February 16, 2007

MATH + SCIENCE = SUCCESS
USG Presidents' Science, Technology, Engineering, and Mathematics (STEM) Initiative
Final Report to Chancellor

Charge: Increase the number of K-12 students interested in mathematics/science/engineering, the number of students in college who pursue the STEM disciplines, and the number of teachers prepared who are better able to keep K-12 students in the STEM pipeline.

Members:

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Intended Outcomes: Excellence in the STEM Initiative is defined as meeting the following intended outcomes:

Item #	By Year	Intended Outcome of the University System of Georgia[1]	Baseline	Baseline Year
1	2013	Number of baccalaureate degrees in STEM disciplines will increase to at least 5,000[2]	3,213	2006
2	2013	Number of baccalaureate degrees with a major in mathematics will increase to at least 400	196	2006
3	2013	Number of baccalaureate degrees with majors in chemistry, geology, and physics will increase to at least 420, 80, and 130, respectively	215-Chm	2006
			41-Geo	
			67-Phys	
4	2013	Number of middle grades teachers with a concentration in mathematics will increase to at least 480 per year	276	2006
5	2013	Number of middle grades teachers with a concentration in science will increase to at least 350 per year	200	2006
6	2013	Number of high school mathematics teachers will increase to at least 270 per year	135	2006
7	2013	Number of high school science teachers will increase to at least 160 in Biology	54	2006
		45 in Chemistry	9	
		15 in Physics	3	
		20 in Earth Sciences	1	
8	2013	Success rates with a grade of C or better in introductory STEM courses will increase to at least 75%	50%-70%	2006
9	2013	Number of high school students taking college preparatory science and mathematics courses will increase by at least 20%	67% or 55,077	2006

[1] As we try to engage more students in the sciences, the availability of labs may become a rate limiting factor.
[2] The University System of Georgia awarded 25,579 baccalaureate degrees in 2006.

Work Plan: The Committee's work plan includes replication of lessons learned from P-16 initiatives in Georgia, from a grant based at Georgia Perimeter College and Darton College called Mathematics, Engineering, and Science Achievement (MESA),[3] and from the Partnership for Reform in Science and Mathematics (PRISM).[4] The Committee's work plan was also informed by studies that describe the changing landscape of higher education on the world stage, and the corresponding implications for the economic competitiveness of the nation.

One recent study from the University of California, Berkeley casts the following scenario:[5] The US now ranks 13th in the percent of its population that attends higher education and earns a baccalaureate degree or higher; together China and India produce close to a million engineers annually, while the US and Europe combined produce only about 170,000; and so forth. Recommendations include a set of "interrelated strategies" that include much better preparation for college in K-12 education; building a "culture of aspirations"; and increased college participation and graduation rates.

A second study, *Commitment to America's Future: Responding to the Crisis in Mathematics and Science*,[6] recommends a "K-16" approach to resolving the "systemic problems" in science and mathematics, with a concurrent emphasis on K-12 education (including a public awareness campaign), higher education, teacher preparation, and continued teacher professional learning.

Accordingly, the Committee's work plan features a systemic approach to problem resolution. It includes:

- Strategies to influence K-12 student preparation for and interest in majoring in STEM in college.
- Strategies to increase the success of STEM majors in college.
- Strategies to produce more and better science and mathematics teachers for the schools, which in turn will lead to increased preparation of K-12 students in science and mathematics.

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[3] MESA is funded by the HP Diversity in Engineering Program.

[4] PRISM is a comprehensive research and development project in 15 public schools districts and seven USG colleges and universities in four geographical regions of Georgia, and at the state-level in the P-16 Department, University System Office, and Georgia Department of Education. Jan Kettlewell serves as PI; Ron Henry serves as Co-PI.

