

*Recommendations to Improve Science,
Technology, Engineering and Mathematics
(STEM) Education in California*

HIGH STAKES: STEM Education

The Essential Ingredient for California Competitiveness



This STEM Collaborative Action Plan is a Product of

The California Space Education and Workforce Institute (CSEWI)

developed with the support of

The Alliance for Regional Collaborations to Heighten Educational Success (ARCHES)

November 2008

"Today's educators are preparing students for jobs that don't yet exist using technologies not yet invented to solve problems not yet identified."

*— Rick Stephens, Senior Vice President, Human Resources,
The Boeing Company*



*May, 2007 Science, Technology, Engineering and Math Collaborative Action Plan Forum:
(l to r) Rick Stephens, Senior Vice President, Human Resources, The Boeing Company;
Mike Gallo, President/CEO, Kelly Space and Technology, Inc./STEM CAP Advisory Group
Chairman; Paula Arvedson, PhD, President, California Space Education and Workforce
Institute Board of Directors; Jack O'Connell, Superintendent of Public Instruction; Warren
J. Baker, President, California Polytechnic State University/CSU Math and Science Teacher
Initiative; Hon. Andrea Seastrand, Executive Director, California Space Authority*

"Science instruction has never been more important in our schools. We now live in a technological age, where information is expanding exponentially. Our students need to become lifelong, critical scientific learners. While California has led the world in many scientific and technological advances, the global economy is increasingly competitive. For California to maintain its position as one of the leading economies in the world, we must take steps now to improve instruction in science, as well as English and math."

*— Jack O'Connell, Superintendent,
California Office of Public Instruction*

*Recommendations to Improve Science,
Technology, Engineering and Mathematics
(STEM) Education in California*

HIGH STAKES: STEM Education

The Essential Ingredient for California Competitiveness

**Goal:
Science, Technology,
Engineering and Math (STEM)
Collaborative Action Plan**

Develop a collaboration and strategic action plan to increase the number and support the development of Science, Technology, Engineering and Math students, graduates, teachers, professors and mentors within the California Innovation Corridor and the State of California, leveraging the resources and efforts not only of education and academia (K-20, public and private) but of industry and the informal science network.

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CALL TO ACTION

As the chair of the Science, Technology, Engineering and Math Collaborative Action Plan (STEM CAP) Advisory Group, I would like to issue a challenge to California industry leaders as well as leaders in government, education, and science. Please join me in supporting a common agenda that puts California back in the lead of innovation in science, technology, engineering and math. In order to do this, we need a systematic, sustained effort that improves the support for STEM education in our schools. We must put aside our short-term episodic thinking and coordinate efforts to seed new innovation, incubate promising practices and scale successful programs. This STEM Collaborative Action Plan provides recommendations and actions that will put California on the path to create a well-trained workforce essential to our economic vitality and competitiveness.



In June, 2005, the Public Policy Institute of California (PPIC) issued a report entitled California 2025: It's Your Choice, with this concluding statement on the economy, "One of the most threatening trends is the potential mismatch between the educational requirements of the new economy and the amount of education its future population is likely to have."

One way to address this issue is to improve our schools in order that more students are prepared to meet California's present and future STEM workforce needs. The jobs are there now and will be there in the future if we can produce adequate numbers of students with the skills required by industry needs. The rigors of math, science, engineering and technology can be combined in demanding, innovative curriculum supplemented by hands-on career technical education classes that prepare students for both higher education and the workplace.

Unlike other reports, the STEM CAP will not be moved aside to a shelf. This document lays the groundwork for a collective California approach to STEM while defining very specific priorities for the state. It combines the base of multiple national STEM reports and the best thinking of approximately 500 California stakeholders into a document that represents what they see as the priorities for success. It also reflects the reality of the hard work that is going to be needed to launch a coordinated effort needed to make substantive changes in the current state of education and workforce preparation. The STEM CAP is accompanied by a statewide STEM inventory of programs and promising practices coordinated by the California Space Education and Workforce Institute (CSEWI). Through Workforce Innovation in Regional Economic Development (WIRED) grant funding from the U.S. Department of Labor, the California Space Authority, and the Institute, the recommendations from this report have been pilot tested in six regions around the state of California working through the Alliance for Regional Collaborations to Heighten Educational Success (ARCHES).

I would like to thank all involved in the creation of the STEM CAP. The STEM CAP Advisory Group comprised of 16 members representing leaders in education, informal science, industry, federal laboratories, and government provided important feedback and guidance to this effort. Gratitude is due NASA for providing the organizing principle for the recommendations and ARCHES leadership, with specific accolades to Jane Zinner, who facilitated the complex process of developing this report, convening participants in over 25 focus groups around the state. Lastly, appreciation must go to the California Space Authority for the STEM CAP vision and bringing federal resources to develop it, to California Space Education & Workforce Institute for convening key partners and stakeholders to address the issue.

I urge industry leaders to participate in supporting the STEM CAP recommendations by getting involved in the six pilot regions and supporting full implementation of the actions steps outlined in this report, including the creation of a new, independent State STEM Council that will champion this work.

Please join me in inspiring, engaging, educating, and employing an expanded California STEM workforce.

Michael J. Gallo

President and CEO
Kelly Space & Technology, Inc.

"In 1970, the U.S. produced more than 50 percent of the world's science and engineering doctorates. If current trends continue, by 2010, the U.S. will produce only about 15 percent of the world's science and engineering PhDs."

— *standardandpoors.com*

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APPENDICES

The STEM Collaborative Action Plan is viewable online at:

<http://www.innovatecalifornia.net/documents/STEMCAPDOC.pdf>

<http://www.csewi.org/documents/STEMCAPDOC.pdf>

The Science, Technology, Engineering and Math Collaborative Action Plan (STEM CAP) has been funded by the California Space Authority, through the California Labor and Workforce Development Agency, as part of the California Innovation Corridor "Workforce Innovation in Regional Economic Development (WIRED)" grant from the U.S. Department of Labor.

EXECUTIVE SUMMARY

RECOMMENDATIONS TO IMPROVE SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) EDUCATION IN CALIFORNIA

HIGH STAKES: STEM EDUCATION

ESSENTIAL INGREDIENT FOR CALIFORNIA COMPETITIVENESS

The 20th Century California is noted worldwide for its innovation, knowledge creation and research discoveries that can be attributed to a steady stream of individuals proficient in Science, Technology, Engineering and Mathematics (STEM). STEM expertise has produced exponential returns on investment for California and the nation and is inarguably an essential component for sustained economic prosperity. The benefit to the 21st Century California by sustaining this legacy of world-renowned success through a deliberate, focused investment and commitment to STEM is priceless. The outcome for a 21st Century California which decides to defer attention and investments in STEM to more prosperous times is an economic downward spiral for California's children and grandchildren.

Goal: **Science, Technology, Engineering and Math (STEM) Collaborative Action Plan**

Develop a collaboration and strategic action plan to increase the number and support the development of Science, Technology, Engineering and Math students, graduates, teachers, professors and mentors within the California Innovation Corridor and the State of California, leveraging the resources and efforts not only of education and academia (K-20, public and private) but of industry and the informal science network.

The stakes are high. California students today have limited interest in studying mathematics and science, the number of teachers well trained in these subjects is not sufficient and attempts to remedy the situation are too modest and fragmented. Preparation for STEM success is one concern. Equally important are trends in the overall supply and employment of STEM workers. The STEM workforce challenge is not just about the supply and quality of those with advanced degrees; a large percentage of the workforce in California industries that rely on STEM knowledge and skills are technicians and others who enter and advance in their field through career technical education (CTE) programs, two-year degrees and certificates. It is imperative that California leaders demonstrate their commitment to all levels of science, technology, engineering and mathematics while motivating our youth to innovate and invent, thus ensuring sustained economic growth for our great State. It is time to invest in our workforce of the future in ways that are strategic, scalable and sustainable.

Accomplishing these crucial goals will require a transformational change in California. This report, "High Stakes: STEM Education," provides a comprehensive action plan to address the fundamental issues and set California on the path to lead the nation in STEM education and ensure that California retains its competitive edge and economic vitality.

The recommendations and guiding principles in "High Stakes: STEM Education" are the result of a major U.S. Department of Labor-funded initiative in California with the goal of establishing a system that will support a sustainable growth economy, create a highly-skilled 21st Century workforce and maintain the state's position of leadership in the global technology market. That system must educate, graduate and employ an exemplary STEM workforce that can drive innovation and invention and propel California's economy, thereby ensuring that it retains a world-wide leadership role. These are nothing short of essential ingredients for California's competitiveness.

EXECUTIVE SUMMARY

GUIDING PRINCIPLES

To compete effectively for the minds, imaginations and career ambitions of America's young people, "High Stakes: STEM Education" proposes a set of guiding principles, recommendations and actions. The guiding principles are the foundation for the recommendations. Without these principles, the recommendations will have minimal impact. The guiding principles establish a new relationship among industry, education and the informal science network.

Shared Vision by Leaders Business and education leaders, in concert with partner stakeholders, must work collectively as strong advocates to create an entity outside of the conventional system that brings together stakeholders to tackle the issues that are beyond the resources of education. Such a collaborative effort will send a strong signal to all Californians that our best and brightest are needed, valued and supported.

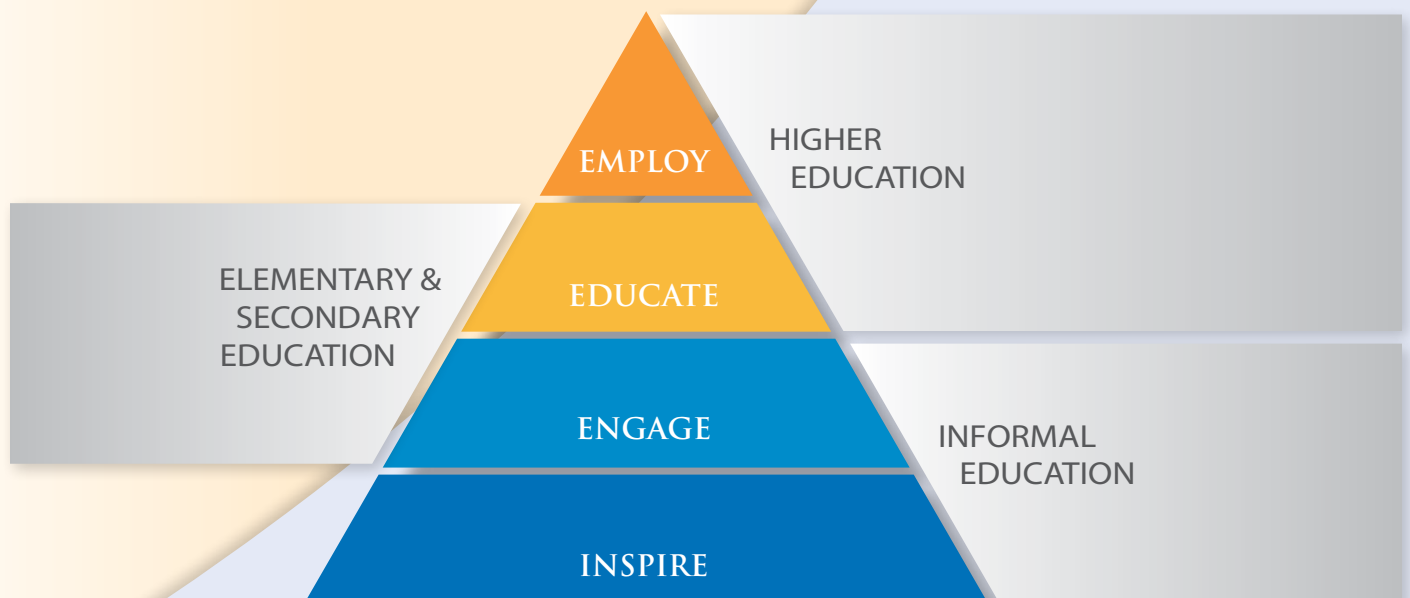
New Relationships to Leverage Resources At the core of achieving the STEM CAP recommendations is building relationships that are sustained over time. This collaborative action plan lays out a structure that will leverage the resources of education, industry and informal science.

Sustained Commitment with a Policy of R&D and Ability to Scale The recommendations of the STEM CAP require a sustained effort and on-going statewide commitment. Taking the lead from industry's practice of research and development, education initiatives must begin with focused pilots that are fully funded with clear metrics, supported by a system that has the resources to scale the most promising.

Regional Approach Improving STEM programs throughout California will require strong local commitment and regionally tailored approaches. It involves coordinating education, business and labor to ensure all elements needed for successful programs are in place.

Inspire and Engage Building on NASA's Education Strategic Coordination Framework, an Agency portfolio approach to education, the STEM CAP addresses the stages of inspiring, engaging, educating and employing students, the future workforce. The goal is to direct a subset of the original audience through the pipeline to pursue a career in STEM while drawing in new participants along the way.

http://education.nasa.gov/pdf/151156main_NASA_Booklet_final_3.pdf



EXECUTIVE SUMMARY

The recommendations in “High Stakes: STEM Education” are linked to the NASA Education Strategic Framework and its four categories of increasing involvement – inspire, engage, educate and employ. No matter where the individual decides to pursue his or her career, the goal is to direct a subset of the original audience through the educational process to pursue a career in STEM fields while intentionally drawing in new participants along the way.

INSPIRE

RECOMMENDATION: Motivate students and adults, using a variety of incentives, to study and enter STEM careers, with a special effort geared to those in currently underrepresented and underserved groups.

RECOMMENDATION: Build public support for and understanding of the value of STEM education for all students and citizens.

ENGAGE

RECOMMENDATION: Provide rigorous, relevant Career Technical Education (CTE) that prepares students for both higher education and the workplace in order to reinforce classroom instruction and provide tangible relevant skills for greater subject matter retention and competency.

RECOMMENDATION: Deliver science and math curriculum that motivates, energizes, reinforces and rewards the natural curiosity and interest students initially bring to the subject.

EDUCATE

RECOMMENDATION: Align state K-12 science and mathematics standards and assessments with postsecondary and workforce expectations of what high school graduates should know and be able to do.

RECOMMENDATION: Implement a comprehensive package of recruitment strategies for mathematics and science teachers throughout grades K-12 to expand and diversify the pool of fully prepared and certified candidates.

RECOMMENDATION: Strengthen teacher preparation programs in mathematics and science through inclusion of hands-on, problem-based instruction and strategies that will benefit all students, including underrepresented and underserved students.


RECOMMENDATION: Provide ongoing, research-based professional development programs, focused on both content and pedagogy, for all mathematics and science teachers and faculty K-Higher Education.

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EMPLOY

RECOMMENDATION: Create Industry partnerships directly engaged with educators to deliver relevant, motivational and exciting instruction to reinforce and enhance STEM curriculum while setting the foundation for building a competitive and qualified workforce in tune with emerging work realities.

RECOMMENDATION: Create hands-on internships and fellowships for students, teachers & faculty with employers in industry, academia, informal science networks, and civic organizations.

 *“Although America has not wavered from its understanding of the power and potential of math and science, it has failed to comprehend that in the highly competitive global economy of the 21st century, math and science are no longer pursuits for the few. They are required for all.*

— A Commitment to America’s Future: Responding to the Crisis in Math and Science Education, Business Higher Education Forum, 2005

CALIFORNIA SPACE AUTHORITY AND THE CALIFORNIA INNOVATION CORRIDOR WIRED INITIATIVE



"Innovation will be the single most important factor in determining America's success through the 21st century"

— Council on Competitiveness, Innovate America

Originally comprised of 60+ private and public sector partners spanning 13 California counties, the California Innovation Corridor was spawned as a result of the U.S. Department of Labor's 2005 Workforce Innovation in Regional Economic Development (WIRED) grant opportunity. In January, 2006, through the California Labor and Workforce Development Agency, the State of California submitted the California Space Authority (CSA)-led WIRED proposal to the U.S. Department of Labor (DOL). In February of that year, the California Innovation Corridor became one of 13 DOL WIRED initiatives nationwide awarded to assist DOL in addressing priorities identified under the American Competitiveness Initiative. For more information about California's Innovation Corridor WIRED initiative, visit: www.innovatecalifornia.net.

The California Innovation Corridor WIRED initiative has as its overarching intention to "optimize the Corridor for innovation and 21st Century workforce competitiveness." Twenty-five separate projects support the initiative, with fourteen of them falling under the category of 21st Century Talent Development. The Science, Technology, Engineering and Math Collaborative Action Plan (STEM CAP) is one of the fourteen projects.

Three signature products form the cornerstone of the Corridor WIRED initiative, fostering the alignment of economic and workforce development and education systems necessary for an innovation culture. The Economic Development Innovation Model and the *Racing for the Future* Workforce Investment Board toolkit address innovation strategies in economic and workforce arenas.

The STEM CAP is the Corridor's third WIRED signature product, and it represents the educational element needed to ensure a globally competitive innovation culture in California. We believe that the STEM CAP is the nation's first comprehensive public/private statewide STEM strategy and that the STEM (statewide) Inventory was also a first.

