Research Article

School Administrators' Perceptions of STEM Awareness and Resources

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Abstract

The purpose of this mixed methods study was to assess the perceptions of K-12 school administrators regarding school and community STEM awareness and to elicit their suggestions for promoting Science, Technology, Engineering and Mathematics (STEM) awareness among schools and communities. A purposeful sample of 175 Texas administrators provided responses to the *STEM Awareness Community Survey* (SACS) assessing their perceptions of their overall STEM awareness of the districts and schools they served. Findings indicated a 77% disconnect between school principals' and superintendents' perceptions regarding STEM awareness/resources of their districts, schools, parents and communities, with superintendents consistently reporting more positive perceptions of the STEM awareness and resources of their districts in comparison to school principals.

Key Words

STEM perceptions, STEM awareness, K-12 administrators, STEM education

Introduction

For the past decade, the United States (U.S.) federal government and all 50 states have invested substantial dollars in Science, Technology, Engineering and Mathematics (STEM) education (Tofel-Grehl & Callahan, 2014) in response to legislation such as America COMPETES (Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science) legislation (H.R. 2272, America COMPETES Act, 2007), reports such as the National Academy of Sciences study, *Rising Above the Gathering Storm* (2007), and enterprises such as President Obama's initiative to commission 1,000 STEM-focused high schools (President's Council of Advisors on Science and Technology, 2010) that highlighted the critical shortage of STEM professionals and students in STEM career pipelines in the U.S. (Stearns, Morgan, Capraro, & Capraro, 2012).

While the number of STEM related jobs has "doubled that of all other fields over the past decade" (Angle et al., 2016, p. 43), the number of students pursuing those jobs has declined. This critical shortage of STEM professionals is negatively affecting America's educational standing in the world and its economic competitiveness among other nations (National Science Board [NSB], 2010).

K-12 educators have responded to the problem of the shortage of students pursuing STEM coursework and STEM related careers by implementing a number of different endeavors including the adoption of specialized STEM curricula; provision of more advanced STEM courses; introduction of STEM-related curricula earlier in childhood; increased collaboration with STEM professionals; incorporation of inquiry-based and problem-based learning strategies in STEM; provision of extracurricular STEM exploration activities such as coding for kindergarteners; offering summer camps related to STEM and STEM after school initiatives, etc. Despite of all of these measures, the U.S. has not been able to effectively motivate enough students to pursue STEM careers and thus an underprepared and inadequate STEM workforce continues to persist.

There is a great need to implement STEM programs with fidelity in order to address the myriad of demands for educators, students, and administrators with a STEM focused expertise.

If the vision of a successful STEM program is to be transformed into practice, there must be collaboration and communication of the desired outcomes among stakeholders, especially among district and school administrators. In spite of recent efforts to reform school districts to become less bureaucratic, education continues to have a great many tendencies founded in bureaucracy, including a "top-down" system of communication.

Many of the educational reform efforts currently call for shared decision making and collaboration between school district leaders and principals with regard to program implementation. Principals and superintendents have critical roles in the implementation of any reform efforts, including curriculum-based programs such as STEM. According to Fullan (2005), reform is successful when district leaders have a "compelling conceptualization" and "envisions both content of reform and includes a special commitment to capacity-building strategies" (p. 211). He goes on to state that building capacity occurs when key leaders are supported and trained.

Knowledge and awareness can help shape an individual's perceptions. Collaboration and communication between stakeholders provide the means necessary to gain knowledge and awareness. In keeping with the "top-down" or hierarchical framework of bureaucracies, when district-wide programs are being implemented, much of the direction given in order to implement the programs originates from the district levels and permeates down to the actual instructional settings.

This is the antithesis of findings of a study conducted by Johnson and Chrispeels (2010). The researchers indicated there must be a clear and coherent message delivered to the schools regarding the reform initiative. The second pattern vital to the reform process was the communication from principals to staff members and back to the central office administrators. This directly contradicts how schools generally operate. Johnson and Chrispeels (2010) also found that principals are the critical link in the communication chain as information is transferred from district administrators to the teachers.

In interviews conducted with teachers in the study, some of the teachers expressed concerns the information was not always delivered correctly which often resulted in "inconsistencies" among the teachers implementing the programs. Two-way communication was essential to the process and the superintendent included in the study saw the need for a clear message from central office leaders, but also expected central office administrators to be open to communication from the principals and teachers. The professional development of principals was a "primary source" linking the district to the schools.

