

A Global Curriculum? Understanding Teaching and Learning in the United States, Taiwan, India, and Mexico

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Abstract

While educators recognize that teaching and learning are complex activities evolving from social and cultural contexts, pressure is mounting to be internationally competitive. This research relates a global and responsive discussion of internationalization in education through comparative analyses of current educational discourse about mathematics, science, and technology in the United States, Mexico, India, and Taiwan. Interestingly, changes in education in countries around the globe seem to be leading to a global curriculum. This research examines that phenomenon in several ways. First, we examine what has been happening in the United States. Second, we examine what has been happening in one area of Mexico. Third, we examine what has been happening in India. Fourth, we examine what has been happening in Taiwan. Fifth, we discuss what we have learned relative to the possibility of a global curriculum, specifically related to mathematics, science, and technology, and sixth, we make recommendations for teacher education. In our search for a “global” curriculum, we use an ethnographic procedure referred to as “walking around” culture, which includes participant observation, personal reflection, and cultural immersion. Four of us made several visits to the three countries: India, Mexico, and Taiwan. The findings show that, even though there is no actual global curriculum, there appears to be a de facto global curriculum. Based on that, six recommendations are provided for preparing pre-service and in-service teachers.

Keywords

global curriculum, international education, higher education, education, social sciences, teacher education, STEM education, comparative education

Introduction

While educators recognize that teaching and learning are complex activities evolving from social and cultural contexts, pressure is mounting to be internationally competitive. In this research, we relate a global and responsive discussion of internationalization in education through comparative analyses of current educational discourse about mathematics, science, and technology in the United States, Mexico, India, and Taiwan. For example, compared with other countries, U.S. average mathematics scores have been consistently lower in the studies conducted by the Organization for Economic Cooperation and Development (OECD) through its Program for International Student Assessment (PISA; Fleischman, Hopstock, Pelczar, & Shelley, 2010). In 2009, the PISA study ranks the United States at 25 out of 33 countries. The impact of the poor state of mathematics education in the United States can be critical considering that “math appears to be the subject in which accomplishment in secondary school is particularly significant for both an individual’s and a country’s economic well-being” (Hanushek, Peterson, & Woessmann, 2011, p. 18). Recent reforms in the

United States (e.g., core curriculum standards; science, technology, engineering, and mathematics [STEM]; Race to the Top Act [RttT]) have attempted to address this issue. Rothstein (2004), however, writes that reforms focused on education alone come up short, unless they are tied to changes in economic and social policies to lessen the gaps children face outside the classroom. It is important, therefore, that education programs everywhere in the world take these issues into account in their preparation of teachers and other education professionals.

Typically, though, in teacher preparation programs, the curriculum too often exists in forms wholly divorced from time, place, and people. Rather, teacher preparation programs exist more as self-contained entities that can be captured and represented in pre-specified activities,

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competencies, and indicators. Education demands seeing the complexity and plurality within teaching/learning situations as a relational field in which the learner (i.e., the teacher) needs to be immersed. Teachers need to learn how to value disruptions, displacements, and dislocations, and to see such “inconveniences” as opportunities to help them continuously assess their values and beliefs about what it means to teach and to learn.

This research evolves from recent discussions about the preparation of educators in the United States and lessons that can be learned from other countries, that is, Mexico, India, and Taiwan. The reality is that education in the United States is currently refocusing on issues that evolved from the modern post-civil rights school culture of the 1960s (Callejo Pérez, 2001; Ravitch, 2010; Woysner, 2009). This includes poverty and the role of poverty in school decisions (McDiarmid, 2011; Rothstein, 2010). Concurrently, the perceived international competition surrounding mathematics and science education and technology use and resultant student test scores has led to a narrowing of the problem of preparing school leaders (Denome, Smith, Baker, & Ueno, 2005; Gunter, 2010).

In championing change, reformers stand by the belief that competency will have an impact on how leaders can turn around schools. The idea remains, however, that often competency is narrowly defined without undertaking the complexity of philosophical and psychological needs required to make competency work (Ayers, Klonsky, & Lyon, 2001; Barone, 2001; Callejo Pérez, 2008; Slater & David, 2010).

Defining the Global Curriculum: Our Perspective

When thinking of a “global” curriculum, we think of widening one’s perspective to look beyond ways in which one teaches (or the ways typical of the particular location/cultural norms) and tries to understand alternative perspectives on curriculum as “what gets taught and how.” For us, then, a “global” curriculum is a concept that is symbiotic with a cosmopolitan community. As we discuss our work (based on our perspectives of what we learned about mathematics, science, and technology from the various countries, and seeking commonalities within our experiences), we sought to see global curriculum as possessing an inclusive ethics, a shared philosophical relationship or structure that encompassed not just different regions, but nations, and, in our cases, people who experience education through schooling.

As we discuss here, we believe, foundationally, that as a global cosmopolitan educational community with people from different nations and states, we are bound by the understanding that there exists an essential relationship of mutual respect. Appiah (2006) suggests the possibility of a cosmopolitan community where individuals from varying locations and beliefs engage in relationships of mutual respect. As

teacher educators interested in the value of global education, we seek to foster the kind of transactional work needed to promote growth and meaning making in a global society. We argue for the need to ensure that all communities that make up schools are cosmopolitan communities (Appiah, 2006; Hansen, 2009; Nussbaum, 1997/2009; Pinar, 2009). Within the broader concept of global education, we have to seek to balance the student as a “being half hidden in a cloud of unknowing” (Huebner, 1975/1999, p. 219) with the larger social aims of becoming critical citizens of the global society. Cosmopolitanism, as a concept within a “global” education, is the ideology that all human ethnic groups belong to a single community based on shared ethics.

Methods and Procedures

Changes in education in countries around the globe seem to be leading to a global curriculum. This research examines that phenomenon in several ways. First, we examine what has been happening in the United States. Second, we examine what has been happening in one area of Mexico. Third, we examine what has been happening in India. Fourth, we examine what has been happening in Taiwan. Fifth, we discuss what we have learned relative to the possibility of a global curriculum, specifically related to mathematics, science, and technology, and sixth, we make recommendations for teacher education.

