What is STEM Education?

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Introduction

The term "STEM", an acronym for science, technology, engineering and mathematics, has come to the forefront of international discourse in education, industry, innovation, and competition. The term is used with students from preschool to post graduate levels, and to describe careers in the respective fields. The National Science Foundation (NSF) in the United States began using the term "SMET" in the 1990s to describe the fields, but an NSF program officer noted that the acronym sounded too much like "smut," From her objection, "STEM" was born in 2001 (Donahoe, 2013; Sanders, 2009). Since then, definitions of STEM have been unclear. For some, STEM refers to education and careers in the hard sciences and mathematics, for others, social sciences and other related fields are included. Some authors argue that "agglomerating dissimilar technical skills," into the catchall phrase leads to a "confusing picture" (Donahoe, 2013). Even professionals surveyed in STEM fields do not seem to understand what the acronym means, often assuming it is related to botany or research on stem cells (Bybee, 2010). Similarly muddled definitions of STEM in school settings, and ideas about what good STEM education looks like, are leading to confusion and disagreement. At times, STEM is simply used as a way to discuss the four disciplines. At other times, authors stress the importance of integrating the fields (Morrison and Bartlett, 2009). As academics in the fields of science and math education, we wonder: what are the skills that students need for STEM subjects and STEM careers? How do we ensure that all students, regardless of race, ethnicity, ability, language, gender, or location, succeed in STEM classrooms around the globe? How should we focus our resources toward that end? Research in truly integrated STEM education is rare, likely because the STEM disciplines are not typically integrated in schools. Worldwide educational systems have typically been discipline-specific; students take singularly focused content courses, with little interdisciplinary work. In this issue, our authors offer diverse perspectives on science, technology and mathematics education, with a focus on underserved populations including African American women in the STEM fields, students -

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 Citation: Marrero, Meghan E., Gunning, Amanda & Germain-Williams, Terri (2014). What is STEM education? *Global Education Review, 1* (4). 1-6.

who do not speak the dominant language, and inclusive classrooms.

Why is STEM Education Important?

The demand for STEM workers is an explosive phase. But apart from the world of work and productivity, the need for STEM education is dire on a personal level as well. Worldwide, technology abounds. Health crises increasingly focus on the spread of life-threatening illness. Climate concerns and extreme weather surface repeatedly in news and politics. Whether citizens are trying to understand how the latest airport screening technology works or how mosquito nets prevent malaria, every person needs some level of STEM education. The necessity of this exposure is not limited to understanding germ theory or how tsunamis form, but studies have shown that learning in STEM fields is linked to increased critical reasoning and logical thinking (Sadler & Zeidler, 2004). In this issue, Morrison-Love (p. 15) examines the importance and methods for teacher education to promote transfer of knowledge for solving complex STEM problems. He explores some of the ideal conditions for the development of these abilities and addresses the residual results on student confidence and independence.

All people need STEM understanding in order to make sound decisions for themselves, families and their communities (Tate, Jones, Thorne-Wallington & Hogrebe, 2012). Denying anyone this piece of their education is tantamount to discrimination (Tate, 2001). We cannot deprive certain members of our society the tools to make good decisions based on their race, class or level of access. It is important that we not only explore how marginalized groups can be reached to develop STEM understandings, but also that we share best practices for educating our teachers to prepare them to teach STEM content and practices so that all students may learn. In this issue, Brusca-Vega, Alexander, and Kamin (p. 37 in this issue) examine collaborative professional development for science and special education teachers with a focus on meeting the needs of all students in their classrooms, resulting in positive outcomes for both teachers and students. STEM understanding and exposure for all students will not only benefit them personally, but will benefit the world, as more engineers, doctors, scientists, and mathematicians grow out of the increased exposure. Surely, many untapped talents exist, due to the simple lack of accessibility to STEM education. STEM fields inherently require some level of creativity and personal influence in terms of what is of interest to study; how these studies should be conducted; and how results will be shared. By including all members of society (increased numbers of women, minorities, marginalized groups within countries, for example) more diverse research and knowledge will be shared, for the betterment of all. Varied perspectives and data fuel robust innovation. Through the internet, it is possible to share information and work like no other time in history. Nancy Heilbronner's editorial (p. 7 in this issue) argues that global STEM talent need not be an international competition. When nations work together, we achieve improved results. Solving the 21st century issues of sustainability, for example health, climate change, access to freshwater, will require strong STEM education of students in all nations and international cooperation (Johnson, 2012). Varied voices from all corners of the world can only add to our depth of knowledge and fodder for solutions to the ever-increasing problems of the 21st century.