There is a clear demarcation between responsibilities at the district administrative levels and local administrators. According to Sanders (2014), district leaders facilitate a school's capacity to change by providing the infrastructures and professional development necessary to "anchor" reform efforts. District leadership create the context necessary for reforms to be implemented and maintained over a period of time. Principals provide the leadership necessary for successful implementation of school reform. Without their guidance and leadership, most efforts prove to be unsuccessful.

One might assume that something as important as implementing a STEM program would encourage and foster two-way communication between school and district level administrators and that the collaboration and communication regarding the implementation would be intensive and those individuals representing both the schools and districts would have similar points of view with respect to implementing such programs as STEM.

There is scant research regarding principals and superintendents and their perceptions of STEM programs in their schools or districts. However, a need exists to explore these perceptions and their awareness of the implementation efforts and resources devoted to STEM. As a result, this mixed methods study assesses the perceptions of K-12 Texas school administrators regarding STEM awareness/resources in their districts/schools and provides a basis of comparison between what district superintendents.

Review of Related Literature

Role of school superintendents

Over the last three decades (1988-2018), the role of public school superintendents has shifted from instructional leader of teachers to encompassing much more complex functions, requiring involvement in local, state, and national politics; in-depth knowledge of school

finance; comprehensive understanding of standards based reform; and, thorough familiarity with student performance demands associated with legislation such as *No Child Left Behind* (2001) (Farkas, Johnson, Duffett, & Foleno, 2001; Feuerstein & Dietrich, 2003; Lecker, 2002; Sherman & Grogan, 2003). In addition, public school superintendents are expected to establish their district's vision; develop worthy dimensions of teaching and learning; introduce and execute policies; and, build quality relationships with integral groups (Carter & Cunningham, 1997; Sharp & Walter, 1997; Waters & Marzano, 2006).

Bjork, Browne-Ferrigno, and Kowalski (2014) conceptualized the work of superintendents into five distinct roles: (a) superintendent as teacher-scholar; (b) superintendent as manager; (c) superintendent as democratic-political leader; (d) superintendent as applied social scientist; and, (e) superintendent as communicator.

According to Bjork et al. (2014), superintendents are considered to be master teachers, and in fact, a 2000 report stated that 40% of superintendents perceived their primary role as that of educational leader (Glass, Bjork, & Brunner, 2000). Similarly, greater than one-third of the superintendents involved in the Glass, Bjork, and Brunner study (2000) stated that effective management was one of the roles their school boards expected them to fulfill. Management tasks of superintendents include budgeting, educational accountability, and compliance with state and federal directives (Glass et al, 2000).

The political savvy of superintendents has also been a critical attribute as superintendents must increasingly handle bond and local school tax issues that require a penchant for inciting support from school board members, parents, citizens and teachers regarding district endeavors (Howlett, 1993).

Moreover, 83% of superintendents indicated school board relations requiring micro-politics were particularly challenging (Glass et al., 2000). Kowalski et al. (2010) characterized superintendents as applied social scientists because they utilize their knowledge of research to inform the educational decisions they make.

Historically, superintendents have worked in an isolated environment, protected from potential interference by parents, citizens, and teachers (Blase & Anderson, 1995). Superintendents were likened to corporate executives, and their communication styles were unilateral and impersonal (Achilles & Lintz, 1983).

Conventional communication methodologies changed when the U.S. became a more information-based society, and superintendents were then expected to maintain communication with the public and interested stakeholders regarding school and student matters (Kowalski, 2001). As a result, the traditional top-down communication model was exchanged for a more interpersonal model that was intended to diminish power disparities. In summary, superintendents have found themselves taking on much broader responsibilities without a substantial reconceptualization of associated training and authority (Fuller et al., 2003).

Role of principals

The formal position of principal was created in response to larger and more complex schools; the growth of secondary education; the change in secondary students themselves; the increase in knowledge about school administration; and, the differing attitudes to specialization in education (Rousmaniere, 2014).

Initially, principals were also teachers, known as principal teachers, but because these

individuals were spending the majority of their time on administrative tasks, school boards had to relieve them of their teaching positions, moving them to full-time principal work (Hart & Bredeson, 1996). Abundant research has been conducted on the tasks principals perform (Byrne, Hines, & McCleary, 1978; Gottfredeson & Hybl, 1987), but most agree that writing reports, engaging in written communication, telephone correspondence, teacher concerns, student supervision, student discipline, extracurricular activities, meetings, contractual management, curricular development, teacher evaluation, special education and professional growth are consistent responsibilities (Hart & Bredeson, 1996).