PRISM is designed to test key strategies to increase student learning and achievement in science and mathematics in schools and colleges, to codify what works, to use it to influence statewide change in policy and practice, and to inform the nation about successes that should be replicated to rebuild America's competitive advantage in science and mathematics. The P-16 Department within the Office of the USG of Georgia serves as the coordinating unit and fiscal agent for PRISM, which is funded by the National Science Foundation. Within the four PRISM regions, strategies cluster into three groups, those designed: 1) to provide all students with highly qualified and ethnically diverse science and mathematics teachers; 2) to ensure all students access to and readiness for challenging science and mathematics courses and curricula; and 3) to increase the engagement of science and mathematics higher education faculty in solving the needs of the public schools.

PRISM is one of only 12 such comprehensive initiatives funded by the National Science Foundation, FY 2004-FY 2008.

PRISM has been evaluated by three external review teams in years FY 2004, FY 2005, and FY 2006. In FY 2005, NSF conducted what is called the Critical Site Visit of PRISM in which the External Review Team assigns one of three possible levels of review:

- High Level Performance.
- Satisfactory Performance.
- Inadequate Performance.

PRISM received a rating of "High Level Performance" from the NSF External Team.

[5] Douglass, John A. The Waning of America's Higher Education Advantage: International Competitors are No Longer Number Two and Have Big Plans in the Global Economy. University of California Berkeley, Center for Studies in Higher Education. June 2006.

[6] Business-Higher Education Forum. Commitment to America's Future: Responding to the Crisis in Mathematics and Science. Washington, DC. June 2005.

A. Strategies to Influence K-12 Student Preparation for and Interest in Majoring in STEM: This section of the Committee's work plan includes three strategies. First, it calls for the collaboration of the University System of Georgia with the Georgia Department of Education in the development of a new high school core curriculum in science and mathematics that will meet the expectations of USG faculty in these disciplines for college admission. Second, it includes the operational costs to replicate the PRISM Public Awareness Campaign, which is designed both to increase K-12 student interest in science and mathematics and to influence changes in middle and high school students' course-taking patterns in science and mathematics. Third, it includes replication of the PRISM Academy for Future Teachers to increase the interest on young people in attending college and becoming science or mathematics teachers.

Strategy 1: Serve as a collaborative partner with the Georgia Department of Education as it leads revisions to the High School Graduation Rule that stipulates the courses required for graduation.

The University System will advocate for the State Board of Education to require four years of high school mathematics, four years of English, three years of science, three years of social science, and two years of a second language in order to earn a regular high school diploma. Through Georgia's participation in the American Diploma Project, the expected level of proficiency for the Georgia Department of Education to require in English and mathematics will be the national ADP standards. The University System Academic Advisory Committees in English and Mathematics have reviewed and accepted Georgia's proposed College and Work Readiness Standards.

USG Annual Cost: In-kind contributions only.

Strategy 2: Replicate the PRISM Public Awareness Campaign to influence middle and high school students' course-taking patterns by positively altering their perceptions about science and mathematics, and to reinforce parental and guardian involvement to increase students' interest in science and mathematics.

The PRISM Public Awareness Campaign is all about "messaging." Through a series of posters, billboards, banners, radio and TV announcements that feature children and youth excelling in science and mathematics, the goal is to help parents and members of the community understand their roles in setting high expectations, conveying the importance of a solid science and mathematics education, providing support in doing school work, and providing enrichment activities outside the classroom. The PRISM campaign also features a grass-roots outreach program that supports hands-on opportunities for parents and students to work collaboratively on science and mathematics activities and links students to non-classroom oriented support that strengthens science and mathematics abilities.

The PRISM Public Awareness Campaign is called "Math + Science = Success". A USG trademark for this name and patch (the recommended name and logo for this initiative) is in process. All of the print materials have been developed through PRISM and could be easily replicated. The costs included here are only for operations. External funds will be raised to replicate the billboards, radio, and television spots.

USG annual cost: No funds in FY 2008; $200,000, beginning in FY 2009.

Strategy 3: Replicate the PRISM Academy for Future Teachers of Science and Mathematics throughout the USG. The 20 USG institutions that prepare teachers are eligible to participate.

