PRINCIPALS OFTEN DO NOT ADVOCATE FOR SCIENCE, TECHNOLOGY, AND ENGINEERING.

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01 CONTEXT AND TRENDS

Americans are all too familiar with the disappointing news of our students performing poorly compared to their international peers in critical academic subjects, with one assessment ranking U.S. students 28th in math and 24th in science (Kuenzi, 2008). The push for higher achievement in these areas is bolstered by the growing recognition that in order to solve the problems of tomorrow, our students need better preparation in science, technology, engineering, and mathematics (STEM) today. In light of these harsh realities, teachers and principals face increasing pressure to improve student test scores while simultaneously innovating instructional approaches to meet the challenges of providing a strong STEM education that is inclusive of all students.

In many cases, the responsibility for school-level efforts to improve student performance in math and science and implement broader STEM programs falls on principals. Consistently, studies show that high-performing schools have strong, competent leaders as their principals (Rodriguez-Campos, L., Rincones-Gomez, R., & Shen, J., 2005). However, strong principal leadership can be challenging. School principals are subject to great demands. For example, they are tasked with ensuring that students meet ever-higher standards, as measured by high-stakes tests, the outcomes of which are frequently tied to critical funding streams, particularly from state education departments. Additionally, principals are expected to "master not only the knowledge base current at the time of their professional preservice education but the skills necessary to ... constantly expand knowledge to their professional actions" (Hart & Bredeson, 1996, p. 26). This expanding knowledge base includes STEM education. However, no evidence yet exists to show that STEM leadership and education has made its way into principal-preparation programs, despite the fact that in today's STEM-focused world, principals across K–12 levels will be held accountable for implementing such programs.

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DISCUSSION

Because principals typically receive little, if any, training to implement school-wide STEM programs, many lack a foundational understanding or appreciation of their value. One study examined a school in a STEM partnership with a local university, and even there, fewer than half of the administrators (including principals, assistant principals, and assistant superintendents) understood STEM education at more than a basic level (Brown, Brown, Reardon, and Merrill, 2011). Ten of the 22 leaders in that district could not generate a definition for STEM education. Several even expressed frustration by the question, with one remarking, "There is not enough time in the day to talk about STEM education," while another was "highly insulted to be expected to know this acronym" (Brown, Brown, Reardon, and Merrill, 2011, p. 7).

Additionally, the curriculum design necessary for a truly meaningful and integrated STEM program is one that is unfamiliar to many principals. American schools typically offer each STEM subject and each non-STEM subject independent of any others. Each academic subject is taught discretely, based on predetermined standards, such as the Common Core State Standards (CCSS), and assessed by standardized tests (as available) at specified intervals. STEM researchers Brown, Brown, Reardon and Merrill (2011) ask: "Is it STEM education when all four concepts are taught in separate classes? If a student takes a course in each of the four STEM areas, is he or she receiving a STEM education?" (p. 6). If so, many schools may already be implementing "STEM" programs. But this definition of what constitutes a STEM education is likely insufficient in terms of providing all students with the new set of critical skills they need for postsecondary and career success in the 21st century.

Herschbach (2011) and Sanders (2009) propose that STEM education should be integrated and unified in terms of how content is delivered throughout the curriculum and in the design and implementation of learning experiences for students. This approach to STEM education, however, requires coordination and planning among many different subject areas—and not just STEM subjects; it is an "integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and treated as one dynamic, fluid study" (Merrill & Daugherty, 2009, p. 1). Principals who are already tasked with meeting standards and demonstrating high rates of proficiency on core subject area tests may be challenged to implement such fluid content, favoring instead a traditional curriculum approach, particularly in the highly tested subjects of math and English/language arts (ELA). As such, principals are less likely to offer teachers the flexibility to redesign either curriculum or instruction in an integrated way that would strengthen STEM education.

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Driven by the assessment expectations noted previously, principals often completely overlook the disciplines of technology and engineering, two fields that have tremendous value in preparing students for postsecondary and career success. Traditionally, academic standards and curriculum have included only math and science. A more recent development in this areas is the integration of engineering design principles in the Next Generation Science Standards (NGSS). However, as of February 2016, only 16 states had officially adopted the NGSS. Indeed, "[d]espite all of the concerns by policymakers, educators, and people in industry about the quality of U.S. K–12 STEM education, the role of technology education and engineering education have hardly been mentioned" (National Academy of Engineering and National Research Council, 2009, p. 150) in discussions about academic standards and curriculum.