Even though it may seem in our examination of each country, each of us used a different methodology, essentially, in our search for a “global” curriculum, we all follow a similar process. We all try to follow an ethnographic procedure referred to as “walking around” culture (Sparapani, Seo, & Smith, 2011), which includes participant observation, personal reflection, and cultural immersion (Best & Kahn, 2006; Fraenkel & Wallen, 2006).

Sparapani et al. (2011) explain “walking around” culture in the following way:

Cultural is communal and shared. To fully understand that communal, shared culture, and to connect to the customs, traditions, thinking, spirituality, social activity, and interactions inherent to the varieties of cultures and races teachers encounter in their classrooms each day, we suggest that teachers must learn to “walk around” culture. By “walking around” culture, we mean that teachers need to put feet to pavement and purposely “walk around” the neighborhoods of their students, similar to ethnographic study. (pp. 54-55)

Four of us (Callejo Perez, Gould, Hillman, & Sparapani) have made several visits to the three countries, India (Gould and Hillman), Mexico (Callejo Perez), and Taiwan (Sparapani). As such, our comments about each country are based on those visits (while “walking around” in the culture) and our knowledge (as teacher educators) of what has been happening in education in the United States. We begin by

discussing what has been happening, educationally, in the United States.

Change and Challenge in the United State

There is no mistake that the federal government and federal funding, in the United States, have become the change agents in education over the last two decades. The federal government has implemented and adopted educational policies and mandates that have been matched with federal funding through competitive grants. In the two decades, the United States educational system has undergone significant changes with nationally developed standards that advocate standards-based education reform, particularly in STEM, as well as English language arts. In addition, these changes have emphasized literacy across content areas and writing across content areas. These nationally developed standards provide a framework for student learning and assessment, that is, what students should know and be able to do. To this end, there have been common goals and standards developed for mathematics, English language arts, technology education, and, most recently, science. These standards have been adopted by many of the states.

Despite the increased educational changes, however, there still remain questions about how these goals translate to, and transform, the educational and instructional practices in the classroom for all students. In addition, competitive grants, as a way of implementing changes, do not ensure that all schools and students will get the needed resources and support to effectively adopt and implement the needed changes for student success. If the United States wants American students to be successful and globally competitive, we must rethink how we implement educational changes, and we must ensure that our poorest schools and students have the best resources and supports for the needed educational changes, to produce global citizens.

These educational reforms have also initiated changes in teacher preparation programs, curriculum design, instructional practices for the classroom teacher, and assessments of student learning. The results of these changes in student achievement are varied. Some of the challenges that have been identified with regard to educational progress are as follows:

1. The time spent on teaching and learning versus time spent on compliance issues.
2. Disconnect between national educational goals and classroom practices.
3. Integration of technology in the teaching and learning process, specifically mathematics and science.
4. Standardized testing versus educational goals that seek to expose students to 21st-century learning and skills that will prepare them to be productive citizens in a global world.

5. Professional development for teachers to prepare them to create exciting classes that are “digitally” and literacy rich.

In 1983, the national report, “A Nation at Risk,” claimed that students in the United States fell behind students in other countries in math and science proficiency, as well as literacy (National Commission on Excellence in Education, 1983). As a result of this report, a new era of standards-based reform began in the United States. In 1989, the National Governor’s Board was established and they produced National Educational Goals, which included content standards for student learning. In 1994, The Goals 2000: Educate America Act was passed in Congress and this act provided monetary funding to schools that created and submitted a school improvement plan. In addition, in 1996, President Clinton introduced the Technology Literacy Challenge Fund, which was a competitive grant for schools to ensure that all students were technologically proficient. Due to the fact that this was a competitive grant, it did not ensure that ALL students got this aspect of education.

In 2000, the International Technology Education Association (ITEA, 2007) developed the Standards for Technological Literacy. These standards were subsequently updated in 2002, and, again, in 2007. In addition, ITEA in partnership with the Center for the Advancement of Teaching Technology and Science (CATTS) developed a national curriculum, Engineering by Design (EbD), for grades K-12. These standards became the adopted standards of many states; however, technology education and engineering were, and still are, elective courses. As a result, implementation of these standards did not result in ALL students receiving this component of education.

In 2001, the federal government approved the “No Child Left Behind Act of 2001” (NCLB), and this act required states to create comprehensive assessments in mathematics and English language arts, based on grade-level content expectations, and this federal legislation provided monetary incentive for states and schools that reported data, through a competitive bidding process.

In addition, NCLB also adopted Joyce Epstein’s (Epstein, 2001) six types of parental involvement, and they became the standards for parental involvement. For the first time in history, parents became a critical partner in student success. This meant that all schools that received federal funding had to ensure that parental involvement standards were met, and that parents were included as a part of all school improvement plans. Most significantly, this act mandated that all student groups and subgroups be held to the standards of learning, which included English Language Learners (ELL) students and students with special needs. For the first time in American history, schools would be graded based on how well students met the standards of learning.

In 2009, President Obama issued a challenge to the states to improve teaching and learning, turn around failing schools,

and make systemic changes in education. The RttT was introduced as a competitive grant for states to garner additional funding for plans to help the lowest achieving schools (U.S. Department of Education, 2009). Many states applied for, and received, this funding. There were, however, states that submitted plans, but did not receive funding.

In 2010, the Common Core State Standards (CCSS) were created by the National Governor's Association and the Council of Chief State School Officers (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). These standards are internationally benchmarked and provide the framework for what students should know and be able to do. The ultimate goal of this legislation, which is not part of the NCLB Act, is to create common goals and assessments across the United States and her global partners. It is important to note that science standards have been the most recent addition to the CCSS.

Based on the National Assessment of Educational Progress (NAEP; National Center on Educational Statistics, 2008), U.S. students showed an increase in mathematical knowledge, and Blacks narrowed the achievement gaps with their White counterparts between 1990 and 2008. According to Gonzales et al. (2008), the 2007 Trends in International Mathematics and Science Study (TIMSS, 2007) shows that U.S. students in the fourth and eighth grades scored higher in mathematics than students in 1995. In science, however, U.S. students' scores in 2007 did not change measurably from the science scores of U.S. students in 1995. In addition, the U.S. position in the rankings among other countries dropped for fourth graders and increased slightly for eighth graders. Finally, according to Baldi, Jin, Skemer, Green, and Herget (2007), based on the 2006 PISA, of 19 nations, the United States scored below 7 nations in 2000, and 15 in 2006 in mathematics. In addition, in science, the United States scored below 6 countries in 2000 and 12 in 2006.

