed money when launching a pilot initiative? What sustainability concerns are there under a site-based management system? Are there advantages in having a traditional financial management system?

**Curriculum beyond the one-day field trip experience.** Research projects might explore how the STEM teacher can take the curriculum beyond the one-day field trip experience. What are some creative ways to tie the art of making into state educational objectives? How would the STEM teacher co-plan topics of interest to other grade levels? What are some ways to extend learning opportunities beyond the initial introductory makerspace experience?

**How to continue elementary makerspace experiences to middle school students.** Research projects might explore how could the elementary makerspace experience be extended to middle school? What are ways to ensure that the makerspace experiences that students have

in elementary school are extended when each child reaches middle school? What are ways to further promote STEM skills in middle school? What are new ways to challenge middle school students?

**A longitudinal study of the impact a dedicated full-time STEM teacher can have on students pursuing STEM careers.** What is the short-term impact a STEM teacher can have on students? What is the long-term impact that a STEM teacher can have on students? How many students who participated in the STEM makerspace lab experience eventually pursue STEM related careers?

**Long-term impact of makerspace lab on students.** What was the most influential factor when visiting the makerspace lab? How did this experience change students' thoughts about engineering? How did this experience change your thinking about yourself? Did the makerspace experience help you become a better problem-solver?

**Long-term impact of makerspace lab on staff.** What are the long-term implications of a makerspace lab on staff? How has the makerspace lab impacted teachers' approach to teaching and learning? What attributes of the makerspace lab are most appealing to them as educational leaders? How are teachers tying components of the makerspace lab to instruction?

The future looks bright, but we will need your help too. Together, we can inspire a brighter future.

## References

- Anderson, C. (2012). *Makers: The new industrial revolution*. Crown Business, New York.
- Bagiati, A., Yoon, S. Y., Evangelou, D., & Ngambeki, I. (2010). Engineering Curricula in Early Education: Describing the Landscape of Open Resources. *Early Childhood Research & Practice, 12*(2), n2.
- Banks-Hunt, J. M., Adams, S., Ganter, S., & Bohorquez, J. C. (2016). K-12 STEM education: Bringing the engineering maker space, student-centered learning, curriculum, and teacher training to middle schools. Paper presented at the 1-5. doi:10.1109/FIE.2016.7757531.
- Basham, J. D., & Marino, M. T. (2013). Understanding STEM education and supporting students through universal design for learning. *Teaching Exceptional Children, 45*(4), 8-15.
- Bass, B. (1985). *Leadership and performance beyond expectations*. New York: Free Press.
- Beer, M., & Nohria, N. (2000). Cracking the code of change. *HBR's 10 must reads on change, 78*(3), 133-141.
- Bonagura, A. (2017). *Embrace makerspace: A pocket guide for elementary administrators*. Rowman & Littlefield. Lanham, MD.
- Britton, L. (2012). The makings of makerspaces, part I: space for creation, not just consumption. *Library journal*. Retrieved from: [Http://thedigitalshift.com/2012/10/public-services/themakings-of-maker-spaces-part-1-space-for-creation-not-just-consumption/](http://thedigitalshift.com/2012/10/public-services/themakings-of-maker-spaces-part-1-space-for-creation-not-just-consumption/).
- Brophy, S., Kelin, S., Portsmouth, M., & Rogers (2008) Advancing Engineering Education in K-12 Classrooms, *Journal of Engineering Education*, p. 19.
- Bryman, A. (1992). *Charisma and leadership in organizations*. London: Sage Publications.

- Bybee, R. W., & Fuchs, B. (2006). Preparing the 21st century workforce: A new reform in science and technology education. *Journal of Research in Science Teaching*, 43(4), 349-352.
- Carless, S. A., Wearing, A. J., & Mann, L. (2000). A short measure of transformational leadership. *Journal of business and psychology*, 14(3), 389-405.
- Chrislip, D. & Larsen, C. (1994). *Collaborative Leadership*. San Francisco: Jossey-Bass.
- Craig, E., Thomas, R., Hou, C., & Mathur, S. (2011). No shortage of talent: How the global market is producing the STEM skills needed for growth. *Accenture Institute for High Performance*. [www.accenture.com/institute](http://www.accenture.com/institute).
- Creswell, J. (2003). *Research design qualitative, quantitative, and mixed methods*. Thousand Oaks, CA: Sage Publications, Inc.
- DeJarnette, N. (2012). America's children: Providing early exposure to STEM (science, technology, engineering and math) initiatives. *Education*, 133(1), 77-84.
- Dougherty, D. (2013). The maker mindset. In Honey, M., & Kanter, D. E. (Eds.), *Design. Make. Play. Growing the next generation of STEM innovators* (pp. 7–16). New York, NY: Routledge.
- Fleming, L. (2015). *Worlds of making: Best practices for establishing a makerspace for your school*. Corwin Press.
- Garvin, D. A., & Roberto, M. A. (2005). Change through persuasion. *Harvard business review*, 83, 26-33.