As program lead for the California Innovation Corridor WIRED grant, the California Space Authority (CSA) is leveraging ten years of experience facilitating education and workforce enhancement. In 1998, CSA established and has facilitated a statewide education and workforce collaborative which has been active in science, technology, engineering and math (STEM)-related activities for a decade. The ongoing work of the California Space Education and Workforce Collaborative spawned the need to launch CSA's affiliate organization – the California Space Education and Workforce Institute (CSEWI). Other CSA STEM-related efforts included, through its State space grant program in the nineties, funding for a graduate program in aerospace at UC Davis, a system design curriculum between industry and CSU Long Beach, support for the Stanford/Cal Poly (San Luis Obispo) CubeSat partnership, space academy projects and infrastructure support for a student satellite sensor project to predict earthquakes. At the Golden State Museum, now the California History Museum, CSA co-sponsored space science exhibits that provided 8000 Sacramento Valley students and their teachers a field trip experience with customized pre and post curriculum activities. CSA also co-sponsored with the National Space Foundation "Space in the Classroom," a STEM-related statewide teacher conference for fourth through eighth grade teachers providing "off-the-shelf," inquiry-based, hands-on classroom curriculum and activities. More recently, CSA assisted the State in attracting the fifty science test takers required to baseline the fast-track teacher foundations exam, providing over 100 test takers to baseline the test now providing a new channel for recruiting science professionals into classroom teaching.

In 2006, CSA supported a corporate project providing a zero gravity experience for 40 teachers, with CSA extending the opportunity to the two California Presidential Teacher awardees.

The California Space Authority, governed by a statewide board of directors, is a nonprofit organization representing the interests of California's diverse space enterprise community in all three domains: commercial, civil and national security. Working closely with the State of California, CSA partners with industry, NASA and other government agencies, workforce entities, education and academia to facilitate statewide space enterprise. CSA is proud to have served as the WIRED program lead enabling the development of the STEM CAP.

The Honorable Andrea Seastrand

Executive Director
California Space Authority

October 2008

Fostering Science Literacy, Enhancing Education and Ensuring a 21st Century California Space Workforce

The California Space Education and Workforce Institute (CSEWI/Institute) is a 501(c)(3) nonprofit which operates in cooperation with its sister organization, the California Space Authority (CSA). The Institute's purpose is to attract, integrate and retain a robust California space workforce and to inspire parents, educators and students to understand, explore and support technical career pathways. www.csewi.org.

The Institute fulfills its purpose through space and technical education program development and support, information and referral, providing a nexus for California space education and workforce development, and supporting production of relevant studies and reports. To implement its programs, the Institute collaborates with the aerospace industry, the State of California, appropriate Federal agencies and other space education and workforce stakeholders.

Through the 2006 U.S. Department of Labor Workforce Innovation in Regional Economic Development (WIRED) grant, the California Innovation Corridor initiative, which is led by the California Space Authority through the California Labor and Workforce Development Agency, the Institute is spearheading and/or participating in eight separate education/workforce projects.

The broadest and most far-reaching of these is the STEM CAP, which CSEWI leads. Leveraging the education/workforce stakeholder network of its affiliate organization the California Space Authority, the Institute convened an impressive steering committee spanning education and academia, government, informal science and industry. Using this steering committee to recruit a statewide collaboration of STEM stakeholders to participate in three STEM CAP forums between 2006-2007, the Institute provided initial guidance for the STEM CAP development through the efforts of its forum working groups and introduced the NASA Education Framework later adopted by the Advisory Group as an organizing principle for the report. Simultaneously, CSEWI put forth a statewide call for STEM-related programs and promising practices to become part of an ongoing statewide effort to identify and describe STEM efforts in education, academia, industry and informal science. Responses to this call populate the STEM Inventory described on page 12.

The STEM CAP Appendices also include synopses of the STEM work of two funded WIRED STEM CAP partner organizations: California Polytechnic State University San Luis Obispo, which analyzed and provides success factors for STEM-related teacher professional development programs; El Camino College, which has facilitated the start-up of Project Lead the Way pre-engineering programs in local high schools. The Institute would also like to thank its WIRED STEM CAP partners: the California Council on Science & Technology (CCST) and Mathematics, Engineering, Science Achievement (MESA) for their support of the forums, stakeholder recruitment and for their STEM insights. A special thank-you to the Office of the Superintendent of Public Instruction, to the Governor's Office of Education, to the University of California President's Office, the Chancellors' Offices of the California State University and California Community College systems and to the Discovery Science Center. We also are grateful to our industry collaborators, with special mention to The Boeing Company, Lockheed Martin and Google.

Much appreciation is due California Space Authority and executive director Andrea Seastrand for early and ongoing STEM CAP WIRED support and leadership. I would also like to recognize WIRED partner Victoria Conner, Strategic Vitality, for providing STEM CAP Forum and project continuity throughout the three year STEM CAP effort.

Well-deserved kudos must go to the Alliance for Regional Collaborations for Heightened Educational Success (ARCHES) in developing the focus groups and the resulting STEM CAP recommendations and actions. The excellent work of ARCHES under the guidance and direction of its executive directors Dennis Galligani and Diane Siri, project director Jane Zinner and STEM CAP Advisory Group chairman Mike Gallo were much appreciated.

Bravo, as well, to all of you who participated and provided the understanding and insight that allowed this broad-based statewide collaboration to identify what we need to do collectively to ensure a competitive 21st Century workforce and ongoing opportunities for our California workers.

Dr. Jack Gregg

Executive Director
California Space Education and Workforce Institute

October 2008



STEM INVENTORY AND STEM CAP-RELATED ACTIVITIES

As all science, technology, engineering and math (STEM) stakeholders know, there are thousands of STEM-related programs and activities occurring in California – conducted by educators, nonprofits, communities, workforce entities, industry, government and the informal science community. Because there has been no central repository through which to find all of these STEM activities, it is nearly impossible to determine if a specific effort is duplicative, or complementary with other STEM efforts currently or previously active. This impacts STEM funder ability to make strategic investments in STEM programs and STEM stakeholder ability to leverage resources and time.

The STEM Inventory initiated and managed by the California Space Education and Workforce Institute (CSEWI) as part of the WIRED grant-funded STEM CAP project, is meant to serve as a centralized and searchable repository for all types of STEM programs, facilitating the opportunity of STEM educators, funders, informal science, industry and nonprofit stakeholders to learn where and how to target their STEM efforts to create the greatest progress. Once critical mass is reached in the statewide STEM Inventory, funders will be introduced to hundreds of potential program models, educators to hundreds of new potential funders, industry to strategic investment opportunities, informal science to potential partners – all supporting STEM collective progress statewide.

The STEM Inventory includes a strong key word search capability, as well as a programs-by-category section, recent additions section and a feature for promising programs. Visit the Inventory to find STEM resources, programs, partners or funders or to share ideas and programs models by uploading your own STEM activities. www.csewi.org/STEM.



El Camino College, STEM CAP partner under the WIRED grant, was not only involved in supporting the STEM CAP Steering Committee and forums, but is piloting in several high schools a promising model program — Project Lead the Way, a pre-engineering, hands-on program complementing math and science college preparatory programs. See Appendix 4 (page A-4).

California Polytechnic State University, San Luis Obispo, under the U.S. Department of Labor-funded WIRED STEM CAP project, has done a study on three California State University-NASA/JPL Collaborative Teacher Professional Development Institutes focused on STEM disciplines, with a potential model developed to serve as a framework for other campuses and institutes to consider implementing. See Appendix 5 (page A-5).

STEM CAP STEERING COMMITTEE

Joe Adams, President/CEO, Discovery Science Center, Santa Ana
Michael Aldaco, Senior Vice President, University of California
Paula Arvedson, PhD, President, Board of Directors, California Space Education & Workforce Institute
Christine Bertrand, Executive Director, California Science Teachers Association
Joan Bissell, EdD, Director, Teacher Education/Public School Programs, Office of the Chancellor, California State University
Gerald Blackburn, President, TEAM Science
Jonathan Brown, President, Association of Independent California Colleges and Universities
Steve Bruckman, Executive Vice Chancellor/General Counsel, California Community College
Kim Burtnyk, Education Office, California Science Center
Margaret Cagle, 2005 Presidential (Teacher) Awardee, Mathematics
Damon Castillo, EdD, Chairman, Science and Technology Education Partnership (STEP), Board of Directors
Caleb Cheung, 2005 Presidential (Teacher) Awardee, Science
Victoria Conner, Principal, Strategic Vitality LLC
Dean E. Davis, PhD, Pre-College Education Chair, Region 6 Southwest, American Aeronautics & Astronautics Assn.
Angela Phillips Diaz, Special Assistant to the Chancellor, University of California, Riverside
Dennis Galligani, PhD, Executive Director, ARCHES
Michael Gallo, President/CEO, Kelly Space and Technology, Inc.
Laura Gilliom, PhD, Director, University Relations Program, Lawrence Livermore National Laboratory
Jack Gregg, EdD, Executive Director, California Space Education and Workforce Institute
Virginia Hamilton, Executive Director, California Workforce Association
Penni Hansen, Manager, Intersegmental Relations, California Department of Education
Valerie Karnes, Dean, Cerro Coso College
Fran Kennedy, Director of Industry Initiatives, California Labor Workforce Development
John Kenney, Physics Education Manager, PASCO Scientific
Carey Kopay, Executive Director, Edward Teller Education Center
Phil Lafontaine, Director, Professional Development and Curriculum Support Division, California Department of Education
Silvia Liddicoat, Adjunct Professor, Engineering, California Polytechnic State University, San Luis Obispo
Oscar Porter, PhD, Executive Director, MESA Program, UC Office of the President
Donna Riordan, Director of Programs, California Council on Science & Technology
Joanna Rummer, Superintendent, Sierra Sands Unified School District
Hon. Andrea Seastrand, Executive Director, California Space Authority
Melanie Sharp, Program Consultant, Business Training Center, El Camino College
Jack Stewart, President/CEO, California Manufacturers and Technology Association
Michael Tomasello, Senior Associate Director, MESA Program, UC Office of the President
Kris Tueller, Senior Technical Operations Manager, Lockheed Martin Space Systems
Gregory Vallone, EdD, Director, Middle Schools, Los Angeles Unified School District
Beverly Young, PhD, Vice Chancellor, Teacher Education and Public School Programs, California State University

STEM SUPPORT: INDUSTRY/EMPLOYER ROLE

Employers recognize the “high stakes” of STEM education for today’s 21st century worker. The need for STEM workers – at both the professional and technician levels – has reached crisis proportions. The high-tech, high-growth field of air and space alone employs an approximate 600,000 people in high-paying jobs spread throughout 6,000 California companies. California employs 18% of the nation’s technical workforce.

In 2020, the number of jobs requiring a college degree will outstrip the number of jobs which do not, with most of those jobs being STEM-related. On top of that, forty-five percent of today’s current science and engineering workforce will retire within the next few years. The need for STEM-related technicians is perhaps even greater, with some citing that every engineering position generates six positions for technicians, illustrating the importance not only of STEM-related baccalaureate graduates, but also the need for career technical education.

Education and academia have traditionally seen industry and the greater employer community as funding and advocacy partners, but the STEM CAP articulates a much more expansive role. The desired role described by employer stakeholders at a 2007 STEM CAP forum was to be an engaged STEM partner/supporter serving as an extension of both the public education system and the informal science community, providing expertise for a variety of functions.

Employers annually spend millions of dollars on training and education. With much in-house training and education taking place, many employers have developed valuable expertise in program and curriculum development and review, assessment, professional development strategies, systems analyses, scaling of programs, development of metrics and tracking systems and other education-related functions. Yet seldom are employers tapped for this expertise.

STEM CAP stakeholders from the industry/employer community have identified three areas of support they can offer: people, facilities and content. Their people can provide content support for professional development of educators, serve as classroom coaches, career advisors, lab mentors, science demonstrators, and internship advisors. Their facilities can be used for career awareness tours, specialized equipment training for educators and/or students, retired equipment contributions, work-ready experience, internships, project sites. In the area of content, industry can support the development of relevant curriculum, provide project and inquiry-based learning challenges, textbook review, case studies, and hands-on training.

The employer challenge to educators is to think of industry and employer stakeholders as a resource beyond advocacy and funding – for leadership, mentoring, advising, program content support, policy development, career awareness and project-based learning. The benefit for California is that, by leveraging employer understanding of today’s workplace and today’s technologies, the state can greatly accelerate the ability of education and academia to meet the career and job preparation needs of their students.

Courtesy California Space Authority — Northrop Grumman educator Flights of Discovery Program



STEM SUPPORT: INFORMAL SCIENCE STAKEHOLDER ROLE

The informal science community provides an under-utilized resource in supporting STEM enhancement. Having come a long way from including simply museums and science centers providing educators with field trip opportunities, today's informal science community is a stakeholder group characterized by diversity of facilities, programs, approaches and opportunities. Informal science education programs are generally now developed and managed by professionals; real world-relevant exhibits and experiences, and stimulating, inquiry-based, hands-on learning often benefit from industry volunteers actually working in STEM careers. Pre- and post-experience curriculum is more often than not linked to California standards and students, teachers and families are introduced to a myriad of exciting applications of STEM disciplines at all ages and levels of understanding.

To inspire, informal science can guarantee access through online, interactive programs and free or low-cost exhibits and experiences. STEM experiences can take place in unusual, interesting locations, at times more flexible than those of the school day, often providing mobility of exhibits and programs to more successfully meet even access and equity goals. Teachers can be exposed to stimulating professional development training immediately applicable in their classrooms.

To help engage and educate students in STEM activities, the informal science community offers hands-on labs, interactive media, tours, programs, immersion experiences, educational enrichment at its finest, often aligned with standards-based educational curriculum. Teachers benefit from the resources and contacts available through the informal science community. One untapped area of potential for education/informal science partnering is in the area of professional development for pre-service teachers.

Already well connected with industry and employers, the informal science community offers a wealth of resources from the local community and from corporate partners. Today's informal science community includes not only museums and science centers, but NASA and Federal Labs, youth clubs, non-profits, after-school programs, faith-based initiatives and a wealth of other organizations comprised of thousands of educated, dedicated staff and volunteers ready, willing and able to support education and academia in building the 21st century skills necessary for today's STEM workers.

Courtesy Discovery Science Center



"Scientific innovation has produced roughly half of all U.S. economic growth in the last 50 years"

— National Science Foundation, 2004

ARCHES AND STEM CAP ADVISORY GROUP

California Space Education and Workforce Institute (CSEWI) engaged with The Alliance for Regional Collaboration to Heighten Educational Success (ARCHES) to facilitate two STEM CAP forums and to establish a STEM CAP Advisory Group to synthesize the work of the Steering Committee and forum representatives into a bold collaborative action plan.

ARCHES was launched in 2005 as an initiative of the California Academic Partnership Program (CAPP) and the California Educational Roundtable. ARCHES is a voluntary confederation of collaborative organizations in the state linked by both their goals and the shared strategies in which they intend to reach those goals. ARCHES also seeks to close the resources and opportunity gaps that are linked to student achievement with a special emphasis on African-American, Latino, and low-income students with which California's public schools' system has been least effective in the past. Since its inception, ARCHES has helped to develop 16 new collaboratives across the State. See Appendix 3 (page A-3).

Dennis Galligani, Ph.D.; Diane Siri, Ed.D.; and Jane Zinner



STEM CAP Project Directors

Dennis Galligani, PhD

Diane Siri, EdD

Jane Zinner

STEM CAP Advisory Group

Chair: Mike Gallo, President/CEO, Kelly Space & Technology, San Bernardino

Michael Aldaco, Senior Vice President, University of California Office of the President, Oakland

Joan Bissell, EdD, Director, Teacher Education/Public School Programs, California State University Chancellor's Office, Long Beach

Jonathan Brown, President, Association of Independent California Colleges and Universities

Steve Bruckman, Executive Vice Chancellor/General Counsel, California Community College Chancellor's Office, Sacramento

Keith Brush, President, Future Scientists and Engineers of America, Santa Ana

Angela Philips Diaz, Special Assistant to the Chancellor, University of California, Riverside

Peter Freiss, President, The Tech Museum of Innovation, San Jose

Javier Gonzales, Department Chair, Pioneer High School, Whittier

Penni Hansen, Manager, Inter-Segmental Relations, California Department of Education, Sacramento

Don Iglesias, Superintendent, San Jose Unified School District, San Jose

Joyce Justus, Vice Provost, Educational Relations, University of California Office of the President, Oakland

Fran Kennedy, Director of Industry Initiatives, California Labor & Workforce Development Agency, Sacramento

Lee Angela Reid, Principal Consultant, Senate Office of Research, Sacramento

Donna Riordan, Director of Programs, California Council on Science & Technology, Capitola

Todd Shimada, Principal, Hyde Middle School, Cupertino

Edward Taylor, Engineering Director, Google, Mountain View

STEM CAP FOCUS GROUPS AND INTERVIEWS

Focus Group Sessions

October, 2007

MESA, Board of Directors
American Institute of Aeronautics and Astronautics (AIAA), Los Angeles Region
California Space Authority, Board of Directors
California Science Teachers (CSTA), Board of Directors
California State University Math and Science Teacher Initiative Directors
California State University Deans of Science
California County Superintendents Educational Services Association,
Curriculum and Instruction Steering Committee
California Education Technology Collaborative
California Community College Chief Instructional Officers

November, 2007

Alliance for Education, Rialto Union High School District
California Math Council, Board of Directors
Alliance for Education, Victor Valley Joint Union High School District
UC Science and Math Initiative
AIAA, San Francisco Bay Area Region
California Council on Science and Technology, California Teacher Advisory Council
Cupertino Elementary School District, Site Administrators
Lawrence Livermore National Laboratory; University of California, Davis,
Edward Teller Education Center
California Mathematics Council Community Colleges

Telephone Interviews

Inverness Research Inc., Founder and President
National Science Resources Center
California Science and Math Coalition, Director
Delaware Foundation for Science and Math Education, Executive Director
Washington State Leadership and Assistance for Science Education Reform, Director
Partnership for Student Success in Science, Director

STEM CAP METHODOLOGY

The STEM CAP builds a common vision for science, technology, engineering and mathematics education and workforce development around which the California STEM stakeholders – education, workforce and economic development entities, industry and informal science - can unite.