High school outreach programs, such as the Academy for Future Teachers (partnership between Georgia State University and Atlanta Public Schools), result in increased student interest in majoring in science or mathematics in college and becoming science or mathematics teachers. All of the 259 participants (99% minority) to date in the PRISM Academy indicate plans to attend college. The first two students from this program who have graduated from high school started at Georgia State this fall, one majoring in mathematics, one in the sciences.

USG annual cost: $800,000, awarded through competitive RFP.

B. Strategies to Increase the Success of STEM Majors in College: Section B of the Committee's work plan includes five strategies. First, it includes a strategy for building the STEM pipeline from two-year colleges. Second, PRISM strategies are replicated to influence changes in how science and mathematics are taught in introductory science and mathematics college courses to help turn them into "gateway" rather than "gate-keeper" courses. Third, targets are set for increasing student success in these introductory courses. Fourth, this work plan includes participation in a national project, Mathematics Success, to learn strategies for student success from other partners in the project. Fifth, institutions will be asked to set targets as to the number of STEM baccalaureate degrees they hope to confer, so that progress can be tracked at the System level towards achieving the targets listed on page 1.

Strategy 4: Replicate Project MESA, which focuses on underrepresented groups. Georgia would be second only to California in offering this program statewide. All USG two-year colleges are eligible to participate.

In California, the initiative is state-wide and began at community colleges as feeders of STEM majors to the senior institutions. In California, 30 percent of their transfer-students from Project MESA are now STEM majors; 100% of the MESA community college students who transfer to four-year institutions are in math-based majors. In addition, 90 percent of California's minority engineering baccalaureate recipients are MESA students.

USG annual cost: $200,000 ($40,000, awarded to 5 two-year institutions through competitive RFP).

Strategy 5: Replicate the PRISM state-level Institute on the Teaching and Learning of Science and Mathematics throughout the USG that focuses on teaching college introductory courses in mathematics and the sciences. All institutions that offer the associate or baccalaureate degree are eligible to participate.

Introductory courses hold the key to student success for those seeking degrees in STEM and for prospective science and mathematics teachers. Through this strategy faculty members will develop teaching methods that have been shown to be more effective, while maintaining high standards and expectations. These techniques include:

- Recognizing that students come to classrooms with powerful preconceptions.
- Addressing students' misconceptions that must be directly challenged through active student engagement.
- Providing rapid feedback to students, not just grades on tests.
- Improving the classroom environment, such as redesigning mathematics and science labs.
- Involving students in planning their learning since all students do not learn in the same way or at the same rate.

Nationally, more than half of the students that entered college intending to pursue majors in the STEM disciplines switched out within the first two years. As the loss occurred early in the students' educational careers, it is reasonable to think that introductory courses may be to blame. The main reasons for the switch, as reported by the students themselves, are poor teaching and "weed out" practices. (Seymore, E. and Hewitt, N.M. (1997). Talking About Leaving: Why Undergraduates Leave the Sciences. Westview Press: Boulder, CO).

USG annual cost: $200,000 for two annual faculty institutes.

Strategy 6: Recommend that all USG two-year colleges and baccalaureate degree-granting institutions set targets as to the percent of students completing the following introductory courses with a grade of A, B, or C, and the percent of students who withdraw:

- Math Modeling, College Algebra, Pre-Calculus.
- Introductory Biology Courses for majors and non-majors.
- Introductory Chemistry courses for majors and non-majors.

For the University System the ABC rates in introductory STEM courses would increase to at least 75% by 2013 (from a baseline of 50%-70% in 2006).

USG annual cost: Institutions will redirect existing funds to achieve these priorities.

Strategy 7: Participate in a national project, Mathematics Success, to determine which interventions might be used to improve student success in Developmental Mathematics, College Algebra, Pre-calculus, and Calculus I.

Since success in mathematics is a gateway to all of the sciences, University System institutions will drill down into the preceding list of courses to explore how well each course in a mathematics sequence is preparing students for the next course; gauge the relative success of students who follow various paths while working their way through the sequences; and identify student characteristics that can serve as predictors of success. Mathematics Success will be coordinated by the System Office.