- Gray, B. (1989). *Collaborating: Finding common ground for multi-party problems*. San Francisco, CA: Jossey-Bass.
- Halverson, E. R., & Sheridan, K. (2014). The maker movement in education. *Harvard Educational Review, 84*(4), 495-504.
- Han, S., Jaeheung, Y., Hangjung Z., & Ciganek, A. (2017). Understanding makerspace continuance: A self-determination perspective. *Telematics and Informatics, 34*, 184-195.
- Hatano, G., & Inagaki, K. (1986). Two courses of expertise. In Stevenson, H., Assume, H., & Hakuta, K. (Eds.), *Child development and education in Japan* (pp. 262–272). New York, NY: Freeman.
- Hatch, M. (2013). *The maker movement manifesto: Rules for innovation in the new world of crafters, hackers, and tinkerers*. McGraw-Hill, New York.
- Hechanova, R. M., & Cementina-Olpoc, R. (2013). Transformational leadership, change management, and commitment to change: A comparison of academic and business organizations. *The Asia-Pacific Education Researcher, 22*(1), 11-19.
- Hlubinka, M., Dougherty, D., & Thomas, P. (2013) *Makerspace Playbook*. Maker Media.
- Holdren, J. (2010). President's Council of Advisors on Science and Technology. *Prepare and inspire: K-12 education in science, technology, engineering, and math (STEM) for America's future*. Washington, D.C.: Executive Office of the President, President's Council of Advisors on Science and Technology.
- Honey, M., & Kanter, D. (2013). *Design, make, play: Growing the next generation of STEM innovators*. New York, NY: Routledge. doi:10.4324/9780203108352

- Kapur, M. (2016). Examining productive failure, productive success, unproductive failure, and unproductive success in learning. *Educational Psychologist, 51*(2), 289-299.
- Kapur, M. (2008). Productive failure. *Cognition and Instruction, 26*(3), 379-424.
- Kotter, J. P., & Cohen, D. S. (2008). *The heart of change: Real-life stories of how people change their organizations*. Harvard Business Press.
- Kotter, J. P. (1995). *Leading change: Why transformation efforts fail*. Harvard Business Review.
- Kouzes, J., & Posner, B. (2007). *The leadership challenge* (4th ed.). San Francisco, CA: Jossey-Bass.
- Maltese, A. V., Simpson, A., & Anderson, A. (2018). Failing to learn: The impact of failures during making activities. *Thinking Skills and Creativity*.
- Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2010). *Stuck in the shallow end: Education, race, and computing*. MIT Press.
- Martin, L. (2015). The promise of the maker movement for education. *Journal of Pre-College Engineering Education Research (J-PEER), 5*(1) doi:10.7771/2157-9288.1099.
- Martinez, S. L., & Stager, G. (2013). *Invent to learn: Making, tinkering, and engineering in the classroom*. Torrance, CA: Constructing Modern Knowledge Press.
- Maxwell, J. C. (2001). *The 17 indisputable laws of teamwork: Embrace them and empower your team*. Thomas Nelson.
- Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative Research : A Guide to Design and Implementation*. San Francisco, CA: Jossey-Bass.

- Mohammadi, G. (2011). Most spectacular failure award at handcar regatta. Make Magazine Blog. Retrieved from <http://makezine.com/2011/09/28/most-spectacular-failure-award-at-handcar-regatta/>.
- Montessori, M. (1912). *The Montessori Method: Scientific Pedagogy as Applied to Child Education in "The Children's House"*. FA Stokes.
- Nadler, D., & Tushman, M. (1990). Beyond the charismatic leader: Leadership and organizational change. *California Management Review*, 32, 77-97.
- National Research Council. (2011). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Committee of Conceptual Framework for the new K-12 science education standards, Board of Science Education, National Research Council. Washington, DC; The National Academic Press.50-70). New York, NY: Routledge.
- National Science Foundation. (2014). Chapter 3. Science Engineering Labor Force. In *Science and Engineering Indicators 2014*. (pp.3-59). Available at: <http://www.nsf.gov/statistics/seind14/content/chapter-3/chapter-3.pdf>.
- Obama, B. (2009). Remarks by the president at the National Academy of Sciences annual meeting. *The White House. Office of the Press Secretary*.
- Oliver, K. (2016). Professional development considerations for makerspace leaders, part one: Addressing “What?” and “Why?”, *Tech Trends*, 60, 160-166.