Regardless of school or geographic location, school principals share similar experiences and goals (Bredeson, 1985). Their work is often fragmented, diverse, and pressing, causing principals to take on a fire-fighting mentality. Most of their daily school related conversations are brief (less than three minutes), resulting in little time for reflection or strategic planning (Kmetz & Willower, 1982; Martin & Willower, 1981). Kmetz and Willower's (1982) study found that elementary school principals "engaged in an average of 14.7 activities per hour;" (p. 72) their deskwork lasted no more than 10-minutes; telephone conversations lasted an average of 2.5-minutes and the longest length of time they spent at once on any one task was 35-minutes for scheduled meetings.

Furthermore, 43% of the time scheduled meetings were interrupted, often more than once. In contrast, secondary school principals engaged in even more activities per hour, had more interruptions, and spent less time at their desks (Kmetz & Willower, 1982). All of these responsibilities must be handled within increasingly unpredictable, conflict-ridden, and sometimes hostile environments (Sergiovanni, 1995).

Superintendent and principal interaction

The value of effective communication among K-12 administrators has been infrequently discussed in the research literature for the last two decades (Carter & Cunningham, 1997; Stokes, 2013). Kowalski (2005) noted that although the critical need for communication is often discussed in administrator preparation documents, rarely is the intended level of proficiency reached.

Additionally, when superintendents utilize effective communication strategies with their principals, school culture and productivity is positively impacted (Friedkin & Slater, 1994; Young, Peterson, & Short, 2002). Norton (2005) emphasized that communication is an element essential to an effective school community and positive school climate.

STEM awareness/perceptions

Examining perceptions of STEM awareness is valuable because perceptions pertaining to STEM impact STEM attitudes and beliefs, which in turn influence behaviors and practices (National Science Board, 2010). The STEM awareness levels/perceptions of school administrators, school districts, schools, teachers, parents, and community business STEM stakeholders are serious concepts to explore because fostering critical STEM collaboration among all of these interested parties is greatly influenced (both positively and negatively) by individually held STEM beliefs.

Knowing administrators' perceptions of STEM for example, can provide practical value by informing where school/district STEM reformers should direct their efforts to move stakeholders to higher attitudinal levels. Knowing community stakeholders' (parents

and STEM business stakeholders for example) perceptions of STEM is also useful in drawing attention to specific needs and postulating attainable goals that will help advance and enhance any collaborative STEM effort (Breiner, et al., 2012).

K-12 administrators' perceptions of STEM awareness

K-12 school administrators play a significant role in the success of curricula implemented in their schools (Rogers, 2007). According to the Interstate School Leaders Licensure Consortium (ISLLC) Standards (Council of Chief State School Officers [CCSSO], 2008) to be effective school leaders, administrators must be: (a) visionary; (b) leaders of instruction; (c) organized; (d) ethical; (e) willing to collaborate with others; and, (f) advocates for their schools and faculty. Given their roles as the instructional leaders of their schools, administrators are essential to the successful implementation of STEM curricula and programs.

Additionally, the perceptions, mindsets, and viewpoints of administrators can influence their decision-making, actions, instructional development, curricular offerings, and school change initiatives (Davis & Leon, 2011; Davis & Darling-Hammond, 2012; Diaz, Cox, & Adams, 2013; Mendels & Mitgang, 2013; Miller, 2013; Praisner, 2003; Verrett, 2012; Versland, 2013). Praisner (2003) stated that attitudes, values, and beliefs held by school administrators affect the amount of support they might put toward implementing change in their schools. Furthermore, Mendels and Mitgang (2013) suggested that school administrator quality directly influences K-12 students' academic success.

While the literature is rife with studies relating to effective broad-spectrum K-12 school leadership practices, research delving into specific school leadership skills required for K-12 STEM advancement is lacking (Brown, Brown, Reardon, & Merrill, 2011). Brown, Brown, Reardon, and Merrill (2011) interviewed 172 school administrators and teachers of STEM to determine their definitions of STEM. Barely half of the administrators and teachers were able to accurately define STEM, with administrators making up those who were least capable of eliciting accurate STEM definitions.

This inability of school administrators to adequately define STEM is indicative of gross STEM misunderstanding among school leadership, those very individuals whose support and guidance is critical to successful STEM initiatives in schools. In addition, Brown et al. (2011) found that science, technology and mathematics teachers had no clear concept of how to implement a school-wide STEM initiative.

