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True STEM
DEDICATED TO IMPROVING STEM LITERACY FOR ALL STUDENTS
TRUE STEM

ABSTRACT

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RESOURCES FOR PROMOTING STEM EDUCATION OPPORTUNITIES

STEM is rooted in interdisciplinary applied application of knowledge designed around a cooperative effort to provide students with a comprehensive, meaningful real world learning experience. This relatively new approach to student and teacher development requires a systematic approach to ensure quality and accountability in meeting today’s disciplinary standards. STEM education provides a bridge for students, education providers and the business community to more effectively develop learning pathways in technology driven careers. School districts across the nation have selected STEM Academy courses as the framework for their STEM based programs. Students enrolled in STEM Academy schools are being taught to evolve and grow with enough knowledge to be viable employees and informed citizens. These school programs reflect the needs of their communities and the businesses that operate in those communities. The on-going research by pedagogy the National Academies, the National Research Council and the National Science Foundation are imperative. If implemented and sustained by schools, the findings and recommendations on what American school systems do to address specific educational programming will position the United States at the top of world economies.
Our efforts to promote STEM careers have only just begun. According to the National Academy of Engineering, the messages we have designed for younger children try to convince them that math and science are easy and fun. Further engineering is challenging, exciting, hands-on and rewarding. Older students have been targeted with messaging that emphasizes personal benefits of a career. These messages also strongly suggest that students have an aptitude and strong interest in these subjects to “succeed” (National Academies Press [NAP], 2008, p. 4). This strategy is flawed in that only a small percentage of students see math or science as “poetry” and are required to take these subjects in order to complete a portion of their programming. For many, math should be viewed as a socket wrench; i.e., a tool to complete a desired task. The majority of students today need to be explicitly shown the rationale and application of the lessons they are learning. Translating the lessons learned to real life and career based examples will capture and retain the attention of students. Relating the subjects taught to the fields of nursing, engineering, automotive, agriculture and entrepreneurship are but a few examples. These students will become leaders in our communities, moms and dads in our neighborhoods and competent capable citizens in our technology-dependent society.
“The medical profession does not market itself to young people by pointing out that they will have to study organic chemistry or by emphasizing the long, hard road to becoming a physician. The image of the physician is of a person who cures diseases and relieves human suffering” (National Academies Press [NAP], 2008, p. 12). When promoting STEM Careers, including engineering and engineering technologists, the appeal should promote the inspirational and optimistic prospects of STEM careers. Jim Keller, Senior Manager and Chief Engineer for Honda Vehicle Chassis Design states that “If people feel like they have the ability to influence the final result and see the result of their work they are much more committed to it (HONDA/Keller, 2009)”. Educators should strive to illustrate to students that they will a difference in our world, no matter their test scores, gender, race or socioeconomic background.
In Wisconsin the framework for STEM pathways emerged through a grassroots effort to quantify the actions and results of diverse models for STEM developed at the local school level. Pre-kindergarten-12 school systems, colleges and universities, educational cooperatives, businesses and industries, youth organizations, local and state government organizations and other supportive professional organizations are working together to provide a fertile ground to grow a "New Wisconsin Idea." Groups in Wisconsin are working together to leverage the collaborative participation of industry to redesign the educational experiences of students at all grade levels; creating a climate of learner engagement, technological literacy, and academic success, allowing teachers and administrators to gauge their school’s performance. This collaborative effort has defined five success markers:

1. Eliminate barriers that prevent learners from exploring STEM careers;
2. Increase emphasis on acquiring STEM knowledge and skills for all learners;
3. Increase public/private partnerships with a focus on STEM skills;
4. Establish a statewide awareness campaign for STEM careers;
5. Invest in pre-and post-professional development for educators to fully understand and integrate STEM throughout the curriculum.

Wisconsin has set the stage for a collaborative state framework to embed STEM into the education outcomes of the state (Wisconsin STEM, 2012). It also represents a shared voice from public and private stakeholders to strengthen the state’s investment in teacher professional development at all levels. The Howard-Suamico School District, a suburban medium size school district near Green Bay, implemented The STEM Academy (www.stem101.org) for both BayPort High School and Bay View Middle School. National industry certifications are earned by 92% of Bayport STEM Academy advanced students. “We performed side-by-side comparisons of The STEM Academy with other popular national programs. The STEM Academy was the clear choice” (Gutschow, 2011).

