SCIENCE EDUCATION IN TEXAS: A SWOT ANALYSIS

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EIGHTH ANNUAL CONFERENCE ON SCHOOL-UNIVERSITY PARTNERSHIPS, SAN ANTONIO, SEPTEMBER 26-28, 2004
High school students are graduating with an unacceptably low level of science and mathematics skills.

There is generally a declining interest in the study of science.

Teachers are being blamed for having inadequate preparation and lack of competence in content and pedagogy.

Students do not learn physics concepts very well under traditional classroom instruction.

They memorize “plug and chug” techniques, get 80% on a physics exam, but only score 50% on a multiple choice concept survey.

The general perception is that scientists are odd and peculiar people, scientists have few other interests but their work, scientific work is dangerous, and that physics is old-fashioned, outdated, irrelevant to modern society.

THE PROBLEM - MULTI-DIMENSIONAL
The supply of scientists and engineers is dependent on the choices young people make at 16.

These choices in turn are determined by the nature and quality of science teaching earlier in their schooling.

The woeful lack of science teachers, particularly in the physical sciences, is of utmost concern.

Only those with confidence and competence can teach a subject well, engaging and enthusing pupils, and motivating them to pursue science and engineering careers.
SCIENCE AND MATHEMATICS EDUCATION: A NATIONAL PRIORITY

“No Child Left Behind

President George W. Bush

“The federal role in education is not to serve the system. It is to serve the children”

“Strengthening Math and Science Education. K-12 math and science education will be strengthened through math and science partnerships for states to work with institutions of higher education to improve instruction and curriculum.”
SCIENCE AND MATHEMATICS EDUCATION: A NATIONAL PRIORITY

“We as a nation must take immediate action to improve the quality of math and science teaching in every classroom in the country. If we delay, we put at risk our continued economic growth and future scientific discovery.”

- Senator John Glenn

“The Glenn Commission”
SCIENCE AND MATHEMATICS EDUCATION: A NATIONAL PRIORITY

“Education is the foundation of America’s future...education in science, mathematics, and engineering has special relevance for the future of U.S. national security, for America’s ability to lead depends particularly on the depth and breadth of its scientific and technical communities.”

“The Hart-Rudman Commission”
“The number of college students in many of the scientific and engineering fields relevant to nuclear weapons work is shrinking while the overall needs in the economy for such graduates continue to grow…The long-term challenge is to restore an adequate flow of new talent.”
Bingaman said the “shortage could impact the ability of DOE labs, like Sandia and Los Alamos National Laboratories, to recruit nuclear scientists and engineers that play a vital role in protecting our national interests.”

Domenici warned: “We just aren’t training enough new specialists to continue to support the wide range of critical initiatives in this country that require nuclear engineering knowledge.”
National Center for Education Statistics. *The Nation’s Report Card*
STRENGTHS

• Affordable, accessible education for a large and diverse student population.
• Strong collaborative student-faculty interactions within and outside of the TAMU System based on close mentoring relationships in laboratory-intensive undergraduate education.
• Research-focused undergraduate and graduate degree programs.
• Preparation of K-12 teachers
• Highly qualified faculty with broad expertise and a variety of interests.
• Administrators who understand the need to support the state’s economy via enhanced educational opportunities.
• Access to state-of-the-art instrumentation and facilities.
• Close involvement with state and national educational centers and institutions.
• Extensive grants support programs for research, curriculum development, professional development, and other joint ventures with industry and government.
• National mandates, national and state level commitments, state performance measures
• Commitment to education at all levels from Governor Rick Perry
“Texas is actually ahead of some other states in one respect. With the establishment of the State Board for Educator Certification and more rigorous standards for teacher education programs, the state has already placed an importance on producing more qualified teachers.”

- Kati Haycock, Education Trust
WEAKNESSES

• Heavy teaching and administrative loads limiting university and school faculty time for professional development in education related activities
• Formula-driven rather than need-driven space, funding and equipment allocations
• Increasing difficulty in designing and developing technology-intensive curricula
• Noncompetitive salaries and insufficient start-up funding for new hires
• Inadequate technical staffing
• Uneven infrastructure for contract and grant support
• Lack of faculty awareness regarding the practice of science in the private sector
• Uneven coordination among campuses, making it difficult to articulate programs
WEAKNESSES

• Emergency hiring of teachers
• Assignment of teachers outside their fields of preparation
• High turnover in underfunded schools
• Covering many science concepts
• Teaching inquiry as a set of processes
• Separating science aspects
• Activities that verify science content instead of investigating science questions
• Process & lab skills out of context with content as opposed to integrating the content
By law, making students better at reading and math is nation’s priority but when it comes to science a quiet crisis is engulfing schools.