A Broad-Based Coalition

In 2006-07, the California Space & Education Workforce Institute (CSEWI) convened a steering committee and a statewide collaboration of STEM stakeholders to assist in the development of the plan. All four public California education segments (K-12, CC, CSU, UC) were actively involved as well as industry, informal science and government. CSEWI hosted three STEM CAP forums involving more than 200 STEM stakeholders statewide to provide direction for the plan.

CSEWI contracted with The Alliance for Regional Collaboration to Heighten Educational Success (ARCHES) to facilitate two of the forums and to establish a STEM CAP Advisory Group to synthesize the work of the Steering Committee and forum representatives into a bold collaborative action plan.

Regional Field Tests

CSEWI's association with ARCHES provides for a distinctive feature for the STEM CAP. Through ARCHES, the recommendations of this report have been field tested by six regional collaboratives located across California. Beginning in April 2008, these collaboratives implemented and tested different aspects of the STEM CAP. This provides an in-depth look at the rigors and utility of the recommendations along with considerations for scaling and sustainability. This field-testing highlights critical insights that will deepen understanding of the steps needed to take the recommendations from policy to practical levels.

An In-Depth Inquiry

It was the intent of the Advisory Group to build upon the legacy of influential STEM related state and national reports written/commissioned by the Business-Higher Education Forum, US Department of Education, Business Roundtable, National Science and Technology Council, Council on Competitiveness, Congressional Research Service, National Governor's Association, US Department of Labor, National Science board 2007 National Action Plan and others, as well as the results of the three CSEWI forums and the STEM CAP focus groups. Contained within these reference documents is an abundance of good, compelling ideas. As stated in *A Commitment to America's Future: Responding to the Crisis in Mathematics & Science Education* (2005): "The crisis has been widely reported for decades...groups invested billions of dollars to isolate and solve the problem...initiatives yielded promising reforms but an underlying problem persists." At its August, 2007 meeting, the STEM CAP Advisory Group reviewed the recommendations from the 22 most cited National and State reports on STEM (see page 24) as well as the results of the three CSEWI Forums. 100+ recommendations were placed into ten categories:

- Teacher recruitment and preparation
- Teacher retention and renewal
- Student recruitment
- Curriculum
- Promising practices/data
- Strategic communication/marketing
- State policy/leadership
- Business collaboration
- Coordination/articulation
- Finance

The Advisory Group selected 25 recommendations, spanning all ten categories, which they deemed to be most appropriate for California today.

Rather than move immediately forward with these recommendations, the Advisory Group chose the unusual step of bringing these recommendations to stakeholder focus groups in order to deepen and broaden the understanding of the issues and relevance to California. Twenty-five stakeholder focus sessions were held with 273 participants representing the K-12 Public Education system, Community Colleges, California State Universities and The University of California, Federal Research Centers and Laboratories, Professional STEM Associations and Private Sector corporations (see page 17). Stanford Research International (SRI), a renowned research group, assisted in the design of the focus sessions, the protocols and the rating scales. (Appendix 1: Focus Group Recommendations; Appendix 2: Rating Scales). The focus sessions were digitally recorded and the discussions were transcribed.

STEM CAP METHODOLOGY

Forum and Focus Group Analysis

At the December, 2007 Advisory Group meeting, a compilation of approximately 35 hours of focus group comments was reviewed. An analysis revealed that there was agreement throughout the focus groups not only of the challenges at hand and the top recommendations, but also in regard to a recurring list of overriding issues that would impact all recommendations.

Embedded in the focus group discussions was consistent litany of the challenges that have prevented California from achieving the goal of a well-qualified STEM workforce. From industry to education to federal research centers, the same challenges were voiced, falling into four major categories.

- Fewer high school students are interested in preparing for and obtaining a college degree in STEM fields
- Too many of California's students do not have access to high-quality science and mathematics instruction or quality materials
- Large percentages of California students, especially those in low performing schools, receive instruction from under-prepared teachers:
- California lacks state-level leadership to make high-quality science and mathematics education for all students a state priority

Regardless of the stakeholder affiliation, the categories of curriculum and teacher recruitment, retention and renewal rose to the top as the areas in which recommendations would have the greatest impact on achieving the goal of the STEM CAP. The following comments are illustrative of what was stated when focus group participants were probed as to why they selected their top three recommendations:

- "Creating a foundation for a scientifically and technologically literate workforce begins with developing highly qualified mathematics and science teachers."
- "The quality of an education system cannot exceed the quality of its teachers."
- "If you do not have inspired teachers, how can you have inspired students?"
- "The best recruitment you could have is a fantastic classroom experience."

An analysis of the focus group comments revealed yet another key learning – overriding all of the recommendations was a consistent message that there are a core set of principles that must be in place for any of the recommendations to be successful. These guiding principles clustered in the categories of promising practices, state policy/leadership, business collaboration and coordination/articulation. They highlight the pivotal role for industry and informal science in achieving the STEM CAP goal. As was stated in one focus session, "It matters less which of the recommendations you decide to pursue, than figuring out how to generate the ability to pursue them."

"In the 2002-03 school year, all segments of California higher education collectively awarded 1,389 mathematics degrees, yet the need for new mathematics teachers that year was 2,131."

— Office of Governor Arnold Schwarzenegger



CHALLENGES AT HAND

"In 1970, the U.S. produced more than 50 percent of the world's science and engineering doctorates. If current trends continue, by 2010, the U.S. will produce only about 15 percent of the world's science and engineering PhDs."

— *standardandpoors.com*

Jobs requiring science, engineering and technical training will increase 51% nationally through 2008, leading to 6 million potential job openings for scientists, engineers and technicians. In California, fewer than 20,000 STEM graduates are produced annually. To make up for the shortfall, the number of such degrees produced in the state would need to increase by nearly 70%. The costs of failing to invest in our STEM infrastructure (human and physical) are potentially catastrophic for our State's economy. What Californians need most is good jobs and good schools. There is a need to build an educated citizenry who can work in, and create, skilled jobs. The very definition of a well-qualified STEM workforce is dependent upon the needs of our technical industry companies. California must invest in people at the front end and throughout their career.

The challenges facing California are serious and must be addressed immediately. Despite fiscal challenges, now is the time for all stakeholders (government and private sector) to make investments. The following challenges surfaced from the CSEWI forum and the stakeholder focus sessions. They are not theoretical; they are real challenges being faced in California today.

1. **CHALLENGE:** Fewer high school students are interested in preparing for and obtaining a college degree in STEM fields
 - Few incentives to pursue STEM major
 - False perception that STEM is reserved for the advanced, college-bound students or is beyond the capability of most students
 - Lack of connection – and often competition - between K-12 science and math courses intended to prepare students for postsecondary education and Career Technical Education (CTE)
 - Little demonstration of STEM contributions and/or relevance to virtually every element of life.

In 2002, only 16% of UC baccalaureate degrees were awarded in math and science, with 75% being in the bio-sciences; in the same year, CSU math and science degrees totaled only 5% of total baccalaureates awarded, with 65% of those being bio-science related.

— *California Postsecondary Education Commission; UC Irvine*

2. **CHALLENGE:** Too many of California's students do not have access to high-quality science and mathematics instruction or quality materials
 - No Child Left Behind mandates testing language arts and mathematics, resulting in minimal instructional time for science in the elementary grades
 - In grades 9-12, only two years of science are required for graduation
 - The state under-invests in science equipment and quality materials for K-12
 - There is a disconnect between real world, hands-on, applications of science, engineering and mathematics and what is taught in the classroom
 - While pockets of excellence in science and mathematics education exist, there are few resources available to create new courses and teaching strategies or to disseminate promising strategies or best practices.

CHALLENGES AT HAND

"Eighty percent of K-5 teachers report spending less than 60 minutes each week on science, and 16% of teachers are spending no time at all on science."

— Bay Area Science Study, Lawrence Hall of Science

3. **CHALLENGE:** Large percentages of California students, especially those in low performing schools, receive instruction from under-prepared teachers:

- California is not producing enough teachers with single subject credentials in science and mathematics and few students are choosing teaching careers
- STEM degrees alone are not sufficient preparation for science and math teaching at the K-12 level. However, additional coursework required for a science or mathematics teaching credential is, for some, a disincentive for a science or math major to consider pursuing a high school teaching credential.
- Teacher preparation programs are not effective in linking rich science or math content with instructional strategies that involve hands-on, practical elements. The result too often is teachers' discomfort with and lack of confidence to teach science and math.
- A significant percentage of teachers without single subject credentials in science or mathematics are teaching those subjects at the middle and high school levels, especially in low-performing schools.
- Elementary teachers are under-prepared to teach science and mathematics

"A conservative estimate is that there will be a shortage of 33,200 single subject middle and high school science and math teachers over ten years."

— Critical Path Analysis of California's Science and Mathematics Teacher Preparation System, 2007

4. **CHALLENGE:** California lacks state-level leadership to make high-quality science and mathematics education for all students a state priority

- A lack of a communication pathway among the education sector, industry, informal science centers, and federal labs results in a disconnect between educational needs and the resources that the other sectors can contribute
- Minimal collaboration and cooperation exists between different segments of education system (K-12 and higher education; community college to CSU; CSU to UC)
- The public does not exhibit an interest in supporting high-quality science and mathematics education, nor an understanding of the role of STEM in society/economy/quality of life
- While rhetorically attention is paid to the importance of science and mathematics education to our nation's competitiveness, there are few policies in place that will result in the scale and sustainability needed to ensure that all students have access to high quality science and mathematics education.
- The state has not articulated a STEM mandate, focused policy or sufficient resources for K-12 mathematics and science education.

GUIDING PRINCIPLES

Underlying the recommendations and implementation strategies is a set of guiding principles that emerged from the reports, forum and focus group sessions. These guiding principles cut across all of the challenges and recommendations. Without these principles, the recommendations will have minimal impact.

1 **Shared Vision by Leaders** What is needed is a shared vision for transforming California STEM teaching and learning and leaders who are ready to commit to make it happen. Underlying all recommendations is a need for leadership from all institutions and organizations to join together to formally place their support behind a statewide collaboration – UC, CSU, CC, K-12, Informal Science, Industry, Government. No entity alone, whether they are university schools of education or divisions of science or engineering, or business or government, can meet the challenge before us. The time has come for business and education leaders, in concert with partner stakeholders, to collectively work as strong advocates to create and sustain a process that redirects resources to STEM while joining forces to create an entity outside of regulations that brings together stakeholders to tackle the issues that are beyond the resources of education. Such a collaborative effort that represents a significant shift in values and practices sends a strong signal to all Californians that our best and brightest are needed, valued and supported.

2 **New Relationships to Leverage Resources** The core of achieving the STEM CAP recommendations is building relationships that are sustained over time. This collaborative action plan lays out a structure that will leverage the resources of education, industry and informal science and collaborates with other well-respected STEM plans in California. The STEM CAP is a tool to define priorities and thus help reduce friction between agencies. It will provide the education and business community, parents and other local officials and community members with leverage to work cooperatively and generate local pressure needed to break through obstacles. The STEM CAP Advisory Group is aware that local and state entities hold the ultimate authority for the policies that guide public education and that many of these entities have STEM plans. The STEM CAP recommendations do not challenge these plans. Rather, this statewide action plan is meant to collaborate with, support and enhance efforts by local and state entities to improve STEM education, to look at the big picture, to identify the gaps and to take the lead in bridging groups to address specific areas.

3 **Sustained Commitment with a Policy of R&D and Ability to Scale** The recommendations of the STEM CAP require a sustained effort and on-going statewide commitment to build a long-term foundation. New initiatives must be sustained beyond the typical three-year pilot commitment in order to realize their impact and evaluate their success. Taking the lead from industry's practice of research and development, education initiatives must begin with focused pilots that are fully funded with clear metrics. The results of the pilots must be evaluated to determine if and how the work should be disseminated and scaled. Those programs that are no longer achieving their results must be boldly discontinued.

GUIDING PRINCIPLES

4

Regional Approach Improving STEM programs in different parts of the state will require different approaches and strong local commitment to succeed. It involves coordinating education, business and labor to ensure all elements needed for successful programs are in place. A regional approach will bring all the education agencies and a broad array of business interests to the improvement process. It provides a scale that is sufficiently large enough to capture regional labor markets but also is small enough to allow the development of close working relationships that are needed. The special issues faced by rural areas (e.g., a lack of robust offerings by two-year colleges and few four-year colleges and major employers) and urban areas must be addressed as they design or upgrade STEM programs. Approaching these special issues on a regional basis will enable stakeholders to utilize their resources in an innovative manner, such as emphasizing the diverse student body at the community colleges as a resource for future STEM teachers in underserved areas.

5

Inspire and Engage Building on NASA's Education Strategic Coordination Framework, an Agency portfolio approach to education, the STEM CAP must address the stages of inspiring, engaging, educating and employing students, the future workforce. "In NASA's framework, education programs and projects draw from the category below them, as a key source for participants and they connect participants to the category above them, thereby providing a more experienced and focused group and creating a measurable pipeline. If a participant's imagination is captured by an inspirational activity, it will be far easier to interest that individual in more interactive engagement activities. As that individual becomes more engaged, he or she may search for opportunities to learn and eventually become employed... The goal is to direct a subset of the original audience through the pipeline to pursue a career in STEM while drawing in new participants along the way."

A

INSPIRE – activities focused on promoting awareness

B

ENGAGE – education activities that incorporate participant interaction for the purpose of developing a deeper understanding.

C

EDUCATE – learning for student learners or pre- and in-service educators designed to develop and/or enhance specific STEM knowledge and skills. These activities promote new knowledge acquisition and strengthen an individual's skills.

D

EMPLOY - targeted development through internships, fellowships and other professional training.

STEM CAP REPORT REFERENCES

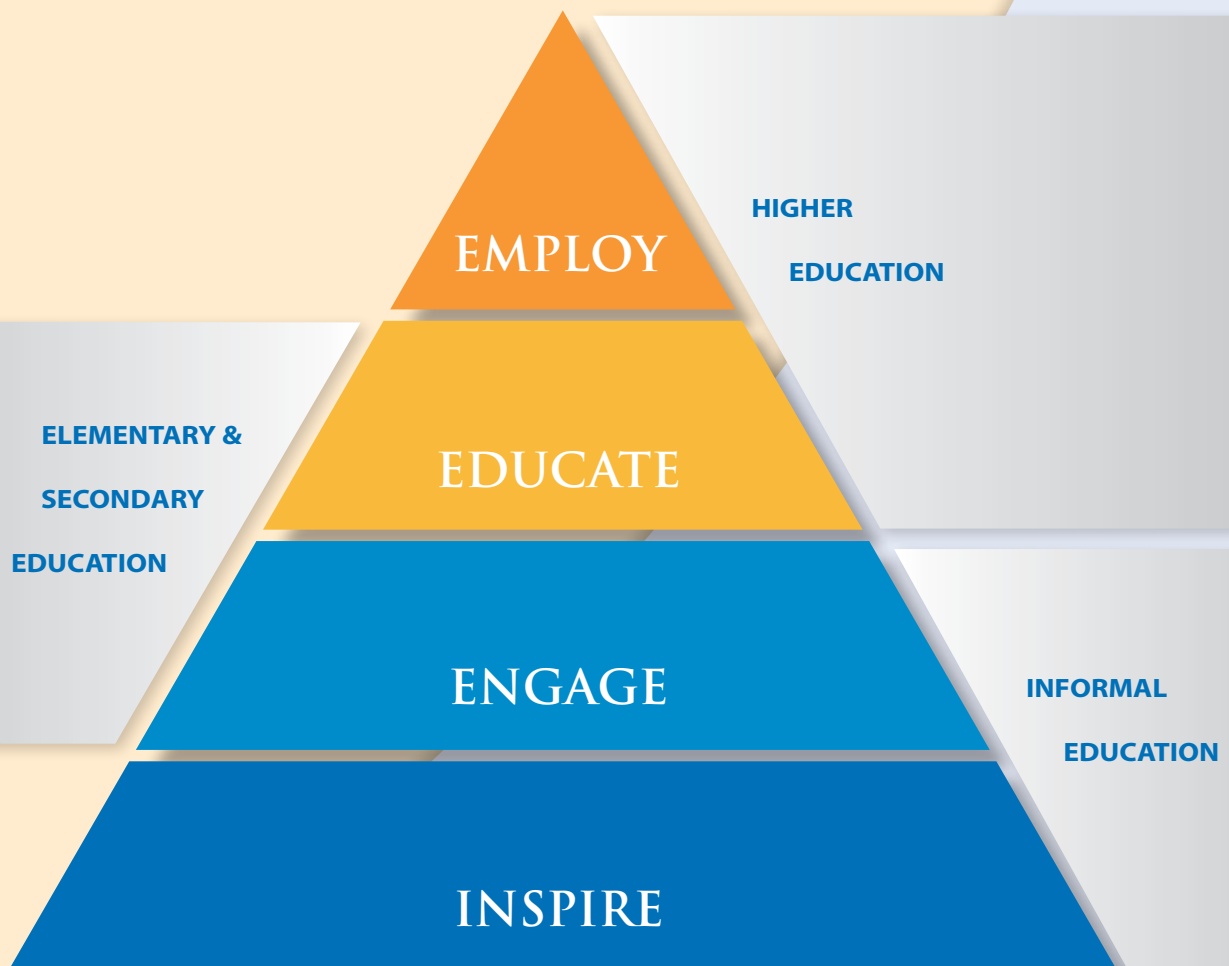
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RECOMMENDATIONS

The recommendations on the following pages build upon an analysis of the most cited national and state STEM reports, the three STEM CAP forums convened by the California Space Education and Workforce Institute and the STEM CAP focus group data. In order to achieve a measurable impact, recommendations need to be implemented statewide for all regions.