Method

Participants

Principals. The majority of participating principals were female (61.5%, *n* = 99), while the remaining identified as male (38.5%, *n* = 62). The racial/ethnic representation of principals were as follows: 10.6% African American/Black (*n* = 17), 60.0% Caucasian/White (*n* = 96), 26.8% Hispanic/Latino (*n* = 43), and 2.5% two or more races (*n* = 4). Pertaining to years of experience, principals reported an average of 18 years of experience as administrators and 33 average years of educator experience. Finally, when principals were queried about the highest degree they held, 10.6% responded with Ph.D./Ed.D., 6.3% with Ed.S., 82.5% with MA/MS, and 0.6% identified as holding BA/BS degrees.

Superintendents. The majority of participating superintendents were female (64.3%, *n* = 9), while the remaining identified as male (35.7%,

n = 5). The racial/ethnic representation of superintendents were as follows: 21.4% African American/Black (*n* = 3), and 78.6% Caucasian/White (*n* = 11). Pertaining to years of experience, superintendents reported an average of 25 years of experience as administrators and 40 average years of educator experience. Finally, when superintendents were queried about the highest degree they held, 23.1% responded with Ph.D./Ed.D., 15.4% with EdS, 61.5% with MA/MS.

Instrumentation

The *STEM Awareness Community Survey* (SACS) was developed by Sondergeld, Johnson, and Walten (2016) using Liu's (2010) framework for the creation of instruments used in the assessment of affective variables in science education. The instrument was validated using a convenience sample of 72 participants completed the initial pilot survey: 39 K-12 teachers, 17 higher education faculty, and 16 business community members.

For field testing purposes, a sample size of 72 is appropriate for this instrument since a 5-point Likert scale was used and the goal is to have a minimum of 10 participants per scale category, thus making 50 the minimum number of participants acceptable for this situation (Liu, 2010).

The 39-item survey consisted of a 4-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree) and four subscales:

(a) Industry Engagement in STEM Education (8-items);
(b) STEM Awareness and Resources (13-items);
(c) Preparation of Students for Success in College & Careers (6-items); and
(d) Regional STEM Careers and Workforce (12-items).

For purposes of this study, only data collected from the STEM Awareness and Resources subscale is reported (Cronbach's alpha = .81).

Data collection & analysis

Following IRB permission, the SACS was emailed to all public-school K-12 Texas administrators (i.e. superintendents, principals, assistant principals) listed in the Texas Education Agency (TEA) administrators' database with information discussing the ethics, details and purpose of the study. In addition, the participants received a SurveyMonkey electronic link to access the survey containing the informed consent, demographic questions, and the SACS.

Data collection took place over a 6-week period of time with a reminder being sent out at 2- and 4-weeks. All quantitative data were analyzed using IBM SPSS. The data obtained from the SACS were analyzed by calculating percentages for each item of the SACS. The criteria used to determine the level of "agreement" versus "disagreement" was less than or greater than a 10% difference respectively.

An inductive coding process was used to analyze the qualitative data obtained from the open-ended survey items. Qualitative data analysis was initiated with data organization and interpretation utilizing MAXQDA analytics software. The researcher read and re-read all qualitative responses provided by participants to search for the emergence of categories of meaning. Once the work of generating categories and themes from the responses from questions two and four was initially completed, the identified categories and themes were coded using MAXQDA. Included in this phase was a period in which the data were reduced according to relevancy, eliminating digressive responses and

simplifying language. Peer debriefing was accomplished by having two researchers independently code the open-ended responses and discuss findings.

Findings

STEM awareness/resources

Superintendents and principals indicated 77.0% disagreement with regards to their perceptions of STEM awareness/resources of the districts and schools they served, demonstrating agreement in only three of 13 areas.

Specifically, superintendents and principals differed in their perceptions that their districts understand the importance of STEM education as 78.2% of principals and 100.0% of superintendents agreed with the statement, "My school district understands the importance of STEM education."

Similarly, superintendents and principals differed in their perceptions of the statement, "The schools in this district understand the importance of STEM education" with 74.3% of principals and 100% of superintendents in agreement. In addition, differences existed between superintendents' and principals' perceptions that parents in their districts understand the importance of STEM education, with 36.3% of principals and 71.4% of superintendents agreeing.

Principals and superintendents also differed in perceptions regarding whether more work needs to be completed to spread awareness of STEM education, with 89.4% of principals and 78.6% of superintendents agreeing. Additionally, principals and superintendents differed in their perception that increasing the STEM talent pool is necessary for economic vitality, with 92.5% of principals and 85.7% of superintendents agreeing. Further differences were found regarding perceptions that students with postsecondary education are more likely to secure a career in a STEM field with 83.2% of principals and 71.4% of superintendents agreeing.