Science is becoming a second-class subject. For instance, under the NCLB, all students in grades 3-8 must be tested annually in reading and math. But science all students must be tested at least once in elementary, middle and high school.

Teachers say they need a lot of help, mainly in professional development and enough class time to be creative. The new federal emphasis on testing and assessment is taking away from the opportunity for discovery and wonder in their classrooms.

Students skip challenging science courses in school.

Disconnect between labs and real world.
The Leave No Child Behind Education Act, passed by Congress last year and signed into law by President Bush on Tuesday, sets aside funds for science and math. However, only $12.5 million was set aside.

Given around 16,000 school districts, this amounts to approximately $7812 per school district.

Put in perspective, that is half of what the Agriculture Department will spend on insect pest control and half of what NASA will spend to repair its vehicle assembly building.

Across hundreds of thousands of classrooms nationally, it would barely create a ripple of change, let alone the wave that the National Assessment of Educational Progress results show we so desperately need.
OPPORTUNITIES

• Texas is one of the leading states in the research and development of biotechnology products.
• TAMUS is a major contributor.
• Houston is an international leader in the energy market.
• Unprecedented need for bachelor’s and master’s level employees.
• Addition of faculty positions in relevant departments System wide.
• Faculty and teacher expertise that industry finds of value.
• System-wide efforts to obtain funding from federal allocations, private foundations, and public granting agencies.
• Industry as a source of equipment, supplies, students, advisors and adjunct faculty.
• Increasing number of community colleges, faculty and programs.
• Increasing awareness for science and technology workforce issues in legislative and government offices.
• Texas’ 227,000 farms that cover 131 million acres, more than twice the number of any other state.
• Since the private sector owns the vast majority of Texas’ infrastructure, such as agricultural and food distribution facilities, utility companies and transportation systems, a close partnership between the federal government, state government and the private sector is necessary in identifying and eliminating any potential threat to our existing critical infrastructure.
• Diverse student population
• Use of distance learning for dissemination of courses and seminars
• Texas’ economic base in industries such as NASA, aerospace, energy, agriculture.
• Governor Perry’s renewed commitment to support for schools.
THREATS

- Lack of understanding of science issues by the public.
- Perception that our teaching mission precludes research activities.
- Economic and budgetary uncertainties in Texas and Texas schools in particular.
- Competition from for-profit, distance learning-based universities.
- Diverse philosophies on training, education.
- Declining pre-college student achievement.
- Declining enrollments in science, especially physics majors.
- Incompatibility of science education to the current needs of the industry, the state and the nation.
- Diminishing resources for education
- U.S. industry under threat from foreign competitors despite leading scientific excellence
- Globalization of industry and markets
- Disconnect between academe and industry
- Homeland security
MAJOR WEAKNESS

Implementation!

Implementation!!

Implementation!!!
State Science Standards

An Appraisal of Science Standards in 36 States

by

Lawrence S. Lerner
California State University, Long Beach
• The *Texas Essential Knowledge and Skills* or *TEKS* is well organized, logical, largely error-free, and carefully graded according to demanding but realistic expectations concerning the intellectual development of growing children.

• However, an overall discourse is lacking, giving the document the flavor of an extended shopping list rather than a guide to the teaching of the highly structured discipline of science.

• *TEKS* would have scored B if its list format had not obscured such general principles as the importance of written and oral expression, of error analysis, of students' growing abilities in various areas, of the significance of scientific methodology, and of the connections between science and technology.
The California Science Framework is unusual in that the standards are presented in the form of short essays rather than as lists of topics.

The approach gives weight to the important concept that the sciences are tightly integrated bodies of knowledge, and not mere lists of things that the student is expected to know.

It also gives strong suggestion, by example, as to how a textbook might be constructed.

The fundamental organizing principles of all the sciences are explicitly discussed, and the Framework is built around them.
• The Illinois Learning Standards includes, as one of its three major goals, the following: "Understanding the fundamental concepts, principles, and interconnections of the life, physical and earth/space sciences."

• The individual items in the standard are terse but complete, and the corresponding expectations that students are to meet are well-chosen, as are the examples that illustrate them. Most of the expectations are age-appropriate; the only exception I found was one which (perhaps over-ambitiously) expects early-high school students to "explain and predict motions in inertial and accelerated frames of reference."