STEM CAP uses as an organizing principle for its recommendations the NASA Education Framework illustrated below, which was shared by NASA education stakeholders participating in the STEM CAP and adopted by the STEM CAP Advisory Group.

http://education.nasa.gov/pdf/151156main_NASA_Booklet_final_3.pdf



Courtesy NASA



“While teacher recruitment and retention is a major factor, sharing the passion of science, sparking the inspiration, encouraging engagement and educating by tapping the natural curiosity of learners is of equal importance.”

— NASA Education Framework: Inspire, Engage, Educate, Employ

INSPIRE

- 1** **RECOMMENDATION:** Motivate students and adults, using a variety of incentives, to study and enter STEM careers, with a special effort geared to those in currently underrepresented and underserved groups.
- 2** **RECOMMENDATION:** Build public support for and understanding of the value of STEM education for all students and citizens.

ENGAGE

- 3** **RECOMMENDATION:** Provide rigorous, relevant Career Technical Education (CTE) that prepares students for both higher education and the workplace in order to reinforce classroom instruction and provide tangible relevant skills for greater subject matter retention and competency.
- 4** **RECOMMENDATION:** Deliver science and math curriculum that motivates, energizes, reinforces and rewards the natural curiosity and interest students initially bring to the subject.

"Our ability to remain globally competitive as a state depends especially on our capacity for scientific and technical innovation. This in turn depends on our ability to engage students at a young age in the study of science and mathematics and to encourage them to embark upon college and university programs in STEM disciplines."

— Dr. Warren J. Baker, President, California Polytechnic State University



Courtesy: Larry Lim/STEM teachers at MESA professional development institute



"Studies report that the interest levels of American students, especially girls, in science begin to drop around middle school. As factors in turning off high numbers of students to STEM disciplines and professions, researchers point to the artificial separation in the curriculum of natural phenomenon into subjects, the focus on natural sciences and lack of attention to the human-made world of engineering and technology, and the disconnect of coursework from the lives of students."

— *Building a Science, Technology, Engineering and Math Agenda*

EDUCATE

- 5 RECOMMENDATION:** Align state K-12 science and mathematics standards and assessments with postsecondary and workforce expectations of what high school graduates should know and be able to do.
- 6 RECOMMENDATION:** Implement a comprehensive package of recruitment strategies for mathematics and science teachers throughout grades K-12 to expand and diversify the pool of fully prepared and certified candidates.
- 7 RECOMMENDATION:** Strengthen teacher preparation programs in mathematics and science through inclusion of hands-on, problem-based instruction and strategies that will benefit all students including underrepresented and underserved students.
- 8 RECOMMENDATION:** Provide ongoing, research-based professional development programs, focused on both content and pedagogy, for all mathematics and science teachers and faculty K-Higher Education.

EMPLOY

- 9 RECOMMENDATION:** Create Industry partnerships directly engaged with educators to deliver relevant, motivational and exciting instruction to reinforce and enhance STEM curriculum while setting the foundation for building a competitive and qualified workforce in tune with emerging work realities.
- 10 RECOMMENDATION:** Create hands-on internships and fellowships for students, teachers & faculty with employers in industry, academia, informal science networks, and civic organizations.

Courtesy Lawrence Livermore Federal Laboratory



Courtesy Raytheon



"47% of high school dropouts said classes weren't interesting while 81% called for more 'real world' learning opportunities."

— The Silent Epidemic
A Report by Civic Enterprises
in association with
Peter D. Hart Research Associates for the
Bill & Melinda Gates Foundation



ACTIONS

To immediately implement the recommendations within the existing state agencies it is imperative that each segment of the system re-examine their mission, reprioritize and reallocate their resources to align STEM education with the work-force needs of California for the 21st century. The following actions must be undertaken:

ACTION: Fully fund an expansion of a rigorous high school CTE and engineering preparation programs to every region in the state for both college-bound and career-bound students. (RECOMMENDATION 3)

ACTION: Mitigate the structure of No Child Left Behind to allow for science to be taught in low performing elementary schools. (RECOMMENDATION 4)

ACTION: Advocate for state policies that encourage the adoption of rigorously developed inquiry-based curricula that respond to students' curiosity – their desire to know and question why. Incorporate technical and academic elements that encourage students to satisfy their curiosity, extend their knowledge through application, and promote the rigor of academics. (RECOMMENDATION 4)

ACTION: Blend generic, broad-based technical education with chosen academic elements to extend knowledge acquisition through application, giving students the freedom to explore possibilities. (RECOMMENDATION 4)

ACTION: Develop collaborations that extend globally (local natural history/science museum with international program) to expand subject matter for applied learning related to math/science careers. Incorporate work experience and/or community service projects to support the importance of application and academic elements. (RECOMMENDATION 4)

ACTION: Align K-12 STEM expectations with post-secondary pathways. (RECOMMENDATION 5)

ACTION: Align STEM expectations between elementary, middle and high school levels to create a coherent K-12 system. (RECOMMENDATION 5)

ACTION: Develop new combined Credential-Master's programs for mathematics and science teachers that enable them to earn a teaching credential and to engage in extended graduate study providing the opportunity for further development of expertise in their discipline and in pedagogical practice. (RECOMMENDATION 7)

ACTIONS

ACTION: Support the University of California and the California State University in their efforts to provide comprehensive, content-based professional development for credentialed science and mathematics teachers through the California Subject Matter Projects, specifically designed science and mathematics programs in higher education and in industry, or other suitable means. (**RECOMMENDATION 7**)

ACTION: Create in institutions of higher education, university-wide Academies for Educator Development that provide a forum for faculty members from all colleges and departments to learn more about K-12 issues and support their active participation in field-based teacher preparation programs. (**RECOMMENDATION 8**)

ACTION: Reinstate funding for the Mathematics and Science Summer Institutes offered through the California Subject Matter Projects as a means of increasing support for high-quality professional development for both pre-service and in-service teachers. (**RECOMMENDATION 8**)

ACTION: Place STEM coaches in schools to provide one-on-one coaching in the classroom for teachers assigned to mathematics and science classrooms who are not yet fully prepared for their assignments. (**RECOMMENDATION 8**)

ACTION: Add paid time to the work year for math and science teachers for professional development. (E.g. an additional 10 days plus release time during the school day for planning, preparation and professional development). (**RECOMMENDATION 8**)

ACTION: Create tax incentives for science and technology-based businesses and industries who offer summer research-related employment to science and mathematics teachers and who loan technical staff to schools for the purposes of informing students about career opportunities and pathways and supporting teachers in the classroom. (**RECOMMENDATION 9**)

ACTION: Collaborate with science and technology-based industries to identify the future demand in their sectors and to integrate projections of workforce demand—both STEM careers and STEM knowledge and skills—as a key factor in planning reforms within the K-16 educational system. (**RECOMMENDATION 9**)


ACTIONS

A NEW STRUCTURE TO LEAD STEM IN CALIFORNIA


STEM initiatives and programs are found in a variety of state and local agencies, the informal learning community, business and industry and private foundations. Education foundations and public/private partnerships across the state raise millions of dollars each year for schools and districts, paying for books and school materials and grants to teachers. Multiple companies offer fellowship programs for teachers and students to work with industry during the summer and year-round. All are well intentioned.

The result, however, is a fractured approach. California is lacking a central mechanism for business and industry to focus their efforts on a common agenda that will have a statewide impact. No consistent forum provides coordination among all of these entities, resulting in a scattered approach with pockets of regional success that lack the leverage to have a significant impact on the state on a larger scale.


STEM CAP proposes a new independent body to bring together all stakeholders. It will provide the much-needed structure to ensure the premier status of STEM in California. A statewide STEM Council, similar to that proposed by the National Science Board in its 2007 National Action Plan, would coordinate among all those involved in STEM and act as a nexus to create a single voice to champion STEM. A statewide STEM Council can leverage its broad reach to companies and individuals to promote increased understanding and education through effective use of promotion, education, research and ultimately achieve the goals of establishing a system that will support a sustainable growth economy, create a 21st Century workforce and maintain California's position of leadership in the global market.




ACTION: Launch a new, independent, non-governmental State STEM Council. The Council's central responsibilities would be to coordinate and facilitate the following actions:



- Create apprenticeship programs that focus on CTE
(**RECOMMENDATIONS 1 & 3**)



- Support STEM education outside the classroom through expanded learning opportunities such as after-school and summer learning programs (**RECOMMENDATION 1**)



- Develop a public information campaign that emphasizes the importance of STEM, of STEM contributions to our world, and how all citizens can be a part of these contributions (**RECOMMENDATION 2**)

- Support initiatives to explore, test and propagate best practices in STEM education (**RECOMMENDATION 5**)
- Fund a scholarship program for students who pursue two-year, four-year and graduate degrees in science, technology, math and engineering (**RECOMMENDATION 6**)
- Coordinate a comprehensive program of scholarships, grants and loans to prospective STEM teachers to cover costs associated with tuition, materials and living expenses (**RECOMMENDATION 6**)
- Design prestigious fellowships for recent STEM degree graduates or those at mid-career that lead to certification and at least a five-year commitment to teach math or science in low-performing schools (**RECOMMENDATION 6**)
- Establish collaboratives among institutions of higher education, federal laboratories and research centers, and business and industry partners to link the preparation of future science and mathematics teachers with opportunities for them to engage in state-of-the-art research. (**RECOMMENDATION 7**)
- Encourage corporations to align their education outreach initiatives, grant making, employee volunteerism, public relations and governmental affairs work with the Council's initiatives. (**RECOMMENDATION 7**)

"Approximately 4% of ninth graders go on to complete a four-year science and engineering degree."

— *Critical Path Analysis of California's Science and Technology Education System, 2002*




Credit: California Science Center

INSIGHTS FROM FIELD TESTING: OVERVIEW OF SIX PILOTS

The six pilot projects selected for the field-testing of the recommendations provided in the STEMCAP report represent different approaches to improving student success in STEM fields. Although diverse in structure and scope, these projects are also similar in many ways including the types of participating partners, program activities, and assessment tools. All six projects were successful in meeting their stated goals. The overall success of these projects suggests that such approaches represent effective mechanisms for transforming the STEMCAP recommendations into actual practice. A general overview of findings from this group of projects is provided in subsequent paragraphs and individual analyses of each of the six pilot projects are provided in the remainder of this report.

Pilot projects addressed all but three STEMCAP recommendations. The three most commonly addressed recommendations were 1, 4, and 6 which broadly relate to increasing student interest in STEM disciplines and inspiring the desire to pursue careers in such domains. Additionally, recommendation 6 includes an emphasis on recruiting a diverse teaching force for STEM fields. Recommendations 2, 7, 9, and 10 were less frequently addressed and recommendations 3, 5, and 8 were not addressed at all.

Many different stakeholders were partners in the work of these six pilot projects. Partners included representatives from California community colleges and universities, K-12 districts and schools, County Offices of Education, foundations, community organizations, businesses, the University of California Office of the President (UCOP), and the California Academic Partnership Program (CAPP).



“This class has been a very positive experience for me. I love working with the kids. I took this class just to gain some experience to see if teaching is what I really wanted to do with my life. After this class, I know for a fact I’m in the right area.”

— Quote from a participant in the Aurora Project

In general, projects included four types of activities intended to address selected STEMCAP recommendations. Such activities included community college and university courses, K-12 curriculum (e.g., inquiry projects, field trips), teacher preparation/professional development opportunities, and resource development (e.g., a recruitment web site for STEM teachers).

In order to assess the efficacy of project activities, several types of measures were used. Participant-reported evaluation data (e.g., student surveys, interviews) and student assessment data (e.g., pre/post tests) were the most frequently used assessment measures. Other data sources included college enrollment data, program attendance data, and community college transfer rates. Project outcomes fell into four thematic categories including increased program participation, increased student engagement with and achievement in STEM disciplines (especially math and science), and increased interest in pursuing teaching as a career (especially in STEM fields).

All six projects reported plans to ensure the sustainability of their activities. However, several common challenges emerged in such discussions. It became clear that securing funding is an ongoing issue for most projects. Additionally, projects identified the need to improve the assessment tools used to measure and document evidence of project success. Recruiting and retaining participants and staff were also frequently mentioned as challenges related to sustainability.

In general, the STEMCAP report was considered to be a useful tool by all projects. More specifically, there was a consensus that the recommendations validated project work and provided a meaningful conceptual framework for designing and implementing project activities.

For additional information regarding the six pilot collaboratives, contact Dennis Galligani or Diane Siri at www.arches-cal.org.



"I thought it was a lot of fun, a really good experience...the reason I did it was to see if it's [Teaching Science] something that I really wanted to do. So it was very, definitely, important for me to do at this time."

— A Cal Poly student's reaction to participation in the Learn By Doing Lab

STEM CAP REGIONAL PILOT: Alliance for Education: San Bernardino County Superintendent of Schools “Making the Connection”: Applications by Business and Labor for Educators (ABLE)

Project Description: On a broad level, the ABLE project represents the mission of the Alliance for Education which is to produce an educated and skilled community that provides a qualified workforce for the continued economic well-being and improved quality of life for all residents of San Bernardino County. More specifically, this project is intended to increase student engagement with mathematics through the development and implementation of three innovative instructional models. Another project goal is to develop useful online resources, including demonstration PowerPoint presentations and newly designed videotaped vignettes that illustrate the project model and efficacy, that can be accessed and utilized by other educators. The design of a marketing campaign to create teacher awareness of the Alliance web site (www.sbcssalliance.org) where resources will be posted, is another aim of the ABLE project.

Participating Partners: ABLE incorporates representatives from the California Teachers Association, Ecclesia Christian Fellowship, Colliers International Bradco, Operating Engineers Training Trust, Kelly Space & Technology, Economic Development Agency, Loma Linda University, Andrew Jaramillo & Associates, Inc., California State University, Bakersfield, Lewis Operating Corporation, the San Bernardino County Superintendent of Schools, ARMAC Insurance Services, San Manuel Band of Mission Indians, Chaffey Community College, Arrowhead Credit Union, Central Labor Council, the Precinct Reporter, Victor Valley Wastewater Reclamation Authority, San Bernardino Community College District, and Victor Valley Union High School District.

STEMCAP Recommendations Addressed: ABLE addresses STEMCAP recommendation 4.

Project Activities: The “Making the Connection” project consists of three instructional strategies including a speaker’s bureau, field studies, and project-based learning. These strategies are implemented in order to provide learning experiences for students that apply academic knowledge within authentic workplace contexts through classroom speaking/demonstrations, workplace field trips that incorporate hands-on activities and apply academic standards, and industry projects in the classroom. Creating useful resources for mathematics educators is an integral project activity and video presentations of the above-mentioned activities in addition to other instructional videos currently exist and are available on the Alliance web site (www.sbcssalliance.org). Current work is being done to develop a marketing packet for the “Making the Connection” instructional strategies and other ABLE resources so that school site staff are aware of and can access these tools.

Project Outcomes: Student surveys and district reported attendance data were used as measures to document the impact of the ABLE project activities. Overall, students reported coming to class more often after attending project presentations, developing the belief that math and science are valuable and relevant in real life, feeling that their career choices were influenced by presenters, and planning on attending college after graduation. Attendance data is still being analyzed in order to substantiate student claims about increased attendance.

Addressing Emergent Challenges and Ensuring Sustainability: The Alliance plans to expand the ABLE program into other counties in California but before doing so believes it is important to continue documenting the practice and efficacy of the instructional modules. As such, there are plans to work with a qualified researcher in order to develop an effective assessment strategy including the revision of participant surveys and the creation of additional evaluation tools.

Usefulness of the STEMCAP Report: The report, more specifically the recommendations, provided validation for the work of the Alliance and was distributed at the year-end Alliance for Education Stakeholder’s Report in May 2008.

Coordinator: Leslie Rodden, Office of San Bernardino County Superintendent of School

STEM CAP REGIONAL PILOT: The Aurora Project

Project Description: The major goal and focus of the Aurora Project, a collaborative that extends throughout California, is to encourage and support community college freshmen and sophomores, especially underrepresented students, in STEM fields to prepare for and pursue a career in teaching middle and high school mathematics and science. As freshman and sophomores, community college students take seminar-type courses, are engaged in field experiences at local schools, and receive scholarship stipend support as they pursue eventual degrees in math/science and a teaching credential. The Aurora Project began in the Foothill De Anza Community College District and is currently in operation at twenty-two community colleges across California. The long term objective is to implement the Aurora Project at one hundred ten California community colleges so that at least 500 community college students transfer annually to four year college/university to complete their degrees and/or obtain a teaching credential.

Participating Partners: The Aurora Project has numerous partners throughout California including representatives from the University Office of the President, Community College District Offices, Community Colleges, California State Universities, University of California campuses, School District Offices, K-12 schools, The Alliance for Regional Collaboration to Heighten Education Success, NASA Ames Moffett Field, The Agilent Technologies Foundation, The Symantec Foundation, The College Access Foundation of California, The Noyce Foundation, and the California Academic Partnership Program.

STEMCAP Recommendations Addressed: The Aurora Project addresses STEMCAP recommendations 1, 4, 6, 9, and 10.

Project Activities: A seminar series and a corresponding field work component constitute the foundation of the Aurora Project. Seminars, taught by community college faculty, address mathematics and science curricular models, pedagogies, and state content standards. Enrolled students are assigned to classrooms at local schools where they spend 3-5 hours/week observing instruction and working with a “mentor teacher” in each classroom. These field experiences are an integral part of classroom discussion and learning (e.g., students share lesson plans and teach practice units). All students receive scholarship stipends, made possible by financial support from industry partners, for course participation and field work. Additionally, students are provided with opportunities to meet with admissions representatives from the University of California and California State University campuses.