USG annual cost: Institutions will redirect existing funds to achieve these priorities.

Strategy 8: Recommend that each of the USG institutions that offers majors in the STEM disciplines sets annual institutional production targets for baccalaureate degrees conferred in the STEM disciplines, FY 2007-FY 2013, and makes reaching these targets high institutional priorities. The Committee sees these targets as realistic, given projected enrollment increases throughout the USG.

Among the baccalaureate degree granting institutions, the following System targets would be met by 2013:

- The number of baccalaureate degrees in STEM disciplines awarded by the USG would increase to at least 5,000 by 2013 (from a baseline of 3,213 in 2006).
- The number of baccalaureate degrees with a major in mathematics awarded by the USG would increase to at least 400 (from baseline of 196 in 2006).
- The number of baccalaureate degrees with majors in chemistry, geology, and physics awarded by the USG would increase to at least 420, 80, and 130, respectively (from baseline of 215 in chemistry, 41 in geology, and 67 in physics in 2006).

USG annual cost: Institutions will redirect existing funds to achieve these priorities.

C. Strategies to Produce More and Better Teachers of Science and Mathematics in the Schools: The Committee's work plan includes four strategies. First, the PRISM "mini-grant program will be replicated to support the participation of STEM and science and mathematics education faculty members in K-16 learning communities to strengthen teaching in the public schools and in work to increase student learning in STEM introductory courses. Second, the work plan includes a strategy to increase interest in K-12 teaching among undergraduate STEM majors. Third, the PRISM self-assessment tool will be replicated so institutions can monitor their progress towards meeting the intent of the new Board of Regents' policy, Work in Schools. Fourth, institutions will be asked to set targets as to the number of middle and high school science and mathematics teachers they hope to prepare, so that progress can be tracked at the System level towards achieving the targets listed on page 1.

Strategy 9: Establish a structured "mini-grant" program for STEM and science and mathematics education faculty to collaborate in K-16 learning communities (defined in attachment A), using the Structured Abstract from PRISM as a guide (attachment B), and for STEM faculty to work on increasing student understanding of the subject matter in introductory science and mathematics courses. All institutions that offer the associate or baccalaureate degree are eligible to participate.

In PRISM, when science, mathematics, and science and mathematics education faculty members participated with teachers in K-16 learning communities focused on teaching:

- Teachers changed their teaching practices to incorporate more inquiry-based strategies into their teaching, which increased student engagement in science and mathematics (change was at a statistically significant level).
- Teachers changed their teaching practices to incorporate more standards-based teaching practices necessary to teach the new Georgia Performance Standards (change was at a statistically significant level).
- Elementary teachers increased their content knowledge in science and mathematics when the content knowledge they were learning was directly applied to teaching practices in the elementary school classroom.
- Higher education faculty members learned techniques for diagnosing student difficulties in college courses in mathematics and the sciences.

In addition, college faculty members who teach introductory science and mathematics courses in the four PRISM regions have demonstrated an interest in working on strategies to increase student understanding of the subject matter in introductory STEM courses, and an interest in verifying their results through use of the structured abstract (attachment B).

USG annual cost: $2 million, awarded through competitive RFP.

Strategy 10: Replicate Project FOCUS from PRISM—a project where undergraduate science and mathematics majors get exposed to teaching in the public schools through working with elementary students. All USG institutions that offer the associate degree or the baccalaureate degree with majors in mathematics and the sciences are eligible to participate.

Through Project FOCUS at the University of Georgia, one-third of the 147 participants have expressed interest in teaching as a career.

USG annual cost: $200,000 ($40,000 per 5 institutions, awarded through competitive RFP).

Strategy 11: Recommend that each USG institution complete an annual self assessment on changes within the institutional culture toward optimizing the intent of the new Board Policy "Work in the Schools". A self-assessment tool (under development this year in PRISM) will be available for institutional use beginning in spring 2007. It is reasonable to expect improvements over time on these annual institutional self-assessments. All institutions that offer the associate degree or the baccalaureate degree with majors in mathematics and the sciences are eligible to participate.