While there are numerous explanations for the variances in the results of international testing, it is clear that the United States' move to standards-based curriculum has had positive impacts on student assessment outcomes; however, there are still achievement gaps between races that must be addressed. There is also a need to ensure that all students are exposed to curriculum that is literacy rich.

The educational changes in the United States have placed schools and their daily practices under the microscope for the world to evaluate education in a new way. These educational changes, however, have also presented challenges that must be addressed if we are to educate a global workforce of individuals who are technologically savvy, critical thinkers, innovators, and problem solvers.

First, education in the United States is highly regulated by the federal government through school improvement funding and competitive educational grants. There is a need to have coordinated efforts among the states, and between national committees who formulate educational change and policy.

Second, if all students are to be educated, then we must provide funding that is not of a competitive nature, but rather based on the needs of the students, families, and communities that we serve. This requires more direct involvement of local educational agencies and state representatives in educational policy that affects teaching and learning. This also requires the United States to take a long hard look at educational disparities and provide a remedy that is equitable for all students.

Third, teachers must be given more time to work together on student learning and not on curriculum alignment that is the result of every reform initiative. We must protect the teaching time and planning time of teachers and create ways to equip them with the necessary content, skill, and strategies for perfecting the art of teaching. The constant educational changes force teachers to constantly refocus on new initiatives that are more compliance oriented as opposed to student centered.

Finally, if we are to use international assessments as a tool of comparison, then we must be sure that our curriculum is reflected in all assessment instruments. In 2014, U.S. students will take the NAEP Assessment, which will include technology and engineering content. This content is not required curriculum, but relegated to electives in many U.S. schools; therefore, some U.S. students will perform well and some will perform poorly, not because they have not learned the information, but rather because they have not been taught the information.

A national report issued in 2008 (National Commission on Excellence in Education, 2008) makes the following points:

- If we were "at risk" in 1983, we are at even greater risk now. The rising demands of our global economy, together with demographic shifts, require that we educate more students to higher levels than ever before. Yet, our education system is not keeping pace with these growing demands.
- Of 20 children born in 1983, six did not graduate from high school on time in 2001. Of the 14 who did, 10 started college that fall, but only five earned a bachelor's degree by spring 2007.
- Fortunately, thanks to the recent standards and accountability movement and the *No Child Left Behind Act*, we are finally taking an honest, comprehensive look at our schools. For the first time in our country's history, we have reliable data to evaluate student performance and address weaknesses in our schools.
- We must leverage this information to achieve better results. We simply cannot return to the "ostrich approach" and stick our heads in the sand while grave problems threaten our education system, our civic society, and our economic prosperity. We must

consider structural reforms that go well beyond current efforts, as today's students require a better education than ever before to be successful. (p. 1)

We know which areas need the most attention. Now we must dedicate ourselves to making sure our students receive the information needed.

Mexico and the United States: Rethinking Competency-Based Education

The analysis provided in this section is an attempt to create a schematic of how mathematics and science are aesthetically taught within the schools of a central Mexican province, Guanajuato. Guanajuato is a colonial-era town (with the same name as the province, Guanajuato) nestled in the Mexican highlands, which is currently the center of a global community interconnected to the world through its renowned language school that attracts thousands of students, adult learners, industry, and travelers seeking to acculturate and immerse in the Spanish language. This ever-expanding influence has been undergirded by a growing automotive industry, first the growth of General Motors and, currently, Toyota.

The internationalization of this colonial-era town (in a sense, the economic internationalization) does not match the political demands on teachers and schools from the Ministry of Education. Thus, to understand the aesthetics of change in Guanajuato, place-based education can be a powerful pedagogical tool that aids students in understanding how social ideas can have great impact on their local communities. Place-based education locates educational practices in familiar contexts in which students are not only encouraged to critically examine relationships and institutional practices but also to create action that stimulates change. In addition, through the study of place, education gains meaning and relevance by addressing tangible content that is not separated by time or space. Students are encouraged to examine and respond to the needs of their communities while gaining understanding of how local institutions function and social relationships shape experiences of privileged and marginalized groups (Callejo Perez, Fain, & Slater, 2004).

Grandiose political platforms can set agendas and contexts for change, but substantive change happens at the local grassroots level. Immersing students into these grassroots contexts and connecting learning to the needs of the community actively engages students with clear, achievable goals, and fosters the connection between academic ideas and standards with real needs (Callejo Pérez, 2008). Although efforts students may take as they move forward in their projects have the real possibility of not coming to fruition, engaging in the process creates a space in which students can see the interaction of ideas, actions, and the community.

By examining teacher preparation at the master's level in Guanajuato, we hope that a metaphor emerges for how teacher education can bridge lifelong learning experiences

for teachers as they evolve from students to practitioners through collaborative research teams. Thus, in a sense, in Guanajuato, teacher educators do not see the teaching degree as an individual isolated goal but as an institutional collective goal, which is integrated by professors and students, especially when addressing technology.

The metaphor that emerged (problem- and place-based education) evolved from a series of conversations by groups of teacher education students and professors sharing the same main interest and way of thinking, in this case mathematics and science teaching. As a result, following the work of Illich (1971), the education program gives shape to a thinking school or theoretical framework to generate, transmit, transfer, apply, and diffuse knowledge as a lifestyle. The faculty propose that mathematics and science be studied as a *lifelong research network* that engenders understanding of scientific pursuit and productivity in a collaborative way between students and professors throughout the program and beyond. Faculty construct the curriculum that allows the master's degree students to work in research teams (either with their fellow graduate students or with new colleagues) around similar issues rather than by "major," thereby creating networks that ritualize an ongoing resource of support for curriculum development and lifelong learning beyond the classroom and degree.

