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SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) PROFESSIONALS' EXPECTATIONS OF HIGH SCHOOL GRADUATES: A REGIONAL STUDY

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Abstract

The number of high school graduates that are both capable and interested in pursuing a STEM career is currently not enough to meet the growing need for a workforce equipped with STEM skills. Business and industry representatives and postsecondary educators are becoming more outspoken about their expectations for high school graduates who have interest in pursuing a STEM career. The following research questions were addressed: 1. What expectations exist among STEM professionals for high school graduates desiring to enter the workforce in a STEM field? 2. What expectations exist among STEM faculty in postsecondary education institutions for high school graduates desiring to pursue a STEM degree? An online survey was distributed to STEM professionals within a 50-mile radius of Shawnee, Oklahoma. Results indicated that adaptability, communication, responsibility and strong work ethic were among the most valuable expectations according to all participants while emphasis on advanced studies in mathematics and science at the K-12 level was not deemed as valuable. Investigating the expectations placed upon these students by the local STEM business and industry community and the local STEM postsecondary education community in this research study, K-12 educators in Shawnee, Oklahoma and surrounding communities may now have the information they need to evaluate current curriculum and instructional practices to prepare their students better for success in their chosen STEM field.

Key words: STEM, education, K-12, workforce development, business, industry, postsecondary education, high school graduates

Chapter 1: Introduction

Nationally, there is a growing need among business and industry leaders for a workforce with increased proficiency in science, technology, engineering and mathematics (Institute of Medicine, National Academy of Sciences & National Academy of Engineering, 2007). The report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, provided a sense of urgency among legislators after being informed by scientists and those in high-technology fields that the United States was “in decline’ with regards to science and innovation (Institute of Medicine et al., 2007). The opinions of the scientists were confirmed by the United States’ declining test results in mathematics, science and technology that lagged behind our global competitors (Institute of Medicine et al., 2007).

To address this national need, state governors were encouraged to lead state-wide efforts to improve K-12 STEM education outcomes that were tied to post-secondary pathways that include higher education and workforce needs (Toulmin & Groome, 2007). STEM networks have since been developed in several states including California, Minnesota and Massachusetts (Toulmin & Groome, 2007). Oklahoma established itself among those states as a champion of STEM initiatives in 2014 with the enacting of Senate Bill 1181, “Oklahoma: A STEM State of Mind” on April 28, 2014 (Oklahoma State Senate, 2014). The bill identified aerospace and defense, energy, agriculture and biosciences, information and financial services and transportation and distribution (logistics) as the five key STEM industries that have impacted the state’s economy. Additionally, the bill established criteria for communities within the state to receive official recognition as an Oklahoma STEM Community by the Governor of Oklahoma (Oklahoma State Senate, 2014).

Shawnee, Oklahoma was the first community in the state to receive designation as an Oklahoma STEM Community on November 20, 2014 (Coalition for the Advancement of Science and Mathematics Education in Oklahoma, CASMEO, 2014). This recognition required the establishment of a partnership between those entities within the community that stand to benefit from STEM education outcomes, including area K-12 school districts, the local business community, and institutions of higher education (CASMEO, 2014). In Shawnee, Oklahoma, and surrounding region, those entities include multiple K-12 school districts, multiple industries representing manufacturing, logistics, technology, agriculture, energy, construction, biomedicine and engineering, and multiple postsecondary education institutions including 4-year colleges and universities, 2-year colleges, and career technology centers (Shawnee Economic Development Foundation, SEDF, 2016).

Since the inception of the acronym for science, technology, engineering, and mathematics (STEM) in 2001, educators from all disciplines have sought ways to bring the relevance of STEM education into the classroom (Teaching Institute for Excellence in STEM, 2016). Prior research (UMass Donahue Institute, 2015) has shown the importance of connecting representatives from K-12 education systems, postsecondary education, and business and industry for the purpose of sharing ideas and information in order to advance STEM education initiatives. The need for connecting these stakeholders is further emphasized by the realization that, depending on the source, the definition of STEM can vary. In fact, there is so much discrepancy that an internet search for the definition of STEM primarily ends with a multitude of sources discussing the reasons why one definition does not exist (Breiner, Harkness, Johnson, & Koehler, 2012; Gerlach, 2012). On one hand, STEM is defined by the subject areas of science, technology, engineering and mathematics, which led to the acronym. This is the definition many in education use to understand the impact on students and teachers (Gerlach, 2012). On the other hand, STEM is defined as a specific set of employable skills obtained by employees prepared to take their place as a member of the 21st century workforce (Bybee, 2013; Gerlach, 2012). Current research suggested that a single definition for STEM may not be possible, nor is it appropriate (Breiner et al., 2012). Instead, STEM is best viewed as a fluid system of practices and processes that weaves together academic disciplines and reveals a particular kind of knowledge and learning (Moon & Singer, 2012). Given the variety of definitions of STEM and the diversity of stakeholders present in a community, the most effective method of advancing STEM education is to focus on the shared outcomes of STEM education (Breiner, et al., 2012). Most stakeholders agree that the desired outcomes of STEM education include creating better teachers, students and workforce (Breiner et al., 2012).

The business and industry sector within a community has much to gain from efforts to advance K-12 STEM education. Our growing population will require innovation from a workforce to address such issues as public health, environmental sustainability, and national security (Bybee, 2013; Institute of Medicine et al., 2007). Given the scientific nature of the forthcoming issues, industries at the forefront of addressing those issues will need employees who possess integrated knowledge across multiple scientific disciplines (Hilton, 2008b). While some of the skills that industry requires can and will be taught within the company, there are some characteristics that employees are expected to possess upon hiring (Hilton, 2008a). Hiring specialists such as human resource directors value skills such as collaboration and communication, adaptability, non-routine problem solving, self-management and systems thinking (Bybee, 2013, Hilton, 2008a). These skills are hallmarks of current instructional strategies and practices utilized in STEM education curriculum (Prince, 2004; Tseng, Chang, Lou, & Chen, 2013).

As with the business and industry sector, the postsecondary educational institutions stand to gain from K-12 STEM education efforts as well. Colleges and universities also rallied behind the report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* The report identified a general concern that undergraduates in the United States were not keeping up with our global competitors in the STEM areas (Institute of Medicine, et al., 2007). One reason was that K-12 education does not seem to produce enough students that are both capable and interested in pursuing a career in a STEM field (Institute of Medicine, et al., 2007). However, students with high school experiences that demonstrate the usefulness of mathematics and science in their futures were more likely to complete a college degree in a STEM field (Maltese & Tai, 2009). A recent study (Tseng et al., 2013) found that students' attitudes were positively influenced by classroom experiences in which STEM education was implemented using problem-based learning, a pedagogic concept that requires students to use knowledge from a multitude of disciplines to solve real-world problems. By connecting classroom experiences to issues that are relevant outside the classroom, students demonstrated a positive attitude toward the possibility of a future STEM career (Tseng et al., 2013). Student interest in STEM leads to positive outcomes for postsecondary institutions. Students who initially declare a major in a STEM field are more likely to complete a college degree, even if they change majors, than students who declare a non-STEM major (Chen & Weko, 2009).

Building relationships between local classrooms and local STEM professionals can help K-12 teachers make sense of the STEM education initiatives by providing context for the interdisciplinary nature of the concepts they teach (Debreaux-Watts, 2005). Additionally, building relationships between local classrooms and local postsecondary educators contributes to consistency across academic disciplines. Instead of a disconnect between the expectation placed on students' academic preparation for a STEM major, students will benefit from the consistency of emphasis placed on the integration of content across disciplines (Daempfle, 2003).

Statement of the Problem

Currently, the number of high school graduates that are both capable and interested in pursuing a STEM career is not enough to meet the growing need for a workforce equipped with STEM skills (Bybee, 2013; Institute of Medicine et al., 2007). Equally important to a specific community is identifying which STEM skills are needed to meet workforce needs. There is a danger of preparing adequate numbers of high school and college graduates for the STEM workforce pool, but with different qualifications than those the industry needs (Atkinson & Mayo, 2010). These shortfalls in the workforce are called "spot shortages" and could have devastating effects on a local economy (Atkinson & Mayo, 2010).

Background and Need

Studies (Chueng & Lewis, 1998; Daempfle, 2003) have shown that high school teachers may have expectations of their graduates that do not coincide with the expectations placed upon them from both business and industry leaders and postsecondary educators. There is a growing body of research devoted to the development of school-business partnerships and the resulting positive outcomes for K-12 education (Engeln, 2003; Scales et al., 2005). There are examples of regions where STEM networks have provided a pathway of information through which expectations from all stakeholders can be shared (Toulmin & Groome, 2007). Unfortunately, the results of many of these studies are not transferrable because much of the research is specific to a particular community or region with unique demographics and business and industry needs. Much of the available research on such networks focuses attention to more urban areas (Scales, Foster Mannes, Horst, Pinto, & Rutherford, 2005; UMass Donahue Institute, 2015).