Science, mathematics, and science and mathematics education faculty members have said they would sustain their involvement with the public schools if the faculty roles and reward system were changed. The new Board of Regents policy "Work in the Schools" that was developed by PRISM represents the "top-down portion" of this change strategy. Institutions need to focus on the "bottom-up" portion of changing faculty roles and rewards in order to bring about the institutional culture change necessary to recognize and reward faculty for significant contributions to the public schools.

USG annual cost: No additional costs anticipated beyond current budgets.

Strategy 12: Recommend that each USG institution that prepares teachers sets teacher production targets in science and mathematics for middle grades and high school teachers, FY 2008-FY 2013, and makes reaching these targets high institutional priorities. The Committee sees these targets as realistic, given projected enrollment increases throughout the USG.

Science and mathematics represent areas of extreme teacher shortages in the Georgia public schools. Table 1 shows the need, for grades 7-12, as reported by the Georgia Professional Standards Commission.

Table 1
Science and Mathematics Teacher Shortages in Georgia, Grades 6-12

Teaching Field	Estimate of New Teacher Need by 2010*
Mathematics	1,740
Life Sciences	590
Physical Science	660
Chemistry	85
Earth Science	75
Physics	45

* Georgia Professional Standards Commission Workforce Report 2006: Estimates determined from current vacancies, increased number of new teachers needed for the projected 13.4% growth in student enrollment, and projected teacher attrition.

In addition to the size of the student population, teacher need in any given discipline is a function of the number of required courses in that field. The State Board of Education currently is considering changes to the High School Graduation Rule, which would require increased numbers of courses in science and mathematics for high school graduation. The proposal under consideration for a regular high school diploma (excludes special education) would require all students to complete four units of mathematics (through Mathematics III of the new Georgia Performance Standards) and three units of science: biology; chemistry or physical science; and physics or earth systems or environmental science or any AP or IB science course. Only biology is required of all students currently.

Among the 20 USG institutions that prepare teachers, the following System targets would be met by 2013:

- Middle grades mathematics: 480 (from a baseline of 276 in 2006).

- Middle grades science: 350 (from a baseline of 200 in 2006).
- High School mathematics: 270 (from a baseline of 135 in 2006).
- High school biology: 160 (from a baseline of 54 in 2006).
- High school chemistry: 45 (from a baseline of 9 in 2006).
- High school physics: 15 (from a baseline of 3 in 2006).
- Earth sciences: 20 (from a baseline of 1 in 2006).

The Georgia Institute of Technology, Southern Polytechnic State University, and Savannah State University are encouraged to collaborate with nearby USG institutions that prepare teachers in innovative programs to help reach these teacher production targets. Funds are requested for this strategy because there is a need to increase the number of faculty members (arts and sciences and education) in order to increase teacher production.

USG annual cost: $1.4 million, awarded through competitive RFP.

Logo:

System Leadership & Coordination: This Initiative, Math + Science = Success, will be led by President Carl Patton, with coordination provided by the System Office P-16 Department. A Director from one of the STEM disciplines will be hired in the USG P-16 Department. Annual USG cost: $200,000.

Total Annual Cost: $5 million.

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Attachment A

Defining PRISM K-16 Learning Communities

PRISM
Partnership for Reform in Science & Mathematics

K-16 Learning Communities provide opportunities for K-16 educators to share what they know, consult with peers about problems of teaching and learning, and observe others at work. They promote a commitment to the following set of values which builds community and respect for diverse ideas:

- As their primary focus, the trying, testing, verifying, and replicating of teaching practices deemed to have a positive impact on student learning in science and mathematics in schools, colleges, and universities.
  - Practices that inform teaching in schools and colleges.
  - Practices that inform teacher preparation.
  - Practices that inform professional learning.

- A shared vision of teaching and learning among K-16 faculty participants.
  - A vision of high quality work for students that includes intellectually challenging tasks.
  - A vision than embodies effective practices, such as guided inquiry, cooperative learning, contextual teaching and learning, conceptual change, and problem-based learning.