Regarding the statement, "There are STEM education Web sites available for this region that include activities for teachers and students," 63.1% of principals and 78.6% of superintendents indicated agreement. Principals and superintendents also differed in their perception that information on regional STEM career opportunities is available online, with 51.2% of principals and 64.3% of superintendents agreeing.

Principal and superintendent differences were also reported regarding perceptions that information related to STEM opportunities in their regions is available online with 51.0% of principals and 71.4% of superintendents agreeing. Finally, perceptions of whether or not STEM online tools are available to their districts differed, with 49.7% of principals agreeing and 71.4% of principals agreeing.

On the contrary, principals and superintendents were in agreement in only three of ten areas of perceptions. First, principals and superintendents agreed that STEM skills are integral to student success today (Principals 92.5%, Superintendents 85.6%).

Administrators also agreed that there are colleges, universities, and community colleges that offer scholarships for students to pursue STEM degrees in their regions (Principals 63.1%, Superintendents 57.1%). Finally, participants were united in their (dis)agreement that local organizations recruit STEM talent online with 30.3% of principals and 28.6% of superintendents agreeing.

Table 1 provides school administrator perceptions regarding STEM awareness/resources in their respective districts/schools.

Table 1

STEM Awareness and Resources (%)

Survey Item		Disagree/ Strongly Disagree	Agree/ Strongly Agree
1. My school district understands the importance of STEM education.	Superintendent	0.0	100.0
	Principal	6.8	85.9
2. The schools in this district understand the importance of STEM education.	Superintendent	0.0	100.0
	Principal	9.4	74.38
3. Parents in this district understand the importance of STEM education.	Superintendent	14.3	71.4
	Principal	35.6	36.3
4. More work needs to be completed to spread awareness of STEM education.	Superintendent	7.2	78.6
	Principal	2.5	89.4
5. STEM skills are integral to student success today.	Superintendent	0.0	85.7
	Principal	1.9	92.5
6. Increasing the STEM talent pool is necessary for economic vitality.	Superintendent	7.1	78.6
	Principal	1.2	93.2
7. Students with postsecondary education are more likely to secure a career in a STEM field.	Superintendent	0.0	71.2
	Principal	1.9	83.2

8. There are colleges and/or universities and/or community colleges that offer scholarships for students to pursue STEM degrees in my region.	Superintendent Principal	28.6 5.0	57.1 63.1
9. There are STEM education Web sites available for this region that include activities for teachers and students.	Superintendent Principal	7.1 6.2	57.1 63.0
10. Information on regional STEM career opportunities is available online.	Superintendent Principal	0.0 3.8	64.3 51.2
11. Local organizations recruit STEM talent online.	Superintendent Principal	14.3 16.7	28.6 30.4
12. Information related to STEM opportunities in my region is available online.	Superintendent Principal	7.1 12.4	71.4 30.4
13. There are other STEM online tools available to this district.	Superintendent Principal	7.1 12.4	71.4 49.7

Strategies to improve STEM awareness

Principals. Qualitative analysis of principals' responses revealed the following overarching themes in order of frequency of occurrence:

(a) educate parents about STEM and STEM education;
(b) provide additional STEM professional development for faculty and administration; and,
(c) provide STEM instruction in elementary schools.

Specifically, 36.3% of principals indicated that parents do not understand the importance of STEM education and offered related suggestions to include:

(a) parents provided more information regarding STEM (why it is important and the reason for STEM classes and clubs);
(b) multiple open houses focusing on STEM to parents; and,
(c) parents educated about the possibilities for and projected growth in STEM careers.

One principal stated, "Our district can do more to raise awareness at the elementary level as well as for parents. Most children (and parents) know what a firefighter, policemen and medical doctors do but don't know what those in STEM fields do, unless mom or dad are engineers, scientists or mathematicians. Our district would do well to implement "fun" Saturday and summer camps promoting STEM fields using both extrinsic and intrinsic incentives for both children and their parents."

Another principal made a similar suggestion regarding parental involvement in STEM education: "Our district needs to host more STEM camps offering extrinsic motivation to participating students and parents."

Furthermore, 21.0% of principals stressed the need for additional professional development regarding STEM for both teachers and administrators.