The graduate students, who themselves are practitioners, begin their programs by forming *research teams* to address a unique kind of work or problem in mathematics and science regardless of differences in the organizational context within which each teacher will practice. In the United States, we thrust student learning in teacher education at the graduate level into the reality of the teacher's world. We ask, as teacher educators, that teachers examine the context of a problem. The approach in Guanajuato's teacher education program, however, is quite different, choosing to model an approach that will serve students through a lifelong research network by pointedly asking that they examine issues from a global perspective. In mathematics and science, for example, studying environmental pollution and using mathematics to address the issue begin not with the current pollution from the mines in the state of Guanajuato but with the relationship of people to the environment across the world. The idea is that by understanding or looking for common threads, the teacher can then understand their own context. In the United State, we see that the major critique against teacher education and teachers is that they are decontextualized to the rest of the nation and the world. Place-based education implies that to understand one's context, one must understand where it rests in the larger human community.

Once topics were selected to be studied, the focus of the research teams and the program built on four actions/tasks that provided the roadmap for the teacher: (a) initial training, (b) lifelong training and career development, (c) industry and academia, and (d) international dimensions. After 2 years of study, these practicing teachers evolve and emerge with a different approach to practice—which has been undergirded

by the philosophies of Paulo Freire (1970) and Jean Piaget (1966, 1974, 1969/1983, 1975), that can be seen in the evolution of their practice and, most importantly, in the role of research and collaboration to address psycho-social, historical, and learning problems within their classrooms and community, while looking at possibilities, and working conjointly with cohort members, fellow teachers, and university faculty.

This first cohort began their study in 2009 building on the philosophical, epistemological, historical, sociological, psychological, and methodological bases of genetic research. The project that drove their educational journey was titled, *Epistemological Basis for Science and Technology Teaching and Research in Genetics*. The group, mostly secondary teachers, developed a model for learning the science and research of genetics to be used at the high school level using new technologies and with a special emphasis toward gender (Arendt, 1958; Berger & Luckmann, 1967). Important was the idea that gender (so important and determinist in social definitions of identity in Mexico) was treated very differently within genetics.

The approach was simple. Using problem-based learning that was place-based, the teachers developed a curriculum around genetics research, mathematics modeling (mostly demographics), and genealogy. About 10% to 15% of Mexican nationals lived abroad (and about 9% of them live in the United States; Instituto Nacional de Estadística y Geografía [INEGI], 2012), which was important, as it was probable that most high school students had connections to family abroad through Facebook, Email, Skype, or other means. Beginning with this notion, the research team designed a study to understand migration, have students create genealogies, and develop general surveys that would be circulated through social media. In the pilot study, the nine members of the cohort received more than 1,500 responses from family and friends. The survey included information on migration of family and friends.

Using simple statistical survey software (relatively cheap via educational demos), the research group created migration maps of the survey respondents tracking locations of immigrants to and from Mexico, duration of the migration process, age of immigrants, and migration routes taken (e.g., airplane, border crossings) in the transmigration of Mexican citizens. The group was able to find patterns and build a small database. The group then applied the respondents' demographic information to genetic studies that had tracked human migration through DNA. The group developed a large bibliography dealing with genetics research, and produced a unique study presented to the Guanajuato Ministry of Education of the state on a new interdisciplinary curriculum to study social studies, science, mathematics, and health.

The cost of the study was minor. Surveys were created using free software, spread through social media; statistical software was free (through demos); and genetics research was available online, as the field of genetics remains one of

the most active in publishing (Maxmen, 2011). Undergirding this simple research approach was the complex issue of gender, that is, as we learn more about genetics we begin to question social definitions of gender roles (Mahowald, 1995; see also the World Health Organization Genomic Resource Centre at <http://www.who.int/genomics/gender/en/index1.html>). In a social culture where gender roles are deterministic and prevent women from receiving equal access, the key to the use of science and mathematics was really to provide a social solution to an ethical problem.

In a sense, the cohort created a transformative teaching model/approach (using technology) reflecting a basic assumption (gender) in improving education practice through the use of multiple disciplines (science and mathematics) and many angles of vision (technology, especially social media and open software). The cohort found that understanding genetics was impossible without addressing the social context of schooling and that teachers must have a wider understanding of learners and learning, curriculum, technology, and science. The Ministry of Education believed this held powerful notions to address several issues from gender inequality to relating science in a "fun" way to learners.

In 2011, much of the potential of the group's research project met resistance. Although five of the group members have created a collaborative curriculum among themselves and now have more than 40,000 surveys and rough data analysis, they resisted pushing the genetic argument for equality because of the controversy in Mexico (and Guanajuato) between science and religious beliefs, an issue that had escaped the group in their graduate experience.

Teaching and Learning as Cultural Practice: Technology Use in India

Over the past two decades, educational technology in India has explored two pre-determined routes regarding the qualitative improvement of schools and increasing government-sponsored programs in teacher's use of technology. The first route explores how schools approach issues faced by mathematics and science teachers in India (and other countries) regarding the organization of classes, low-cost teaching materials, innovative learning activities, and increased/enhanced support for teacher training in technology. The second route explores government-sponsored programs and their present-day partnerships with members of the local and global society. Components of this program include the use of radio-cassette players, color televisions, microcomputers, computer labs, and the internet in the science and/or mathematics classroom. These programs witness triumphs and defeats, based in part on access to funding, intensity of usage, and evaluation/analysis of results.

Use of technology in India varies greatly from region to region, and from school to school. In many settings, technology is limited to a single computer lab or to a handful of teachers. Although it is known that technology integration

into the instructional system facilitates collaborative learning while complementing theories of social-constructivism (Bose, 2006), an emerging need exists to redefine pedagogy in teacher education institutions to promote collaborative learning (Safran, Helic, & Gütl, 2007). With this in mind, teachers of mathematics and science in India are encouraged to embrace technological literacy in their educational work.

In India, though, many science and mathematics teachers still teach through traditional chalk-board style presentations, as students record their thoughts via pencil and paper. Although computer labs, presentation equipment (document cameras and video projection units), and internet-accessing devices may be available and utilized in some schools with limited disruptions, other schools in India find the technology a wonderful addition to their teaching repertoire, but remains under-utilized in some classrooms, due to an inconsistent source of power to effectively run the equipment. With this in mind, teachers remain steadfast and creative in bringing student comprehension of conceptual concepts to the forefront of the discussion, embracing “alternate forms of technology” which are not reliant on the power grid.

