Principal Preparation in STEM: An Action Research Project

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Traditionally, the impetus of principal preparation programs is a focus on educational administrative leadership theories, facilities management, human resources, and systems of supervision. However, principals are more than a by-product of the education law and theory systems; they are the key component of the public education organizational management driving student outcomes (Hallinger & Heck, 2010). As recipients and disseminators of school board policies and instructional trends, the evaluation of their effectiveness is linked to accountability standards (Shohno & Barnett, 2010). Principals are the sole leaders at the campus level, hence, they are responsible for exercising leadership practices associated with improving classroom instruction (Lochmiller, 2014). Relatedly, according to the National Science Teachers Association (NSTA) president, the gap in Science, Technology, Engineering and Mathematics (STEM) pedagogical knowledge is underscored by the fact that principals are not trained in areas of STEM education (Falk, 2015). Therefore, there is a pressing need for principals to increase their roles as knowledgeable, instructional leaders who will develop and implement the academic mission of the school. In that case, the primary goal of an effective instructional leader is to dedicate attention to closing instructional achievement gaps, especially in subject areas where students’ state performance data indicate the largest difference, like science and mathematics (THECB, 2015a).

This paper provides an examination of the relationship between the current state of affairs of STEM attainment and the STEM-specific preparation of principals. The researchers argue that STEM-knowledgeable principals can help close the content-specific gap by receiving better preparation in mathematics and science areas, which is lacking in principal preparation programs. As evidenced by the creation of the Texas College and Career Readiness Standards (CCRS), Texas leads the nation in reform efforts in college preparation; consequently, this paper targets the principal-STEM issue as it exists in Texas (Gewertz, 2009; THECB, 2009). Although this paper discusses the void in STEM-specific principal preparation, it will also propose that administrators can learn through collaborative relationships where teachers, and principals work, learn, and teach together and ultimately, lead together. Relatedly, the researchers’ expectation is for this paper to lay the groundwork for an action research project that aims to analyze the impact of STEM-specific, collaborative training in preservice principal preparation.

Principal Preparation Programs

According to Firestone and Riehl (2005), despite the abundance of research on principals’ preparation programs and leadership practices, understanding what principals do to make a difference in teaching and student learning remains limited. Traditionally, the practicum has focused on field-based experiences at previously and mutually selected school settings where the university supervisor visits and observes the principal candidate (Stevenson, Conner, & Fritz, 2008; Frye, Bottoms & O’Neil, 2005). For example, at Delta State University, pre-service principals are required to complete a total of 38 weeks of field-based hours divided into 12 weeks at the elementary, middle and high school campuses, and two weeks in a central office setting (Davis & Darling-Hammond, 2012). Another example is Wichita State University which utilizes an entirely field-based curriculum in which they reduce classroom hours and maximize students’ experiences in local school districts (Orr, 2006). Additionally, Kearney and Valadez (2015) identified three important categories for principal preparation programs: enhanced entry criteria, increased field-based experiences, and heightened support after graduation.

Furthermore, researchers shed light on other issues related to principal preparation programs (Lochmiller, 2015; Arshavsky, Edmunds, Miller & Corritore, 2014). In that case, research findings suggest that principals’ jobs may not be coordinated with principal preparation programs. Frye, et al. (2005) surveyed 156 department chairs in 126 principal preparation programs within the Southern Regional Education Board (SREB, 2005). SREB researchers found that not only were the principal preparation programs uncoordinated with the principals’ job realities, principal preparation programs failed to collaborate with the school districts to adequately supervise the candidates, and the candidates felt unsupported (2005). In fact, Frye, et al.’s (2005) research findings suggest that “only three states—Alabama, Maryland, and Texas—have standards that focus more on student learning-focused knowledge and skills” (p. 8). Even in these three states that have prin-
principal preparation programs with a focus on knowledge and skills, rigorous understanding of content-specific knowledge is still lacking. The authors believe that teachers’ STEM preparation via professional development or professional learning communities (PLC’S), spearheaded by principals who are knowledgeable and committed to STEM content, can have a positive impact on STEM matriculation (Capraro R.M., Capraro, M.M., Scheurich, Jones, Morgan, Huggins, Corlu, Younes, & Han 2016).

