Strategic Growth Opportunities in Stem (Science, Technology, Engineering and Math) Education

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1. Introduction

The increased emphasis on STEM (science, technology, engineering, and mathematics) education is evident across all levels of education today. The motivation behind this new emphasis is to increase the number of graduates pursuing STEM careers, which is critical to the economic prosperity of society. Economists broadly agree that more than half of economic growth since World War II can be attributed to technological innovation [1]. Growing a STEM workforce is a sound economic development strategy that has a significant impact on a nation's competitiveness, economic growth, and overall standard of living. Increasing the number of high school, college, and postgraduate students majoring in STEM subjects is therefore critical for economic prosperity. STEM skills are also highly transferable and useful in contexts outside the traditional STEM disciplines and occupations. A mix of technical preparation as well as preparation in other disciplines is increasingly advantageous across a wide array of occupations [2].

2. Goals of the STEM initiative

The STEM agenda has two basic goals. The first goal is to expand the number of students prepared to enter postsecondary study and pursue careers in the areas of science, technology, engineering, and mathematics. This goal is designed to bolster the innovative capacity of the workforce. The second goal is to boost the proficiency of all students in basic STEM knowledge. This goal is designed to improve the ability of students and workers to assess problems, employ STEM concepts, and apply creative solutions in their daily lives. These abilities are highly transferable skills that enhance an individual's success across a wide array of disciplines in school and beyond. These skills include: (a) using critical thinking to recognize a problem; (b) using math, science, technology, and engineering concepts to evaluate a problem; and (c) correctly identifying the steps needed to solve a problem [3].

3. Current status of STEM education

A shortfall in the numbers of qualified math and science classroom teachers has been a chronic challenge in the K–12 system [4]. For example, less than two-thirds of high school math teachers in the United States hold both a degree in math and are certified to teach math [5]. For high school science teachers, the statistics aren't any better. In chemistry, about one-third of teachers hold a major and certification in the subject. In earth sciences, only one-fourth of teachers majored and held a certificate in the subject. More than 20 percent of teachers in the physical sciences and 40 percent of the teachers in the earth sciences hold neither a degree nor a certificate in the subject.

4. Strategies for growing STEM education

To improve K–12 STEM instruction, we need to recruit and retain more qualified math and science teachers. Postsecondary systems must establish goals to produce more teachers, enhance preparation programs, and create alternative pathways to allow math and science professionals to enter the teaching profession. Upgrading the training of teachers before they enter service is particularly important; this helps them acquire the hands-on skills to ensure that students learn and apply math and science knowledge.

Students are not often exposed to the connections between the work they are currently doing in math and science and postsecondary fields of study and STEM occupations. Helping students see the connections between math and science and future career opportunities is a critical aim of the STEM initiative. Part of this can be addressed by expanding classroom teaching strategies with hands-on math and science activities that focus on real-world problem solving through collaborative projects outside the classroom [3].

5. STEM Education Initiatives at Boise State University

A 2009 survey of approximately 300 school principals from public secondary schools in the state of Idaho assessed both the current and projected needs for secondary mathematics and science teachers [6]. The results indicated that there will be an anticipated need for 540 math and 430 science teachers during the next five years. The implications of the demand and dwindling supply of secondary math and science teachers has led to a number of endeavors in Idaho involving multiple constituencies. Following is a description of some of the initiatives undertaken in the College of Education at Boise State University to improve STEM education in our state.

Currently, Boise State University is graduating about four science and 15 mathematics teachers each year. That, along with the national emphasis on improving mathematics and science education, is a call for a change in how we recruit, prepare, and retain our mathematics and science education majors. We need to increase the number

of teachers we are preparing and attend to the need for better preparation so that teachers remain in the field longer. Through Boise State's participation in the American Public and Land Grant University sponsored Science and Math Teacher Imperative (SMTI); we are striving to increase the quantity, quality and diversity of science and mathematics teachers [7].

Boise State University is implementing "IDoTeach" - a U-Teach program for Idaho. U-Teach started at the University of Texas at Austin in 1997 as a new way to prepare secondary science, math, and computer science teachers. Its strength lies in collaboration between the Colleges of Natural Sciences and Education and its unique approach to teacher preparation. The program has a robust commitment to student recruitment into STEM education majors, offers early field experiences, has progressively transformed the teacher preparation curriculum, student internships, enhanced the retention of teachers early in their careers, and continued connections with program alumni [6].

The primary goal of IDoTeach is to increase the quality, quantity and diversity of STEM teachers graduating from Boise State. IDoTeach will coincide with the enhancement and integration of other university programs designed to improve the institutional effectiveness in graduating more math and science teachers. At Boise State, the IDoTeach program integrates elements that include the learning facilitator program, a teacher preparation pathway in the engineering curriculum, and summer research experiences for teachers.

Developing Mathematical Thinking (DMT) is a Mathematics Science Partnership grant funded by the National Science Foundation (NSF). The DMT program promotes best practices and curricula in math teaching at the elementary and middle school levels, and has realized significant gains among the students whose teachers participate in this training. DMT started as a three-year project focused on developing teachers' understanding and ability to teach mathematics, which then translates into developing students' mathematical understanding. Four Idaho schools with over sixty elementary teachers and specialists participated in the initial project. The professional development was varied and continuous over the three years. Each teacher participated in a week-long institute during the summer and met with DMT project staff one day each week through the academic year. During this time, the teachers engaged in professional development, observed lessons taught by DMT staff, and received reflective feedback after their lessons had been observed. The focus was on how students' develop mathematical ideas over time and how teachers build learning environments to best promote this process. In the first three years of the project's existence, students and teachers demonstrated positive changes in the DMT schools. Teachers demonstrated increased knowledgeable about mathematics, better insight into how students develop mathematical ideas and, as a whole, were more excited about teaching mathematics. Students were also enthusiastic about math time and are more capable of solving difficult problems with understanding. This has translated into having more students proficient on the ISAT (Idaho Standards Achievement Test) for each grade level from second through sixth [8]. The project has now expanded to statewide training for elementary and middle school teachers of mathematics.