• At 10 pages long (plus about five pages of general introductory material covering all subjects), the science Standards is about as short as such a document might be.
## Quick Comparison

<table>
<thead>
<tr>
<th>State</th>
<th>Purpose, Expectations, and Audience</th>
<th>Organization</th>
<th>Coverage and Content</th>
<th>Quality</th>
<th>Negatives</th>
<th>Raw Score (out of 75)</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>10</td>
<td>9</td>
<td>26</td>
<td>15</td>
<td>12</td>
<td>72</td>
<td>A</td>
</tr>
<tr>
<td>Illinois</td>
<td>10</td>
<td>9</td>
<td>22</td>
<td>15</td>
<td>12</td>
<td>68</td>
<td>B</td>
</tr>
<tr>
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<td>10</td>
<td>9</td>
<td>20</td>
<td>15</td>
<td>12</td>
<td>66</td>
<td>C</td>
</tr>
<tr>
<td>Arkansas</td>
<td>6</td>
<td>6</td>
<td>17</td>
<td>8</td>
<td>9</td>
<td>46</td>
<td>F</td>
</tr>
<tr>
<td>Louisiana</td>
<td>11</td>
<td>9</td>
<td>23</td>
<td>15</td>
<td>12</td>
<td>70</td>
<td>B</td>
</tr>
</tbody>
</table>
A new study asks why, despite decades of reform, massive infusions of funds, aggressive efforts by policymakers, and the strong commitment of educators, there is no significant improvement in academic proficiency of high school graduates, closure of the achievement gap, and increase in high school graduation rates.

*From the study, Paying For Education, Texas Public Policy Foundation co-published with the Milton and Rose D. Friedman Foundation.*

STATE BOARD OF EDUCATION (SBOE) PROPOSED HIGH SCHOOL SCIENCE REQUIREMENTS BEGINNING IN 2005-06

One credit must be a biology credit (Biology, Advanced Placement (AP) Biology, or International Baccalaureate (IB) Biology).

Two credits from (no more than one credit from each of the areas): (i) Integrated Physics and Chemistry (IPC), (ii) Chemistry, AP Chemistry, or IB Chemistry, and (iii) Physics, Principles of Technology I, AP Physics, or IB Physics.

One credit from one of the following areas:

I. Geology, Meteorology, and Oceanography (GMO);
II. Environmental Systems;
III. Aquatic Science;
IV. Astronomy;
V. Anatomy and Physiology of Human Systems;
VI. AP/IB Biology;
VII. AP/IB Chemistry;
VIII. AP/IB Physics;
IX. AP/IB Environmental Science; and
X. Scientific Research and Design.

Little meaningful content can be adequately taught in this way.
### Percentage of Time Spent on Core Disciplines

<table>
<thead>
<tr>
<th>Subject</th>
<th>Average</th>
<th>Range</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Language arts</td>
<td>41%</td>
<td>14%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>20%</td>
<td>14%</td>
</tr>
<tr>
<td>Science</td>
<td>10%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Social Studies</td>
<td>12%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Humanities (art, music, dance)</td>
<td>7%</td>
<td>0%</td>
</tr>
<tr>
<td>Physical Education</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Foreign Language</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

1994-1995 Maine Public School Census Survey
We need to rethink our goals and approaches!
It is important to note that Standards set a floor, not a ceiling, on what students are expected to learn.

Good standards are not a magic solution to the problem of improving science teaching and learning in our schools.

In the primary grades, in particular, there is a crying need to improve the science knowledge of the teachers.

In our high schools, only a small fraction of all those who teach physics majored in the subject in college.
FRAGMENTATION

What policymakers decide should be done.
(minimal standards/benchmarks)

What teachers do.
(teach to the test)

What students learn.
(how to pass tests)

Questions:
Is this adequate? Does this meet the state’s and nation’s workforce needs?

P-16 alignment between various stages of the educational process is not enough.
TODAY’S STUDENT IS DIFFERENT!

Traditionalists: Build a Legacy
Baby Boomers: Build a Stellar Career
Generation X: Build a Portable Career
Generation Y: Build Parallel Careers
PVAMU’S APPROACH
A SYSTEMIC SOLUTION

Components of our approach:

- Interactive Learning Environment - Science Education Center
- Student projects - relevant to learning and real world
- Teacher-Faculty collaboration - Teacher In Residence, Faculty In Residence, continual feedback and assessment
- Involvement of parents and community leaders in student development
- Sustainability via throughout-the-year mentoring, periodic interaction with university and industry personnel, and building communities of practice.
We in the Physics Department have initiated a large-scale effort on enhancing awareness of science and mathematics to school students, parents, teachers and community leaders.

We substantially restructured our academic program to be more relevant to tomorrow’s world, updated and upgraded our laboratories, and improved all our services to our customers.