However, little is known about the development of a network in a bedroom community, such as Shawnee, Oklahoma, with both suburban and rural community economic and educational implications. In order to ensure that K-12 educators are providing the best foundation for students as they graduate from high school and enter the STEM workforce or postsecondary education STEM programs of study within the community of Shawnee, Oklahoma, expectations placed upon those graduates by the aforementioned entities should be identified. Through the application process of Oklahoma STEM Community program, Shawnee, Oklahoma is uniquely positioned to utilize established relationships among stakeholders to determine the expectations that exist for high school graduates within the community who desire to pursue a position in the STEM workforce or as a STEM college major.

Purpose of the Study

The purpose of this study is to determine the expectations placed upon high school graduates by the STEM professionals representing the business and industry sector and the postsecondary education sector within the community of Shawnee, Oklahoma and surrounding region. By determining the expectations that exist among STEM professionals in a local community, K-12 educators can better prepare students that matriculate through their school districts for the STEM opportunities available to these students.

The methodology used in this study was a cross-sectional survey design (Creswell, 2013) to capture the current expectations of high school graduates from the perspective of STEM business and industry leaders as well as postsecondary STEM educators within a 50-mile radius of Shawnee, Oklahoma. A survey was created using Qualtrics survey software to discover the expectations of STEM professionals for high school graduates wishing to further their experience in a STEM field. The survey was distributed by email to the business and industry community. Contact information for those participants was obtained through the Shawnee Economic Development Foundation, Gordon Cooper Technology Center Business and Career Services Center, Shawnee Chamber of Commerce and Oklahoma City Chamber of Commerce. The survey was also distributed by email to postsecondary STEM educators from 2-year and 4-year colleges and universities as well as postsecondary technical schools that specialize in STEM fields of study. Data collected through the survey were exported to an Excel spreadsheet for data analysis.

The results of the study may give K-12 educators in Shawnee, Oklahoma and surrounding region the information necessary to align STEM education initiatives and develop practices to meet those expectations. The long term benefits for the community may include the realization of shared outcomes of STEM education, including better teachers, better students, and a better workforce (Breiner et al., 2012).

Research Questions

In order for K-12 educators to prepare students to meet the STEM workforce needs within the community of Shawnee, Oklahoma and surrounding region, the following research questions were addressed.

1. What expectations exist among STEM professionals for high school graduates desiring to enter the workforce in a STEM field?
2. What expectations exist among STEM faculty in postsecondary education institutions for high school graduates desiring to pursue a STEM degree?

Significance of the Study

For the business and industry community, engaging in discussions regarding what is expected of students seeking employment in their STEM industry promotes a positive relationship between their company and local school districts. Making expectations known results in more effective recruitment of employees. For the postsecondary education community, ensuring that students desiring to major in a STEM program of study are initially aware of the expectations could result in lower attrition rates into other majors.

This study initiated thoughtful and intentional collaboration among the business and industry community and the postsecondary education community within the STEM community of Shawnee, Oklahoma and surrounding region. The results may help K-12 educators align STEM education initiatives to meet the expectations revealed through this study.

Specific Study Considerations

Because the audience to whom this study was aimed included those in business and in education, clarification of the terminology used throughout this study is necessary. As stated previously, STEM is an acronym for the subjects of science, technology, engineering and mathematics. A STEM professional refers to anyone who employs significant science, technology, engineering and mathematics skills in their job (National Science Board, 2014). A K-12 school district is a school district that educates students from kindergarten through twelfth grade. However, Shawnee, Oklahoma also has multiple school districts that do not include grades nine through twelve. These are typically referred to as K-8 school districts. For the purposes of this study, all school districts, regardless of level, are equally important in the development of partnerships. Therefore, all references to K-12 school districts will also have relevance to the K-8 school districts. Additionally, K-12 educators include any staff members employed by the K-12 school district that guide students in making decisions for life after high school. These staff members can include teachers, principals, coaches, school counselors, or other administrators or staff members. A postsecondary institution refers to academic, vocational, technical, professional colleges or universities that offer educational instruction, credentials, or services to persons who have completed or discontinued secondary education (Putnam, 1981).

There are limitations to this study. Use of the anonymous survey instrument offered no assurances that participants understood and complied with the eligibility requirements. Additionally, because this was a regional study, results may not be transferrable to other communities.

Application for research was made to the University of Oklahoma Institutional Review Board (IRB). The application included assurances that online consent to participate in the study would be obtained for each participant. The IRB approval letter authorizing this study is included in Appendix A. The survey was distributed using an email invitation approved by the IRB. The invitation email and the reminder email are included in Appendix B. The *STEM Professional Survey* is included in Appendix C. No electronic identifiers were collected for each response, which ensured the anonymity of each participant. Participants were given full opportunity to accept, decline, or withdraw their participation in the study.

Chapter 2: Review of Literature

There is an apparent mismatch of expectations between business and industry leaders and educators, particularly in the areas of STEM workforce development (Daempfle, 2003). With the release of the report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* business and industry leaders are becoming more outspoken about workforce needs and their expectation of students leaving the K-12 education systems (Institute of Medicine et al., 2007). Unfortunately, at this time, K-12 education systems are not producing enough high school graduates with both the knowledge and skills to fill the needs of the STEM workforce (Bybee, 2013; Institute of Medicine et al., 2007).

The literature review addresses three areas related to the shortage of STEM skills within the workforce pool within a given community. The first section addresses research related to business and industry involvement. The second section focuses on studies about postsecondary education institution involvement. The third section focuses on research studies related to the development of partnerships between the local K-12 school districts, business and industry community, and postsecondary education institutions.

Business and Industry Involvement

Efforts to find research relating to STEM industry involvement within local K-12 school districts in education journals proved to be difficult. The first two studies in this literature review were conducted internationally but were published in education journals and have relevance to the systemic nature of STEM workforce development. Cheung and Lewis (1998) conducted a regional study in Hong Kong in which the expectation of employers were explored to determine if high school graduates were recruited based on academic achievement or the possession or a wider range of competencies such as attitudes and values. The employment sectors in this study included those recognized by the state of Oklahoma as distinctly STEM related, including finance and the information industry based on technology. The study was a response to the growing realization that skills learned in secondary schools in Hong Kong may not be transferrable to the community or the workplace. The researchers developed a survey, using a Likert scale, asking employers to assign a level of importance to specific skills that fall under the categories of general skills, academic achievements, attitudes, and employee requirements. The survey was distributed to human resource managers among representatives of the major enterprises in the economic community of Hong Kong. Selected survey responses were followed by interviews of representatives of some of the categories. The interviews took place at the employers' place of business and were tape-recorded.

Regarding general skills, most employers listed the ability to apply logic in following procedures as very important. Information recall and ability to make a reasoned argument were of the lowest importance for new graduates. Follow-up interviews revealed that reasoned argument were more important for management positions and not necessary for entry level positions. Regarding academic achievements, the most important skill was the ability to communicate effectively with others verbally. The most important attitudes that employers sought were responsibility and reliability. Interestingly, the least important attitudes were imagination and curiosity. Again, interviews implied that imagination and curiosity were attitudes most desired in positions that required company-based decision-making, such as management and administration. The most important employee requirement, according to the survey, was showing initiative. The least important employee requirement was obtaining very good results in school examinations.

Cheung and Lewis found that the current secondary curriculum in Hong Kong prepared students more for advanced academic studies rather than preparation for employment in the current workforce. Therefore, the secondary schools in Hong Kong are not producing the well-rounded young people that many employers, including those from STEM industries, are looking to recruit to fill the workforce needs. The solution is for school curriculum to be more responsive to the needs of employers (Chueng & Lewis, 1998).

The concept of skill level of potential employees prior to their employment has economic impact on a company's bottom line. Smoorenburg and Velden (2000) looked at the economics of training the workforce after employment. Data for this study were obtained through analysis of a previous survey designed to report the flow of school-leavers into the labor market which is distributed approximately 18 months after leaving school. The survey analyzed in this study was the 1996 survey of the 1994/1995 cohort of school-leavers and included 11,901 participants from 129 different fields of study. Using Human Capital Theory and Matching Theory, the study examined the educational attainment of the participants from the selected cohort within the Dutch education system to see if there was any correlation to the participation in "firm training," that is, training after employment (Smoorenberg & Velden, 2000). The education levels were categorized as low, medium, and high levels of educational attainment. This is referred to as an individual's "initial education," the education an individual receives before leaving school and entering the workforce (Smoorenberg & Velden, 2000). In the Dutch education system, the initial education level is referred to as vocational education. It is important to note that the industry sectors into which these school-leavers are employed include those key STEM industries found in the state of Oklahoma, including agriculture, transportation and communication.

Human Capital Theory proposes that the skills acquired during training represent human capital and leads to higher productivity, higher education, and the training is thus seen as an investment. Matching Theory proposes that hiring individuals with an education level above that required for the job, overeducation, results in a decreased need for training. Conversely, hiring individuals with an education level below that required for the job, undereducation, results in a greater need for training. The difference between the two theories lies in how employers view training. Training can be viewed as complementary to the initial education or as a substitute for deficiencies in initial education.

The results of the study indicated that there was a correlation between education level and participation in training that supports both theories. Additionally, the researchers discovered that the narrowness of the field of study was also a factor in training participation. High educational attainment resulted in higher probability of training, particularly if the field of study was narrow, as in pharmacy assistant. School leavers from a narrow field of high level of educational attainment that found work within their field were more likely to participate in firm training than their peers that studied a broader field, as in mechanical engineering, and found work within that field.