Impact of Principals on STEM
Moreover, research conducted by Branch, Hanushek, and Rivkin (2012), support the premise that student educational outcomes are directly linked to a principals’ effectiveness, when measured by student achievement. For instance, Lai (2015) identified three leadership practices that can positively impact STEM instructional campus capacity: (1) support for teacher learning, (2) utilizing campus teachers’ expertise to mentor and coach teachers, and (3) flexibility within organizational structures (i.e., school’s norms and district external demands). As instructional leaders, principals are expected to be influential in affecting student performance on high-stakes testing especially for the target population of underprepared/underrepresented/underserved students. Relatedly, these researchers perceive that STEM-knowledgeable principals can positively motivate students to transcend the dismal national trends and become instructional leaders, especially in the advent of new mandates (Strauss, 2015a; Strauss, 2015b). STEM-knowledgeable principals can promote hands-on and minds-on instruction, particularly for students that have been underrepresented/underserved/underprepared in the STEM fields.

The fact remains there are few studies that investigate STEM-specific leadership as it relates to the principal (Lochmiller, 2015; Arshavsky, et al, 2014). For example, a study conducted by Sayed (2014) indicated that the principals’ role has changed “over the last decade, going from a role that revolved around “buses, boilers, and books” to one that centers on promoting high-quality teaching and learning in classrooms” (p.47). High-quality teaching and learning in classrooms can be supported by strong content-specific instructional leaders and can result in increased students’ success in STEM throughout college (Arshavsky, et al, 2014).

According to a statistical analysis report from the Institute of Education Sciences, “among Bachelor’s degree students entering STEM fields between 2003 and 2009, nearly one-half (48 percent) had left these fields by spring 2009. Some left STEM fields by switching their majors to a non-STEM field (28 percent) while others exited college entirely without earning a degree or certificate (20 percent)” (NCES, 2013b, p.14). Yet, the low retention in STEM education can change if content-specific instructional leaders lead by example by “setting high expectations, monitoring student progress, supporting teachers and parents, and helping students academically and socially” (Murakami, Garza, & Merchant, 2012, p.68). Successful school principals who have strong instructional leadership knowledge understand that improving students’ education outcomes cannot be accomplished without the adaptation of curriculum and instructional programs alone, teachers need to be included in this process (Goodwin, 2015; Fullan, 2006). Since 2001, NCLB mandated school districts to increase research-based classroom practices and teacher professional development in all content areas (Gurley, Anast-May, & Lee, 2015; Carraway & Young, 2015).

Furthermore, Fullan (2006) notes that building campus capacity begins with the effective implementation of the intended curriculum. Unequivocally, school principals need to possess the content-specific knowledge to deliver professional development to the campus teachers and to be able to influence rigorous instructional delivery (Klar & Brewer, 2013). Outstanding approaches in STEM teaching that focus on inquiry, standards-based and student-centered approaches can produce positive results. For example, one study in Texas investigated STEM teaching in high schools where students were engaged in learning, developing scientific literacy and utilizing project-based learning approaches. The results from this study indicated students increased knowledge and conceptual understanding, STEM interest in research, career, as well as gains in communication and collaboration skills. The researchers also found students utilizing a STEM model performed better in state tests as compared to their counterparts (Sahin & Top, 2015). In fact, mathematics attainment is the cornerstone to college access, degree completion, and to STEM pursuit and matriculation. According to two landmark studies conducted by the U.S. DOE, “the highest level of math taken in high school is the most powerful predictor of whether a student will ultimately earn a bachelor’s degree. Students completing Algebra II in high school more than doubled their chances of earning a four-year college degree” (Massachusetts Department of Elementary & Secondary Education, 2007, p.10). Relatedly, principals that understand struggling mathematics learners
can become more effective leaders (Morrison, French & McDuffie, 2015). For example, in one research study, university-based facilitators studied mathematics and cultural anxiety in eight algebra-based sessions with secondary principals from six surrounding school districts. As a result of the study, principals had greater confidence, more in-depth discussions of mathematics knowledge and reasoning and could understand struggling mathematics learners (Carver, 2010).