We established a Science Education Center for middle and high school students and teachers so as to enhance their awareness for science and its relevance to the world.

Our efforts are aligned well with Governor Perry’s Texas Science Initiative and the Texas A&M University System’s Regents' Initiative.

The synergy among these efforts meets the goals in the Closing the Gaps Plan of the Texas Higher Education Coordinating Board as well as exceeding the national science standards.
THE ACADEMIC ROADMAP

Feedback-Assessment-Continuous Refinement

Drivers

Enablers/Influencers

Implementers

Student Standards

Teacher Standards

LNCCB

State/TAMUS Expectations

PVAMU

Curriculum Alignment

EHS

Aligned Curricula

New Courses/Programs

Systematic Interfaces

Admission Policies

Collaborative Research

Parents/Community

HCCS

Teacher Preparation

Drivers Enablers/Influencers Implementers
Alignment is A Good Starting Point But More is Needed!

**School Curriculum** → **College Curriculum** → **Workforce Preparedness**

### A MORE REALISTIC PICTURE

- Uneven Curriculum
- Limited Physics Requirements
- Inadequate Teacher Preparation
- Inadequate # of Physics Teachers
- Inadequate exposure to physics
- Diverse Curricula
- Content vs. Pedagogy
- Lack of interested faculty
- More focus on content, less on how to teach
- Workforce Preparedness

- Several successful efforts, but not scalable or sustainable
- Partial involvement in curricular preparation
- Little, if any, involvement in curricular preparation
Joint Collaboratories between school and university campuses

Joint proposal development for funding

Dual Credit programs in physics and chemistry

Go Center interactions
Strategic Plan Development
College/Workforce awareness programs

Pre-service and In-service Teachers internships
Students learn best when they study subjects in the context of a personal or social application, and with hands-on instruction and activity-based experiences.
SCIENCE EDUCATION CENTER
SELECTED PROJECTS

ROLLERCOASTER
ROBOT PITCHER
SCIENCE EDUCATION CENTER
SELECTED PROJECTS

FERRIS WHEEL
SCIENCE EDUCATION CENTER
SELECTED PROJECTS

ROLLERCOASTER
CYBERSWARM
SCIENCE EDUCATION CENTER
SELECTED PROJECTS

IMPACT MACHINE
SCIENCE EDUCATION CENTER
SELECTED PROJECTS

ROLLERCOASTER
SCIENCE EDUCATION CENTER
SELECTED PROJECTS

IMPACT MACHINE
PENDULUM
ROLE OF SEC IN TEACHER PREPARATION

- Students from the colleges of education and in-service teachers will be exposed to field-based classroom activities in addition to the laboratory sections they enroll in physical science courses.
- The SEC also allows students from the colleges of education start their field-based classroom activities earlier via their involvement in student projects.
- The SEC provides a practical perspective rather than just a theoretical approach to pedagogy.
- It will provide an excellent framework for teacher-faculty collaborations to explore new techniques of teaching and for publications in physics education research.
- It will provide an excellent venue for linking teachers with industry personnel.
A Science Teacher In Residence (STIR) Program to recommend to the physics faculty curricular revisions.

STIR can serve as a reality check for pre-service teachers and university faculty.

STIR can use this experience to develop professionally, in particular obtain graduate degrees.

A mentoring program conducted by STIRs can provide induction experience for pre-service and novice science teachers.

Create and disseminate a list of appropriate Internet sites appropriate to age groups.

Create an Internet community for each student group - history, cultures, sharing of information, etc.
4 Middle/High School students participating in a series of projects during June-July.

16 11th-12th graders (Summer Transportation Institute) from across Texas participated in 1-day event on 23rd June.

A strategic planning session was held with Bellville and Royal High Schools in August.

A half-a-day meeting with science teachers is being planned for science and mathematics teachers from Waller, Hempstead and Royal HS in July.
SEC’S ACTIVITIES THIS FALL

- Students, teachers, parents from Waller, Hempstead, Royal, and Eisenhower HS will participate in 1-day project building events at least once a month.
- Physics Faculty/Staff visiting schools with Mobile Labs.
- Physics Department hosting science teachers’ webpages with news and resources updated frequently.
- Periodic meetings between physics faculty and science teachers to continually evaluate and assess activities, plans and determine future actions.
- Prepare and submit collaborative proposals for simultaneously enhancing the schools and the university.
- Enhance programs for teacher development - professional development and educational advancement.
PVAMU’S APPROACH SUPPORTS THE TEXAS SCIENCE INITIATIVE

Still under development by the Texas Education Agency, the Texas Science Initiative aims to eliminate student performance gaps in science by developing and implementing training for science educators, improving the quality of science instructional materials and creating higher standards for science education.

http://www.governor.state.tx.us/priorities/education/perryrecord
Where beauty and science meet

Allie Shah, Star Tribune
August 20, 2004

What do lip gloss and lotion have to do with science?