A few of these alternate technologies include the use of colored chalk, wax pencils, and transparency sheets. Colored chalk is used on traditional slate or green-boards to highlight important concepts showcased by the teacher. Wax pencils are employed to demonstrate student understanding; sometimes student comprehension is placed literally on a window to the world outside the classroom walls. Transparency sheets provide a reusable medium for students to record thoughts and share the voice of the classroom with the teacher. These techniques also make thinking and learning both tangible and visible.

As many teaching methods remain somewhat stagnant, with most teaching still occurring through lectures, books, and marked assignments, digital technologies are needed to support a new forum for teaching (Laurillard, 2002). To this end, one of the authors (Gould) visited iron works foundries to witness first-hand how technology is utilized in the industrial and business world, and to observe some of the connections between schools and society in situ in India.

Of the seven plants toured, one housed a research and development lab filled with young engineers of P1 and P2 (11th and 12th grades in the United States), working side-by-side with older students and degreed colleagues, to explore variations to design via a computer-aided design (CAD) program. Integrating technology, which complemented content knowledge and effective instructional practices (Earle, 2002), was an end-product to this style of teaching and learning. In the years to come, increased use of this approach in connecting the classroom to the content, culture, and colleagues in the business world could serve the science and mathematics teachers of India well.

To complement this philosophy, India has proposed a six-fold increase in the spending on technology in education over the next few years. These moves reflect the urgency to

harness systemic change in the education sector (Bose, 2011). India is on its way.

Teaching and Learning as Cultural Practice in India: Informing Teacher Education

Experiencing ways of teaching mathematics in schools located in rural and urban cities of India provide an opportunity to examine one's own teaching practices as cultural activity. Hofstede and Gert's (2004) five “dimensions of culture” (power distance, individualism, rigidity of gender roles, uncertainty avoidance, and long-/short-term orientation), long a critical tool of international business, remain largely unused in education. These dimensions provide different lenses to view how international experiences with teaching and learning mathematics inform and shape practices in mathematics teacher education.

International studies (e.g., Ma, 1999; Stigler & Hiebert, 1999), which address mathematics teaching in the United States and other countries, suggest that studying mathematics teaching and learning as a cultural activity provides a broader and deeper perspective on teaching practices in the United States. While these international studies and comparisons provide evidence of general trends, personal experiences with mathematics teachers and students from India (places not documented in well-known international studies) provide a sharper image of what it means to teach and learn mathematics that complements broad generalizations from large international studies, for example, the TIMSS (2007).

The ways these international experiences in mathematics education might shape perspectives about the approach to mathematics education in U.S. contexts are based on more than 256 mathematics classroom observations (by Hillman) in more than six schools (Kindergarten through 10th grades), located primarily in remote cities of south India, with some observations in the large urban city of Mumbai, India. These observations and more than 116 meetings with teachers occurred over 6 visits to India between 2000 and 2010; the majority of observations and meetings occurred at a school (preK-10th) over a 10-week period in 2006, and another school (6th-10th grades) over an 8th-week period in 2010. Nearly all schools visited had some level of government funding in addition to tuition-based funding. All schools visited were English medium, with all instruction of content in the English language (except for classes in Hindi and the mother-tongue language).

Teaching as cultural practice involves the language, tools, beliefs about teaching and learning, customs, traditions, and rituals used in teaching. In the United States, teaching cultural practices in elementary schools includes teaching in the native language (English), locally controlled curriculum (to a certain extent), and a healthy history of debates on what and how students should learn mathematics. Recent trends in the

United States include using “hands-on” active learning, teaching for critical thinking and problem solving, and infusing technology (including calculators and other hand-held technologies). Most recently, the CCSS (CCSS Initiative, 2010) in mathematics has consolidated standards for what and when students should learn specific content, standardizing curriculum guidelines across the 40-plus states that have adopted these standards.

Teaching as cultural practice in India, however, involves a rich and long history of “gurukul,” where sons are sent to live and study with teachers. The curriculum is holistic and includes mental, physical, and spiritual aspects. One of the legacies of the British occupation that influences education in India is providing a common language (English), and the British model of education. Curriculum is centralized through state or federal agencies, with high-stakes assessments. Recently, national mandates in India include providing education to all children 7- to 14-years-old, and instruction in three languages that include the mother-tongue language, Hindi as a national language, and English as an international language. Many parents are eager to have their children learn English well, to get a good job.

Although India has a strong record of centralized curriculum and national mandates in education, and the United States is moving toward a nationally based curriculum with standardized testing contributing to measures for accountability, classrooms are still the strongest influence on actual opportunities to learn, as teachers interact with students around the content they teach. This is why teaching and learning as cultural practice must be considered to understand what happens inside classrooms as teachers teach and students go about the task of learning.

Making sense of different teaching methods in the contexts in which they are used requires an open mind. The five dimensions of culture mentioned previously (i.e., power distance, individualism, uncertainty avoidance, masculinity, and long- or short-term orientation) provide different lenses through which to examine teaching practice (Hillman, Moskowitz, Stein, & Beckman, 2011; Hofstede & Gert, 2004). The first three of these are addressed in this article.

The “power distance” dimension of culture considers who has authority, respect, and control. The vast majority of observations in Indian schools indicates a hierarchical control structure. The curriculum is published in textbook format by State or national organizations; the national curriculum is more rigorous than the State curriculum and hence provides students with more and better options for post-secondary education. There is pressure on teachers from school governing boards to not deviate from the curriculum due to high-stakes assessments and accountability. On another level, the teacher is highly respected in the classroom and in the community; students stand when a teacher enters the room and students only speak when the teacher gives permission. The ancient practice of living and studying in gurukuls places authority on the teacher as the provider of knowledge.

The “individualism” index is a measure of the sense of being part of a collective group (i.e., for the common good) versus individual effort, identity, and competition. Every school visited (by Hillman) in India had at least one school-wide assembly every day, usually at the beginning of the school day. This assembly included spiritual chants and national songs with hundreds of students and their teachers in “one voice.” The strong sense of national identity and pride was visible. In classrooms, it was common for students to give choral responses in “one voice” as the teacher prompted. When a single student was called to respond individually, and if the response was incorrect, the teacher would call upon other students as if their responsibility was to make sure that all classmates should know the correct response. While a strong collective sense was clearly evident throughout classroom observations, there was also an undercurrent of competition by individuals for high marks to increase future educational opportunities leading to “good jobs.”