STEM Attainment in Texas

Notwithstanding research that indicates outstanding approaches in STEM teaching can potentially increase test scores, a persistent problem with high school graduates in Texas is they do not have the knowledge, skills, and abilities necessary for college mathematics and science work (THECB, 2015a). Moreover, the state’s 2009 accountability report, the Academic Excellence Indicator System (AEIS), indicated that compared to white students, minority students are less likely to: (a) score college-ready on SAT or ACT; (b) score college-ready on the state’s standardized assessments for graduation; and, (c) earn credit from advanced course work or dual enrollment (TEA, 2013-2014).

Texas aims to ensure students in high school are prepared for college with the creation of the Texas CCRS in 2007 (Gewertz, 2009). Since 2009, there have been consistent positive gains in the Texas students’ science achievement scores but Texas was not significantly different in their average science scores as compared to public schools in the nation (NCES, 2011). In 2011, Texas students’ science scores in the eighth grade were higher than the nation and as compared to other Mega-States – California, Florida, New York and Illinois (NCES, 2013a). However, more recently in Texas, legislative changes to mathematics education are inciting debate about the role of mathematics in Texas schools. In 2013, House Bill 5 unanimously passed -dropping Algebra II as a requirement for most students. The only track where Algebra II is required is in endorsements in STEM – science, technology, engineering and math and in other distinguished level tracks. Under the circumstances, teachers maintain that Algebra II is necessary for students in college tracks and that algebraic principles are used in everyday lives (Gross, 2014). Thus, the Texas graduation dropout continues, and is projected to get even worse in the coming years particularly among the Hispanic underprepared/underrepresented/ underserved students (IDRA, 2010; THECB, 2015b). Moreover, many underprepared/underrepresented/underserved graduates will need remedial courses, when they enter postsecondary education, thereby increasing their likelihood of dropping out of college without a degree and reducing their earning potential to pay back college student loans (IDRA, 2014; THECB, 2015b).

Background for the STEM Future Action Research Project

The standardized accountability system in the state of Texas was the model governing our nation’s most comprehensive education policy, The Elementary and Secondary Education Act, commonly known as the No Child Left Behind Act (NCLB) (McNeil, Coppola, Radigan, & Heilig, 2008). Furthermore, the original NCLB mandates did not include school principals in any of the subject-specific professional development (Carraway & Young, 2015; USDE, 2001). More recently, the NCLB underwent a significant re-write, titled the Every Student Succeeds Act (ESSA) (Strauss, 2015a; Strauss 2015b). The reauthorized NCLB, now known as ESSA, has now allowed individual states to improve schools that are the lowest performing as well as schools with high dropout rates (Texas AFT, 2015; Strauss, 2015a; Strauss, 2015b). The shift to state control from ESSA necessitates increased states’ responsibility to provide rigorous education in STEM initiatives in order to prepare students for college, particularly in areas of concern like mathematics. Contrary to the NCLB, ESSA calls for states to be “developing and providing professional development and other comprehensive systems of support for teachers, principals, or other school leaders to promote high quality instruction and instructional leadership in science, technology, engineering and mathematics subjects, including computer science” (Strauss, S 1177-121, 2015b). Guidance for statewide administration under ESSA also states that state-wide agencies should utilize performance-based assessments in the form of projects, portfolios, and extended-performance tasks, and utilize universal design for learning principles to help students with challenging academic standards (Stonehill & English, 2015). Student knowledge and understanding, and scientific literacy has been shown to increase when students are engaged in project based approaches (Sahin & Top, 2015). While principals are integral to this change, the research we propose in this paper also suggests an approach that calls for a project-based learning style utilizing inquiry-based STEM teaching in an after-school setting for pre-service teachers and during the pre-principal practicum. The proposed research study focuses on future teachers and principals and their collaborative field-based experience to learn together and ulti-

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mately, to lead together. These hands-on, inquiry-based experiences will provide a framework to teach future principals and teachers how inquiry is conducted using performance-based tasks in mathematics and science. These performance-based tasks will also incorporate universal design for learning principles, as outlined in ESSA, to offer alternate assessments and accommodations for all learners, particularly among our underserved and underrepresented Hispanic population.