Project Outcomes: Three primary data sources were used to measure the impact of program activities. These data sources include freshman and sophomore enrollment data from participating community colleges, data provided by the University Office of the President regarding STEM transfer rates from California community colleges, and community college student evaluations. Data analysis revealed that student enrollment in Aurora Project seminars is increasing, that growing numbers of students are transferring to UCs and CSUs to complete a bachelors degree, and that many participating students report plans to pursue a career in teaching.

Addressing Emergent Challenges and Ensuring Sustainability: In order to accommodate project expansion, the Aurora Project must secure ongoing private support to build the number of scholarship stipends available to participating community college students. As such, there is a continued effort to seek financial support from outside agencies. Ensuring that students engaged in the Aurora Project continue their studies of math and science, transfer to a 4 year college/university, and obtain a teaching credential is another programmatic challenge which has inspired the provision of ongoing academic advising and counseling to participating students.

Usefulness of the STEMCAP Report: The report provided standards and benchmarks which individuals engaged in collaborations can use in order to demonstrate program progress and emergent challenges to funding agencies.

Project Director: Edward M. Landesman, Professor Emeritus, Mathematics, University of California Santa Cruz

STEM CAP REGIONAL PILOT: Monterey Bay Educational Consortium/UCSC Educational Partnership Supporting STEM Education: Teacher Pipeline and Industry Partnerships

Project Description: The project described here represents a smaller part of the larger Community College Cal Teach program, a new program to increase the number and retention of new, highly-qualified math and science teachers (part of the UC Math and Science Initiative). In addition to the group of sixteen Academic Interns already hired and trained by the UC Santa Cruz Educational Partnership Center, this project provided funding for the hiring of an additional five community college student. These students are majoring in STEM fields and expressed an interest in teaching as a possible career. Academic Interns provide tutoring support and mentor underrepresented high school students in the Summer Algebra Academy at Seaside High School. The intent of this academic internship program is to increase Algebra passage rates in the region and more importantly to encourage more local college students who are strong in mathematics to consider teaching in STEM fields as a future career choice.

Participating Partners: This project is part of a larger collaborative project that includes representatives from the University of California, Santa Cruz, California State University, Monterey Bay, Salinas Union High School District, Pajaro Valley Unified School District, San Benito County Office of Education, Monterey Peninsula College, Cabrillo College, Gavilan College, Hartnell College, Monterey County Office of Education, Santa Cruz City Schools, North Monterey County Unified School District, San Benito High School District, Monterey Peninsula Unified School District, Santa Cruz County Office of Education, and Alisal Union School District.

STEMCAP Recommendations Addressed: This project addresses STEMCAP recommendations 6 and 7.

Project Activities: The Summer Algebra Academy at Seaside High School served 150 rising ninth grade students and provided them with an engaging, hands-on Algebra experience as well as pre-college learning. Importantly, the academy is not a remedial program; instead, the emphasis is about getting students ready for success in Algebra in high school, a critical gate keeping course in the A-G course pattern for college eligibility. The summer initiative also proactively addresses any potential barriers to going to college and supports students' successful transition from middle to high school. Academic Interns participating in the program leadership gained classroom experience (e.g., workshop development, classroom management) and mentorship opportunities with teachers. They also received support on transfer planning by connecting community college students with teams of other undergraduates from four-year universities for peer mentoring and advising.

Project Outcomes: Three primary data sources were utilized to measure project impact including student achievement data, Academic Intern surveys and interviews, and community college transfer rates. Data analysis revealed that ninth grade students demonstrated an increased Algebra readiness. Community college students (Academic Interns) reported learning important teaching skills and also indicated an increased interest in pursuing a teaching career in STEM fields.

Addressing Emergent Challenges and Ensuring Sustainability: To ensure wider implementation and sustainability of the project, additional resources are needed to recruit more community college students into the Cal Teach program and hire them as Academic Interns during the academic year and summer. Dedicated scholarships need to be provided for transfer students and a loan forgiveness program must be developed for students who complete credential programs and teach in STEM fields, particularly in communities with a high cost of living and equally high need for qualified, well-prepared teachers.

Usefulness of the STEMCAP Report: The guiding principles and recommendations included in the STEMCAP report provided a useful framework for thinking about the work and project design. They also outlined the need and call to action for improvements in STEM education, which influenced the project components and overall approach.

Director: Carrol Moran, Executive Director, University of California Santa Cruz Educational Partnership Center

STEM CAP REGIONAL PILOT: The Sacramento Collaborative for Regional Education and Workforce (CREW) STEM Teacher Recruitment at Sacramento State University

Project Description: This is an internal project at Sacramento State University created with the intention of increasing the pool of qualified teacher applicants in STEM fields. A specialized STEM committee within the College of Education was established to focus on issues related to teacher recruitment for STEM disciplines. Additionally, efforts are being made to coordinate a university-wide plan for increased faculty and student awareness of pathways to becoming STEM teachers. The project also involves the creation of a comprehensive teacher recruitment web site that can serve as an information hub for faculty, students, and community members.

Participating Partners: This project is internally coordinated at Sacramento State University and involves the Center for STEM Excellence, the College of Education, The College of Mathematics and Natural Sciences, Academic Technology and Creative Services, and Undergraduate Studies.

STEMCAP Recommendations Addressed : This project addresses STEMCAP recommendation 6.

Project Activities: The College of Education STEM Group meets monthly to identify ways in which it can recruit candidates into teacher certification that might not have otherwise considered a teaching career. There is an emphasis on identifying strategies for expanding and diversifying the pool of teacher candidates. Currently the COE-STEM group is working on a CSUS Discipline-Based Algebra grant with the department of Learning Skills. Work is still ongoing for the university-wide plan for informing students of pathways to STEM teaching careers. As of September 2008, a beta version of the recruitment web site has been developed. Future plans for the web site include providing vignettes of compelling interviews with veteran and novice teachers and sharing regional data that highlights the urgent need for STEM teachers

Project Outcomes: To date, no data has been collected in order to measure the impact of this pilot project which is still in an early developmental stage. The long term objective of this project is to create and sustain a multifaceted recruitment strategy for STEM teachers.

Addressing Emergent Challenges and Ensuring Sustainability: At this point, more funding and technology resources are needed in order to further develop the web site design and capacity. Additionally, more meetings of the COE STEM group are needed to continue project work as are more cross-campus meetings with other departments.

Usefulness of the STEMCAP Report : The report provided the conceptual framework for the design of project activities.

Contact: Greg Wheeler, Associate Dean for Undergraduate Studies, California State University, Sacramento

STEM CAP REGIONAL PILOT: San Luis Obispo County P-16 Council's Cal Poly State University Learn By Doing Lab

Project Description: The Learn by Doing Lab (LBDL) is a nexus for recruiting and training new science teachers, supporting the professional development of in-service science teachers, and stoking the fires of college and careers in science for middle school students. Project goals center on the three stakeholders brought together in the LBDL classroom: California Polytechnic State University San Luis Obispo students, in-service partner teachers and middle school students. The central goals for Cal Poly Students include giving Cal Poly students a positive teaching experience with an opportunity to “think like a teacher”; increasing the likelihood that Cal Poly Science majors will choose teaching as a career, and enabling our students to gain hands-on experience with inquiry-based pedagogy. LBDL is meant to serve as a meaningful professional development activity for in-service teacher partners and to promote inquiry-based science in their classrooms. For the participating middle school students, the primary goals are to reinforce fundamental grade-appropriate scientific concepts and to engender excitement about science and about going to college.

Participating Partners: The LBDL project incorporates representatives from Cal Poly State University, the San Luis Obispo County Office of Education, Twin Cities Community Hospital, Pacific Gas & Electric Company, Cuesta Community College, the Economic Opportunity Commission, the San Luis Obispo Coastal Unified School District, and the San Luis Obispo County Community Foundation.

STEMCAP Recommendations Addressed: The LBDL project addresses STEMCAP recommendations 1, 2, 4, and 7.

Project Activities: The SCM X302 undergraduate course is the backbone of the LBDL project. It was piloted in the spring of 2008 as a joint venture between the College of Science and Mathematics at Cal Poly, the Cal Poly Center of Excellence in Science and Mathematics Education (CESaME), and the San Luis Obispo County P-16 Council. Based on a longstanding model implemented at Chico State University, this course offers Cal Poly undergraduate Science majors an opportunity to use inquiry-based, standards-appropriate pedagogical approaches to actively engage 6-8th grade students on the Cal Poly campus. In the spring of 2008, twelve Cal Poly undergraduate students enrolled and supported 600 visiting middle school students from eight school sites across Central California in an inquiry-based science lab experience that consisted of two content modules (i.e., Density Exploration, Phase Exploration) tied to 8th grade content standards.

Project Outcomes: Pre and post interviews with and written surveys of Cal Poly undergraduates were utilized in order to assess the impact of the Learn By Doing Lab. Data analysis revealed that Cal Poly undergraduate science majors who participated in LBDL demonstrated an increased interest in pursuing a career in teaching. Students also reported experiencing “thinking like a teacher”, developing an openness to alternative pedagogical approaches to teaching science, and developing an increased confidence using inquiry-based tools to teach science.

Addressing Emergent Challenges and Ensuring Sustainability: There are two keys to the success and sustainability of LBDL: physical infrastructure and careful long-term assessment of the impact of LBDL on all stakeholders. Additional space on campus has been allocated for the 2008-09 academic year so that two concurrent sessions of the program can be offered. In terms of assessment, work is in progress to expand upon existing measures related to undergraduates and to develop additional assessments (e.g., surveys, concept inventories) to include teacher partners and middle school students.

Usefulness of the STEMCAP Report: The STEMCAP recommendations constitute the backbone of the LBDL model and program activities.

Contact: Brad Schultz, Educational Services, San Luis Obispo County Office of Education, P16 Math/Science Steering Committee Co-Chair

STEM CAP REGIONAL PILOT: Southern Alameda County Regional Alliance (SACREA)

Project Description: The primary objective of the Southern Alameda County Regional Alliance is to develop a plan of action to deal with the alarming standardized test passage rates, particularly in mathematics, of the region's African American students. First year initiatives are focused on providing direct student services and educator professional development related to math and science. To this end, SACREA co-sponsored the 2008 Summer Algebra Academies which consisted of three, five week summer algebra courses that provided pre-algebra and algebra refresher instruction for 7th, 8th, and 9th grade students.

Participating Partners: SACREA has many partners including representatives from California State University East Bay, the Alameda County Office of Education, San Leandro Unified School District, San Lorenzo Unified School District, RTFisher Educational Enterprises, Inc., Southern Alameda County Alliance of African American Educators, JL Davis Family Resource Center, and Johnson Controls, Inc.

STEMCAP Recommendations Addressed: SACREA addresses STEMCAP recommendations 1 and 4.

Project Activities: A team of educational specialists developed a customized, standards-based pre-algebra and algebra curriculum which included instructional, collaborative, and project-based lessons arranged in the same thematic units found on the California Standards Test and the California High School Exit Examination. This curriculum was implemented by program staff (one instructor and two college student coaches per classroom) and was supplemented with field trips to locations such as the NASA Ames Research Center, CSU East Bay, the Lawrence Livermore Lab, and the Chabot Space and Science Center. These "Friday Field Trips" provided students with opportunities to explore the real world of math and science by helping them understand the practical application of the concepts they were learning in the classroom.

Project Outcomes: Student assessments, including pre and post tests and weekly quizzes, were administered in order to assess the impact of the program on student learning. Program evaluations were also completed by students, staff, and parents. Data analysis revealed that the small staff to student ratio created a meaningful and productive learning environment for students. Evaluation data also indicated that the flexibility of the instructional context allowed for the curriculum to be further customized to the unique needs of the students. Overall, students also demonstrated increased knowledge of algebraic concepts as measured by pre/post measures and ongoing assessments.

Addressing Emergent Challenges and Ensuring Sustainability: SACREA has identified four considerations related to enhancing their program and ensuring its sustainability. Recruiting quality instructional staff in order to maintain a small staff to student ratio is essential for continued student success. Additionally, there are plans to develop a more targeted student recruitment strategy that can be implemented earlier with the goal of reaching more eligible students. Accessing additional student academic data (e.g., transcripts) and administering the pre-test at an earlier time (such that scores are available before program onset) would allow the program staff to further customize instruction so as to meet student needs. This type of data would also inform staff development and placement.

Usefulness of the STEMCAP Report: The report provided the conceptual framework for the design and selection of daily activities and the summer field trips.

Project Manager: Robyn Fisher, RT Fisher and Associates, Oakland

CONCLUSION

STEM CAP's message is simple: without strong steps to improve support for STEM, the quality of life in California is threatened. For years reports from the federal government, industry and think tanks have been stacking up in offices throughout California, all carrying the same basic message -- California is losing its competitive edge because of a lack of coordinated investment in STEM education to produce a well-trained workforce that supports both technical industries and research. If California does not respond quickly, the consequences will be predictable and straightforward - California will lose quality jobs to other states and industries will move.

The failure to invest in STEM has been caused by a pattern of short-term thinking and episodic spending rather than a long-term investment. As stated in *Rising Above the Gathering Storm*, the "scientific and technical building blocks of our economic leadership are eroding at a time when many other nations are gathering strength. We fear the abruptness with which a lead in science and technology can be lost, and the difficulty of recovering a lead once lost, if indeed it can be regained at all.

This report contains 10 recommendations and 17 specific actions that government, education, industry must take.

The time is now for coordinated efforts to seed innovative new ideas, incubate the most promising of these initiatives and scale demonstrably successful programs to strengthen the STEM pipeline.

No one's counting on the government by itself to solve the problems. Rather this challenge requires the resources and expertise of all stakeholders throughout the state – industry, higher education, school districts, federal laboratories, parents, and all levels of government. Many of the actions cited are underway on a small scale – they will have greater impact if they are collaborative and strategic. All the actions and recommendations require state, regional and local leadership, innovation and commitment.

Unless it translates into action, then it's just another chapter that tells us about the past.

The work, which must begin immediately, requires California's commitment to resources and time to sustain the effort. This effort is vital to the continued success of our state. The time for action is now.

APPENDICES

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Credit: California Science Center

FOCUS GROUP: RECOMMENDATIONS

category	recommendation
A. TEACHER RECRUITMENT & PREPARATION	1. Implement a comprehensive package of mathematics and science teacher education recruitment strategies, starting in P-12 and extending through graduate school, to expand and diversify the pool of candidates.
	2. Strengthen the content of teacher preparation programs in mathematics and science.
	3. Strengthen the pedagogy of teacher preparation programs in mathematics and science, including strategies for working with underrepresented minority students.
	4. Expand teacher preparation programs to produce more single-subject science and mathematics teachers.
B. TEACHER RETENTION & RENEWAL	1. Develop and implement research-based induction programs for all new mathematics and science teachers.
	2. Implement comprehensive policies and programs that address the leading causes of teacher job dissatisfaction .
	3. Provide ongoing, research-based professional development programs, focused on both content and pedagogy, for all mathematics and science teachers.
	4. Revamp teacher license renewal programs to incorporate measure of teacher effectiveness.
C. STUDENT RECRUITMENT	1. Motivate U.S. students and adults, using a variety of incentives, to study and enter STEM careers, with a special effort geared to those in currently underrepresented groups.
	2. Provide students access to high quality post-secondary education and skill training.
D. CURRICULUM	1. Deliver science and math curriculum that reinforces and rewards the natural curiosity and interest our students initially bring to the subject.
	2. Increase real world expertise in STEM content .
	3. Align state K-12 STEM standards and assessments with post secondary and workforce expectations.
E. PROMISING PRACTICES/DATA	1. Establish comprehensive statewide data collection systems that track student progress, teacher effectiveness, and employment trends of mathematics and science teachers.
	2. Foster knowledge of effective practices through improved evaluation and-or implementation of proven-effective, research-based instructional materials, methods and best practices and bring them to scale.
F. STRATEGIC COMMUNICATION /MARKETING	1. Engage business and higher education in more effective P-12 reform roles.
	2. Build public support and appreciation for making improvement in STEM performance a priority.
	3. Build public support for the value of STEM education for all students and citizens.
	4. Build a case for increasing time to teach science in K-12.
G. STATE POLICY/LEADERSHIP	1. Identify senior legislative champions for STEM on both sides of the aisle.
	2. Stimulate state dialogue and local, grass-roots initiatives through alliance building and collaboration among business, education, and government resulting in policies supporting STEM at K-12 and Higher Education.
H. BUSINESS COLLABORATION	1. Commit to an agenda of regional growth and development based on public-private partnerships and workforce talent.
I. COORDINATION /ARTICULATION	1. Forge education and job training programs into a coherent system of skill development that is responsive to the long-term needs of the California economy .
J. FINANCE	1. Provide financial support for new math and science teachers.
	2. Strengthen California's infrastructure for STEM education.

FOCUS GROUP: RATING SCALE

Focus Group: Date: _____

RECOMMENDATION: _____

How difficult will it be to implement the recommendation?

Easy Hard NA

What is the timeframe for the recommendation to have an impact?

1 year 3 years 5 years 7 years 10+ years NA

To what extent would resources need to be diverted from existing programs as opposed to new dollars?

0% 100% NA

What is the degree of impact this recommendation will have on the mission to increase the number, quality and diversity of STEM students and teachers?

Low High NA

How would you rate the return on investment for this recommendation?

Low High NA

RECOMMENDATION: _____

How difficult will it be to implement the recommendation?