“Uncertainty avoidance” involves how change and differences are viewed; uncertainty, or difference, or change could be viewed as something to avoid or something to embrace and encourage. In the context of teaching and learning, observations in most classrooms in India focused on structured learning sequences with correct answers, that is, often “one correct answer.” With a centralized, standardized curriculum, responses were sought and given in a relatively standardized manner. The textbook was literally the curriculum, so that different teachers in different schools were observed teaching the same lesson in nearly the same way at nearly the same time. Teachers voiced an expectation that they (i.e., the teachers) were supposed to know all the answers. Tension was evident when teachers admitted any uncertainty about knowing particular content they were expected to teach; some appeared confident in their knowledge even when errors or misconceptions were evident in their instruction to students. Practice and drill for the standardized assessments focused on structured and standardized responses. Tutoring and coaching classes outside of school hours were expected and routine activities for students and for teachers.

Yet, with all of these pressures on teaching and learning, there were a handful of teachers across several schools in India who encouraged students to think, problem solve, inquire about the unknown, and seek out challenges. There was one school that deviated from the centralized curriculum and hierarchical structures of governance to embrace a curriculum emphasizing problem solving and critical thinking (vs. standardized responses) and a democratic structure of governance that included all voices of the students, staff, faculty, and administrators.

Several implications for teacher education emerge from these reflections on observations of teaching and learning in classrooms in India. One implication is to be cautious about defining teaching and learning in narrow ways. For example, “hands-on” active learning appears to be a rare occurrence in Indian classrooms, but this raises the question: Are we

teaching “stuff” or are we teaching thinking? Whether or not manipulatives are used in mathematics lessons, the key to learning is if there are opportunities to think about the mathematical ideas. In making international comparisons, it is easy to consider surface-level comparisons such as using materials and activities that allow each student to have “hands-on” experiences versus “chalk and talk” with few models, if any, and teacher demonstrations with materials. Listening carefully to the kinds of questions teachers ask students, and how they respond to students with words and actions allow for glimpses of small but significant differences in expectations about the kinds of thinking expected from students.

Another aspect to consider was that the content was taught in a language that was, at best, a second or third language for the teacher, and learned by students in a language that was, at best, a second or third language. This leads to considering the role of language in teaching and learning; additionally, in mathematics, words used in daily communications take on specific mathematical meanings, and when this occurs through a language that is not a native language for the teacher and students, there are bound to be complex negotiations of meanings. This leads to rethinking the meaning of, or the role of, standardized responses and repetition so often evident in mathematics classrooms. Considering how one might teach a language at the same time as teaching particular content provides an alternative perspective.

Teaching and Learning Mathematics, Science, and Technology in Taiwan

We live in a global society, and in that global society nations are becoming more and more economically competitive. To that end, many countries, including the United States and countries in Asia, are legislating national curriculum expectations, particularly in mathematics and science (Yang & Lin, 2004; Zhao, 2005). The possibility of having a “national” curriculum is relatively new in the United States; however, Asian countries have had national curricula for many years.

Here in the United States, it is generally believed that Asian societies are rich in technology, and that technology plays a key role in how education is administered in those societies. Indeed, Asian societies are rich in technology, and extant literature shows that Asian teachers are supported by their governments and by their schools in their use of educational technology, and often have had opportunities to learn about how to use technology in their pre-service programs. Knowing about technology, however, may not always be enough. For various reasons, such as cultural beliefs (Leu, 2005; Lin, Gorrell, & Taylor, 2002; Liu & Chien, 1998) and attitudes about instructional practice based on what they have experienced as junior high school and high school and undergraduate students in their content specializations (Chang & Mao, 1999; Lee & Lin, 2005), Asian teachers, as has been mentioned previously, tend to use traditional (“chalk and talk”) instructional practices. In addition,

technology is used considerably by Asian adolescents, but is not used often in secondary schools. Level of use seems to be based on teacher knowledge (Cheung, 2009; Wu, Hsu, & Hwang, 2008), perceived need to use technology (Wu et al., 2008), and size of school (Wu et al., 2008). Larger schools seem to use less technology than smaller schools.

There is much research and scholarly literature about Asian educational systems, particularly regarding mathematics, science, and the use of technology. Cheung (2009), for example, has studied the use of media in Asian societies, and has found that the use of media in education is relatively new in Asia, but young people spend large amounts of time watching television, playing computer games, and surfing the internet. Wu et al. (2008) survey junior high school mathematics and science teachers in Taiwan to determine factors that affect use of technology in classrooms. Wu et al. find that most mathematics and science teachers in Taiwan have 13 to 15 years of teaching experience. They also find that factors affecting the use of technology in the classroom include teacher beliefs and attitudes about technology, school supported resources, a school culture that focuses on use of technology, collegiality among teachers, and subject taught. Mathematics teachers, they find, are more likely to use technology than science teachers.

Boe and Shin (2005) compare national test scores across nations, and find that, contrary to popular opinion, students in the United States do not do as “poorly” as believed when compared with other industrialized nations, but there is work to be done. Boe and Shin find that U.S. students do significantly better in reading and civics, and average in mathematics and science. Tsao (2004) compares U.S. and Taiwanese fifth-grade students about their perceptions about mathematics and their attitudes toward mathematics. Tsao is interested in this because Chinese students score at the top in mathematics in cross-national studies, and U.S. students score below the international average. Tsao finds that U.S. students are much more positive about learning mathematics than the Taiwanese students. The Taiwanese culture values mathematics; however, Taiwanese students, according to Tsao, learn mathematics because of fear of punishment rather than having a strong interest in mathematics. Chalker, Haynes, and Smith (1999) claim that a problem that the U.S. schools have, that other countries do not have, is the lack of diversity in other countries. U.S. schools, and Canada as well, have much higher diversity in their schools, and high schools in the United States and Canada are much more comprehensive than in other countries. This high level of diversity is a problem, they believe, in cross-national comparisons of academic achievement, particularly in mathematics and science.