Boise State University has made a strong commitment to STEM education through the establishment of the STEM Central Station, a center designed to promote research and educational strategies to enhance STEM initiatives and support learning partnerships for students and faculty in a centralized station. The STEM Central Station is an office for coordinating grant-related and other STEM programs on campus and throughout Idaho. Through the STEM Central Station office, Boise State hopes to research and further develop emerging STEM education best practices to help overcome a national dearth of qualified teachers in STEM-related subjects and entice more students to pursue those areas of study. The underlying theme of the project is student self-authorship, an educational framework in which students immerse themselves in genuine experiences such as research, teaching kindergarten through 12th grade students, and intellectually engaging with peers and faculty. Personally identifying as a scientist, engineer, mathematician or STEM teacher enhances student learning and success. The STEM Central Station involves faculty across campus by promoting and supporting faculty understanding of student-centered teaching methods in STEM courses and the inclusion of students in research.

An excellent example of partnering with business and industry is the iSTEM program that features professional institutes and teaching materials for Idaho teachers to increase their knowledge and confidence in teaching STEM topics. This work includes the support of the Idaho Department of Education, Idaho National Lab, and the Batelle Energy Alliance. The SySTEMic Solution project is another excellent example of collaboration across colleges, school districts and private corporations like PCS Edventures, whose focus is on educational products that help student learn science concepts. Supported by U.S. Department of Education funding, this project focuses on teacher professional development, and has impacted over 200 kindergarten through fifth grade teachers in Idaho by enhancing capacity for inquiry based STEM teaching and learning.

Initiatives for curriculum and faculty development at Boise State University also support STEM endeavors. The Center for Teaching and Learning provides a wide range of workshops and confidential consulation services for faculty. Services are designed to complement one another, and instructors are encouraged to use them in whatever combination will help them meet their teaching goals. The Noyce Scholarship program funded by NSF provides on-going professional development for STEM secondary education graduates. Increasing quantity, quality, and diversity of STEM education graduates at Boise State University is achieved through multiple paths that attend to a range of needs through tutoring, academic advising, and tuition assistance.

At the graduate level, the College of Education at Boise State University is proud to offer a master's degree in STEM education. This degree is designed to address a growing national emphasis on student improvement in

STEM subjects and to meet the high demand for qualified high school STEM teachers created by new requirements that Idaho high school students take three years of math and science. Because increased emphasis in being placed on mastery of STEM education, we intend to foster success and inspire teachers to engage their students by giving them the tools and resources that they need to develop their expertise.
We are also looking beyond US borders to help strengthen STEM education. There is an abundance of math and science majors in Korea who are interested in securing teaching positions in the public schools. Teaching is a respected occupation in Korea and jobs are highly competitive. It is interesting to note the growth of exchange programs that focus on bringing Korean teachers to the United States to fill math and science positions. Boise State University is strengthening partnerships and exchange agreements with several Korean universities to bring Korean STEM education students to Boise State, as well as sending our students to Korea.

6. Conclusions and Recommendations

The practices and strategies for recruiting and preparing STEM educators described above illustrate a commitment toward improving STEM education in Idaho, which will positively impact the students we serve. The need for qualified STEM educators will continue to challenge the US education system and the development of creative programs to recruit and retain educators in STEM disciplines is crucial.

References

[1] Susan Hockfield. February 13, 2009. “After Stimulus: An Economic Growth Program.” *The Boston Globe.* http://web.mit.edu/hockfield/speeches/2009-globe-1.html
[2] Anthony Carnevale, Nicole Smith, and Michelle Melton. October 2011. “STEM: Science, Engineering, Technology, and Mathematics.” Georgetown University Center on Education and the Workforce. http://cew.georgetown.edu/stem
[3] National Governors Association, December 2011, Building a Science, Technology, Engineering, and Math Education Agenda. http://www.nga.org/cms/home/nga-center-for-best-practices/center-publications/page-edu-publications/col2-content/main-content-list/building-a-science-technology-en-1.html
[4] The Education Trust. November 2008. “Core Problems: Out-of-Field Teaching Persists in Key Academic Courses and High-Poverty Schools.” http://www.edtrust.org/sites/edtrustorg/files/publications/files/SASSreportCoreProblem.pdf
[5] U.S. Department of Education. 2007–2008. “Public School Teacher Data File.” National Center for Education Statistics. Schools and Staffing Survey (SASS). http://nces.ed.gov/surveys/sass/tables/sass0708_009_t1n.asp
[6] Louis Nadelson. 2010. “IDoTeach: A U-Teach Replication Initiative for Idaho.” A Boise State University White Paper for Addressing Secondary STEM Education in Idaho.
[7] “Science and Mathematics Teacher Imperative.” Association of Public and Land Grant Universities/NSF MSP program. http://www.aplu.org/page.aspx?pid=1694
[8] Jonathan Brendefur. 2006. “Developing Mathematical Thinking.” College of Education News, The Center for School Improvement & Policy Studies.