Overeducation, in general, did result in a lower probability of training participation, however, the opposite was not true for undereducation.

In summary, Smoorenburg and Velden demonstrated that the need for additional training is stronger for school leavers who must move to a different field of study than that experienced in their initial education. While the study does suggest that training functions to bridge the skill gaps between what is attained and what is required among school leavers, it stops short of claiming that training can compensate for deficiencies in formal education (Smoorenburg & Velden, 2000).

In 2008, the National Academies Press published a report by the National Research Council entitled, *"Research on Future Skill Demands: A Workshop Summary."* Workshop participants discussed the labor market and the implications of skill development for the STEM workforce Of primary concern was the polarization of the labor market. According to the United States Department of Labor, the two fastest growing job clusters at that time included the professional cluster and the service cluster. The term polarization referred to the fact that these two job clusters were on opposite ends of the labor market in terms of wages and education. The professional cluster typically required a higher level of education and corresponded with higher wage earnings, whereas the service cluster required lower education levels and received lower wages. However, it was noted by the participants that the boundaries between the professional work and service work are becoming increasingly blurred as technology advances. A new type of occupation is emerging known as "technoservice" (Hilton, 2008b, p. 67). The growth of the service cluster impacted STEM professional careers as well. It was noted that job requirements for scientists and engineers have expanded to include more interpersonal skills as well as technical skills. Additionally, advancing technology has resulted in some of the tasks formerly performed by scientists or engineers now being carried out by skilled technicians. For example, Genentech, a biotechnology company in San Francisco, California, shifted its workforce from 70% master's degree and above to 70% bachelor's degree and below (Hilton, 2008b).

The clearest connection to K-12 education is mentioned in a panel discussion in which Richard Murnane of Harvard University discusses the acquisition of broad competencies, skills such as communication, problem-solving, creativity and adaptability (Hilton, 2008a). Murnane suggests that these skills can and should be taught within the context of specific academic content such as reading, writing, and mathematics, and through hands-on inquiry science. However, even though these skills were officially deemed important by the United Stated Department of Labor in 1991, public schools have not consistently taught them. He suggests that career-technical education is a step in the right direction as a possible way to teach not only the broad competencies, but also occupational and academic skills.

Economist Tom Bailey of Columbia University acknowledged during the panel discussion the difficulty of accurately predicting future skill demands. He suggested that strong relationship with local companies minimized the need for a skills forecast. This consistent contact with employers is the key to more closely linking the world of education with the world of work (Hilton, 2008a).

Postsecondary Education Institution Involvement

There is also a mismatch of expectation between high school educators and college educators. Daempfle (2003) recognized the possibility of damaging effects of the inadequacies of the current educational system on the future of scientific discoveries. He investigated several studies on the attrition rates in science, mathematics and engineering (SME) areas among first year SME majors. One ethnographic study took place over a three-year period and interviewed 460 students that were considered to be well-prepared for a college SME major as determined by a previously set math SAT score of 649. Of the 460 students, half of them persisted as an SME major and half of them switched majors (Seymore & Hewitt, 1994, as cited in Daempfle, 2003). Both switchers and non-switchers described the college SME environment as discouraging and intimidating and preferred the high school instruction over the primarily dull, lecture-driven college instruction. The students viewed the SME faculty at the college level as cold, unavailable and indifferent, contributing to what Daempfle referred to as the "chilly climate hypothesis" (p. 40). The students felt a general lack of nurture by the faculty leading them to switch majors, and the faculty believed that attrition was due to the students' inability to cope with the difficulty of the workload (Daempfle, 2003).

Daempfle examined other studies (Daempfle, 2000; Mitchell, 1990; Razali & Yager, 1994, as cited in Daempfle, 2003) that focused on differing expectation of high school faculty and postsecondary faculty. Secondary teachers viewed their role as curriculum developers to prepare students for success in college SME courses. However, when postsecondary instructors had different expectations for incoming students than the secondary instruction addresses, there was a mismatch between what is taught and what is expected, leaving students ill-equipped to make the transition from high school to college. Two similar studies of both secondary teachers and postsecondary teachers from two-year and four-year colleges, specifically examined chemistry instruction (Mitchell, 1990; Razali & Yager, 1994, as cited in Daempfle, 2003). High school teachers rated knowledge of chemistry and skill in chemistry as the most important factors in preparing students for college chemistry courses. However, college chemistry faculty valued personal traits such as good study skills, creativity and imagination as more important. Similar differences were found among high school biology teachers and college biology teachers in a later study (Daempfle, 2000, as cited in Daempfle, 2003). However, communication between the teacher groups resulted in increased agreement on expectations. Daempfle concluded that, “When high school teachers are preparing students for college SME environments inappropriately, a contribution is clearly seen to the increased attrition rates in SME areas and the expansion of the gap between the two levels of schooling” (Daempfle, 2003, p. 47).

Even within a single university, differences in expectations and understanding of the requirements of STEM majors can be evident. In a qualitative study conducted at the University of Cincinnati (UC), Breiner, Harkness, Johnson, and Koehler (2012) emailed an open-ended survey to all full-time members from the various colleges across UC to explore their conceptions of STEM. The study was conducted in 2009 during which time the university was deeply involved in a STEM movement that included the launching of two new STEM public schools, a regional STEM partnership, and a STEM education center. The two questions on the survey, in addition to being open-ended, were intentionally ambiguous, to determine if the STEM acronym was understood. The two questions asked were, “What is STEM?’ and “How does STEM influence and/or impact your life?” Even within a single university that was leading a STEM movement, the study revealed that more than one quarter of the faculty did not know the meaning of STEM. In both STEM and non-STEM disciplines, the faculty displayed no common operational definition for or conceptualization of STEM. The researchers concluded that to develop a common definition of STEM would be difficult at best. However, most faculty did agree on the shared outcomes, such as creating better teachers, students, and workforce (Breiner, Harkness, Johnson, & Koehler, 2012).

Partnership Development

Current literature (Carnegie Science Center, 2014; Scales et al., 2005; UMass Donahue Institute, 2015) supports the development of partnerships among K-12 school districts, the business and industry sector, and postsecondary educational institutions within a defined region for the purpose of improving education outcomes. These partnerships facilitate the development of shared expectations for high school graduates wishing to pursue a STEM career or a STEM major in college.

Scales et al. (2005) conducted a mixed-methods study that explored school-business partnership activities and their relationship to specific developmental assets among 429 students at an urban high school in Houston, Texas. The study defined developmental assets as those strengths self-reported by students that are considered necessary for all young people to successfully engage in responsibilities of daily life. The study explored forty developmental assets grouped into eight categories: support, empowerment, boundaries and expectations, constructive use of time, commitment to learning, positive values, social competencies and positive identity (Scales et al., 2005).

Prior studies led to a compilation of a large amount of data, primarily from affluent, suburban areas with a minimal population of ethnic minorities. The purpose of the Scales et al. study was to determine if the relation between levels of developmental assets and positive academic outcomes would also be observed in samples of students who are non-white, not affluent and not suburban. The Houston, Texas high school was selected because it was considered inner city urban, had many students of color and low-economic families, and demonstrated evidence of existing school-business partnerships. Such partnerships included mentorships and internships with local businesses, parenting programs, and outreach through the local colleges and universities. The methodology included extensive observations, interviews, focus groups, and surveys. The results of the study indicated that regardless of the demographic background, school-business partnerships added value to the educational experience and resulted in positive academic outcomes (Scales et al., 2005).

When compared to the aggregate sample, this student population did have a lower average level of reported developmental assets. However, among those assets that research links to school success, such as the commitment to learning category, students in this study reported levels that were as high or slightly higher that the aggregate sample. Overall, school-business partnership activities and developmental assets were positively related. Increased developmental asset level was associated with decreased high risk behaviors and increased thriving behaviors. Repeated exposure to the school-business partnership activities also seemed to be a factor in the acquisition of the developmental assets, particularly those related to academic performance. Even students with low to middle level of exposure to school-business partnership activities self-reported that the experience helped them with basic academic skills such as reading, writing and mathematics. The implication is that such experiences may provide the motivational link to the real world that students need to realize the relevance of classroom instruction. By providing high levels of exposure to local STEM professionals, students with an interest in pursuing a STEM career were more likely to discuss college with their teachers and talk to adults already employed in a STEM field (Scales et al., 2005).

The study does have its limitations. The self-reported data require thoughtful interpretation particularly when analyzing the quantitative data and qualitative field work. Additionally, because this study was specific to the urban setting with a population of non-white, lower economic status student sample, the information may not be transferrable to other situations. However, the methodology could be useful for other settings to determine the value of the local school-business partnership opportunities available within a specific region (Scales et al., 2005).

Region-based STEM initiatives have demonstrated success in terms of facilitating communication among stakeholders. Carnegie Science Center of Pittsburgh, Pennsylvania (2014), commissioned a study of the role of STEM education in the workforce development within a specific region that included southwestern Pennsylvania and adjacent counties in Ohio and West Virginia. Data were collected through in-depth individual interviews with 47 K-12 educators and business leaders, 978 parent surveys, and seven in-home family dialogues. Given the geographic diversity of the region, data describing the location of the participants as rural, suburban, or urban were also recorded (Carnegie Science Center, 2014).