Some 40 seventh- and eighth-grade girls studied the chemistry behind cosmetics during a novel 10-week summer course designed to get girls their age hooked on science.

Jennifer Rose, a Minneapolis public school science teacher, helped develop the class with a $10,000 grant from the Toyota Foundation for science education.

Called MakeUp Your Mind, the course was part of a free summer program run by the Minneapolis Public Schools and Augsburg College in Minneapolis.

It's tied to Girls in Engineering, Mathematics and Science (GEMS), an after-school and summer program offered to Minneapolis girls in fourth through eighth grades.
The Bologna declaration, made in June 1999 in Bologna by the higher-education ministers from 29 European nations (now signed by 40 nations), commits their governments to reforming their university systems to create a so-called European Higher Education Area by 2010.

The declaration has four ambitions.

(i) Improve the quality and effectiveness of the education provided by Europe's universities, particularly so that graduates are more employable.

(ii) Promote mobility of students, especially graduates.

(iii) Make European universities more attractive in the emerging global market for students.

(iv) Extend the notion of a European "identity" from politics and economics into the cultural and educational spheres.
"Any country with an old-fashioned or peculiar degree structure will run the risk of having problems in relation to other countries, and its students may suffer when their degrees are not understood by foreign employers. If we want to create a competitive common European labor market, a common degree structure will be essential."

- Torsten Kälvemark, International Developments in higher education for the Swedish government
£1billion Boost for UK Science
The UK government announced that it will increase its annual expenditure on science by more than £1bn over the next three years.

Indian Scientists Welcome Broad Increase in Funding
Science spending is to get a major boost under a budget laid out on 8 July by India's new Congress-led government. Total expenditure on research and development will increase by almost a quarter to Rs 152 billion (US$3.3 billion) under the budget for the financial year which began in April.

Budget Delays Threatens to Leave US Scientists in Limbo
Science lobbyists in Washington are feeling tense about the state of the US budget. Indications seem to be that science agencies are unlikely to get much in the way of new funds even when the spending bills do pass.
Standards in Science Education

Need to strengthen the bridge

- NMLB
- Limited professional development
- Public perception

Implementation of Science Education

The Valley of Death

The Chasm Between Standards and Implementation!
“There are young people out there cutting raw cocaine with chemicals from the local hardware store. They are manufacturing new highs and new products by soaking marijuana in ever changing agents, and each of these new drugs is more addictive, more deadly, and less costly than the last. How is it that we have failed to tap that ingenuity, that sense of experimentation? How is it that these kids who can measure grams and kilos and can figure out complex monetary transactions cannot pass a simple math or chemistry test?”

- Senator Kohl, from the U.S. Senate Hearing: "Crisis in Math and Science Education"
We have heard more frequently since Sept. 11 that eternal vigilance is the price of freedom. But the next generation will be hard-pressed to maintain that vigilance in an age of threats of chemical or biological attacks or sabotage in cyberspace if we fail to grasp that scientific knowledge is our countervailing weapon.

More than 180 years ago, Thomas Jefferson wrote of "a conviction that science is important to the preservation of our republican government, and that it is also essential to its protection against foreign power." We need to preserve and protect the nation more than ever, and we must prepare scientifically literate children today to do the same tomorrow.

- Craig R. Barrett, Former CEO of Intel, January 10, 2002
http://www.quotegarden.com/teachers.html
Most teachers have little control over school policy or curriculum or choice of texts or special placement of students, but most have a great deal of autonomy inside the classroom. To a degree shared by only a few other occupations, such as police work, public education rests precariously on the skill and virtue of the people at the bottom of the institutional pyramid. ~Tracy Kidder

Teaching is the only major occupation of man for which we have not yet developed tools that make an average person capable of competence and performance. In teaching we rely on the "naturals," the ones who somehow know how to teach. ~Peter Drucker

Teachers are expected to reach unattainable goals with inadequate tools. The miracle is that at times they accomplish this impossible task. ~Haim G. Ginott

When a subject becomes totally obsolete we make it a required course. ~Peter Drucker
Thank You For Your Attention!
ANY QUESTIONS?

Support from the Regents’ Initiative &
The US Department of Education
is Gratefully Acknowledged.
WE ARE A NATION OF EXPLORERS.

Please visit us at
http://www.i2i.pvamu.edu/physics