

Reshaping Mathematics, Science and NCLB To Achieve World Class Performance

“Mathematics is the foundation of science, engineering and technology. Without strong mathematics there can be no strong science, engineering or technology.

The students in Kindergarten this year will graduate in 2020. As we look to America’s future, we must also reflect on the present:

- By 2010, if current trends continue, more than 90 percent of all scientists and engineers will be living in Asia.
- Only 7% of U.S. college students currently major in math or science fields, and this number decreases to 3% by the end of the first year of college.
- Enrollment in undergraduate degree programs in computer sciences is more than 50 percent lower than it was five years ago.
- More than 57% of our post-doctoral engineering students are from outside of the U.S.
- U.S. Patent applications from Asian countries grew by 759% from 1989 to 2001. Patent applications from the U.S. during the same period grew at 116%.
- Since the 1960’s, the demand for skills has changed significantly – the demand for routine manual tasks have decreased, while the demand for non-routine interactive task skills have increased significantly.
- The Department of Labor reports that out of 55 industries, education is last in its use of technology.
- In the majority of schools, teachers and students cannot maximize the potential of technology.

The U.S. Naval Academy is planning for more technical majors. “By the time the next incoming class graduates in 2013, at least 65 percent of the midshipmen must have majored in science, technology, engineering, or math – commonly know as STEM.”

“To account for attrition, we’ll likely need 70 percent STEM and to do that we need to get them interested in these kinds of majors”, said William Miller, the academy’s academic dean and provost.

Mathematics and Science are taught in every grade throughout the entire thirteen years of school, K-12. Consistent growth in skills, maturity, and understanding of science and mathematics is essential as students move from one level to the next. As a chain that breaks at its weakest link, science and math instruction is especially vulnerable to weakness in any grade or course. For this reason, the preparation of teachers is a crucial factor in revitalizing curricular practice.

Too often, elementary teachers take only one course in mathematics and none in science, approaching these critical areas with trepidation and leaving them with relief. Such experiences leave many elementary teachers totally unprepared to inspire children with confidence in their own science/math abilities. Those who would teach science and mathematics need to learn contemporary content appropriate to the grades they will teach, in a style consistent with the way in which they will be expected to teach. They need to learn science (including technology, business and social science) so that they can teach mathematics in the contexts where it arises most naturally – in measurement, graphs, prediction, decisions, and data analysis.

The United States is one of the few countries in the world that continues to pretend – despite substantial evidence to the contrary – that elementary school teachers are able to teach all subjects equally well. It is time that future and present elementary teachers with special interests in mathematics and science, who would be well prepared to teach young children both mathematics and science in an integrated, discovery-based environment are identified and placed in appropriate teaching assignments.

Universities must implement new courses with open constructive instructors so that prospective elementary school teachers can grow in confidence as a result of their university study of science and mathematics.

Mathematics teachers themselves need experience in doing mathematics – in exploring, guessing, testing, estimating, arguing, and proving – in order to develop confidence that they can respond constructively to unexpected conjectures that emerge as students follow their own paths in approaching mathematical problems. Too often, mathematics teachers are afraid that someone will ask a question that they cannot answer. Insecurity breeds rigidity, the antithesis of mathematical power and STEM.

Recommendations

- Prospective elementary teachers should learn mathematics in a manner to encourage active engagement with mathematical ideas.
- Prospective elementary teachers should learn mathematics as a process of constructing and interpreting patterns, of discovering strategies for solving problems, and of exploring the beauty and applications of mathematics.
- Additionally, elementary teachers should have at least two courses in STEM to understand the connections and to prepare them for our 21st century world class math and science curriculum for all students.

What is STEM?