- Collaboration between K-12 and higher education faculty.
  - They provide opportunities for K-16 educators to find solutions to vexing problems in the teaching and learning of science and mathematics.
  - They eliminate the isolation of faculty in the classroom.

- Shared leadership by faculty from schools, colleges, and universities—learning communities are faculty led.
  - They provide opportunities for K-16 educators to reflect on practice and work with others to improve practice.
  - They are supported by the school, college, and university administration.

- Making the work of learning community participants public.
  - Learning community members share their work, making it open for discussion, verification, refutation, and modification.
  - Learning community members share effective and authenticated practices across schools, districts, regions, the state, and nation.

- Results oriented work.
  - That leads to improved student achievement.
  - That leads to improved teaching and learning of science and mathematics.

- Collaborative inquiry.
  - Reflect on and assess their teaching.
  - Explore and test new ideas, methods, and materials (implement a plan for improvement).
  - Assess effectiveness of plan for improvement (collect and analyze student achievement data and teacher effectiveness data).
  - Make decisions about which new approaches work and why.

Attachment B
Structured Abstract Template for PRISM Mini-Grants

Background/Context: Description of prior research on the subject and/or its intellectual context and/or its policy context.

Purpose/Objective/Research Question/Focus of Study: Description of what the research focused on and/or why.

Setting: Specific description of where the research took place.

Population/Participants/Subjects: Description of the participants in the study: who (or what), how many, key features.

Intervention/Program/Practice: Specific description of the intervention, including what it was, how it was administered, and its duration.

Research Design: Description of the research design (e.g., qualitative case study, quasi-experiment, secondary analysis, analytic essay, randomized-controlled field trial).

Data Collection and Analysis: Description of plan for collecting and analyzing data, including description of data.

Findings/Results: Description of main findings with specific details.

Conclusions/Recommendations: Description of conclusions and recommendations of author(s) based on findings and overall study.

◆ From Educational Researcher, January/February 2004.

An Example

Structured abstract:

Background: Class size reduction continues to attract attention as a school reform measure. Prior research on the effects of class size has been inconclusive, leading to ongoing controversy and debate about the magnitude, if any, of a "class-size effect" on learning outcomes for children.

Purpose: To assess the effects of a statewide experiment where class size was substantially reduced in kindergarten and first-grade classes.

Setting: 76 public elementary schools drawn from inner-city, urban, suburban, and rural locations in Tennessee. A total of 328 kindergarten classes and 347 first-grade classes participated in the study.

Subjects: 6,570 students enrolled in kindergarten in the 1985-1986 school year

Intervention: Students were randomly assigned by project staff to one of three class types: small (13-17 pupils), regular (22-25 pupils), or regular with a teacher aide (22-25 pupils). Students assigned to small classes stayed in small classes for kindergarten and first grade.

Research Design: Randomized-controlled field trial.

Data Collection and Analysis: The Stanford Achievement Tests in reading and mathematics were administered in the spring of each school year, and a set of Tennessee curriculum-referenced tests were administered at the beginning of first grade. Means on each outcome measure were calculated for each class, then separately for White and minority students in each classroom. Two analyses were conducted using multivariate analysis of variance: a cross-sectional analysis of the entire first-grade sample and a longitudinal analysis of a subset of pupils (n = 2291) who were in the study for both kindergarten and first grade and had complete SAT achievement test data.

Findings: Significant benefits of class size reduction were seen across all academic measures. The cross-sectional analysis of first graders yielded an overall difference of about one fourth of a standard deviation among students in small classes vs. regular classes. Minority students benefited in particular, averaging a difference of a third of a standard deviation over their regular class counterparts on five of the six academic measures. In the longitudinal analysis, students in small classes had a highly statistically significant advantage in reading and mathematics over regular classes in both kindergarten and first grade.

Conclusions: This study demonstrates that small classes have an advantage over larger classes in reading and mathematics in the early primary grades. The analysis also strongly suggests that small classes especially benefit the academic performance of minority students.