Oliver, K. (2016). Professional development considerations for makerspace leaders, part two: Addressing “How?”, *Tech Trends*, 60, 211-217-166.

Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L. (2017). Empirical studies on the maker movement, a promising approach to learning: A literature review. *Entertainment Computing*, 18, 57-78.

Papert, S. (1980). *Mindstorms: children, computers, and powerful ideas*. New York: Basic Books.

Patton, M. (2015). *Qualitative research and evaluation methods* (4<sup>th</sup> ed.). Thousand Oaks, CA: Sage.

Petrich, M., Wilkinson, K. & Bevan, B. (2013). It looks like fun, but are they learning? In Honey, M. & Kanter, D. *Design, Make, Play. Growing the next generation of STEM innovators* (pp 50-70). New York, NY: Routledge.

Piaget, J. (1976). Piaget’s theory. In *Piaget and his school* (pp. 11-23). Springer, Berlin, Heidelberg.

Rothwell, J. (2013). “The hidden STEM economy.” *Metropolitan Policy Program at Brookings*, p. 38.

Sargent, J. (2014). “The U.S. science and engineering workforce: Recent, current, and projected , employment, wages, and unemployment.” Congressional Research Service. Vol 7-7500.

Sheridan, K. M., Halverson, E. R., Litts, B. K., Brahm, L., Jacobs-Priebe, L., & Owens, T. (2014). Learning in the making: A comparative case study of three makerspaces. *Harvard Educational Review*, 84(4), 505.

- Suarez-Orozco, M. & Sattin, C. (2007). Wanted: Global citizens. *Educational Leadership*, 64 , 58-62.
- Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. John Wiley & Sons.
- Vansteenkiste, M., Simons, J., Lens, W., Sheldon, K. M., & Deci, E. L. (2004). Motivating learning, performance, and persistence: the synergistic effects of intrinsic goal contents and autonomy-supportive contexts. *Journal of Personality and Social Psychology*, 87(2), 246.
- Vossoughi, S., & Bevan, B. (2014). Making and tinkering: A review of the literature. *National Research Council Committee on Out of School Time STEM*, 1-55.
- Wagner, T. (2012). *Creating innovators: The making of young people who will change the world*. Scribner, New York, NY.
- Warshauer, H. K. (2015). Productive struggle in middle school mathematics classrooms. *Journal of Mathematics Teacher Education*, 18(4), 375-400.
- Wyld, J. (2014). Does this count as making? ISTE Connects Blog. Retrieved from <https://www.iste.org/explore/articleDetail?articleid=123>.
- Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.
- Yoder, B. (2014). Engineering by the numbers. American Society for Engineering Education. Available at: <http://www.asee.org/papers-and-publications/publications/11-47.pdf>. Accessed March 14, 2014.

## **Appendix A: Questions for the Superintendent**

Tell me the story of how this makerspace lab came into existence. How did this happen?

What was your role in this process?

What specific actions did you take to help make this happen?

What factors were required for this elementary makerspace lab to be successful?

Which of these really stand out?

How important were the community partners in this initiative (Champion University, Computers Inc.)?

How important is it for you, the Superintendent, to support a project for it to be successful?

How important is it to have the school board support an initiative?

What process was used to finalize the decision to move forward at central office?

Who, at central office, played an instrumental role in securing these resources? What did they do that was instrumental?

How was it decided that the makerspace lab would receive additional funding?

What do you see as the benefits to this elementary makerspace lab?

What were your concerns regarding this initiative?

How were these concerns addressed to move forward with this initiative?

What did you learn from this initiative?

## **Appendix B: Questions for the Director of LIGHT**

Tell me the story of how this makerspace lab came into existence. How did this happen?

What was your role in this process?

What specific actions did you take to help make this happen?

What was LIGHT's role in this implementation?

How did LIGHT assist with securing resources for this initiative?

How did school leadership interact with LIGHT during this process?

What resources did the school leaders secure that were essential to this initiative?

How did school leaders go about securing these resources?