The study revealed that opinions of parents, educators and business leaders were not always aligned. For example, all agreed that schools must do a better job of preparing students for success after graduation. Also, all agreed that a robust STEM education should include engaging, collaborative, hands-on and project-based components. However, differences appeared when referring to workforce development. Educators believed that there was evidence of progress in workforce development through STEM education, but business leaders reported seeing very little progress. The types of improvements needed varied depending on the geographic location of the business. Business leaders from rural areas suggested a need for more technology training in the age of computers (Carnegie Science Center, 2014). In addition to the STEM opportunities available to students within this region, educators noted some obstacles to providing STEM education for their students. Some of the obstacles included lack of business support and lack of collaboration with colleges and universities (Carnegie Science Center, 2014).

Another example of a region-based STEM initiative is located in Massachusetts. The Massachusetts STEM Pipeline Fund was established in 2004 for the purposes of increasing the number of Massachusetts students entering the STEM pipeline, increasing the number of qualified STEM teachers, and improving overall STEM education efforts (UMass Donahue Institute, 2015). The Massachusetts Department of Higher Education initiated the development of regional STEM networks across the state to facilitate the achievement of those purposes. To evaluate progress, the University of Massachusetts Donahue Institute was contracted to conduct regular qualitative studies of the networks and present their findings. This methodology included an online survey in which 158 stakeholders responded with representation distributed among the seven regions of the network. The findings suggested that the network’s greatest value was to serve as a convener to connect STEM stakeholders, encourage collaboration and disseminate information. The study also revealed that participation was strongest among K-12 and higher education stakeholders. All network participants considered business to be a critical component, but acknowledged the difficulty in promoting engagement (UMass Donahue Institute, 2015). Since the birth of the STEM networks in 2004, the long term benefits of the efforts of these regional networks are now becoming evident. These networks have the capability to engage a wide variety of stakeholders and therefore received much of the credit for any positive change in the region (UMass Donahue Institute, 2015).

The literature suggests that there is a need to communicate expectations of the business and industry community as well as colleges and universities to educators in K-12 systems (Breiner, Harkness, Johnson & Kohler, 2012; Cheung & Lewis, 1998; Daempfle, 2003; Hilton, 2008b; Scales et al., 2005; Smoorenburg & Velden, 2000). In order for the data to be relevant, the communication should be confined to those businesses and postsecondary education institutions located within a specific region (Carnegie Science Center, 2014; Cheung & Lewis, 1998; Scales et al., 2005; UMass Donahue Institute, 2015). Assuming all stakeholders have a vested interest in outcomes for K-12 education, a collaborative framework can facilitate the development of a partnership network among the stakeholders (Breiner, Harkness, Johnson & Kohler, 2012; Carnegie Science Center, 2014; UMass Donahue Institute, 2015). Shawnee, Oklahoma has established itself as a STEM Community, implying the presence of stakeholders from the business and industry community as well as the postsecondary education institutions that have a vested interest in K-12 STEM education (Oklahoma

State Senate, 2014). Unfortunately, a formal investigation into the expectations of the local STEM business and industry community and the local STEM postsecondary education institutions has yet to be conducted. This study provides an avenue for K-12 educators to learn the expectations placed upon their students by relevant STEM stakeholders within the local community. Educators could then use this information to design and develop appropriate STEM education initiatives to better prepare the students in this region to meet the expectations of those stakeholders and experience success in the STEM workforce.

Chapter 3: Methods

The community of Shawnee, Oklahoma and surrounding region hosts a growing economic community that requires a STEM ready workforce (SEDF, 2016). There are local and surrounding K-12 school districts and postsecondary education institutions in place to ensure the development of such a workforce, provided clear communication exists, between the business and industry community and the education community. To ensure that K-12 educators have the information necessary to prepare students for the STEM opportunities available to students in the regional workforce and postsecondary institutions, the following research questions were addressed:

1. What expectations exist among STEM professionals for high school graduates desiring to enter the workforce in a STEM field? and
2. What expectations exist among STEM faculty in postsecondary education institutions for high school graduates desiring to pursue a STEM degree?

To discover these expectations, a cross-sectional survey design methodology was utilized (Creswell, 2013) and approved by the University of Oklahoma Institutional Review Board (see Appendix A). A survey was developed using Qualtrics survey design software and distributed via email to the business and industry community and STEM professionals in higher education. To maintain regional relevance, distribution of the emails was limited geographically to within a 50-mile radius of the city limits of Shawnee, Oklahoma. Survey data were collected anonymously and exported to an Excel spreadsheet for detailed data analysis.

Setting

The region identified for this study included a 50-mile radius of the city limits of Shawnee, Oklahoma. The purpose for this limitation was to clearly define a reasonable distance in which students that graduate from K-12 school districts within this region might find employment or further their education. The average commute time for the state of Oklahoma is 21 minutes (Oklahoma Average Commute Time, 2013). For the region of Shawnee and surrounding communities, that time increases to 25 minutes (Ok Average Commute Time by County, 2013). The mileage traveled during that commute could range from approximately 20-30 miles. By extending the selected distance 20 additional miles, the designated region provides increased opportunities for all students from the region to further their education in a variety of postsecondary schools. Additionally, this region has employment opportunities available for graduates in the specific areas designated by the "Oklahoma: A STEM State of Mind" legislation (Sharp, 2014).

Population/Sample/Participants

The population in the study consisted of STEM professionals within a 50-mile radius of the city limits of Shawnee, Oklahoma. For the purposes of this study, a STEM professional was someone who employed a significant amount of STEM skills in their job (National Science Board, 2014). Therefore, the population of STEM professionals from the business and industry community included areas of aerospace, defense, energy, agriculture, biosciences, information technology, financial services, and transportation and distribution (CASMEO, 2014). The population of STEM professionals from the education community included technology centers, 2-year colleges and 4-year colleges and universities.

A multistage sampling procedure (Creswell, 2014) was conducted by setting the selection criteria, identifying groups or organizations that aligned with the criteria, and then obtaining names and email addresses for STEM professionals within these groups or organizations. Names and email addresses were acquired from the Shawnee Chamber of Commerce, the Oklahoma City Chamber of Commerce, the Shawnee Economic Development Foundation, and the official postsecondary school websites. Some business and industries did not have specific email contacts available; therefore, all emails were sent through the company website's online contact form.

Instrumentation

The *STEM Professional Survey* (see Appendix C) was developed for this research study using key characteristics, skills, and knowledge found in the literature that high school graduates are expected to possess upon entering the STEM workforce or continuing their education at a postsecondary institution. The survey was designed to measure the value placed upon certain expectations by STEM professionals in both the business and industry sector and the postsecondary education sector. These expectations included soft skills such as creativity, imagination, and nonroutine problem-solving, and hard skills such as math and science academic achievement (Bybee, 2013; Chen & Weko, 2009; Daempfle, 2003; Rask, 2010).

The Qualtrics online survey platform was used to construct the survey. The first question of the survey asked participants to state whether they identified as a member of the STEM field or as a STEM educator. Business and industry participants were then asked to identify the specific business sector they represented, and STEM faculty were asked to identify the specific area(s) of STEM in which they specialized. The following question asked the participants to assign a value of importance to each of 22 characteristics that have been described in the literature as expected among high school graduates in both the STEM workforce and in postsecondary education. The list includes skills, knowledge, and personal character traits. To aid in reporting data from the survey, the characteristics are collectively called "expectations" (see Table 1). The values ranged from 0 to 100, with 0 being extremely important and 100 being not important at all. The survey concluded with an open-ended question in which participants could suggest an expectation they felt should have been included and then assign a value of importance to the suggested expectation.

Table 1

Expectations for High School Graduates

Expectations
Successful completion of computer science in high school
Successful completion of advanced or AP science in high school
Successful completion of trigonometry, precalculus or calculus in high school
Basic computer literacy
High achievement in high school science
High achievement in high school math
Effective study skills
Collateral thinking across disciplines
Basic technology skills
Knowledge of basic math concepts and content
Knowledge of basic science concepts and content
Ability to integrate STEM knowledge with non-STEM disciplines
Ability to adopt "systems thinking' and contribute to the betterment of a group
Enthusiasm for learning science
Enthusiasm for learning math
Self-management
Nonroutine problem solving
Adaptability
Clear career goals
Imagination
Ingenuity
Creativity

The *STEM Professional Survey* was reviewed by representatives of each of the stakeholders with expertise in their field. The reviewers include a group of eight pre-service teachers from a 4-year university, a biology researcher and professor from a 4-year university, a business and industry community leader, and a technology center employee who holds a doctorate in occupational education. The reviewers were consulted to ensure that data collected from the survey would adequately address the research questions proposed in this study.

Data Collection/Procedures

All members of the sample were sent an invitation email (see Appendix B) that included a statement of consent and a link to the *STEM Professional Survey* (see Appendix D). An Excel spreadsheet was created to list names and email addresses for all potential research participants, their affiliation with the business and industry community (BI) or the postsecondary education community (PSE), and the dates of email distributions. Approximately two weeks later, a reminder email (see Appendix C) was sent to all members of the sample to encourage participation from those who had not yet responded. As the data collection time period came to a close, an additional 49 reminder emails were sent to specific members of the sample to encourage participation from the business and industry community and the 2-year college community. The responses to the online survey were collected and securely stored using Qualtrics survey software. At the conclusion of the data collection period, the survey was closed and the data stored in the survey software were exported into an Excel spreadsheet for data analysis.