It is important that educators learn as much as they can about the educational systems in other countries, particularly Asian countries, and how mathematics and science are taught in those countries, and how technology is used. To this end, one of the authors (Sparapani) conducted a research project during the months of May and June, 2011, to determine the extent of use of technology in mathematics and science

classrooms in Taiwan. The specific purpose of the project was to examine the use of technology in mathematics and science instruction in secondary schools (junior high schools and high schools) in an Asian (Taiwan) educational system.

This purpose led to the following three objectives:

1. To learn about the level of use of educational technology in mathematics and science classes,
2. To explore why mathematics and science teachers used (or did not use) educational technology, and
3. To provide a perspective about the availability of and support for the use of educational technology in mathematics and science.

Data were gathered in face-to-face interviews (by Sparapani) with all the participants (teachers, administrators, teacher educators), and were scheduled at a time and in a location convenient for the interviewee. Also, as all the participants were Taiwanese and spoke mainly Mandarin Chinese, and most had limited English abilities at best, a graduate student who was a native Chinese speaker and was completing a master's degree in Teaching English as a Second Language served as an assistant to help with Chinese and English translation as needed. The assistant scheduled all the interviews and observations.

In addition to the interviews, 10 teachers (5 mathematics teachers and 5 science teachers) were observed (by Sparapani) teaching a class. Because all classes were taught in Chinese, the same assistant who participated in the interviews also sat in the classrooms during the observations. The focus of the observations was to determine teaching practice as it related to what teachers said about their practice in the interview and what they had learned about instructional practice in their teacher preparation programs. In the observations, specific attention was given to the use of, and availability of, technology.

The interviews were conducted over a 6-week period in the months of May and June 2011, and, although formal, were conducted more like conversations, and typically lasted from 30 min to an hour, depending on the interviewee and what the interviewee had to say. Observations lasted one class period, 45 min in junior high schools (Grades 7-9) and 50 min in high schools (Grades 10-12). All interviews were scheduled at a time and in a place that was convenient and comfortable for the interviewee. Typically, the interviews were conducted at the participants' school, either in their office or in a conference room.

It must also be noted that no pupils were interviewed. Furthermore, no information was gathered by using audio- or video-recording equipment. In addition, no pictures of classrooms or schools were taken.

Several points have emerged across all interviews and observations. These points are as follows:

- The most current technology is readily available in all classrooms for all teachers, including the mathematics

and science classrooms. Actual use of the available technology, however, varies greatly from school to school, and from teacher to teacher.

- Students, except in specific mathematics or science courses that address statistics, are not permitted to use calculators to solve mathematics problems. This is true in the mathematics and science classrooms as well as on the high-stakes assessments.
- The Taiwanese government and the junior high school and high school principals encourage the use of technology in the mathematics and science classrooms. Actual use of the available technology, though, is dependent on two things: (a) teacher interest in the technology and (b) the level of involvement of the principal. There is a much higher use of the available technology in the schools in which the principals do more than just pay lip service to using the available technology.
- Few mathematics or science teachers integrate or use the available technology into either mathematics or science classes, unless the class is specifically related to a mathematics or science profession. Science teachers, however, seem to use technology more often than mathematics teachers, which contradicts Wu et al. (2008) who find that mathematics teachers use more technology than science teachers. In addition, some mathematics and science teachers provide "homework" assistance by posting helpful information on school web sites for students to consult during after-school hours.
- The mathematics and science teachers have learned a variety of instructional practices in their teacher preparation programs; in practice, however, classroom instruction is very traditional, that is, lecture, textbook/workbook, test oriented. Taiwanese teachers are not provided specific training in the use of technology as a regular part of their teacher preparation programs nor do schools expect that teachers have such training. Prospective teachers, however, do have access to such training, if they want it. Such training is voluntary and done mainly in online tutorials provided by teacher preparation programs, or in university computer labs. In addition, there are professional development opportunities for teachers to learn how to use the technology and technological advancements. Most of the training, however, may not be directly related to use in education or in the classroom.
- Technology use by teachers of science and mathematics is affected by two specific issues. These issues are as follows: (a) the expectations of the Taiwanese government science and mathematics curriculum as assessed by the high school and university entrance examinations, and (b) perceived student performance in those examinations.

In Taiwan, the integration of technology into mathematics and science instructional practice was quite limited. Mathematics and science teachers did not use much technology, or did not use technology at all (as mentioned previously, calculators, for example, were never used except in very specific mathematics and science courses) because the teachers believed that such use interfered with the teachers teaching the curriculum, and was viewed as a distraction to the students' learning the curriculum.

The Possibility of a Global Curriculum: Mathematics, Science, and Technology

All one has to do is spend some time in a supermarket or a department store and it becomes immediately apparent that we live in a global society, and we have lived in a global society for some time. With a global society comes a cosmopolitan community and a global economy. Education in all countries is affected by that global/cosmopolitan society/community/economy. We have found that there is no specific, global curriculum in mathematics, science, and technology, but there appears to be a *de facto* global curriculum. In this section, we present our perspective on that *de facto* global educational curriculum and how that curriculum may affect preK-12 and higher education here in the United States.

This concept currently enveloping the United States and many other members of the OECD around how to globally measure knowledge and knowledge transfer in science, mathematics, and technology really conveys the muddy conceptual foundations of both knowledge in these areas and *globalness* in education; and, therefore, "global identity" that should permit eclecticism in research and framing of problems for educational reform that is place-based. Researchers and analysts rightly ask what is "global" and, subsequently, what is a "global education, especially in science, mathematics, and technology?" In response to this problem, we propose a conceptual framework of measuring—or more precisely understanding—that will allow for educational research that moves beyond static measures (between sovereign nations) and ignore the impact of culture on learning to focus on a historical-spatial identity. We propose a conceptual approach that re/creates a sense of what educational research and reforms might mean for a nation (or a subgroup) within this larger global concept. This, in turn, will permit a definition of global education/curriculum in science, mathematics, and technology to encompass and move beyond geographical location and static measures (on norm-referenced testing), allowing us to envisioning a robust sense of place for research and reform that all landscapes within the members of OECD encompass.