STEM education is an interdisciplinary curriculum providing context around science, technology, engineering, and mathematics. STEM students engage in an inquiry learning process and are problem solvers, critical thinkers, innovators, independent learners, logical thinkers, and strong communicators, both orally and written. STEM students address real-world problems in their education, helping them to make sense of the world around them. On a given school day, students benefiting from a STEM education may use technology to collaborate on the Interactive White Board, graph and model formulas through Excel to learn algorithms, manipulate molecules to understand reactions, collect and analyze data to solve real-world environmental problems, or understand the connections between music and mathematics. All of these experiences contribute to the deeper learning of STEM skills, and connects students to 21st Century learning.

Research shows that schools practicing problem-based learning experience an increase in student motivation, an increase in cooperative learning skills in the use of higher-order thinking, and an improvement in student achievement.

Problem-based learning is both a curriculum organizer and an instructional strategy that presents a problem, which is relevant and related to the context where students are the stakeholders. Students synthesize and construct knowledge to help them actively grapple with complexities of the problem and develop strategies to direct their own learning. When students experience a problem in context, they are more likely to make connections and thus see the value in what they are learning.

What can we do now?

NCLB has moved many schools, districts, counties and states forward in addressing appropriate standards and developing consistency in mathematics content. What NCLB has not addressed is the need to increase the number of U.S. college students majoring in mathematics, engineering, and science. Nor have they addressed the problem, at the undergraduate level of decreased enrollment in mathematics and science majors by the end of the first year of college.

Over the years, international comparisons have shown that the academic performance of U.S. students is not as high as it is in other industrialized countries. The Third International Math and Science Study (TIMSS) is the most recent report to illustrate this achievement gap. Although some people use that information to attack public schools in this country, most people understand that it is a strong public education system that is responsible for the high levels of achievement in other countries. The real questions that need to be asked are: What do the countries whose students out-perform ours do differently in their public schools? What are some of the factors that lead to such high levels of student achievement? **And what are some of the things we need to do now in our schools to help our students achieve their academic potential?**

Recommendations

Schools, districts, counties, and states need to:

- Define and encourage opportunities for students that motivate, encourage, and experience performance based learning.
- Provide enrichment materials for teachers that extend students deep understanding of math and science standards versus acceleration of students.
- Document performance on enrichments and applications of mathematics by developing portfolios of students' work.
- Use performance tasks in mathematics and science aligned with state and district standards.
- Use STEM units that are aligned with standards at each grade.
- Focus attention on teachers and students PreK – 8 mathematics and science expectations and success.
- Document the increase participation and success of students in high school AP course.
- Undergraduate program in mathematics and science need to develop and document their effort to retain and increase enrollment of U.S. students in math and science.
- Document the number of elementary and middle school students at each grade level participating in STEM programs.

Create STEM Classrooms for ALL Students

In a STEM classroom, students engage in project-based learning environment where students investigate real-world problems while working in collaborative groups, and simultaneously developing cross-curriculum skills. Project-based learning encourages students to think critically and work together to help solve problems – preparing students for the skills needed in the 21st Century workplace. Project-based learning projects include problem solving, investigations, and decision-making. Students are evaluated based upon their projects, which often provides more meaningful feedback than traditional tests or exams. Research also shows that in school where students are engaged in a project-based learning student motivation, cooperation learning skills, higher-order thinking skills, and student achievement increases.

Conclusion

The U.S. is planning to build the infrastructure of our highways, bridges and our schools. Schools need to be rebuilt in many ways. First, schools/teachers need 21st Century technology that encourages teachers to explore, investigate, and discover with their students science, technology, and mathematics. Additionally, schools need technology that facilitates project-based learning. Second, schools/teachers need materials that enhance, encourage and facilitate learning and motivation of students. Third, elementary and middle school teachers need undergraduate courses that are problem-based with STEM curriculum materials. Fourth, the U.S. needs a SPUTMK emphasis/urgency to change. Nothing moves higher education like money. The U.S. needs to fund curriculum materials and courses for all undergraduate students, elementary students and middle school students. The U.S. needs project-based learning and STEM now.