Easy Hard NA

What is the timeframe for the recommendation to have an impact?

1 year 3 years 5 years 7 years 10+ years NA

To what extent would resources need to be diverted from existing programs as opposed to new dollars?

0% 100% NA

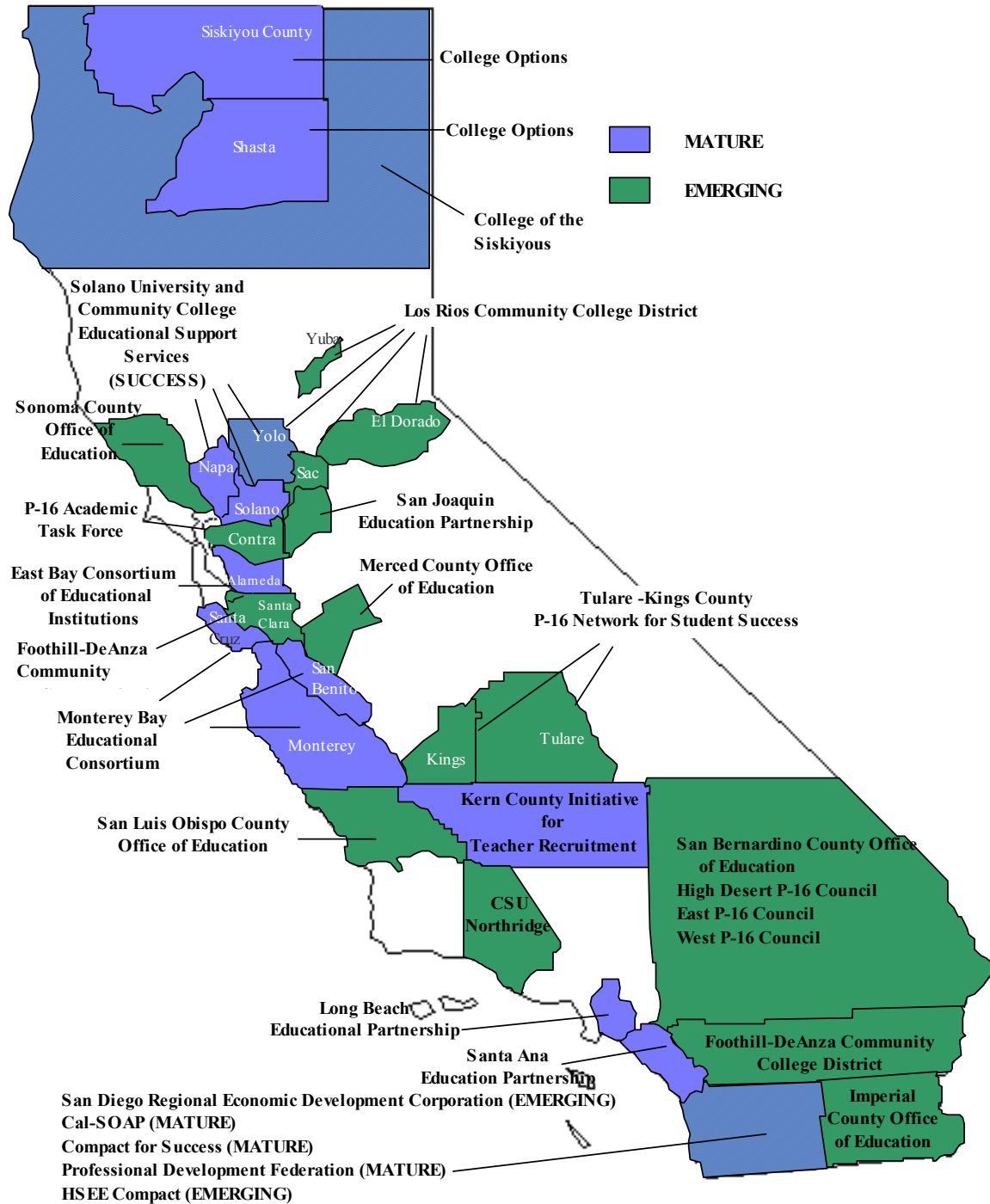
What is the degree of impact this recommendation will have on the mission to increase the number, quality and diversity of STEM students and teachers?

Low High NA

How would you rate the return on investment for this recommendation?

Low High NA

ARCHES COLLABORATIVES



EL CAMINO COLLEGE STEM CAP PROJECT

El Camino College's activities for the U.S. Department of Labor "Workforce Innovation in Regional Economic Development – WIRED" Science, Technology, Engineering and Math Collaborative Action Plan (STEM CAP) centered around two main areas: participation in the STEM CAP forums and development activities, and the Pre-Engineering "Project Lead the Way" (PLTW) program also supported by the QuickStart grant (SB70), considered a model program for the STEM Collaborative Action Plan. PLTW supports STEM education by having the high school students participate in a hands-on, activity-oriented program that utilizes team efforts. The courses, which include Computer Integrated Manufacturing, and Principles of Engineering, complement math and science college preparatory programs to establish a solid background in engineering and technology. PLTW takes mathematics and science out of the confined realm of textbooks and into the challenges of the real world, demonstrating to students the endless possibilities that are before them.

In the area of STEM CAP development, El Camino College has participated in the Steering Committee meetings, forums, and webinars. The College also recruited representatives from the college and its partner high schools for further assistance with the STEM CAP meetings and goals. Further participation was achieved by attending and making presentations at the California Space Authority (CSA) 2007 Transforming Space Conference workforce and education discussion panel and at the California Innovation Corridor WIRED grant "All Partners" meetings.

In the area of the PLTW program, El Camino College continues to recruit students and support activities at partner high schools for STEM and PLTW programs. Documenting career pathways for STEM technical programs on campus, the College has given presentations on PLTW and STEM CAP at the El Camino Tech Prep Consortium meetings.

Status of the PLTW program with El Camino in fall of 2008, end of the grant period is as follows:

Over 1,500 students have attended El Camino College pre-engineering Project Lead the Way courses on the campus and at partnered high schools through concurrent enrollment. Momentum is building and El Camino College is discussing partnerships with more local high schools and is actively pursuing middle schools as we continue the project through the recently awarded CTE (Career Technical Education) Community Collaborative grant awarded from the California Community College Chancellor's Office in June of 2008.

The El Camino College PLTW program had a quiet, yet enthusiastic beginning when Ron Way, then Dean of Industry & Technology, started a basics robotics course on weekends for high schools students. Soon afterward, Dean Way had an idea to grow the El Camino College Engineering Technology program at the high school level using the nationally recognized Project Lead the Way program. El Camino College formed a partnership with Hawthorne High School, and City Honors High School in Inglewood and collaborated with the El Camino College Center for Applied Competitive Technology to submit for a Quick Starts grant from the California Community College Chancellor's Office. When El Camino College received the grant, work was nearly complete in gaining three additional high school partners on the project. Palos Verdes High School, Southern California Regional Occupational Center, and Redondo Beach High School signed as funded partners and work began at expanding the PLTW program to these schools. Additional funding was obtained via the WIRED STEM CAP grant and two additional high schools were added to the project, Lennox Math & Science Academy, and California Academy of Mathematics & Science (CAMS).

What started as a small robotics classes held on Saturdays with about 40 students has grown to over 800 students per semester. Students are learning engineering skills that will lead towards further education and careers in engineering or related technologies. Training may lead to a certificate of completion or a degree in Engineering Technology. The El Camino College plan is to add two additional high school partners from its district area, and to expand to other high schools through partnerships with El Camino College Compton Educational Center, and Cerritos College districts.

<http://www.innovatecalifornia.net/success/search/details/participant/16?q=el+camino&d=all-all>

CALIFORNIA POLYTECHNIC STATE UNIVERSITY STEM CAP PROJECT

As a WIRED 3.5 STEM CAP partner, California Polytechnic State University, San Luis Obispo was a member of the Steering Committee and supported the STEM CAP forums. Cal Poly, as a leader in polytechnic education, conducted a study on model teacher professional development institutes within the California State University and found three CSU-NASA/Jet Propulsion Laboratory (JPL) Teacher Professional Development Institutes met the criteria for this study. NASA/JPL began a partnership eight years ago with the California State University Office of the Chancellor to create a CSU-NASA/JPL Education Collaborative. The goal of the Collaborative is to increase the availability and quality of STEM education for current and future teachers of California, which supports the main goal of the STEM CAP.

The 17-page whitepaper and study written by Silvia Liddicoat (see below) was the first study and analysis of model teacher professional development institutes where the data was synthesized across institutes into common themes of successes, challenges, lessons learned and best practices. The paper proposes replicable, sustainable implementation models for widespread dissemination.

NASA Enriched Collaborative STEM K-12 Teacher Professional Development Institutes within the California State University System

December 2007

Silvia Liddicoat

California Polytechnic State University, Electrical Engineering Department

San Luis Obispo, CA 93407 sliddico@calpoly.edu

Abstract - The State of California must remain a leader in Science, Technology, Engineering, and Mathematics (STEM) education to maintain its competitive edge and economic vitality. The California State University system has a long-standing commitment of providing a quality education to its diverse student population.

The System recognizes the urgency to increase the STEM talent pool for California. A research review on teacher quality and student achievement from the Center for Public Education (November 2005) indicates that more than two decades of research findings are unequivocal about the connection between teacher quality and student learning. Sustained teacher professional development is a path to increased teacher quality. This paper presents and analyzes three NASA/Jet Propulsion Laboratory (JPL) Enriched Collaborative STEM K-12 Teacher Professional Development Institutes held in 2007: California Polytechnic State University, San Luis Obispo; California State Fresno; and California State Bakersfield. The three institutes implemented unique practices based on trial and error, past experiences, and institutional learning. This paper highlights the critical elements, extracts the best practices from the three institutes and proposes an implementation model as a framework for other campuses and institutes.

This paper was accepted at the Institute of Electrical and Electronics Engineers, Frontiers In Education (FIE) Conference and presented as a peer-reviewed paper at the FIE conference in Saratoga Springs, New York in October 2008.

<http://www.innovatecalifornia.net/success/search/details/participant/11>



Photo courtesy Cal Poly and NASA/JPL

"This CSU-NASA/JPL institute was better than expected, and I had high expectations. I will be able to use most of the content to meet my grade level standards."

"This CSU/NASA JPL institute absolutely improved my teaching and learning. It has changed my approach to teaching earth science this year. I hope to use my new knowledge to weave together standards rather than in disconnected units."



Photo courtesy Cal Poly and NASA/JPL



AGENDA

STEM Partnership-Building Forum - June 28, 2006
Renaissance Montura LAX Hotel, 9620 Airport Boulevard, Los Angeles

8:00 a.m.

Welcome/Forum Overview

The Honorable Andrea Seastrand, Executive Director, California Space Authority (CSA)
Paula Arvedson, PhD, President, California Space Education & Workforce Institute (CSEWI)
Bruce Gardner, PhD, Co-Chair, CSEWI Education/Workforce Collaborative;
Principal Director, Learning Systems Center, The Aerospace Institute, The Aerospace Corporation

8:15 a.m.

Industry-Driven Workforce Development and STEM Education The WIRED Initiative

Tom Hooper, Industry Lead/WIRED California Team
Business Relations Group, US Department of Labor

8:35 a.m.

Development of a Technical Workforce: The Employer Perspective

Moderator: Michael Aldaco, Assistant Vice President, University of California, Office of the President
Laura Gilliom, PhD, Director, University Relations, Lawrence Livermore National Laboratory
Ray Haynes, PhD, Director, University Relations, Northrop Grumman Space Technology
Susan Johnson, College Relations, Southern California Edison
Edward Taylor, Google, Inc.

9:35 a.m.

California STEM Education and the American Competitiveness Agenda

Susan Hackwood, PhD, Executive Director, California Council on Science & Technology (CCST)

9:55 a.m.

CSU STEM Strategy: A Successful Federal Lab Partnership

Moderator: Beverly Young, PhD, Assistant Vice Chancellor
Teacher Education/Public School Programs, California State University
Jeff Gold, Associate Director, Academic Technology, California State University Chancellor's Office
Art Hammon, Jet Propulsion Laboratory
Ron Hughes, Professor/Faculty Coordinator, California State University/NASA Collaborative

10:50 a.m. – 11:05 a.m.

BREAK

11:05 a.m.

Community Colleges as STEM Assets

Steve Bruckman, Executive Vice Chancellor, California Community College



AGENDA (Cont'd)

STEM Partnership-Building Forum - June 28, 2006
Renaissance Montura LAX Hotel, 9620 Airport Boulevard, Los Angeles

11:25 a.m.

Industry Associations and the Informal Science Network: Hardworking STEM Supporters

Moderator: Jordi Puig-Suari, PhD, Chairman, Aerospace Engineering, Cal Poly San Luis Obispo
Joe Adams, President, Discovery Science Center
Paula Arvedson, PhD, President, Satellite Educators Association (President, CSEWI Board)
Dean E. Davis, PhD, Chairman, AIAA K-12 Strategy; Principal Scientist/Engineer, Boeing Integrated Systems

12:20

Luncheon Program Critical Issues in STEM K12 Education and Teacher Preparation

Introducing Dr. Brunkhorst:
Kathy Norman, President, National Association of Science Teacher Education (ASTE)
Herbert K. Brunkhorst, PhD, Professor and Chair
Department of Science, Mathematics, and Technology Education, CSU San Bernardino;
Committee on Science, Mathematics and Teacher Preparation, National Academy of Sciences

K-12 STEM Education – the Teacher Perspective

Peter Arvedson, Cal TAC/Lead Teacher, Academy of Science, La Puente High School
Barbara Shannon, PhD, Cal TAC/Faculty, Westridge School

1:45 p.m.

Session I Break-Out

Option One: Effective Recruitment: Strategies and Outcomes
Option Two: Access and Equity Strategies

2:30 p.m.

BREAK

2:45 p.m.

Session II

Option One: Transition Points and Strategies
Option Two: A Successful STEM Partnership: Barriers, Opportunities & Outcomes

3:30 p.m.

What Are the Needs? Insights from the New 21st Century Technical Workforce

Emily Chi, Engineer/Chair, CONNECT, Northrop Grumman Space Technology
Matt Everingham, Special Projects Manager, California Space Authority

4:15 p.m.

Closing Remarks



The STEMCAP project is being managed by the California Space Education and Workforce Institute, and is funded by the California Space Authority as part of the California Innovation Corridor "Workforce Innovation in Regional Economic Development (WIRED)" grant from the U.S. Department of Labor through the California Labor and Workforce Development Agency

Saturday, December 9, 2006

Westin LAX Hotel, 5400 W. Century Boulevard, Los Angeles

STEM Collaborative Action Plan (STEMCAP) Forum/Working Group Session

WORKING AGENDA

10:00 a.m.

Welcome

STEMCAP and STEMCAP Inventory Overview

The Honorable Andrea Seastrand, Executive Director, California Space Authority
Deborah Hirsch, Executive Director, California Space Education and Workforce Institute
Matt Everingham, Special Projects Manager, California Space Authority

10:20 a.m.

Opening Remarks

Angela Diaz, Director, Strategic Communications & Development, NASA Ames Research Center
Damon Castillo, EdD, President/Chairman, Science and Technology Education Partnership

11:00 a.m.

Featured Speaker

Keith Thompson
STEM Lead, Department of Defense STEM Education Activities

11:20 a.m.

Introduction to STEMCAP Working Groups

11:30 a.m.

STEMCAP Working Group Sessions

Recruitment/Retention of STEM Students, Graduates, Teachers, Professors and Mentors
STEM Academic Curriculum, Industry/Workforce Relevancy
Seamless STEM Transitioning Strategies, Elementary School to Workforce Entry

12:30 p.m.

Buffet Working Lunch

1:00 p.m.

Working Group Session (continued)

2:45 p.m.

Closing Remarks/Next Steps



STEM Collaborative Action Plan (STEMCAP) Forum Saturday, May 19, 2007

Forum Agenda

9:30 a.m.

Participant Registration/Group Assignments New Participant Briefing

10:00 a.m.

Welcome and STEMCAP Overview

Deborah Hirsch

Executive Director, California Space Education and Workforce Institute

California Innovation Corridor Initiative

The Honorable Andrea Seastrand

Executive Director, California Space Authority

10:20 a.m.

Opening Remarks

Dr. Warren J. Baker

President, California Polytechnic State University
California State University Lead
Math and Science Teacher Initiative

10:40 a.m.

U.S. Global Competitiveness: Workforce Development through Community Collaboration

Rick Stephens

Senior Vice President, Internal Services, The Boeing Company

11:00 a.m.

STEM and the California Department of Education

The Honorable Jack O'Connell

California Superintendent of Public Instruction

11:20 a.m.

Moderated Dialogue

The Honorable Jack O'Connell

Dr. Warren Baker

Rick Stephens

Moderator: Diane Siri

Executive Director, Alliance of Regional Collaborations for
Heightened Education Success (ARCHES)

11:55 a.m.

Buffet Luncheon

Breakout Session Facilitators

Dennis Galligani

Executive Director, ARCHES

Diane Siri

Executive Director, ARCHES

Jane Zinner

Victoria Conner

Principal, Strategic Vitality, LLC

12:30 p.m.

Breakout Working Session: Four Groups Rotating through Four Stations

Building the Framework for STEMCAP
Integrating Key Concepts from Working Groups
Best Practices/Model Programs and Relevant Studies

12:30 p.m. – 1:10 p.m.

First Station

1:10 p.m. – 1:40 p.m.

Second Station

1:40 p.m. – 2:05 p.m.

Third Station

2:05 p.m. – 2:30 p.m.