Data Analysis

Although the survey was anonymous and no identifiable data were collected, all responses were combined and a descriptive analysis of data for means, standard deviations, and range of scores was conducted. Responses were then sorted by STEM business and industry participants and STEM postsecondary education participants and descriptive analysis of data was repeated. The data from the open-ended question at the conclusion of the survey were categorized into recurring themes according to skills needed in today's STEM workforce. Comparisons were made between data collected from the STEM business and industry community and the STEM postsecondary education community to identify any apparent mismatches of expectations.

Chapter 4: Results

The community of Shawnee, Oklahoma and surrounding region hosts a dynamic system of opportunities for students with an interest in pursuing a STEM career or furthering their education by majoring in a STEM field. The business and industry sector of this region has expressed their need for qualified individuals to meet the growing STEM workforce need. Many of those industries along with the local postsecondary education institutions have STEM programs of study and training certification programs in place and are looking to the high school graduates from the local K-12 school districts for the employees and the students to fill these positions. In order for K-12 educators to most effectively contribute to the STEM workforce needs and the needs of the STEM programs at postsecondary education institutions, clear communication of expectations from each stakeholder needs to occur. This study addressed this need by clearly asking the business and industry community and the local postsecondary education institutions what the expectations are for those high school students seeking employment in their STEM industry or seeking to major in their STEM programs of study.

The *STEM Professional Survey* asked participants to describe their background as either from the business and industry sector or the postsecondary education sector and their role within that sector. The survey also included 22 expectations that, according to relevant literature, are expected of high school graduates seeking to pursue a STEM career. Participants were asked to assign a value to each of the expectations ranging from 0 (extremely important) to 100 (not at all important) to provide the quantitative data for this study. The final question on the survey was an optional open-ended question that provided the qualitative data for this study. Participants were given the opportunity to suggest an additional expectation that they felt should have been included and assign a value of importance to that expectation.

The survey was distributed via email to members of the STEM population within a 50-mile radius of the city limits of Shawnee, Oklahoma. This geographic area includes a major metropolitan city, several suburban and rural communities, multiple 2-year and 4-year colleges and universities and technical schools. A total of 945 sample members were invited to participate via email. Of the 945 individuals, 628 represented the business and industry sector and 317 represented the postsecondary education sector. A total of 90 participants responded to the survey, 21 responses from the business and industry sector, 41 from the postsecondary education sector, 11 from participants that identified as both business and industry and postsecondary education, and 17 who did not answer the question regarding their background and were listed as unknown. The unknown responses were not included in the data analysis.

Data analysis began by exporting the data from the Qualtrics survey software to an Excel spreadsheet. Individual responses were analyzed for reliability. Eighteen participants lacked sufficient responses to the 22 expectations and characteristics that were the primary data for the survey and were discarded. Of the 72 remaining participants, 10 sets of responses were further investigated due to peculiarity of the data. For example, an administrative executive from the aerospace and defense industry who also served as a STEM faculty member at a 4-year college assigned a value of 100 to several characteristics including high achievement in high school mathematics, basic technology skills, and knowledge of basic mathematics and science concepts and content, indicating that these characteristics were not at all important. Based on other responses from this particular participant as well as other participants with similar backgrounds, it was decided that this individual misinterpreted the scale and the responses should have the reverse values. This was the case for the other nine participants and their responses; therefore, these responses were reversed scored and included in the data analysis. Of the 90 responses, a total of 72 responses were included in the detailed data analysis.

The participation was decidedly weighted toward the postsecondary education community. The response from the education community nearly doubled that of the business and industry community. Additionally, there was a relatively large number of participants that identified as both STEM business and industry professionals as well as STEM faculty members. To avoid overlap of data, those participants were treated as a separate group. Therefore, the subsets of participants include STEM business and industry professionals (BI) (see Table 2), postsecondary education STEM faculty members (PSE) (see Table 3), and those that identified as both BI and PSE (Both) (see Table 4). Not all participants chose to answer the optional open-ended question at the end of the survey. The distribution of participants that provided the qualitative data for this study is included in Table 5.

Table 2

Numbers of Business and Industry (BI) Participants by Industry Sector and Position

Sector	*n*
Aerospace and Defense	
Administrator/Executive	5
Engineer	3
Other	1
Agriculture and Biosciences	
Administrator/Executive	3
Energy	
Administrator/Executive	1
Engineer	1
Information and Financial Services	
Administrator/Executive	1
Transportation and Distribution (Logistics)	
Administrator/Executive	1
Engineer	3
Technician	1
Other	1
Total	21

Table 3

Numbers of Postsecondary Education (PSE) Participants by Type of Institution and Area

Type of Institution	*n*
2-Year College	
Science	1
Technology	1
Mathematics	2
4-Year College	
Science	12
Technology	1
Engineering	13
Mathematics	3
Other	3
Technical School	
Science	1
Technology	1
Mathematics	2
Other	1
Total	41

Table 4 Participants

Numbers of Participants Identifying as BI and PSE by Sector and Institution Type

BI Sector	Job Description	PSE Type	Area	*n*
Aerospace and Defense	Administrator /Executive	4-Year College	Engineering	2
Aerospace and Defense	Administrator/ Executive	4-Year College	Other	1
Aerospace and Defense	Engineer	4-Year College	Engineering	1
Aerospace and Defense	Technician	Technical School	Technology	1
Agriculture and Biosciences	Administrator/ Executive	4-Year College	Science	1
Agriculture and Biosciences	Other	4-Year College	Science	1
Energy	Administrator/ Executive	4-Year College	Engineering	1
Energy	Administrator/ Executive	4-Year College	Other	1
Transportation and Distribution (Logistics)	Unknown	4-Year College	Unknown	1
Total				10

Note. BI = Business and Industry; PSE = Postsecondary Education.

Table 5

Participants Who Responded to Open-ended Survey Question

Subset	*n*
Business and Industry	9
Postsecondary Education	21
Both	7
Total	37

The low response rate from the business and industry community provided an element of bias into the study. Both the quantitative and qualitative results of the study gave more voice to the expectations of the postsecondary education community than the business and industry community. Because of previous studies (UMass Donahue Institute, 2015), the possibility of this bias was anticipated and was addressed during the research design process by a nearly two to one distribution of invitation emails favoring the business and industry community. In spite of this effort to minimize response bias, the results of this study provide more reliable insight into the expectations of the postsecondary education community than the business and industry community.

In order for K-12 educators to prepare students to meet the STEM workforce needs within the community of Shawnee, Oklahoma and surrounding region, the following research questions were addressed in this study.

1. What expectations exist among STEM professionals for high school graduates desiring to enter the workforce in a STEM field?

2. What expectations exist among STEM faculty in postsecondary education institutions for high school graduates desiring to pursue a STEM degree?

Quantitative data were collected as participants indicated a numerical value (0-100) associated with each of the 22 expectations listed in Table 1. For each of the three subsets of participants, the data were analyzed statistically and the means, standard deviations, and range of scores for each expectation are reported.

Qualitative data were collected as participants were asked if there was any other characteristic that they expected of high school graduates entering their STEM fields that was not previously addressed in the survey. ParticipantsThey were given the option to include that expectation and assign a value using the same scale as the previous list (0 = Extremely Important and 100 = Not at all Important). None of the expectations listed referred to hard skills such as technical skills or academic knowledge. Instead, the responses included expectations such as communication, perseverance, dependability and curiosity, among others. These skills and characteristics are often referred to as soft skills. Soft skills are the interpersonal skills, or people skills, that a person possesses (Robles, 2012). The data from the open-ended question are grouped into similar soft skills according to a 2012 study that identified the top 10 soft skills needed in the workplace (Robles, 2012). Those skills include communication, courtesy, flexibility, integrity, interpersonal skills, positive attitude, professionalism, responsibility, teamwork and work ethic (Robles, 2012). For each of the three subsets of participants, responses to the open-ended question are reported along with their frequency. The numerical values assigned to each suggested expectation fell within the range of Extremely Important (0-20) except for one instance of the expectation "Curiosity," which was given a value of 40 (Very Important.) Give the narrow range of values for the each of the suggested expectation, statistical analysis of the assigned values was not included.

Tables 6 and 7 address the first research question regarding the expectations of high school graduates by the STEM business and industry community. Quantitative data collected as participants assigned a value to the 22 expectations (see Table 1) is summarized in Table 6.