Slinger High School, a medium sized rural school, implemented the STEM Academy curriculum along with other traditional offerings. "These are the only courses our school has that bring together multiple departments. I have been involved with other department meetings. I have had science and math folks brainstorming ideas and working through activities in my room. Other academic teachers have used the curriculum. The flexibility and variety allows many teachers to pull from the curriculum,” says instructor Russ Hermann (R. Hermann, personal communication, November 25, 2012). Student enrollments are up including two yearlong Principles of Engineering courses that fulfill one credit of the newly required three credits of science for graduation. Enrollment in the Introduction to Engineering course has tripled since adopting the STEM Academy. Hermann goes on to state that “Slinger High School creates thinkers, doers and problem solvers. If some become engineers, great. If some become technologists, awesome. If all students walk away with a better sense of problem solving, Slinger and the STEM Academy accomplished their goals.”
Success in today’s changing economy depends on having skills that adapt to increasing skill and knowledge of career requirements. “Having a technically skilled workforce is the new requirement that separates companies in a global economy” (Pinchuck, 2009). STEM education provides a foundation for students to build upon, into, and throughout their postsecondary education career pathway. Career Pathways provide a framework for seamless education by:

- Promoting the connection between education and workforce/economic development.
- Providing a seamless transition from high school to college.
- Focusing on high skill, high demand, and high wage careers.
- Increasing emphasis on attainment of a technical skill proficiency, degree/credentials.

At Gateway Technical College in Kenosha, WI students are introduced to higher level thinking skills while in high school by integrating the secondary and postsecondary experience. Lakeview Technology Academy, a small specialty high school is one such school. Beginning in the junior year of high school, students are enrolled in college course work in advanced manufacturing, engineering, electronics, information technology and biotechnology. Graduating from high school with 26 college credits in technology and STEM related fields provides a solid foundation for continued career success in a STEM related career.

Gateway Technical College embraces STEM as a strategy to improve student retention and course completion by providing professional development and student led project-based learning. One example is the college robotics competition for middle and high school students. College faculty work with secondary school teachers on basic robotics concepts, electronics and intelligent design. This transfer of knowledge allows students to build upon existing skills and motivates them to excel in a team environment.

Gateway’s programs of study implement career pathways from secondary through postsecondary in STEM related career studies. Since 2008, this approach has increased enrollment in associate degree engineering programs by 26% and university transfer upon completion of the associate degree by 10%.

Building systems based on programs of study and career pathways are critical to improving America’s workforce (Oates, 2010). Programs of study that align secondary with postsecondary occupational courses provide a seamless education pathway to work and careers (Hull & Hinckley, 2007).

The message emanating from high school guidance departments across the nation is that in order to be successful, students must go to college. While an excellent message, our responsibility as educators is to inform them that a college degree does not necessarily guarantee success as it once did. What it almost certainly does guarantee is student loan debt. Post secondary training is needed to be successful. This comes in many different forms. Job training programs, apprenticeship programs, community and technical college programs as well as college and university degrees are all viable post secondary training environments.
The United States is facing a shortage of STEM professionals that is expected to escalate as a result of the retiring of baby boomers in the coming years. Data from a 2009 study of eighth-graders conducted by the National Assessment of Educational Progress showed that 43 percent of Hispanics, 44 percent of American Indians and 50 percent of African-Americans scored “below basic” in math. In 2008, more than 40 percent of children in the United States under age 5 were Hispanic, African-American or Native American, according to the U.S. Census Bureau.

If we fail to develop a robust pipeline of STEM professionals containing women and those from underrepresented communities, the consequences will be dire: a shortage of technical innovation, lower economic growth and higher unemployment for all Americans (Watson, 2011).