Considering best practices of teaching internationally (i.e., globally) would lead one to think that there are some generalizations possible for identifying which practices

benefit and maximize a learning curriculum for students. Teaching as cultural practice, however, suggests that internationally benchmarked practices of "what good curriculum looks like" in education must be contextualized to particular places, people, communities, and resources. The dimensions of culture (i.e., power distance, individualism, uncertainty avoidance, masculinity, and long- or short-term orientation) provide a framework for thinking about situating the practices of teaching and learning within a cultural context that then allows examination of these practices for affordances and obstacles to learning.

As the educational system of the United States evolves, through exploration of and exposure to varying educational systems of the world, one might ask if a global curriculum could (or should) exist—one remaining steadfast in pursuit of excellence at the local level, while attempting to affect student understanding of science, technology, and mathematics at the global level. Forward-thinking scholars (and practitioners alike) understand the need for continued conversation(s) toward this end, and grapple with the question of, "Whose voice is missing from the conversation?" Understanding the notion that technology does not replace effective teachers or high-quality teaching, but merely enhances them both, lies at the forefront of the conversation.

While the goal for a global curriculum is a novel idea, it is incumbent upon lawmakers and policymakers to ensure that all students and all teachers receive and become trained in STEM curriculum, which is a very integrated approach that can achieve the critical thinking skills, problem solving skills, and inquiry-based learning skills that will advance the abilities necessary for citizens of the 21st century. As long as new educational initiatives are relegated to competitive funding, where only the privileged schools are positioned to apply for, and receive the funding, schools in urban and rural areas, which educate a majority of students in poverty, and face fiscal and financial challenges regarding resources and support, will continue to struggle to prepare highly qualified teachers and have classrooms that are rich in STEM curriculum, materials, and resources. This kind of funding strategy will continue to perpetuate the gaps in learning and achievement for underrepresented populations, and the continued disparity of resources, funding, and support that currently exists in schools, both here in the United States and globally.

Recommendations for Teacher Preparation in the United States: Mathematics, Science, and Technology

Teachers and teacher educators in the United States are becoming more and more interested in any information connected with education in other countries. U.S. schools today are more diverse than at any other time in history (Futrell,

Gomez, & Bedden, 2003; Hodgkinson, 2000/2001). Asians represent approximately 27% of the foreign-born population (Grieco & Trevelyan, 2010; Pew Hispanic Center, 2011). Furthermore, at present, the 10 leading countries by birth, of the foreign-born population in the United States, are (in order) Mexico, China (including Taiwan and Hong Kong), the Philippines, India, Viet Nam, El Salvador, Korea, Cuba, Canada, and the Dominican Republic (Grieco & Trevelyan, 2010; Kandel, 2011). With this diversity in mind, and based on what we have learned from our analysis, we make the following recommendations for teacher preparation in the United State.

One recommendation for teacher preparation is to provide opportunities to examine cultural contexts of teaching and learning by using dimensions of culture to frame analysis of what works well and why.

A second recommendation for teacher preparation is to examine oneself in terms of the cultural context of schooling experience and consider ways to consider the implications for working within a given cultural context and/or actively working to challenge change in such contexts.

A third recommendation for teacher preparation is that along with our responsibilities to provide spaces for learning, we need to embrace—as difficult as it is—global viewpoints that exist within a sphere of plurality. We ask that teachers and students trust each other in their journey. The teachers and students are themselves embarking on an expedition of faith with only their interest in globalization as a vessel. We must understand the uneasiness of letting go, and in asking our students to trust that it is in that uneasiness where globalization be discussed. Innovations lie in the adoption of an approach that deliberately places practitioner knowledge at the center respecting the power of educators to significantly affect learning. Giddens (1991) believes that “the reflexivity of the self, in conjunction with the influence of abstract systems, pervasively affects the body as well as psychic processes” (p. 7). While educators recognize that teaching and learning are complex activities, documented professional development efforts reflect shortcomings in addressing differences in classrooms and communities. The literature also identifies the problematic nature of professional development as an “international phenomenon.” The problem of transferring theory to practice in professional development is well documented, but the traditional “application-of-theory model” persists, despite little empirical evidence of improved teaching practices and student achievement.

A fourth recommendation for teacher preparation is to increase practices that move away from doing “old things in new ways” (witnessed when a teacher creates the presentation medium, such as a PowerPoint presentation, to share information with students) to doing “new things in new ways” (witnessed when the students create the visual medium in which new information is provided to classmates).

A fifth recommendation for teacher preparation in this move toward a global curriculum that effectively integrates

STEM would be to ensure that every teacher preparation institution is provided the necessary funding to create laboratories that are STEM rich, and to create integrated curriculum across the major disciplines that provides a model of learning for all students.

A final recommendation is that we must rethink field experience as a culminating activity, where the candidate is immersed in the classroom at the end of their learning to practice their skills. Teacher preparation candidates must be in schools early in their programs, so that they can be mentored by highly effective teachers, and work with students, while continually applying their learning to the classroom. In this way, “new” teachers are not so new to the realities of teaching and learning, but rather familiar and competent as a result of “doing learning” over the course of the preparation program.

Conclusion

The issues we write about have initiated challenges (both here in the United State and abroad) in teacher preparation programs, curriculum design, instructional practices for the classroom teacher, and assessments of student learning, and have fueled international and national debates. This article examines these challenges by looking at the United States, Mexico, India, and Taiwan with regard to educational progress (or lack thereof) in the areas of mathematics, science, and technology. To live out the challenges, we must emphasize the instructional capacity of teachers, described by Cohen and Ball (1997) as the interaction between teachers, students, and educational materials. Historically, according to Cohen and Ball, educational policy has not targeted all three elements successfully. Implementation research has shown that “policy does not tell teachers how to translate standards or assessment into instruction, often leading to superficial enactment of the intended policy” (McGill-Franzen, 2000, p. 905). Furthermore, Fullan (1991) describes an “implementation dip,” that is, a dip or a decrease in performance when a new initiative, requiring new knowledge, skills, and competencies gets put in place. In other words, the United States must be more attentive to how schools, administrators, and teachers interpret and implement new educational policy. Policy, however, is just one of the multiple variables that affect teaching and learning; teacher knowledge and decision making as well as situational content and context are layered within the implementation of educational policy (McGill-Franzen, 2000).

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