Table 6

Descriptive Statistics of Expectations for BI Participants (n = 21)

Expectations	*M*	*SD*	Range
Successful completion of computer science in high school	39.9	26.4	82
Successful completion of advanced or AP science in high school	50.0	26.4	100
Successful completion of trigonometry, precalculus or calculus in high school	38.0	30.1	96
Basic computer literacy	9.1	10.4	28
High achievement in high school science	41.7	24.3	93
High achievement in high school math	26.3	19.4	65
Effective study skills	28.9	25.7	84
Collateral thinking across disciplines	18.2	13.1	43
Basic technology skills	16.4	14.3	57
Knowledge of basic math concepts and content	11.5	11.2	33
Knowledge of basic science concepts and content	23.0	24.0	85
Ability to integrate STEM knowledge with non-STEM disciplines	24.2	18.2	67
Ability to adopt "systems thinking" and contribute to the betterment of a group	11.8	11.2	28
Enthusiasm for learning science	41.5	26.8	99
Enthusiasm for learning math	30.5	23.7	80
Self-management	10.4	11.1	40
Non-routine problem solving	18.4	17.2	51
Adaptability	13.4	13.7	46
Clear career goals	47.6	25.8	98
Imagination	30.4	21.3	67
Ingenuity	28.2	21.7	68
Creativity	35.3	24.7	79

Note. BI = Business and Industry. *M* = Mean; 0-20 = Extremely Important; 21-40 = Very Important; 41-60 = Moderately Important; 61-80 = Slightly Important; 81-100 = Not at all Important.

Qualitative data were collected as participants answered the optional open-ended question at the end of the survey. Not all STEM business and industry participants answered the open-ended question. However, the responses of those within this subset that did participate in this question are summarized in Table 7.

Table 7

BI Responses (n = 9) to Open-ended Survey Question

Expectations	Frequency
Responsibility	2
“Discipline”	
“Overcoming obstacles”	
Communication	3
“Communication/interpersonal skills” x 2	
“Communication”	
Work ethic	2
“Hardworker”	
“Strong work ethic”	
Descriptive Responses	2
“Soft skills – Presentation; Communication skills, proper-respect – shaking hands and looking someone in the eye; using yes sir/ma’am, no sir/ma’am, expediency.”	
“Math science and computer skills are very important to do the work but motivation, responsibility, attitude, enthusiasm, initiative, and dependability go a long way too. I have seen a lot of smart marginal employees.”	

Note: BI = Business and Industry participants. All responses fell within the range of Extremely Important (0-20).

As with the business and industry community, quantitative and qualitative data were obtained for the postsecondary education community as well. Those data are summarized in Tables 8 and 9, respectively.

Table 8

Descriptive Statistics of Expectations for PSE Participants (n = 41)

Expectations	*M*	*SD*	Range
Successful completion of computer science in high school	48.3	30	100
Successful completion of advanced or AP science in high school	43.2	28.6	100
Successful completion of trigonometry, precalculus or calculus in high school	24.9	28.6	100
Basic computer literacy	17.4	19.6	79
High achievement in high school science	28.5	21.8	100
High achievement in high school math	22.6	18.5	83
Effective study skills	12.7	19.5	99
Collateral thinking across disciplines	32.4	25.3	97
Basic technology skills	30.4	23.2	90
Knowledge of basic math concepts and content	11.1	20.3	97
Knowledge of basic science concepts and content	18.5	19.2	80
Ability to integrate STEM knowledge with non-STEM disciplines	42.6	29.1	100
Ability to adopt "systems thinking" and contribute to the betterment of a group	31.5	26.9	90
Enthusiasm for learning science	18.4	22.4	98
Enthusiasm for learning math	21.4	23.7	95
Self-management	12.5	14.1	58
Non-routine problem solving	20.0	19.5	80
Adaptability	17.9	16.7	50
Clear career goals	55.2	24.8	100
Imagination	31.3	24.6	83
Ingenuity	27.7	20.0	80
Creativity	30.7	23.6	80

Note. PSE = Postsecondary Education. *M* = Mean: 0-20 = Extremely Important; 21-40 = Very Important; 41-60 = Moderately Important; 61-80 = Slightly Important; 81-100 = Not at all Important.

Table 9

PSE Responses (n = 21) to Open-ended Survey Question

Expectations	Frequency
Responsibility	7
"Determination"	
"Determination and focus"	
"Discipline"	
"Grit"	
"Persistence"	
"Persistence with difficult and challenging work"	
"Tenacity when confronted with obstacles in the field"	
Communication	2
"Ability to communicate ideas effectively"	
"Communicate effectively both verbally and in writing"	
Work ethic	4
"Dependability"	
"Strong work ethic" x 2	
"Work ethic"	
Flexibility	4
"Willingness to learn"	
"Pose questions, actively listen and identify opportunities"	
"Curiosity"	
"Passion for continual learning"	
Positive Attitude	3
"have fun"	
"passion for your STEM field"	
"emotional maturity"	
Teamwork	1
"Being able to work independently as well as in a team"	

Note: PSE = Postsecondary Education participants. All responses fell within the range of Extremely Important (0-20) with the exception of "Curiosity" which was given a value of 40 (Very Important).

Due to the number and distribution of responses, a group of the participant population emerged as a significant subset in addition to the business and industry community and the postsecondary education community. Ten participants indicated that they identified as members of both the business and industry community and the postsecondary education community. Quantitative and qualitative data for this subset are summarized in Tables 10 and 11, respectively.

Table 10

Descriptive Statistics of Expectations for BI and PSE Participants (n = 10)

Expectations	*M*	*SD*	Range
Successful completion of computer science in high school	29.5	25.6	83
Successful completion of advanced or AP science in high school	46.1	28.5	80
Successful completion of trigonometry, precalculus or calculus in high school	41.4	26.0	99
Basic computer literacy	10.5	16.3	51
High achievement in high school science	24.8	18.9	53
High achievement in high school math	18.8	18.1	51
Effective study skills	33.5	27.1	99
Collateral thinking across disciplines	21.7	26.2	83
Basic technology skills	22.4	20.1	56
Knowledge of basic math concepts and content	14.9	21.3	50
Knowledge of basic science concepts and content	13.3	15.0	39
Ability to integrate STEM knowledge with non-STEM disciplines	29.1	33.0	100
Ability to adopt "systems thinking" and contribute to the betterment of a group	14.2	13.1	41
Enthusiasm for learning science	25.2	34.0	100
Enthusiasm for learning math	30.7	32.6	99
Self-management	15.3	11.0	28
Non-routine problem solving	16.6	16.7	51
Adaptability	15.4	15.9	46
Clear career goals	51.0	26.3	81
Imagination	23.3	16.4	46
Ingenuity	22.0	18.1	53
Creativity	25.1	25.6	80

Note. BI = Business and Industry; PSE = Postsecondary Education. *M* = Mean: 0-20 = Extremely Important; 21-40 = Very Important; 41-60 = Moderately Important; 61-80 = Slightly Important; 81-100 = Not at all Important.

Table 11

BI and PSE Responses (n = 7) to Open-ended Survey Question

Expectations	Frequency
Responsibility	2
“Perseverance” x 2	
Communication	1
“Communication”	
Flexibility	1
“Curiosity”	
Positive Attitude	1
“motivated, passionate, character, competency”	

Note: BI = Business and Industry participants; PSE = Postsecondary Education.Two responses were discarded due to insufficient data in the text box field. All recorded responses fell within the range of Extremely Important (0-20).

To provide an overall view of the value STEM professionals within the STEM community of Shawnee, Oklahoma and surrounding region place on these 22 expectations from the *STEM Professional Survey* (see Table 1), Table 12 summarizes composite data from all three subsets. To assist in making comparisons among the three subsets, Table 13 reports the ranking of each expectation within each subset.

Table 12

Descriptive Statistics of Expectations for all Participants (n = 72)

Expectations	*M*	*SD*	Range
Successful completion of computer science in high school	43.2	29.4	100
Successful completion of advanced or AP science in high school	45.7	29.1	100
Successful completion of trigonometry, precalculus or calculus in high school	31.2	26.8	100
Basic computer literacy	13.8	17.1	79
High achievement in high school science	31.8	22.8	100
High achievement in high school math	23.1	18.6	83
Effective study skills	21.1	24.2	100
Collateral thinking across disciplines	26.8	23.2	97
Basic technology skills	24.9	21.1	90
Knowledge of basic math concepts and content	11.9	18.0	97
Knowledge of basic science concepts and content	19.2	20.3	85
Ability to integrate STEM knowledge with non-STEM disciplines	35.4	28.0	100
Ability to adopt "systems thinking" and contribute to the betterment of a group	23.5	23.6	90
Enthusiasm for learning science	26.5	27.4	100
Enthusiasm for learning math	25.6	25.2	100
Self-management	12.3	12.8	58
Non-routine problem solving	18.3	17.2	80
Adaptability	15.9	15.2	50
Clear career goals	51.3	25.5	100
Imagination	32.4	23.9	83
Ingenuity	25.1	19.4	80
Creativity	30.2	22.4	80

Note. *M* = Mean: 0-20 = Extremely Important; 21-40 = Very Important; 41-60 = Moderately Important; 61-80 = Slightly Important; 81-100 = Not at all Important.