Suggestions in this regard included:

(a) offering STEM symposiums and workshops;
(b) providing professional development to include observations on STEM campuses;
(c) offering district presentations pertaining to STEM;
(d) delivering training sessions on how to integrate STEM into class projects; and,
(e) providing ongoing training for administrators regarding the importance of STEM education.

However, several principals voiced concerns pertaining to the need for additional funding to support STEM related professional development for teachers, and for the purchase of STEM supplies and equipment for teaching.

One principal stated: "For the majority of rural school districts, STEM awareness is known throughout. However, the factor holding most schools back is funding. We don't have the funds to hire personnel or purchase equipment to utilize for STEM advancement."

Another principal offered this suggestion: Increase funding to public schools to pay for the resources and training needed to bring more STEM/STEAM focus into our schools. Increase pay through stipends, or other sources, to encourage more high-quality teachers into this field."

Finally, 13.3% of principal participants suggested that STEM instruction be provided earlier in students' educational trajectories

(during elementary and middle school).

Specific suggestions included:
(a) hiring a STEM teacher to run a STEM lab;
(b) providing a STEM specialist at each elementary campus;
(c) providing more information regarding STEM and STEM careers to elementary schools; and,
(d) implementing specific STEM curricula at the elementary level.

Superintendents. Qualitative analysis of superintendents' responses revealed the following overarching themes in order of frequency of occurrence:
(a) more access to technology;
(b) connect schools with STEM professionals;
(c) educate parents about STEM and STEM education; and,
(d) provide STEM instruction in elementary schools.

Specifically, 64.0% of superintendents offered suggestions related to the need for technology, including the following:
(a) more coding and robotics opportunities;
(b) one-to-one computer availability; and,
(c) the creation of dual credit courses in STEM technology.

In addition, 18.1% of superintendents indicated a need for increased collaboration between STEM professionals and K-12 schools.

One superintendent specifically voicing the need for more collaboration between K-12 schools and universities: "I would like to see more college and school district joint ventures." Suggestions in this regard included:
(a) open houses for parents, faculty and students in which STEM employers come and speak about STEM careers and
(b) more university and K-12 school STEM-related partnerships.

Additionally, 14.3% of superintendents felt that parents in their district did not have an adequate understanding of the importance of STEM education and offered the following related suggestion:
(a) providing open houses in which parents can come to hear STEM professionals speak about STEM careers and
(b) lastly, superintendents (9.1%) also indicated that more emphasis needs to be placed upon STEM instruction at the elementary school level.

Discussion

The lack of perceptual congruence between administrator groups' (superintendent, principal) responses to 10 of the 13 STEM awareness/resources statements could be considered by some as troubling.

One must ask how it is possible that differing levels of school administrators could hold different views of STEM awareness and STEM knowledge importance in their districts and schools.

What can account for the differences in the perceptions of STEM awareness/resources between superintendents and principals included in the study?

Do these mixed messages between the district and school leaders impact stakeholders in a negative way? What are the underlying

factors that contribute to the lack of congruence between the administrators in this area?

There are probably several underlying reasons as to why there is a lack of agreement between superintendents and principals.

Regardless of the contributing factors, the lack of agreement in the perceptions of superintendents and principals with regards to STEM is alarming.

As previously mentioned, superintendents have historically worked in isolated environments, often protected from potential interference by parents, citizens, and teachers (Blase & Anderson, 1995); their communication styles were thought to be unilateral and impersonal (Achilles & Lintz, 1983); and, communication was top-down in nature, often serving to maintain the status quo (Kowalski, 2001). Decman, Badgett, Shaughnessy, Randall, Nixon, and Lemley (2018) indicated superintendents need to involve all stakeholders in observing current trends and making collaborative decisions regarding the direction of a district prior to change implementation.

Involvement of stakeholders early in the process fosters a smoother transition and creates a culture of support. In short, superintendents should involve everyone concerned with the implementation of STEM in the schools in the district. Collaboration will facilitate the implementation process, leading to a better understanding of the process by all involved, including the principals and superintendents.

According to Whitt, Scheurich, and Skrla (2015), superintendents often relegate instructional leadership to principals. Most of the research conducted regarding instructional leadership has occurred at the school level. At first blush, this makes sense.

Principals are the caretakers of the schools in their charge. However, more attention is being given to the role superintendents hold as instructional leaders. Whitt et.al (2015) also indicated that instructional leadership on the part of the superintendent may be the most critical factor in the success or failure of school improvement efforts.

The findings of this study reflect the need for superintendents to not just be aware of the implementation of STEM and the resources needed for successful implementation, but to actually have an integral role in the collaboration, planning, and implementation of STEM.