Fourth Station

2:30 p.m.

Synthesis/Synergy

Lessons Learned

2:45 p.m.

Next Steps

3:00 p.m.

Adjourn



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STEM Collaborative Action Plan (STEMCAP) Preview
Saturday, April 5, 2008 - Sheraton Gateway, LAX
Preview Event Agenda

8:30 a.m.

Opening Remarks

Introduction of the STEM Inventory

Video: STEM-Related Update on the Interagency Aerospace Revitalization Taskforce
Jack Gregg, EdD, Executive Director, California Space Education & Workforce Institute

9:15 a.m.

Overview: STEM Collaborative Action Plan

Introduction of "Who Is Responsible?" Exercise

STEM CAP Advisory Group Chairman:

Michael J. Gallo, President/CEO, Kelly Space & Technology, Inc.
Alliance for Regional Collaboration to Heighten Educational Success (ARCHES)
Dennis Galligani, PhD, Executive Director
Diane Siri, EdD, Executive Director
Jane Zinner, STEMCAP Project Lead

10:10 a.m.

Completion of Responsibility Exercise/BREAK

Overview: STEMCAP Demonstration Projects

Edward Landesman, The Aurora Project
Carrol Morran, Monterey Bay Educational Consortium
Leslie Rodden, Alliance for Education—San Bernardino County Superintendent of Schools

Recap of "Who Is Responsible?" Exercise

11:15 a.m.

STEMCAP: Industry/Informal Science Panel

Moderator: Jack Gregg, EdD

Ray Haynes, PhD, Director, University Strategic Alliances, Northrop Grumman Corporation
Kris Tueller, Senior Technical Operations Manager, Lockheed Martin Space Systems
Kim Burtnyk, Manager, Education, California Science Center

11:45 a.m.

STEMCAP: Higher Education Panel

Moderator: William W. Durgin, PhD, Provost/Vice President, Academic Affairs
California Polytechnic State University, San Luis Obispo

Margaret Heisel, Deputy Associate Provost, University of California, Office of the President
Steve Bruckman, Senior Vice Chancellor, California Community Colleges
Joan Bissell, EdD, Director of Teacher Education/Public School Programs

12:15 p.m.

LUNCHEON Keynote

Anthony Monreal, EdD, Deputy State Superintendent
Curriculum and Instruction Branch, California Department of Education

STEM CAP PARTICIPATION LIST

CSEWI acknowledges the following individuals who contributed to the development of the STEM CAP as focus group or working group participants, Forum speakers and attendees or supporting data providers, content developers, outreach volunteers, or STEM CAP support personnel. Please note: since the STEM CAP was a three-year project, some titles and affiliations may have changed. To the STEM Inventory participants and others who may not be listed individually, but who contributed significantly, please accept the appreciation of all STEM stakeholders.

Reza Abbaschian, Dean, Bourns College of Engineering, UC Riverside - Riverside
 Joe Adams, President/CEO, Discovery Science Center – Santa Ana
 Michael Aldaco, Senior Vice President, University of California Office of the President - Oakland
 Dan Aldrich, Vice Chancellor, University of California, Office of the President - Oakland
 Stacey Aldrich, Deputy State Librarian, California State Library - Sacramento
 Beth Ambos, Associate Vice President, Research & External Support, California State University Long Beach
 Jennifer Anastoff, Chief Executive Officer, EnCorps Teaching Program - San Francisco
 Laura Anderson, Biology Teacher, Eisenhower High School, Rialto Unified School District - Rialto
 David M. Andrews, PhD, Executive Director, Math/Science Education Center, California State University Fresno
 Denise Antrim, Science Coordinator, Orange County Office of Education
 John Peter Arvedson, California Teacher Advisory Council, California Council on Science and Technology; Lead Teacher, Academy of Science, La Puente High School
 Paula Arvedson, PhD, Founder, Satellite Educators Conference; President, California Space Education & Workforce Institute – Los Angeles/Pasadena
 Jaime Arvizu, Math/Science Counselor, Science & Math Education, California State University, Fresno
 Cathie Atkins, Associate Dean, College of Sciences, San Diego State University - San Diego
 Eric Atkinson, Earth Science Teacher, Eisenhower High School, Rialto Unified School District - Rialto
 Sheldon Axler, Dean, College of Science & Engineering, San Francisco State University
 Cheryl Babler, Vice President, Instruction, Coastline College - Fountain Valley
 Philip Bailey, Dean, College of Math and Science, California Polytechnic State University San Luis Obispo
 Kevin Baker, Alliance for Education, Business Community Liaison, San Bernardino County Office of Education
 Dr. Warren Baker, President, California Polytechnic State University San Luis Obispo; CSU Lead, Math and Science Teacher Initiative
 Frances Basich Whitney, Project Director, Mathematics, Santa Cruz County Office of Education
 Laura Beck, Chief Operations Officer, EnCorps Teaching Program - San Francisco
 Roberta Becka, Director of Grants Development, El Camino College Business Training Center - Hawthorne
 Steve Beitler, Manager, Silicon Valley Government and Public Affairs, Agilent Technology
 Glen E. Beltz, Associate Dean for Undergraduate Studies, College of Engineering, University of California, Santa Barbara
 Ken Berry, EdD, CSU Northridge; California School Boards Association - Northridge
 Anne Marie Bergen, California Teacher Advisory Council, California Council on Science and Technology
 Christine Bertrand, Executive Director, California Science Teachers Association - Sacramento
 Carleen Beste, Public Affairs Manager, Northrop Grumman Corporation - Redondo Beach
 Larry Bethel, Mechanical Engineer, Northrop Grumman Corporation; AIAA - Sunnyvale
 Nadine Bezuk, PhD, Professor, Teacher Education, San Diego State University - San Diego
 Joan Bissell, EdD, Director of Teacher Education/Public School Programs, Office of the Chancellor, California State University – Long Beach
 Gerald Blackburn, President, TEAM Science - Whittier
 Katherine Blackburn, Executive Secretary, Aerospace Legacy Foundation - Downey
 Julio Blanco, PhD, Dean, College of Natural Sciences and Mathematics, California State University Bakersfield
 Roberta Bloom, Instructor, Mathematics, DeAnza College - Cupertino
 Carole Bogue-Feinour, Vice Chancellor, Academic Affairs, California Community College - Sacramento
 Martin Bonsangue, Professor, Mathematics, California State University Fullerton
 Mitch Boretz, Administrator, Bourns College of Engineering, University of California, Riverside
 Raymond Brie, PhD, Professor, Department of Elementary Education, CSU Northridge - Northridge
 Jonathan Brown, President, Association of Independent California Colleges and Universities - Sacramento
 Steve Bruckman, Executive Vice Chancellor, California Community College Chancellor's Office - Sacramento
 Herbert Brunkhorst, PhD, Professor/Chair, Committee on Science, Math & Teacher Preparation, National Academy of Sciences – San Bernardino
 Bonnie Brunkhorst, PhD, Past President, National Science Teachers Assn.; Professor, Math and Science Teacher Education, California State University San Bernardino
 Keith Brush, President, Future Scientists and Engineers of America – Santa Ana
 Debbie Budd, Vice President, Instruction, Berkeley City College
 Ana (Kari) Buitrago, Business/Finance Analyst, The Boeing Company – El Segundo
 Dorian Buitrago, The Aerospace Corporation
 Kim Burtnyk, Education Office, California Science Center – Los Angeles
 Jenise Bush, GEAR UP, Eisenhower High School, Rialto Unified School District - Rialto
 Leslie Bushong, Director, California Teach-Science/Mathematics Initiative - Riverside
 Kara Butler, Principal, Cupertino Middle School
 Margaret Cagle, 2005 Presidential Teacher Awardee, Mathematics - Chatsworth
 Patrick Callan, Executive Director, University of California Science and Mathematics Initiative
 David Cantu, Director, Multi-Cultural Engineering Program, California Polytechnic State University San Luis Obispo
 Diane Carahan, K-12 Alliance Regional Director, WestEd
 Greg Carisio, Chief of Program Requirements, 30th SW/XPR, Vandenberg Air Force Base
 Damon Castillo, President, Science & Technology Education Partnership – Riverside/San Bernardino
 Mike Cellini, Assistant Principal, Lawson Middle School - Cupertino
 Rita Cepeda, President, San Diego MESA College
 Ivan Cheng, EdD, Assistant Professor, Secondary Education, California State University Northridge
 Steven Chesser, Senior Manager, Community Relations, The Boeing Company
 Caleb Cheung, 2005 Presidential Teacher Awardee, Science; Oakland Unified School District
 Emily Chi, Engineer/Chair, CONNECT, Northrop Grumman Space Technology – Los Angeles
 Craig Chivatero, Lockheed Martin Space Systems; AIAA
 Anne Cichowski
 Robert Cichowski, PhD, Professor Emeritus, California Polytechnic State University, San Luis Obispo

Bob Cisneros, Counselor, Eisenhower High School, Rialto Unified School District - Rialto
 Charles Coble, Co-Director, Science and Math Teacher Imperative, National Association of State Universities and Land Grant Colleges
 Philip Cojanis, Systems Engineer, bd Systems; AIAA Los Angeles Section Regional Liaison
 Alan Colburn, PhD, Professor Science Education, California State University Long Beach
 Neide Colvin, Principal, Ninth Grade, Silverado High School - Victorville
 Terry Colvin, Principal, Silverado High School - Victorville
 Victoria Conner, Principal, Strategic Vitality LLC – Santa Maria/Los Angeles
 Jacqueline Cooper, Geosciences Teacher, Riverside County
 Cecilia Cordova, Informal Science Education Officer, NASA Dryden Flight Research Center
 Don Correll, PhD, Fusion Energy Sciences Associate Director, Lawrence Livermore National Laboratory
 Joshua Costodio, Project Lead the Way Instructor, Silverado High School - Victorville
 Stephanie Couch, Director, Collaboration, Outreach & Communications, CENIC
 Thomas Cowan, Mechanical Engineer, Northrop Grumman Space Technology – El Segundo
 Duane Crum, San Diego State University
 Juan Cruz, Principal, Yerba Buena High School – San Jose
 Tim Cuneo, Principal, Cuneo-Zinner Group – San Jose
 Daphne Dador, Manager, Education and Workforce Development, California Space Education and Workforce Institute - Pasadena
 Eric Daniels, Director, State and Local Government Relations, California Space Authority
 Dean Davis, PhD, AIAA Western U.S. Pre-College Outreach Deputy Director; Sr. Principal Aerospace R&D Scientist/Engineer, Boeing Advanced Systems, El Segundo
 Ivor Dawson, Founder and President, Traveling Space Museum
 Duneen DeBruhl, Assistant Superintendent, Victor Valley High School District - Victorville
 Fred DePiero, Interim Assistant Dean of Curriculum and Innovation, College of Engineering, California Polytechnic State University San Luis Obispo
 Raymond Deutsch, Community Relations Director, Westberg and White Architects & Planners - Irvine
 Vincent Devlohovich, Instructor, Glendale Community College
 Jivan Dhaliwal, Math Coordinator, Santa Clara County Office of Education
 Angela Phillips Diaz, Special Assistant to the Chancellor, University of California, Riverside
 Kathy DirRanna, K-12 Alliance Statewide Director, WestEd
 Chris Douglas, Principal, Victor Valley High School - Victorville
 Joe Dumond, Assistant Principal, Eisenhower High School - Rialto
 William W. Durgin, PhD, Provost/Vice President, Academic Affairs, California Polytechnic State University, San Luis Obispo
 Randall Echeverria, Project Manager, California Space Authority - Sacramento
 Wade Ellis, Professor, Mathematics, West Valley College - Saratoga
 Janet English, California Teacher Advisory Council, California Council on Science and Technology
 Matt Everingham, Special Projects Manager, California Space Authority – Santa Maria
 Kellie Michele Evans, Associate Professor, California State University Northridge
 David Ewat, Science Coordinator, Shasta County Office of Education
 Deb Farkas, Middle School Science Content Specialist, San Francisco Unified School District
 Dick Farnsworth, Manager, Science & Technology Education Programs, Lawrence Livermore National Laboratory
 Leslie Fausett, Superintendent, Solana Beach Elementary School District
 Mary Fay-Zenk, Assistant Principal, Miller Middle School – San Jose
 Steve Ferron, Partnership Coordinator, Manufacturing Academy, Hawthorne High School
 Kathleen M. Fisher, Professor of Biology Emeritus, Center for Research in Math & Science Education, San Diego State University
 Robyn Fisher, RT Fisher and Associates - Oakland
 Leo Florendo, STEM Teacher, Freestyle Academy of Communication and Technology - Mountain View
 Celeste Ford, President/CEO, Stellar Solutions, Inc. – Palo Alto
 Laura Forrest, PhD, Faculty Liaison Math & Science Teacher Institute, California State University Long Beach
 Carolishca Forster, California Space Education and Workforce Institute – Pasadena
 Peter Freiss, President, The Tech Museum of Innovation, San Jose
 Norm Fujimoto, Vice President, Academic Affairs, Santa Ana College
 Dennis Galligani, PhD, Executive Director, Alliance for Regional Collaborations to Heighten Educational Success - Irvine
 Michael J. Gallo, President/CEO, Kelly Space and Technology, Inc. – San Bernardino
 Bruce Gardner, PhD, Principal Director, Learning Systems Center, The Aerospace Institute, The Aerospace Corporation – Los Angeles
 Lori Gaskin, Vice President, Academic Affairs and Student Services, Lake Tahoe Community College
 Camron Gauginpour, Executive Director, Space Science Outreach and Research, University of California Berkeley
 Linda Gaylor, SBCSS - ROP, San Bernardino County Office of Education
 Mo Geraghty, Instructor, Mathematics and Statistics, DeAnza College - Cupertino
 Dean Gilbert, Los Angeles County Science Consultant; Past President, California Science Teachers Association – Los Angeles
 Sandie Gilliam, California Teacher Advisory Council, California Council on Science and Technology
 Laura Gilliom, PhD, Director, University Relations Program, Lawrence Livermore National Laboratory - Livermore
 Howard Gobstein, Co-Director, Science and Math Teacher Imperative, National Association of State Universities and Land Grant Colleges
 Scott Godfrey, Associate Principal, Barstow High School
 Jeff Gold, Associate Director, Academic Technology, California State University Chancellor's Office – Long Beach
 Barry Goldman, Human Resources/Recruitment Programs, Lawrence Livermore National Laboratory – Livermore
 Manuel Gomez, Vice Chancellor, Student Affairs, University of California, Irvine
 David Gonzales, Director, California Applied Competitive Technologies Program, El Camino College - Hawthorne
 Javier Gonzales, Department Chair, Pioneer High School - Whittier
 Yno Gonzalez, Senior Vice President, Network Operations Planning, AT&T - San Ramon
 Daniel Howard Greene, Executive Assistant to the President, California Polytechnic State University, San Luis Obispo
 Judith Green, PhD, Professor, Department of Education, University of California Santa Barbara
 Larry Green, Math Success Center Coordinator, Lake Tahoe Community College
 Jack Gregg, EdD, Executive Director, California Space Education and Workforce Institute (2007-2008) - Pasadena
 Jeanne M. Grier, EdD, Professor, Department of Education, California State University Channel Islands
 Michael Gutto, Executive Vice President/Director of Imagery, Space & Launch, Scitor Corporation
 Susan Hackwood, PhD, Executive Director, California Council on Science and Technology - Riverside
 Allen Haile, PhD, Director, Community and Government Relations (Emeritus), California Polytechnic State University
 Kamal Hamdan, EdD, Department of Teacher Education, California State University Dominguez Hills
 Virginia Hamilton, Executive Director, California Workforce Association - Sacramento
 Art Hammon, Pre-College Education Specialist, NASA Jet Propulsion Laboratory – Pasadena
 Tapp Hancock, Presidential Awardee for National Math & Science Teaching; Teacher, Owens Primary – Bakersfield
 Jane Hansen, AIAA National Pre-College Outreach Chair; President, HRP Systems
 Penni Hansen, Manager, Inter-Segmental Relations, California Department of Education - Sacramento
 Philip "Scott" Hara, Chief Reservoir Engineer, Tidelands Oil Production Company - Long Beach
 Mark Harbison, Professor, Mathematics, Sacramento College
 Danielle Harlow, Assistant Professor, Science Education, University of California, Santa Barbara
 Jeannette Harper, QEIA, College Prep Programs, Rialto Unified School District - Rialto