Table 13

Rankings Comparison of Expectations by Participant Group

	Group		
Expectations	BI	PSE	Both
Successful completion of computer science in high school	18	21	17
Successful completion of advanced or AP science in high school	22	20	21
Successful completion of trigonometry, precalculus or calculus in high school	17	11	20
Basic computer literacy	1	4	1
High achievement in high school science	20	13	13
High achievement in high school math	11	10	8
Effective study skills	13	3	19
Collateral thinking across disciplines	7	18	9
Basic technology skills	6	14	11
Knowledge of basic math concepts and content	3	1	4
Knowledge of basic science concepts and content	9	7	2
Ability to integrate STEM knowledge with non-STEM disciplines	10	19	16
Ability to adopt “systems thinking’ and contribute to the betterment of a group	4	17	3
Enthusiasm for learning science	19	6	15
Enthusiasm for learning math	15	9	18
Self-management	2	2	5
Nonroutine problem solving	8	8	7
Adaptability	5	5	6
Clear career goals	21	22	22
Imagination	15	16	12
Ingenuity	12	12	10
Creativity	16	15	14

Note. BI = Business and Industry participants (n = 21); PSE = Postsecondary Education participants (n = 41); Both = BI and PSE participants (n = 10).

Chapter 5: Discussion

The community of Shawnee, Oklahoma and surrounding region has a wide range of opportunities available for high school graduates who desire to begin a career in a STEM field or who would like to further their education by majoring in a STEM program of study. The business and industry community and the postsecondary education community need students who are not only interested in STEM, but who are also capable of success upon entering these STEM programs. This study sought to identify the expectations that the business and industry community and the postsecondary education community hold for high school graduates for the purpose of communicating those expectations to the K-12 school districts within this region.

Discussion

The *STEM Professional Survey* was developed using expectations collected from relevant literature that are considered desirable among members of the STEM community. The participants in this study were categorized into three subsets, STEM business and industry professionals, STEM postsecondary educators, and those that identified as both a STEM business and industry professional and a STEM postsecondary educator.

Each subset returned results indicating that there are varying degrees of importance for the listed expectations. Each subset reported a wide range of values assigned to each expectation indicating that there are discrepancies even among STEM professionals with similar backgrounds. However, the mean values for each subset suggest that the expectations can be ranked according to their relative value. The data become more meaningful when the rankings of each expectation as determined by each subset are listed side by side as in Table 13.

The expectations were ranked with number one corresponding to the expectation with the lowest mean value and number 22 corresponding to the expectation with the highest mean value within each subset. Expectations with similar rankings indicated more agreement among the three subsets and expectations with dissimilar rankings indicated discrepancies among the three subsets regarding value. The results of the survey questions regarding the 22 expectations indicate that the business and industry community may have priorities different from that of the postsecondary education community. This finding echoes the findings of Chueng and Lewis' 1998 study in Hong Kong in which the local workforce expressed dissatisfaction concerning the preparation of secondary students to meet the expectations of the local workforce. Secondary education in Hong Kong gave priority to preparing students for postsecondary studies over workforce needs which led to employer disappointment in the qualification level of potential employees (Chueng & Lewis, 1998).

Additionally, Dampfle's 2003 study indicated that attrition of SME majors to other majors of study were due to differences in expectations on behalf of the teachers, both secondary and postsecondary, and the students. The current study confirms that differences in expectations exist between the business and industry community and the postsecondary education community within the region of Shawnee, Oklahoma, as well. For example, according to the business and industry sector, the ability to adopt "systems thinking" and contribute to the betterment of a group was ranked as the fourth most valuable expectation. The postsecondary education sector ranked this same characteristic as number 17 out of the 22 expectations. Consulting those within the region that identify as both a member of the business and industry community and the postsecondary education community may provide insight as to which value is more reliable. In this case, this subset gave the expectation concerning “systems thinking” a value of 3, indicating that this expectation should be given more consideration by the PSE community as they prepare their graduates to enter the local STEM workforce. Other expectations that demonstrated a large discrepancy between the BI and the PSE communities include effective study skills, enthusiasm for learning math, enthusiasm for learning science, and collateral thinking across disciplines. For each of these four expectations, the third subset representing participants that identify as both BI and PSE sided with the BI community in terms of value.

There are some expectations for which all subsets agree on value. When looking at a list of the top 10 expectations for each subset, the following expectations appear in all three lists: basic computer literacy, knowledge of basic math concepts and content, knowledge of basic science concepts and content, self-management, nonroutine problem solving, and adaptability. Equally important are those expectations that fall toward the bottom of the list for each subset. Successful completion of advanced or AP science in high school and clear career goals have landed solidly at the bottom of all three lists. These results indicate that the value of mathematics and science knowledge should not be defined by academic achievement in those subject areas. This study supports previous studies by Daempfle (2003) and Hilton (2008ab) in that the knowledge gained in high school and not necessarily the academic achievement contributes to students success as a college STEM major.

It is critical that this information is communicated to all K-12 educators within this region, because, any student interested in pursuing a STEM career, regardless of their immediate plans post-high school, may likely have these six expectations placed upon them. Students who are interested in joining the STEM workforce at an entry level position immediately upon graduation from high school should know that they may likely be expected to have basic technology skills as well. Technology skills can be obtained through many career and technology education programs of study available to high school students. Students who are interested in furthering their education and pursuing a STEM major in college should know that they may likely be expected to actually like mathematics and science, as indicated by the values placed on enthusiasm for those subjects. Additionally, intentional practice on improving study habits while in high school will help students meet study skills expectations in college.

There was very little discrepancy among the three subsets regarding the responses to the open-ended question. The qualitative data from the open-ended question indicate that the business and industry community and the postsecondary education community are united in the expectations listed and the value assigned to each. The responses were grouped into similar themes according to the top 10 soft skills needed in today's workplace: communication, courtesy, flexibility, integrity, interpersonal skills, positive attitude, professionalism, responsibility, teamwork and work ethic (Robles, 2012). This list of soft skills provided the framework in which to report the expectations as seen in Tables 7, 9, and11. Most responses fell under the theme of responsibility followed by communication and work ethic. Again, these findings are consistent with the findings of Chueng and Lewis (1998) in their regional

study in Hong Kong. Responsibility and the ability to communicate with others verbally were listed as the most important employee attributes (Chueng & Lewis, 1998).
All of the open-ended responses, except for one of the "curiosity" responses were assigned values of 0 to 20, indicating each respondent felt these expectations were extremely important.

In the current study, references to learning and learning outcomes among the open-ended responses were grouped under "flexibility" to emphasize a willingness to continue education at a postsecondary education insititution and gain additional training in the STEM workforce (Robles, 2012). Interestingly, although previous studies show that business and industry communities have in-house training programs (Smoorenberg and Velden, 2000), the business and industry community of Shawnee, Oklahoma, did not address learning or continuing education within the industry in the open-ended response field. This finding raises questions that should be investigated further about whether prior industry-specific training is expected for employment within the local STEM business community.

The low participation of the business and industry community suggests that there is not enough understanding among the local STEM industries regarding their role in STEM education. This low participation rate of all potential participants also speaks to the lack of a broad common conceptualization of what is meant by STEM in general and STEM education in particular (Breiner et al., 2012).

The expectations listed in the survey ranged from technical and academic knowledge to personal traits. There are discrepancies of the value of these expectations between members of the local STEM business and industry community and the local postsecondary education community. However, the results of this study suggest that K-12 educators from the school districts within Shawnee, Oklahoma and the surrounding region can enhance their students' level of preparation to enter the STEM field by incorporating opportunities for students to develop the skills and characteristics that are shared expectations of the local STEM community.

Limitations

The low response rate from the survey distribution limits the study in terms of reliability and transferability of the results. The method of distribution via email did not provide an opportunity to engage with the participants to ensure understanding of their role in STEM education. Therefore, many in the business and industry sector may not have recognized their eligibility as a participant. The time of year may also have limited the response rate from the postsecondary education community. The initial invitation to postsecondary educators was distributed on May 7, 2016, following receipt of the IRB approval letter. This timing may have conflicted with other priorities of the postsecondary education community. The reminder email distributed two weeks later may have been missed as the semester had ended for most of these faculty. Data regarding specific areas of expertise were collected from the participants; however, with a limited response rate, comparisons between areas could not be made.

An additional limitation is that the survey instrument may have been misunderstood by some of the participants. The scale was intended to rank the expectations with a lower number corresponding to a more valuable expectation. However, it appeared that some participants viewed the scale as a grading scale, assigning high numbers to the expectations they felt were of more value. Attempts were made to evaluate any outliers in which it appeared that was the case and reverse the values. However, with an anonymous survey, follow-up interviews were not possible to confirm the responses.

Recommendations for Future Research

A critical next step would include a comparative study in which the same 22 expectations are evaluated by educators from the local K-12 school districts within this same region. Any discrepancies between the value placed upon these expectations by K-12 educators and the local STEM community could be quantified and provide a baseline for improvement efforts with the goal of aligning expectations for students matriculating from the local K-12 school districts into the local STEM community.

Efforts to increase participation should be considered in moving forward with continued studies. For example, a combination of surveys and personal interviews would ensure potential participants understood their role in advancing STEM education initiatives within the region of study and could encourage participation. Within Shawnee, Oklahoma, this study should be repeated after a prescribed length of time using data from this study as a baseline. Comparison of data from future studies could determine if current STEM education initiatives are successful in aligning the expectations of high school graduates held by STEM business and industry professionals and STEM postsecondary faculty members.

Conclusion

The results of this study suggest that there is still much to be done to build a network of stakeholders to strengthen STEM education in the local K-12 school districts to provide better students, better teachers, and a better workforce (Breiner et al., 2012).