Presently and for a variety of reasons, it is imperative superintendents serve as the instructional leaders of their districts. Only by being directly involved in the implementation process can superintendents understand all of the complexities of implementing a STEM program with fidelity.

The research literature portrays the school principalship as comprehensive, fast-paced, and requiring communication with all school personnel, from students to staff to teachers and includes tasks such as writing reports, engaging in written correspondence, communication via the telephone, teacher concerns, student supervision, student discipline, extracurricular activities, meetings, contractual management, curricular development, teacher evaluation, special education, and professional growth (Hart & Bredeson, 1996).

The comprehensive nature of the principalship does not allow for isolation and indicates that principals are in touch with their schools as a whole. While it is imperative for superintendents to assume an instructional

leadership role, principals do indeed serve as the instructional leaders of their schools.

The need for superintendents to assume a role as instructional leader does not lessen the need for principals to lead instruction on their campuses. It stands to reason that the perceptions of the participating principals shared in this study of their schools' STEM awareness/knowledge are likely to be more accurate of the two administrative groups examined. Unless superintendents have been involved in the collaborative planning process for implementing STEM, principals would naturally be more cognizant of the implementation process as it pertains to their particular schools.

This lack of perceptional congruency between K-12 superintendents and principals is also indicative of their lack of communication. Clearness of communication at all levels among all stakeholders is an outgrowth of collaboration.

When superintendents and principals do not adequately communicate about critical issues such as STEM education, misunderstandings may result that can negatively impact perceptions about STEM education, leading one party or another to falsely believe that their school and or district is effectively addressing STEM, when the reality could be the opposite.

Given that STEM education is critical to the economic competitiveness and sustainability of the U.S. and its global standing as the STEM leader, it is critical that all STEM education stakeholders are on the same page. Anything to the contrary will likely have a negative impact on school and district STEM education initiatives. The onus for taking the initiative for establishing and sustaining a trusting superintendent/principal relationship should fall on the superintendent, as he/she is the one with the greater power (Tschannen-Moran, 2004).

Implications

The implications of this study are multifaceted and addressing these areas from a district standpoint could go a long way towards fostering a climate that is favorable for implementing STEM. While differences in the perceptions of the superintendents and principals were evident in the results of this study, certainly steps can be taken that will foster improvement in these areas.

There are at least six possible areas that could be impacted by the results of this study:

(a) teacher preparation program;

(b) professional development programs for teachers and administrators;

(c) consistency in job performance standards for principals and superintendent;

(d) improvement of all stakeholders' STEM understanding, knowledge and support;

(e) improvement in the general knowledge communication, and support between educational administrators; and,

(f) improvement in the overall number of individuals qualified to apply for and serve in STEM professions.

Teacher preparation programs

Currently, there is a critical shortage of STEM professionals and students. Teacher preparation programs in colleges and universities lack emphasis in STEM areas. Presently, human resource personnel and school administrators often find it difficult to hire knowledgeable educators able to teach science, technology, engineering, and mathematics. This lack of preparation for educators trained in the STEM areas results in teachers who are ill prepared to work with students in STEM.

Pressure to provide more qualified employees must come from lawmakers and private entities. As colleges and universities recognize the need in society for graduates in STEM areas, perhaps the emphasis placed on STEM professions will prompt more students to consider the possibilities of STEM careers. Until colleges and universities begin to address weak STEM education programs, K-12 schools will continue to suffer the consequences of underprepared STEM teachers.

This apparent lack of focus on STEM education results in the perpetuation of a cycle which lacks the emphasis necessary to change the current culture regarding STEM in schools. Once teacher candidates and future administrators have been appropriately trained in STEM education and assume teaching and administrative positions, the focus on STEM in K-12 schools should improve.

This particular study provides information colleges and universities could use to bolster their teacher preparation programs, resulting in a greater number of better qualified teacher candidates trained in the STEM areas. If administrators are able to hire better prepared teachers, the culture surrounding STEM implementation will be more conducive to STEM education.

Professional development

This study expresses the need for systemic, continuous professional development activities in STEM for all educators. School districts must begin to place the proper emphasis on continuing education for teachers and administrators.

The research literature has emphasized the need for STEM related professional development that is ongoing and offers the follow-up necessary for new STEM related practices to become ingrained in the K-12 curriculum.

If this is true, then educators must not only offer professional development in STEM-related contexts but must offer opportunities for teachers to collaborate and share with each other the results of integrating STEM in the classroom setting.