**Intent and Timeliness for STEM Future Action Research Project**

Action research is a process whereby school personnel as well as teachers are able to “carry out investigations systematically, reflectively, and critically using strategies that are appropriate for their practice” (Efron & Ravid, 2013, p.4). Similar research projects involving afterschool STEM programs have used action research methods to help researchers understand “cycles of data collection and reflection to develop understanding” (Lingwood & Sorenson, 2014, p.41). In particular, a focus on inquiry through a model of initial training followed by sustained support and concentration on the curriculum and facilitation skills allowed for ongoing learning experiences (Lingwood & Sorenson, 2014). Pre-service teachers that master pedagogical skills in the classroom are given the opportunity to teach mathematics and science content supported by activities that engage students. Inherently, action research is “constructivist, situational, practical, systematic and cyclical” (Efron & Ravid, 2013, p.7).

Therefore, the intent of the Principal Preparation in STEM action research project is for pre-service teachers to teach mathematics and science content supported by project-based activities that engage students and enrich their school day experiences. In this case, principals, as collaborators, evaluators and instructional leaders as well as teachers can benefit from practicum experiences that train teachers and principals as STEM instructional leaders. A key element of this project is the concurrent preparation that pre-service teachers and pre-service principals will experience through continual reflection in their unique contexts. The pre-service principals will be the active instructional leader of an afterschool program where teachers will be working with a range of students and teaching from a pool of different mathematics and science lesson outlines. Pre-service teachers will adapt their teaching techniques based on the students’ individual needs. Thus, pre-service teachers, and pre-service principals, will conduct a continual cycle of evaluation - which involves an initial reflection on lesson outlines, an amendment phase, a re-teaching and reflection phase and finally a post-reflection. The researchers propose that a syllogism of STEM knowledgeable instructional leaders will positively impact teachers’ effectiveness and increase student matriculation in STEM fields.

**Timeliness for STEM Future Action Research Project**

This innovative novel model of simultaneous pre-service training for teachers and principals in a STEM enriched school setting will require that pre-service principals observe the pre-service teachers deliver the STEM lessons using the STEM lesson observation instrument. The aim of the mathematics and science lesson outlines is to provide the context for pre-service teachers’ to develop their pedagogical skills and to effectively implement lesson plans. Pre-service administrators will simultaneously develop their instructional ability in STEM lesson plans through observation and reflection of the pre-service teachers. The researchers believe that the STEM Future Action Research Project will positively contribute innovative instructional practices for training future principals and teachers. Relatedly, Lochmiller (2015) concluded that “the message that appears to emerge from the literature is that principals who exercise leadership in math and science do so for the distinct purpose of improving instruction in these content areas” (p. 31).

Innovative instructional methods and best practices like hands-on, minds-on STEM activities built on the promising idea of extending mathematics and science content to students will be utilized. Pre-service principals will also receive the STEM curriculum in a class setting, and they will be responsible for observing the pre-service teachers deliver the STEM curriculum at the school setting, ensuring that the pre-service teachers and principals understand the curricular objectives and expectations and establishing a mutual understanding amongst of STEM curriculum and activities. Pre-service teachers and principals will demonstrate and implement their instructional and leadership skill-set in a school setting, respectively. Moreover, both pre-service teachers and principals will simultaneously identify best instructional practices in mathematics and science lessons while gaining important field-based collaborative skills.

**Conclusion**

The purpose of this paper was to discuss the principal as a stakeholder to STEM attainment and to lay the groundwork for the Principal Preparation in STEM action research study that focuses on the integration of STEM programs in pre-service principal preparation.
The research design presented in this paper aims to increase the simultaneous STEM attainment of both teachers and principals. Ultimately, the expectations of school environments set by school principals and teachers filter into expectations for college readiness and can have positive impacts on student success.

References


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