The low participation rate, particularly among the business and industry sector, indicates that those in the education community should be intentional about clearly communicating with the business community that they are a critical component in improving STEM education. Administrators should seek professional development opportunities in which to invite local business and industry professionals to present their industry and its relevance to core curriculum. Curriculum directors should collaborate with local business and industry professionals as well as STEM faculty from postsecondary education institutions to ensure alignment not only with Oklahoma Academic Standards, but also with the expectations discovered in this study. Shawnee, Oklahoma has entities in place for the facilitation of such communication, including the Shawnee Economic Development Foundation and the local career and technical education institutions, both of which have established partnerships with the local postsecondary education institutions.These pre-existing relationships provide an easily accessible avenue to initiate the dissemination of the results of this study.

The expectations listed and the value assigned to each helps K-12 educators understand what may be expected of their students as they graduate high school. It is valuable for teachers to be able to share with their students the reasons behind the lessons, particularly as students talk to their teachers about plans after high school (Scales,et al., 2005). Teachers will be able to tell students seeking employment in the STEM workforce specifically what will likely be expected of them by their employers. Likewise, students wishing to pursue a STEM program of study at a local postsecondary institution can know what will likely be expected of them as well. Knowing these expectations at the K-12 level may help to prepare students better for success as they matriculate into the local STEM community in Shawnee, Oklahoma and surrounding region.

Given the diverse backgrounds of members of each of the stakeholders addressed in this study, the local STEM business and industry community, the local STEM faculty members of postsecondary education institutions, and local K-12 educators, the language regarding STEM education initiatives may not be clearly understood by all. This study indicates that there are some expectations that are shared by all stakeholders; therefore, initiatives that include this terminology may be a good place to start. The six expectations from the survey, basic computer literacy, knowledge of basic math concepts and content, knowledge of basic science concepts and content, self-management, nonroutine problem solving, and adaptability, may provide the foundation on which to build a concerted effort toward improving STEM education. Additionally, the soft skills discovered from the open-ended question reveals some of the characteristics that should be encouraged as students progress through their K-12 education.

Communication among the local stakeholders is key to enhancing the STEM community. Shawnee, Oklahoma and the surrounding region provides multiple opportunities for students with an interest in pursuing a STEM career. By investigating the expectations placed upon these students by the local STEM business and industry community and the local STEM postsecondary education community in this research study, K-12 educators in Shawnee, Oklahoma and surrounding communities now may have the information they need to evaluate current curriculum and instructional practices to prepare their students better for success in their chosen STEM field.

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Appendix A: Institutional Review Board Approval Letter

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Initial Submission – Expedited Review – AP01

Date: May 02, 2016 **IRB#:** 6814

Principal Investigator: Michelle Lee Dominy

Approval Date: 05/02/2016
Expiration Date: 04/30/2017

Study Title: Science, Technology, Engineering, and Mathematics (STEM) Professionals' Expectations of High School Graduates: A Regional Study

Expedited Category: 7

Collection/Use of PHI: No

On behalf of the Institutional Review Board (IRB), I have reviewed and granted expedited approval of the above-referenced research study. To view the documents approved for this submission, open this study from the *My Studies* option, go to *Submission History*, go to *Completed Submissions* tab and then click the *Details* icon.

As principal investigator of this research study, you are responsible to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations 45 CFR 46.
- Obtain informed consent and research privacy authorization using the currently approved, stamped forms and retain all original, signed forms, if applicable.
- Request approval from the IRB prior to implementing any/all modifications.
- Promptly report to the IRB any harm experienced by a participant that is both unanticipated and related per IRB policy.
- Maintain accurate and complete study records for evaluation by the HRPP Quality Improvement Program and, if applicable, inspection by regulatory agencies and/or the study sponsor.
- Promptly submit continuing review documents to the IRB upon notification approximately 60 days prior to the expiration date indicated above.
- Submit a final closure report at the completion of the project.

If you have questions about this notification or using iRIS, contact the IRB @ 405-325-8110 or irb@ou.edu.

Cordially,

Fred Beard, Ph.D.
Vice Chair, Institutional Review Board

Appendix B: Initial Invitation Email

Dear Community Professional,

My name is Michelle Dominy and I am a graduate student in Instructional Leadership and Academic Curriculum at the University of Oklahoma. I am nearing the completion of the requirements for my master's degree in science education and I would like to ask for your participation in my thesis research project. My research focuses on the science, technology, engineering and mathematics (STEM) skills that high school graduates need to successfully enter the STEM programs in our region of Shawnee, Oklahoma and surrounding communities. Specifically, I want to know what characteristics you expect of high school graduates that will contribute to their success as either a member of the STEM workforce or as a student pursuing a STEM degree.

The online survey will take approximately 10-15 minutes to complete. No identifiable information will be collected. No electronic tracking of IP addresses will be recorded, therefore, there will be no identifiers associated with your responses. Participation in the study is completely voluntary and you are free to withdraw at any time. There are no consequences associated with your choice to decline participation, to withdraw from participation, or to fully participate.

To participate in this study, you must answer "Yes" to at least one of the following questions:

- **Are you a post-secondary educator at either a 2-year college, 4-year college, or a technical school within a 50-mile radius of Shawnee, Oklahoma?**
- **Are you a STEM professional employed at a business or industry located within a 50-mile radius of Shawnee, Oklahoma?**

For the purposes of this study, a STEM professional is defined as, "A worker who employs significant STEM knowledge and skills in their job."

If you answered "yes" to at least one of the above questions, please select the link below to participate in the study.
https://ousurvey.qualtrics.com/SE/?SID=SV_4NLb5s9jkUsMnqd

If you have any additional questions, please feel free to contact me.

Thank you for your time and participation.

Michelle L. Dominy
University of Oklahoma
Norman, OK 73019
Michelle.L.Dominy-1@ou.edu

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Appendix C: Reminder Email

Dear Community Professional,

Two weeks ago, I contacted you about participating in my thesis research study. Thank you to those that have already participated. For those of you who have not yet participated and would like to do so, **please complete the online survey within the next week**. As you may remember, my research focuses on the science, technology, engineering and mathematics (STEM) skills that high school graduates need to successfully enter the STEM programs in our region of Shawnee, Oklahoma and surrounding communities.

The online survey will take approximately 10-15 minutes to complete. No identifiable information will be collected. No electronic tracking of IP addresses will be recorded, therefore, there will be no identifiers associated with your responses. Participation in the study is completely voluntary and you are free to withdraw at any time. There are no consequences associated with your choice to decline participation, to withdraw from participation, or to fully participate.

To participate in this study, you must answer "Yes" to at least one of the following questions:

- **Are you a post-secondary educator at either a 2-year college, 4-year college, or a technical school within a 50-mile radius of Shawnee, Oklahoma?**
- **Are you a STEM professional employed at a business or industry located within a 50-mile radius of Shawnee, Oklahoma?**

For the purposes of this study, a STEM professional is defined as, "A worker who employs significant STEM knowledge and skills in their job."

If you answered "yes" to at least one of the above questions, please select the link below to participate in the study.
https://ousurvey.qualtrics.com/SE/?SID=SV_4NLb5s9jkUsMnqd

If you have any additional questions, please feel free to contact me.

Thank you for your time and participation.

Michelle L. Dominy
University of Oklahoma
Norman, OK 73019
Michelle.L.Dominy-1@ou.edu

The University of Oklahoma is an Equal Opportunity Institution.

Appendix D: STEM Professional Survey

Q1. Answer this question if you are a STEM business or industry professional

Use the drop boxes below to describe your current position.

Primary industry sector:
- Aerospace and Defense
- Energy
- Agriculture and biosciences
- Information and financial services
- Transportation and distribution (logistics)

Primary job description:
- Administrator/Executive
- Engineer
- Machinist
- Technician
- Other

Q2. Answer this question if you are a postsecondary STEM faculty member.

Use the drop boxes below to describe your current position.

Type of institution:
- 2-year college
- 4-year college
- Technical school

Area of expertise:
- Science
- Technology
- Engineering
- Mathematics
- Other

Q3. Consider high school graduates applying to attend your institution as a STEM major or seeking employment at you place of business. How important are the following student characteristics in leading to successful completion of a STEM degree or attainment of a position in a STEM field?

	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Value (0-100)	**0**	**20**	**40**	**60**	**80** **100**
Successful completion of computer science in high school					
Successful completion of advanced or AP science in high school					
Successful completion of trigonometry, precalculus or calculus in high school					
Basic computer literacy					
High achievement in high school science					
High achievement in high school math					
Effective study skills					
Collateral thinking across disciplines					
Basic technology skills					
Knowledge of basic math concepts and content					
Knowledge of basic science concepts and content					
Ability to integrate STEM knowledge with non-STEM disciplines					
Ability to adopt "systems thinking' and contribute to the betterment of a group					
Enthusiasm for learning science					
Enthusiasm for learning math					
Self-management					
Non-routine problem solving					
Adaptability					
Clear career goals					
Imagination					

Ingenuity	
Creativity	

Q4. Is there another characteristic that you believe is important that is not listed? If so, then please list it here. If not, then you have completed this survey.

____

Q5. Using the same scale (1 = Extremely important, 100 = Not important at all), give a numerical value of the importance of the item you listed in the previous question. _____