While much of the focus of professional development activities is for teachers, if STEM is to become ingrained in practice, district and school administrators must also attend these trainings. To change the culture, STEM must become the focus of the professional development efforts for all personnel in the district.

District and school administrators often mistakenly believe professional development designed for use in the classroom setting should be left to instructional personnel. In addition, if STEM is to be integrated in classroom settings with fidelity, then administrators must also understand and support its implementation.

The entire district must be onboard with making the changes necessary to focus on STEM, including the implementation of appropriate teaching strategies, curricular subject matter, and activities. Emphases must be included in textbooks, curriculum guides, and teaching methodologies.

New opportunities must be created to implement STEM. This can be accomplished through a system-wide focus on STEM and ultimately, improving the communication among superintendents, principals, and other educators. As the knowledge level of superintendents and principals improves, perceptions surrounding STEM readiness and implementation will also improve.

Instructional leadership

This study affirms the need for leaders in education to assume the role of being and becoming the instructional leaders for their districts and schools. The jobs superintendents and principals perform daily are quite complex.

While more emphasis is being placed on the administrator's role as an instructional leader from an accountability standpoint, the actual job performance continues to be wrought with tasks that are managerial in nature.

Thus, it is easy to become bogged down in the day to day operation of the district or school and, ultimately neglect the most important aspect of their jobs, that of being instructional leaders.

Administrators must not only conscientiously focus on becoming instructional leaders who emphasize the importance of STEM, but also its successful implementation. Administrators must free themselves as much as possible from job responsibilities that are managerial in nature and focus on being leaders willing to see STEM successfully implemented at both the district and school levels.

Stakeholders and the implementation process

The concept of STEM remains cloudy and perplexing to many. STEM continues to be misunderstood by educational stakeholders. This study should increase awareness among stakeholders regarding the need to pursue STEM at all educational levels. Administrators must lead and support the effort to implement a STEM program with fidelity. District and school leaders must incorporate a vision of what a quality program incorporating STEM would entail.

The superintendents and principals must clearly communicate the vision to all stakeholders. However, simply having a vision is not sufficient. The mission, or plan, must be detailed and provide the pathway for successful implementation of STEM.

As STEM becomes a focus of the district at all levels, instructional leaders must continually evaluate the implementation process. Many sources of literature stress the importance of periodic reflection and evaluation of the overall progress towards programmatic implementation. Instructional leaders must include follow-up which provides the feedback needed to those implementing the program in order to facilitate the implementation process.

Increase in qualified STEM professionals

The shortage of STEM professionals has adversely impacted the United States with regard to its economy and global competitiveness. Presently, there are not enough high school and college graduates who are able to fill the number of positions available in STEM. It has been determined that the need for STEM professionals will continue to increase.

This study has the potential to assist in increasing the numbers of individuals with STEM knowledge and skills. Additionally, as interest and knowledge regarding STEM increases, the number of qualified graduates will increase and schools and universities will better meet the high demand for individuals with STEM backgrounds.

The suggested implications are not intended to be an exclusive list. Undoubtedly, there are other areas that may impact stakeholders' perceptions and knowledge of

STEM. But STEM education programs must be implemented with fidelity. It is never easy to implement change. However, if STEM becomes the focus of administrators at the district and school levels, the ability to meet society's demand for candidates trained in the STEM areas should improve.

Conclusion

This study's findings indicated that participating principals and administrators possessed differing perceptions (77.0% of the time) regarding their schools'/districts' STEM awareness/resources.

Superintendents believed their districts were significantly aware of STEM and STEM related resources while principals' perceptions revealed that they held less positive perceptions of the STEM awareness/resources of their schools. These findings indicate that one's administrative role influences one's perceptions of school/district STEM awareness/resources.

In sum, the data and results of this study spur further consideration of the following related questions:

1. If superintendents feel STEM awareness/STEM resource presence is already extremely positive among stakeholders in their district, will they be less likely to consider additional STEM initiatives?

2. Will principals accept the possibly inaccurate positive perceptions of STEM held by the superintendents of their schools as unchallengeable?

3. When superintendents and principals are made aware of their perceptual incongruency regarding the STEM awareness/STEM resource presences in their districts/schools will actions be taken toward better communication?

It is hoped that once administrators become aware that their leadership positions can influence their perceptions in a way that negatively affects the schools and districts they serve; they will craft new communication systems that will serve as avenues for new dialogue resulting in more accurate perceptions of concepts that could lead to reform initiatives.

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