Perspectives on the "STEM Workforce Crisis"

Is there a lack of able STEM workers? It seems to depend on who you ask. The lack of "STEM talent" has been discussed worldwide. In the United States, a recent study found one jobseeker for each thousand openings in STEM (St. Louis Community College, 2014). Norway, a country with many natural resources, reports that there are not enough skilled professionals to fill the need for engineers and other technical jobs (Johnson, 2013). In India, it has been found that although the country produces the most engineers worldwide, "only 25% of them are readily employable" (Craig, Thomas, Hou, and Mathsur, 2012, p. 2). The lack of employability is attributed to outdated curriculum and dearth of innovation (NASSCOM, 2013). The same report notes that in the United Kingdom, businesses are struggling to find employees with the technical skills they need, and that there is a "global shortage" of STEM PhDs.

On the other hand, others suggest that the lack of available talent is an exaggeration. Some US studies find that the number of undergraduates studying in STEM fields has actually increased, and that the number of STEM majors from underrepresented groups in the United States, for example, Latinos and African Americans, has increased by more than 50% (Gonzalez and Kuenzi, 2012). Other studies note surpluses in some STEM fields, and unemployment rates in highly-touted STEM "shortage areas" that are similar to other fields (Metcalf, 2010). The Urban Institute, a US-based non-partisan research group composed of ten centers, published a study not only disputing the perception that American college students are lagging in mathematics and science achievement, but also concluded that colleges graduate far more scientists and engineers than are hired each year (Lowell, 2007). In China, Apple was able to find and employ 8,700 industrial engineers in just 15 days to oversee iPhone manufacturing in 2007 (Duhigg & Bradsher, 2012). The volume and availability of that number of engineers is astounding. In our search for international research or data on the STEM crisis, we found a number of blogs and news articles making observations about the supply of STEM workers in a number of countries. However, a lack of policy documents and peer-reviewed research calls to question the existence of hard data to justify the commentary. Understanding how varied nations support the development of STEM graduates is important for the continued development of STEM fields. Nahar Arshad (p. 53 in this issue) investigates the level of efficiency in the use of money to increase student achievement in mathematics and science in 16 non-western countries to drive work-place-ready graduates. Their study helps us understand how we define and analyze efficiency and productivity in education. STEM skills are a transferable set that are readily useful to all citizens. While mathematical calculations can help balance a budget or help us to understand discounts and charges, the value of logic and analytical skills are even more valuable for everyday thinking. Understanding the nature of science or the engineering design process can influence how we think about the world around us and inform personal decision-making. Effective communication, creative thinking and problem solving are consistently hailed by employers as the most important skills of their best team members. STEM educators must think further about building STEM practices at all levels of education in order to assure achievement in these areas and lifelong critical thinking skills. For example, Tzohar-Rozen and Kramarski (pp. 76 of this issue) examine the social and emotional implications of learning and understanding mathematical problem solving. They address the critical ages for mathematical problem solving skill development and the impact of attitude and emotion on mathematics achievement. Their study asks: *What is the distinction between metacognitive and motivational-emotion self-regulatory processes and what is the impact of each on the learning of mathematics at this critical age?*