William "Bill" Harper, Vice President, Strategic Sourcing and Operations Support - San Francisco
 Cathy Hart, Executive Director, Antelope Valley Board of Trade
 LeeAnne Haworth, Executive Project Administrator, California Space Authority
 Ray Haynes, PhD, Director of University Relations, Northrop Grumman Corporation
 Daren Heidgerken, Lockheed Martin Space Systems; AIAA
 Margaret Heisel, Deputy Associate Provost, University of California, Office of the President – Oakland
 Tamara Helfer, Community Relations/Education Programs, Lawrence Livermore National Laboratory – Livermore
 Teresa Henderson, Project Manager, California Space Education and Workforce Institute - Pasadena
 Thomas Henderson, Project Lead the Way Instructor, Silverado High School - Victorville
 Dave Hendry, President, Real Curriculum - Glendale
 Laura Henriques, PhD, Chair, Department of Science Education, California State University Long Beach
 Arturo Hernandez, Director, MESA Program, El Camino College, Torrance
 Edna Herring, Superintendent, Rialto Unified School District
 Laura Hickie, Coordinator, Special Projects and Assessments, Sierra Sands Unified School District
 Jim Hill, PhD, Chair, Department of Physics, California State University Dominguez Hills
 Debra Hirsch, Executive Director, California Space Education and Workforce Institute (2006-2007) - Pasadena
 Stan Hitomi, California Teacher Advisory Council, California Council on Science & Technology
 Jim Hoffman, Business Instructor, El Camino College Center for International Trade Development - Hawthorne
 Wendy Holford, NASA Ames Research Center – Moffett Field, Mountain View
 Cheryl R. Hom, Northrop Grumman Corporation – El Segundo
 Tom Hooper, California Innovation Corridor Liaison, US Department of Labor – Washington, DC
 Chris Hoeber, Senior Vice President, Program Management/Systems Engineering, Space Systems Loral – Palo Alto
 Michael Horton, Science Coordinator, Riverside County Office of Education
 James Houppis, Dean, College of Natural Sciences, California State University Chico
 Ann House, SRI International, Center for Technology in Learning
 Brandi Hucko, Assistant Principal, Cupertino Middle School
 Jan Hustler, PS3
 Katie Hutchens, English Teacher, Eisenhower High School - Rialto
 Ron Hughes, PhD, Professor/Faculty Coordinator, California State University/NASA Collaborative - Bakersfield
 Don Iglesias, Superintendent, San Jose Unified School District
 Imperial County Office of Education
 Barbara Illowsky, Project Director, Basic Skills Initiative, California Community College
 Jay Ishakowa, Vice Principal, Edward Harris Jr. Middle School (NASA Explorer School) - Elk Grove
 Jacqueline Jacobs, Vice President, Instruction, Pasadena City College
 Jonathan Janzen, Science Consultant, Tulare County of Education
 Carolyn Jeffries, Assistant Professor, Science Education, California State University Northridge
 Susan Jezyk, Assistant Principal, Kennedy Middle School - Cupertino
 George Johnson, Professor, Mechanical Engineering; CAL Teach, University of California Berkeley
 Susan Johnson, College Relations, Southern California Edison – Rosemead
 Allison G. Jones, Assistant Vice Chancellor, Academic Affairs, Cal State University Long Beach
 Juliana Jones, California Teacher Advisory Council, California Council on Science and Technology
 Richard Jones, Project Lead the Way Instructor, Victor Valley High School - Victorville
 Jackie Joyce, California Space Authority – Pasadena
 Joyce Justus, Vice Provost, Educational Relations, University of California Office of the President - Oakland
 Valerie Karnes, Interim Dean, Occupational Education and Workforce Development, Cerro Coso College - Ridgecrest
 Parvin Kassaie, PhD, Manager, Education Office, Jet Propulsion Laboratory – Pasadena
 John Keller, PhD, Summer Institute Leader, California Polytechnic State University San Luis Obispo
 Fran Kennedy, Director of Industry Initiatives, California Labor and Workforce Development Agency - Sacramento
 Brian Kenner, Learning Solutions – Cabrillo
 John Kenney, Physics Education Manager, PASCO Scientific
 Laura Kingford, Dean, College of Natural Sciences & Mathematics, California State University Long Beach
 John Knezovich, PhD, Director CAMS/Senior Scientist, Lawrence Livermore National Laboratory – Livermore
 Bonnie Konopak, PhD, Dean, College of Education, California Polytechnic State University
 Carey Kopay, Executive Director, Edward Teller Education Center, Lawrence Livermore National Laboratory - Livermore
 Phil Lafontaine, Director, Professional Development and Curriculum Support Division, California Department of Education - Sacramento
 Kai Lai, Engineering Consultant; AIAA
 Libby Lai, Engineering Consultant; AIAA
 Corwin Lakin, Founder, LEO.COM; AIAA
 Dr. Edward Landesman, Associate Director, Intersegmental Relations, UC Science and Math Initiative, Office of the President; Coordinator, The Aurora Project
 Miriam Landesman, Education Lead, NASA Smart Skies Project, NASA Ames - Moffett Field/Mountain View
 Tamika Lang, Community Investments in Education, The Boeing Company – Huntington Beach
 Sandra Lapham, Director of Education Technology, Orange County Office of Education
 Philip LaPolt, Chairman, Department of Biological Sciences, California State University Los Angeles
 Michael Leung, Dean, College of Science, California State University East Bay
 Albert A. Liddicoat, PhD, Interim Assistant Vice President of Academic Personnel, California Polytechnic State University San Luis Obispo
 Silvia Liddicoat, Adjunct Professor, Engineering, California Polytechnic State University, San Luis Obispo
 Mark Lieu, Chair, ICAS, Academic Senate California Community Colleges President
 Los Angeles Unified School District
 Noe Lozano, PhD, Associate Professor, Engineering, Stanford University – Palo Alto
 Michael Manchak, President/CEO, Economic Vitality Corporation San Luis Obispo
 J. Campbell Martin, Director, Office of External Affairs, NASA Dryden Flight Research Center
 Jeff Martin, California Space Authority – Pasadena
 Catherine Martin-Dunlop, PhD, Assistant Professor Science Education, California State University Long Beach
 Victoria Martinez, Career and Technical Education Coordinator, El Camino College - Torrance
 Gail Mathews, Assistant Superintendent, Rialto Unified School District - Rialto
 R. Mathews, Dean, Math and Science, Mira Costa College - Oceanside
 Steve Matuson, Math Instructor, San Jose/Evergreen Community College - San Jose
 Gloria McGee, ROP, Victor Valley High School District - Victorville
 James McGlothlin, President/CEO, Quintrion Systems – Santa Maria
 John Means, PhD, Dean, Community Advancement, El Camino College - Torrance
 James Megas, Teacher, Edward Harris Jr. Middle School (NASA Explorer School) - Elk Grove
 Marco Milinaro, Chief Education Officer, Center for Biophotonic Science & Tech; University of California, Davis
 Jose Millan, Vice Chancellor, Economic Development & Workforce Preparation, California Community College – Sacramento
 Lois Miller, Vice President, Instruction, Golden West College - Huntington Beach
 Anthony Monreal, EdD, Deputy State Superintendent, Curriculum and Instruction Branch, California Department of Education
 Carrol Morran, Executive Director, Monterey Bay Educational Consortium; University of California Santa Cruz, Educational Partnership Center

David M. Morse, CEO, Pocketfinder, Inc. - Yorba Linda
 Kirran Moss, EdD, Department of Communication Studies, California State University Long Beach
 Rose Marie Mungaray, Education Outreach, The Boeing Company – Huntington Beach
 Alice Murillo, Vice Chancellor of Academic Affairs, City College of San Francisco
 Diane Murphy, Director, Communications, Northrop Grumman Corporation – Redondo Beach
 Marian Murphy-Shaw, Curriculum, Siskiyou County Office of Education
 Steven Murray, Dean, College of Natural Science & Mathematics, California State University, Fullerton
 Suzanne Nakashima, California Teacher Advisory Council, California Council on Science and Technology
 Sue Nelson, Vice President, Instruction, Napa Valley College - Napa
 Melinda Nish, Vice President, Instruction, Orange Coast College - Costa Mesa
 Carol V. Nitz, Vice President, Global IT Delivery - San Ramon
 Kathy Norman, President, National Association of Science Teacher Education
 Nicole Nunes, PhD, Cal Teach Program Director - Berkeley
 The Honorable Jack O'Connell, Superintendent of Public Instruction, State of California - Sacramento
 Robert E. Oakes, Vice President, External Relations and Research, Association of Independent California Colleges and Universities - Sacramento
 Jeff Ordway, Director, Hawthorne Engineering Academy, Hawthorne High School
 Louise Ostrov, Principal, McAuliffe Alternative Program K-8 - Saratoga
 Ross Ottey, Principal Miller Middle School - San Jose
 Margaret Owens, PhD, Associate Dean, College of Natural Sciences, California State University, Chico
 Steve Pa, Mesa Union School District
 Lucas Pacheco, Career Technologies, Hawthorne High School
 Rick Palmero, University of California Davis
 Nikita Parmar, PhD, Assistant Professor, California State University, Channel Islands
 Roxy Peck, Associate Dean, College of Science and Mathematics, California Polytechnic State University San Luis Obispo
 Bill Pence, City Honors High School Robotics Team Advisor, Inglewood City Honors High School
 Georgette Phillips, Project Lead the Way Instructor, Silverado High School - Victorville
 Kathy Plum, Instructor, Mathematics, DeAnza College - Cupertino
 A.J. Polizzi, President, Rocket Science Tutors, Inc.; Vice President, Customer Integration, Universal Space Network, Inc.
 Oscar Porter, Executive Director, MESA Program, UC Office of the President - Oakland
 Vicki Powell, University of California, San Diego
 Susan Pritchard, California Teacher Advisory Council, California Council on Science and Technology
 Jordi Puig-Suari, PhD, Department Chair, Aerospace Engineering, California Polytechnic State University San Luis Obispo
 Christine Purcell, Manager, Industry, Workforce and Manufacturing Development, California Space Authority – Manhattan Beach
 Milton Randle, Director, Maximizing Engineering Potential (MEP) Program, California Polytechnic State University Pomona
 Debasree Raychaudhuri, Assistant Professor, College of Natural and Social Sciences, California Polytechnic State University San Luis Obispo
 Kate Reed, PhD, Assistant Professor Teacher Education, California State University, East Bay
 Lee Angela Reid, Principal Consultant, Senate Office of Research - Sacramento
 Donna Riordan, Director of Programs, California Council on Science and Technology - Capitola
 Armando M. Rivera, PhD, Assistant Professor, Chemistry, MESA Program, East Los Angeles College
 Joseph M. Rivera, Director, Gas Engineering, Southern California Gas Company - Los Angeles
 Chris Roberts, Math Instructor, Barstow High School
 Leslie Rodden, Coordinator, Alliance for Education, San Bernardino County Office of Education
 Miriam Rodon-Naveira, Sr. Physical Sciences Technology Manager, NASA Dryden Flight Research Center
 Mary Kay Rudolph, Vice President, Instruction, Santa Rosa College
 Joanna Rummer, Superintendent, Sierra Sands Unified School District – Indian Wells
 Barry Russell, Vice President, Instruction, College of the Siskiyous - Weed
 Stephanie Saccoman, EdD, Project Director, Science IMPACT, California Polytechnic State University, Pomona
 Felicitas Salez, Engineering Consultant
 Edgar Salazar, Project Lead the Way Instructor, Victor Valley High School - Victorville
 San Bernardino Community College District
 Rafaela M. Santa Cruz, PhD, Director, San Diego Mathematics Project, San Diego State University
 Prakash Sarathy, Northrop Grumman – El Segundo
 Brad Schultz, Educational Services, San Luis Obispo County Office of Education, P-16 math/Science Steering Committee Co-Chair
 Elane V. Scott, Future Workforce Strategist, birth2work.org
 The Honorable Andrea Seastrand, Executive Director, California Space Authority
 Barbara Shannon, California Teacher Advisory Council, California Council on Science and Technology
 Melanie Sharp, Program Consultant, Business Training Center, El Camino College - Hawthorne
 Zahed Sheikholeslami, PhD, Director, Project-Based Learning Institute, College of Engineering, California Polytechnic State University San Luis Obispo
 Eliza Sheppard, AIAA Los Angeles Section Chair; Manufacturing Engineering Manager, Northrop Grumman – El Segundo
 Todd Shimada, Principal, Hyde Middle School - Cupertino
 Richard Shope, PhD, Director, World Space Foundation - Whittier
 Gwynne Shotwell, Vice President, Business Development, Space Exploration Technologies – El Segundo
 Diane Siri, EdD, Executive Director, Alliance for Regional Collaborations to Heighten Educational Success – La Selva Beach
 Lynne Slivosky, Assistant Professor, College of Engineering, California Polytechnic State University San Luis Obispo
 Drexel Smith, Senior Vice President, Wyle Labs – El Segundo
 Lori Smith, Director of Research and Evaluation, Project Tomorrow, Orange County Office of Education
 Mary Perry Smith, MESA Co-Founder - Oakland
 Philip Smith, Chief Executive Officer, California Space Grant Foundation
 Karl Sonntag, Principal, Lawson Middle School - Cupertino
 Tom Springmeier, Vice President, Manager, Worldwide Sales and Marketing, Educational & Productivity Solutions, Texas Instruments Inc. - Dallas, Texas
 Rita Starnes, K-12 Alliance Regional Director, WestEd
 Mark Stefanski, California Teacher Advisory Council, California Council on Science and Technology
 Jules Stein, Director of Special Projects, Governor's Office, State of California – Sacramento
 Bruce Stenslie, Deputy Director, California Workforce Association – Sacramento
 Rick Stephens, Senior Vice President, Internal Services, The Boeing Company – Chicago
 Jack Stewart, President/CEO, California Manufacturers and Technology Association – Sacramento
 John Swensson, Interim Vice President, Instruction, DeAnza College - Cupertino
 Sue Tacke, Assistant Superintendent, Education Services, Franklin-McKinley School District - San Jose
 Lisa Taormina, Assistant Principal, Hyde Middle School - Cupertino
 Lindsay Tartare, EdD, Mathematics Education Coordinator, California State University Long Beach
 Thomas Taverney, Senior Vice President, Space Applications International Corporation (SAIC)
 Edward Taylor, Engineering Director, Google, Inc. – Mountain View
 Richard Taylor, Principal, Miller Middle School - San Jose
 Ron Taylor, Vice President, Instruction, Chabot College - Hayward
 Reginald Thompkins, Principal, Eisenhower High School - Rialto

Keith Thompson, Manager, STEM Education and Workforce Development, Office of the Secretary of Defense, US Department of Defense
 Linda Tiggs-Taylor, Executive Director, Education Partnerships in Pre-Collegiate Programs - Science, Technology, Engineering and Mathematics, California State University Long Beach
 Michael Tomasello, Senior Associate Director, MESA Program, University of California Office of the President - Oakland
 Jo Topps, K-12 Alliance Regional Director, WestEd
 Yvette Toro, CASLE Coordinator, Victor Valley High School - Victorville
 Jean Treiman, Executive Director, California Subject Matter Projects, Office of the President, University of California, Oakland
 Chris Tsuji, Treasurer, California Math Council
 Kris Tueller, Senior Technical Operations Manager, Lockheed Martin Space Systems – Sunnyvale
 Judy Turner, Programs and Partnerships Director, California Space Authority; Program Manager, California Innovation Corridor Initiative – Pasadena
 Robert Twiggs, Director, Space Systems Development Laboratory, Stanford University - Palo Alto
 Sharon Twitty, Assistant Superintendent, Merced County Office of Education
 University of California Cooperative Extension
 University of California, San Diego
 Ignatios Vakalis, PhD, Chairman, Computer Science Department, California Polytechnic State University San Luis Obispo
 Gregory Vallone, EdD, Director, Middle Schools, Los Angeles Unified School District
 Sue Vieira, Teacher, James Lick High School, East Side Union High School District - San Jose
 Lonny Villalobos, Science Teacher, NASA School Coordinator, Edward Harris Jr. Middle School - Elk Grove
 Hal Walker, Chairman and Founder, International Science Discovery and Learning Center, Inglewood
 Edward D. Walton, PhD, Professor of Chemistry, California Polytechnic State University Pomona; National Academy of Science Working Group/Standards
 Bruce Westermore, Director, Project Lead the Way, San Diego State University
 Greg Wheeler, Associate Dean for Undergraduate Studies, California State University Sacramento
 Peggy Wheeler, ROP Coordinator, Rialto Unified School District - Rialto
 Richard Whelan, Vehicle Systems Engineer, Lockheed Martin – Sunnyvale
 Kathy Williams, Associate Professor, Biology, College of Sciences, San Diego State University
 Katrina Williams, California Teacher Advisory Council, California Council on Science and Technology
 Scott Williams, Assistant Principal, Silverado High School - Victorville
 Tim Williamson, Science Consultant, Los Angeles County Office of Education - Los Angeles
 Krisztina Wilmoth, Director of Education and Public Outreach, NASA Astrobiology Institute – Moffett Field/Mountain View
 Jim Wright, Vice President, Academic Affairs, Ohlone College - Fremont
 Ann Willougby, Manager of Education & Community Outreach, Lawrence Livermore National Laboratory – Livermore
 Judi Wilson, Director Science and Special Projects, San Joaquin County Office of Education
 Karen Withy-Smith, Science Teacher, Ramona High School - Riverside
 Beth Yaeger, Director, Center for Literacy and Inquiry, Graduate School of Education, UC Santa Barbara
 Janet Yamaguchi, Vice President, Discovery Science Center, Santa Ana
 Henry T. Yang, Chancellor, University of California Santa Barbara
 Sandra Yellenberg, Science Coordinator, Santa Clara County Office of Education
 Beverly Young, PhD, Assistant Vice Chancellor, Teacher Education/Public School Programs, Office of the Chancellor, California State University
 Connie Zandate, Coordinator, Career and Technical Education, El Camino College
 Jane Zinner, Principal, Cuneo-Zinner Group; STEM CAP Project Lead, Alliance for Regional Collaborations to Heighten Educational Success – San Jose


California Mathematics Council

Kathy Woods, President
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 Jerry Neidenbach
 Rebecca Newburn
 Royce Page
 Janet Smith Kimberly Stiewig
 Jeannie Toshima
 Janet Trentacosta
 Melanie Tucker
 Lisa Usher-Staats
 Vicki Vierra
 Molly Whiteley

Interviews

Mark St. John, Founder and President, Inverness Research, Incorporated
 National Sciences Resources Center
 Sue Neuen, Director, California Science and Math Coalition
 Ross Armbricht, Executive Director, Delaware Foundation for Science and Math Education
 Washington State Leadership and Assistance for Science Education Reform, Director
 Partnership for Student Success in Science, Director



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