What process was used to finalize the decision to move forward at central office with the makerspace lab?

Who, at central office, played an instrumental role in securing these resources? What did they do that was instrumental?

How was it decided that the makerspace lab would receive additional funding?

What do you see as the benefits to the makerspace lab?

How important were community partners in this initiative? (Champion University/Computers Inc.)

Describe the community partner's role in this process.

What were your concerns regarding this elementary makerspace lab?

How were these concerns addressed to move forward with this initiative?

What did you learn from this initiative?

## **Appendix C: Questions for the Director of Finance**

Tell me the story of how this makerspace lab came into existence. How did this happen?

What was your role in this process?

What specific actions did you take to help make this happen?

What process was used to finalize the decision to move forward with this initiative at central office?

What factors contributed to the makerspace lab receiving additional funding?

Who, at central office, played an instrumental role in securing these resources? What did they do that was instrumental?

What did the school leaders do to influence the decision to fund part of the makerspace lab?

What resources did the school leaders secure that were essential?

What do you see as the benefits to the makerspace lab?

What were your concerns regarding this elementary makerspace lab?

How were these concerns addressed to move forward with this initiative?

What did you learn from this initiative?

## **Appendix D: Questions for the Associate Superintendent**

Tell me the story of how this makerspace lab came into existence. How did this happen?

What was your role in this process?

What specific actions did you take to help make this happen?

How did school leaders interact with central office to help move this initiative forward?

What steps or actions were essential in this process?

What did the school leaders do at the school level to make this initiative possible?

What process was utilized to finalize the decision to move forward at central office?

Who, at central office, played an instrumental role in securing the necessary resources to fund the lab?

What did these individuals do that was instrumental in this initiative?

What do you see as the benefits to this elementary makerspace lab?

What were the perceived concerns?

How were these concerns addressed in a way that made central office feel comfortable in moving forward?

What did you learn from this initiative?

## Appendix E: Questions for the Champion University Professor

Tell me the story of how this makerspace lab came into existence. How did this happen?

What was your role in this process?

What specific actions did you take to help make this happen?

Why did you bring your cohort to the Champion University's Makerspace Lab?

What factors were required for this elementary makerspace lab to be successful?

Which of these really stand out?

How important were the community partners in this initiative (Champion University, Computers Inc.)?

What was it about King ES that influenced you to work with our school as a hub to the Champion University's Makerspace Lab?

What do you see as the benefits to this elementary makerspace lab?

What were the perceived concerns?

How were these concerns addressed in a way that made Champion University feel comfortable in moving forward?

What did you learn from this initiative?

What makes this elementary makerspace lab unique?

## **Appendix F: Questions for Lab Director at Champion University**

Tell me the story of how this makerspace lab came into existence. How did this happen?

What was your role in helping establish the makerspace lab?

What specific actions did you take to help make this happen?

What do you see as Champion University's role in supporting the elementary makerspace lab?

What factors were necessary for this elementary makerspace lab to be successful?

Which of these really stand out?

How important were the community partners in this initiative (Champion University, Computers Inc)?

What was it about King ES that influenced you to work with our school as a hub to the Champion University's Makerspace Lab?

What did you see as the benefits to this elementary makerspace lab?

What were the perceived concerns about this makerspace initiative?

How were these concerns addressed in a way that made Champion University feel comfortable in moving forward?

What did you learn from this initiative?

What makes this elementary makerspace lab unique?

## **Appendix G: Questions for school leaders (Principal and STEM teacher)**

Tell me the story of how this makerspace lab came into existence. How did this happen?

What was your role in this process?

What specific actions did you take to help make this happen?

What factors had to fall into place for this elementary makerspace lab to be successful?

Which of these really stand out?

Why were these factors critical to the success of this project?

How did school leaders interact with central office to help move this initiative forward?

What steps or actions were essential in this process?

What did the school leaders do at the school level to make this initiative possible?

Did anything get in the way during the implementation process?

What do you see as the benefits to this elementary makerspace lab?

What were the perceived concerns with this initiative? How were these concerns addressed during the implementation process?

What did you learn from this initiative?

## **Appendix H: Questions for the Teacher Cohort**

What are your thoughts about the elementary makerspace?

What went well with the makerspace initiative?

How would you describe the implementation process for the makerspace lab?

What could have been changed to make the makerspace lab implementation process better?

What do you see as the benefits to the elementary makerspace lab?

What impact did the makerspace lab have on your instruction?