“Everyone has agreed that the STEM Academy is 21st Century curriculum meeting the needs of students to be self-directed, responsible learners. In the digital world that our students live in, it is refreshing to find a curriculum that students can access on their time away from school. The data driven curriculum is vibrant and alive” (Lake, 2010). According to Lexington Technology Center Director Ken Lake (Lexington, SC), when Lexington students take three courses, 95.7% graduate on time and, with four courses, 99% graduate on time. Lexington One school district serves more than 23,000 students from pre-kindergarten to Grade 12 with more than 3,400 employees and 28 schools: 16 elementary schools; seven middle schools; four high schools and one technology center. “The STEM Academy curriculum is designed for all children and centered on the middle level student that doesn’t have the light bulb on, yet. It is also unlimited at the top end, these students can reach as high as they desire since they can access the content 24/7. This ubiquitous environment reinforces the concept that learning can occur at any time and in any place through the use of technology. Many of the case studies and project based activities engage students in collaborative activities which colleges and business partners seek in 21st Century learners” (Lake, 2010).
Mount Juliet High School is a four year high school in Wilson County, Tennessee with 1822 students and 100 classroom teachers. Mr David Haines, Math Department Head, a veteran math instructor of 11 years, found himself learning right along with his students using STEM Academy curriculum. Mr Haines reports, “It has been the most fun I have had teaching in years. The students are excited to learn and are enjoying the process.” Mount Juliet has seen three-year growth in Tennessee Value-Added Assessment scores and has narrowed the achievement gap between Hispanic and white students in math.

“An educated person in the 21st century will need to innovate continuously as new technologies and ideas impact all aspects of our society and world,” says Colleen Thompson, Director of Instruction for the North Idaho STEM Charter Academy in Rathdrum, ID. Rathdrum is a city in Kootenai County, Idaho, United States. The population was 6,826 at the 2010 census, up from 4816 in 2000. “STEM Education is different from the way we’ve always taught science and math. When questions become a natural part of the education process, dilemmas can be seen
as opportunities for discovery rather than barriers to progress”. Thompson states that the STEM Academy develops creative and innovative minds capable of discovery as students develop the ability to pursue independent and original investigation. Students learn through collaboration to appreciate their own creativity and that of others. Students understand and practice innovation, which leads to new products and processes that sustain our economy.

Dr. Ryan Baxter is the STEM/Physics teacher at the Promise Academy at Dr. Martin Luther King High School, a neighbourhood school that serves 879 students. 97% of students are African American and 2% are Latino with 26% special education and 100% on free and reduced lunch. “The STEM Academy at the Promise Academy at Martin Luther King High School was formed in the summer of 2012 with our first annual summer academy for robotics and renewable energy. We received an overwhelmingly positive response from the summer program, and used that momentum to roll into the beginning of our school year. A very interesting part of that transition was the mixture of the two groups: summer group vs. non summer group. For the first time, I saw students bragging about building, soldering, designing, etc. over the summer. From that point, it was very important to keep the students on-track to have a project-based curriculum that challenged their problem-solving faculties; this has been a very user-friendly process with the Stem Academy or STEM101.org curriculum” (R. Baxter, PhD, personal communication, November 27, 2012).

The STEM Academy at MLK HS includes a major component of both the arts and entrepreneurship. In those areas, the staff is working to highlight skills in entrepreneurship as an extension of the Engineering Design Process. As part of their class, students are investigating an innovative solution to an important global problem, writing business plans, and seeking funding opportunities. Dr. Baxter and his students have a mission to build a natural gas car to save money, to help the environment, to drive technological innovation, to inspire others and to create extensive new job opportunities for the region. The MLK student cohort is teamed up with Knowledge@Wharton High School, an initiative of the Wharton School and Aberdeen Asset Management. This initiative promotes financial literacy, entrepreneurship, business insight and leadership. Nationwide, there are 20 schools participating in the event, which include Bodine 10 HS, George Washington HS, Central HS, Imhotep Charter HS, Friere Charter HS and Martin Luther King Jr. HS. “Through these extracurriculars and the STEM101 platform, we are striving to equip this and future student cohorts with key 21st century skills,” said Dr. Baxter.