Even in more traditionally recognized core academic subjects like science, the strict focus on preparing students for reading and math assessments has been shown to negatively affect the resources and time given to science education. A 2011 study involving more than 1,100 elementary school teachers and administrators in Los Angeles reported that only 33 percent of elementary teachers felt prepared to teach science, and nearly all teachers reported that they had to buy their own science supplies (Watanabe, 2011). Funding and resource allocation is devoted to math and ELA courses because those content areas are the primary focus on high-stakes tests, the performance on which schools are held accountable and to which a school's funding is often tied. Even principals who may want to develop strong, integrated STEM programs are likely to struggle to fund strong science (let alone fully integrated STEM) programs with the supplies and resources they need. The 2011 National Survey on STEM Education reinforces this dilemma, with 74 percent of the 515 participating educators from across the country identifying funding as the top challenge for K–12 STEM education (Interactive Educational Systems Design [IESD], 2011). Nearly 32 percent of those respondents identify grants from private foundations, not their schools or districts, as the primary funding source for STEM initiatives.

The second challenge defined by the 515 participating educators is a low number of qualified STEM education teachers (IESD, 2011). Schools report staffing vacancies in STEM fields more than any other subject areas (Cowan, Goldhaber, Hayes, & Theobald, 2015). Principals struggling to recruit and hire qualified STEM teachers are working with their districts to offer incentives such as signing bonuses, housing assistance, and even salary adjustments to address these shortage areas (Barth, Dillon, Hull, & Higgins, 2016). Despite these efforts to address the STEM teacher shortage, the continued emphasis on high-stakes testing in math and reading, diminishing funding, and a lack of professional training in STEM leadership creates a formidable challenge for any school principal trying to implement an effective and innovative STEM program.

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BRIGHT SPOTS

Despite these challenges, some valuable resources have been created to assist principals with STEM leadership. One such program, the STEM Education & Leadership Program at Illinois State University, has aimed to improve STEM-related teacher content knowledge, instructional practices, professional development, and organizational support. Notably, this program emphasizes the involvement of the building principals, since without principal support, change will not be possible. By participating in professional development themselves, school leaders improve their own knowledge and increase the likelihood of the success of their teachers in implementing a true STEM program (Kuenzi, 2008). While data is not yet available regarding the impact of this program on student test scores, the program still can serve as a model for other schools and universities who are looking to further the development of STEM programs through strategic partnerships.

Another bright spot for principals is the development of professional learning communities (PLCs) for STEM teachers, supported by resources available through the National Commission on Teaching and America's Future (NCTAF). Based on the research of the National Science Foundation regarding learning teams of STEM teachers and PLCs, NC-

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> By participating in professional development themselves, school leaders improve their own knowledge and increase the likelihood of the success of their teachers in implementing a true STEM program.”

TAF designed a helpful resource, free of charge and available to any school, to guide principals and teachers in implementing PLCs. This resource, “STEM teachers in professional learning communities: From good teachers to great teaching,” provides direction for developing PLCs, as well as guidance for principals both in utilizing low-cost resources and in securing outside funding, necessary in today’s climate of scarce resources. This program was piloted in eight high schools in Maryland; an independent evaluation at the end of their first year showed positive impacts on both teachers and students (Fulton, 2011). Additional research compiled by the NCTAF shows evidence of positive changes in both STEM teachers and STEM instruction, as well as positive effects on both student learning and achievement in math following the implementation of STEM PLCs (Fulton, 2010). Those studies also reported that the support of principals, combined with good facilitation, is critical to the success of the PLC. Principals striving to implement STEM programs will find that the very low cost of this support program enables them to effectively bring their teachers together for collaborative professional development and support, forming a strong backbone for a powerful STEM program, even in an environment of scarce resources.

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CONCLUSION

While significant strides are being made in STEM program implementation in schools across the nation, much work remains to be done. Herschbach (2011) notes that expectations for significant STEM curriculum progress will be largely unrealized “unless STEM initiatives are accompanied by significantly different ways to organize and deliver instruction” (p. 121). School principals, who have the ability and authority to lead these instructional changes, are the key to successful and widespread implementation in the future. According to Brown, Brown, Reardon, and Merrill (2011), “If your vision of STEM education is going to come to fruition, it must start with raising the awareness and understanding levels of your administrators” (p. 9). The future of successful STEM education will partly depend on strong school leadership support for STEM development, specifically to promote the inclusion of the oft-overlooked fields of technology and engineering. Building the capacity of today’s and future principals to become the STEM education leaders the nation needs will be achieved only with better training, support, education, and resources for building principals.

ABOUT THE GRAND CHALLENGES WHITE PAPERS

In 2017, 100Kin10 released an unprecedented representation of the big, systemic challenges to preparing and supporting STEM teachers following over two years of extensive research alongside more than 1,500 STEM teachers and hundreds of other education experts. As a part of this work, 100Kin10 commissioned a series of short white papers from well-versed thinkers and practice-oriented researchers to synthesize the most relevant research around the specific challenge areas. Together, they compose a thoughtful and well-rounded examination of the systemic challenges currently facing STEM teaching.

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