Composition of the STEM Fields

Trends in mathematics and science achievement suggest that underperformance is disproportionate in subpopulations of students, including students with special needs, students who are not native speakers of the dominant language, and non-white students. The overrepresentation of white males in STEM careers illustrates the urgent need to diversify the workforce (Landivar, 2013). While the subjects of mathematics and science are readily associated with STEM, designing solutions requires the type of creativity that comes from diverse perspectives. There are initiatives and grants focusing on the recruitment of minority groups to increase exposure and spark interest in STEM, but as the workforce grows increasingly diverse much more support is required to ensure that those who may not have been interested in STEM are both exposed and encouraged to major and persevere in the field. Two well-documented issues with women in science are the high rates of attrition, or "leaky pipeline," first in pursuing college STEM majors and next in the workforce upon the childbearing years (Raymond and Brett, 1995; Brainard and Carlin, 1997; Beasley and Fischer, 2012). Advancements in all fields would be bolstered by increased participation from these untapped talent pools. Ezella McPherson's article (p. 96 in this issue) illustrates the importance of early experiences for developing life-long STEM learning in the minority population of African-American women. These experiences became sources of cultural capital, leading to STEM careers. This research indicates how diverse perspectives may provide clues for minority groups' and women's retention and persistence in the STEM fields.

In discussions of STEM education, language is often overlooked as a barrier; non-native speakers of the dominant language, in any country (Ball, 2010) are often underserved. For instance, a study in the Netherlands found that Turkish-Dutch and Moroccan-Dutch students fall behind their monolingual Dutch peers, beginning in preschool and persisting into primary school and beyond (Scheele, Leseman, and Mayo, 2010). In the United States, Latino students who are native Spanish speakers do not pursue and persist in STEM careers at the same rates as their white peers (Anderson and Kim, 2006;) Wills, Reuter, Gudie, Hessert, and Sewall's article (p. 114 of this issue) seeks to understand how disparities in achievement manifest in Madagascar. They present a case study that documents the barriers to student success in mathematics and science in developing countries and how language becomes a factor in mathematics and science achievement in a multilingual community. Knowing that outside factors influence the priorities of the educational system, their work takes into account the impact of the political climate and structure on mathematics and science achievement. Naslund-Hadley, Parker, and Hernandez-Agramonte (p. 135 of this issue) explore how a mathematics intervention in Paraguay may help ameliorate the divide between classes and the different languages spoken in the same region. They note the importance of fostering pre-mathematics skills in preschoolers, as studies show that students from lower socioeconomic backgrounds that do not build these skills often struggle in mathematics later in their educational careers. This pilot study shows promise for educating young children in bilingual settings using audio and arts-based lessons in two languages to engage these early learners in mathematics. Teachers around the globe struggle to meet the needs of their students who represent different cultures and to contextualize STEM learning for these students, while studies indicate that using students' home language might result in a richer understanding of STEM concepts (e.g., Clarkson, 1992; Setati, 2008; Ball, 2010; Ewing, Cooper, Baturo, Sun, and Matthews, 2011). In the United States, the Department of Education (2000) found that only 27% of teachers felt "very well prepared" to meet the needs of students with limited English proficiency. DellaCarpini and Alonso (p. 155 of this issue) seek to understand how the preparation of teachers of English language learners (ELLs) impacts the achievement gap of bilingual students and monolingual students who speak the dominant language. They investigate how teachers are prepared to support ELLs in the United States and how we can prepare secondary mathematics and science teachers to more effectively teach these students. This study outlines which methods are most successfully integrating content and language in mathematics and science classes.

STEM: Global Issues and Regional Perspectives

Through this special themed issue of *Global Education Review*, we sought to bring varied voices to the forefront, highlighting issues in the four disciplines of STEM, as they affect different nations around the world. All of the studies in this volume have a common thread of examining how STEM education may be developed to be accessible and appropriate for all learners, worldwide. Each context is different, but the articles share the same goal of illuminating a piece of how STEM education might be made accessible for all learners. The authors' ideas bring up many questions about how to meet the needs of STEM learners, and how their work might look in different contexts around the world. Understanding how these issues affect each of us, in our own nations, can shed light on making STEM education accessible to everyone. As highlighted in Heilbronner's editorial, we will all benefit from shifting to a more global, rather than nationalistic mindset.

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