THE SHIFT IN DEMOGRAPHICS

According to the National Center for Education Statistics there will be 2,912,480 public high school graduates at the end of the 2012-2013 school year. Sixty percent are classified as white, 15% African American, 17% Hispanic, 6% Asian/Pacific Islander and 1% American Indian/Alaska Native. In eight short years at the end of the 2020-2021 school year, the NCES predicts that there will be 2,981,170 high school graduates. The first changes to be noted are in the white and African American populations, decreasing by 2.7% and 3% respectively. This represents a decline of 31,910 students over the next eight years. There is a predicted growth of 2% in the Hispanic population of graduates and 2% in the Asian/Pacific Islander graduates. In the American Indian/Alaska Native population, there is a predicted growth of .6%. These three groups together represent a predicted growth of 66,990 high school graduates (National Center for Education Statistics [NCES], 2011, table 13).

![Figure 2: Projected percentage change in the number of public high school graduates, by state: School years 2007–08 through 2020–21(NCES, 2011, figure 8).](image)
According to the U.S. Census Bureau, there were 55.5 million students enrolled in Pre-kindergarten through 12th grade in 2011. Eleven percent were enrolled in private schools. In the nation’s colleges there were 19.7 million students enrolled, up from 14.4 million twenty years ago. In 2009, 16% of these college students were 35 and older and comprised 37% of part-time students. In 2009, 50% of 18-19 year olds were enrolled in college. In the 2008-2009 academic year, the average tuition, room and board for instate students at the national four-year public colleges and universities was $15,876. For private colleges and university students in 2008-2009, the average cost was $40,633 for tuition, room and board; double the cost from 1990.

Projecting that half of all students are enrolled in college as stated above, and the average cost of that education is calculated at the 2008-2009 rate of $15,876 then institutions that cater to white and African-American students stand to lose massive revenue each year due to the predicted decline. In 2020 there will be 41,520 fewer white high school graduates. Using the 2009 statistic that half will attend college, the total lost revenues of $329 million (based on 2008-2009 tuition rates) will further increase these losses. In 2020 there will be 22,300 less African-American graduates and therefore 11,150 less college students with total loss of $177 million, based on 2008-2009 tuition rates. In 2020, projections suggest that there will be 70,460 more Hispanic high school graduates. If half of these students attend college at 2008-2009 tuition rates, they represent a tuition increase of $559 million over the next 8 years. The NCES projects 60,900 more Asian/Pacific Islander students in 2020. Reports do show that more than 50% of this demographic will go to college; however, for these calculations, the authors will maintain the standard rate of half of these students matriculating to higher education. These students will represent $483 million in tuition over the next 8 years. Native American/Alaskan Native student represent an additional 2,530 graduates. Based on the premise that half of these students will attend college, these students represent a $20 million tuition increase.

![Figure 3: Actual and projected numbers for public high school graduates, by region: School years 2002-03, 2007-08, and 2020-21 (NCES, 2011, figure 9).]
When the dust settles, institutions that only cater to one demographic or another stand to lose or gain massive revenues. As the general population of the United States continues to grow, it will continue to change. In a few short years, the group(s) labelled “minority” will become the majority. According to the 2011 U.S. Census Bureau, 50.4% of children born in the 12-month period ending July 2011 were Hispanic, black, Asian-American or from other minority groups (Stableford, 2012). As of August 2008, minorities were roughly one third of the U.S. population and are expected to become the majority by 2042. The nation’s population of children is expected to be 62 percent minority by 2050 (US Census Bureau, 2010). Institutions of higher learning must adapt their programming, their faculty and perhaps admissions procedures to accommodate a diverse population of future students. Business and Industry will drive the trend to hire personnel who culturally and demographically represent the populations that will purchase their products.
Teaching children specific content is important in order to develop their experiences and exposures, but the heart of our educational system is simply teaching students to think (Gomez, 2004, p. 1). The strengths that each individual brings have to be developed as well as their whole person. This is very different from offering a standardized set of facts and figures for each person to master, and then ranking people according to how well they do that (Yero, 2002). Problem solving is one of most valuable ways we think. “Problem solving has been considered broadly as a higher form of learning which depends on other less complex forms of learning. It is seen as part of the process of investigation where the solution is not obvious to the researcher at the outset of the activity” (Okebukola, 1992).
Reviewing best practices of teaching students how to think produced the following list of what students need in their studies:

1. Students need to think more deeply about how technology can be managed so that they control it rather than the other way around.
2. Students should discuss and think systematically about personal, national and global decisions, interactions and consequences.
3. Students need to recognize and identify the rights and responsibilities of citizens and help set directions for public policy and participate in community services.
4. Students should build on their prior knowledge, learning more varied and more sophisticated problem-solving techniques.
5. Students should increase their abilities to visualize, describe, and analyze situations in mathematical terms.
6. Student designed tasks should explore a range of contexts including both those immediately familiar in the homes, school, and community of the students and those from wider regional, national or global contexts.
7. Successful completion of design problems requires that students meet criteria while addressing conflicting constraints.
8. Students need to be given the freedom to investigate possibilities and not relegated to the expectation of what is known to be the “correct” answer.

When an assignment or case study has particular parameters placed on it and those parameters are met, the students have accomplished their task. The “plug and chug” method of regurgitating information as presented by the teacher is quite traditional, as is the retention rate of that information from year to year.

The importance of understanding memory in the classroom is that memory determines what students know and can do. Memory not only creates the bridge between successive experiences, making it possible to learn from them, but it also determines how experiences are related to each other and how what is learned changes over time. The design of effective instructional programs must take into account how remembering and forgetting occur (Nuthall, 2000, p. 133).

“The road to the solution is just as important, if not more important as finding the solution itself. Educators need to teach the learning process that students require in order to navigate that road” (Gomez, 2000, p. 17). Students can retain more in the classroom if they hear it, see it and then do it. Students must be allowed to investigate and explore open-ended problems that allow them to create the answer. Dr. Alan H. Schoenfeld of the University of California at Berkeley writes:

Most textbooks present “problems” that can be solved without thinking about the underlying mathematics, but blindly applying the procedures that have just been studied. Typical classroom instruction subverts understanding even further by providing methods for solving problems that allow students to answer problems correctly, without making an attempt to understand them (Shoenfeld, 1988, p. 163).

Our challenge is to ensure that our students evolve and grow with enough knowledge to be viable employees and informed citizens. Our school programs need to reflect the thoughts and needs of the communities we live in and the businesses that reside in those communities. “Schools spend a great deal of time teaching facts outside the context of inquiry. Students spend much of their time memorizing such facts, which they promptly forget after tests. If the inquiry genuinely matters to students, they will seek out the facts and remember them long after the problem has been solved” (Mina, Omidvar, & Knott, 2003).
CONCLUSION:

The on-going research by the National Academies, the National Research Council and the National Science Foundation are imperative. The findings and recommendations on what the school systems of America must do to develop specific educational programming will position the United States at the forefront of the world’s economies, if implemented and sustained by schools.

It is most disconcerting, with the information that is readily available from the NRC and NAE, that many professional teachers’ associations and special interest groups have not embraced the recommendations of the NAE or NRC. They have, instead, used the situation to advance their own role or agenda that falls significantly short of a true systemic and collaborative effort in addressing the need to prepare our students for a globally competitive workforce and citizenry.

The authors recognize that they cannot revitalize the educational system in this country by themselves. Nor do they condemn all of the work done so far by the educational agencies that played a role in making necessary upgrades to the actual curriculum and research based practices occurring in each of the separate STEM disciplines. What has fallen considerably short are the changes needed in the actual classroom, and the ineffectiveness by local education agencies and state departments of education to integrate STEM subject matter or have full-STEM literacy as a right and expectation for all students pre-kindergarten through post secondary.

When content is taught in a contextual or applied manner, knowledge can be retained by students and become more meaningful to them, thus intrinsic and quickly stored in their brain in an organized, connected manner so they may readily retrieve the information at a later date. STEM education provides an educational experience where academic and elective coursework is integrated or linked together and utilized to solve problems.

In closing, the authors would like to quote John Dewey from 1897: “It is impossible to foretell definitely just what civilization will be twenty years from now. Hence it is impossible to prepare the child for any precise set of conditions. To prepare them for the future life means to give them command of themselves; it means so to train them that they will have the full and ready use of all their capacities; that their eye and ear and hand may be tools ready to command, that their judgment may be capable of grasping the conditions under which it has to work, and the executive forces be trained to act economically and efficiently.”
References


