Training California's New Workforce for 21st Century Nanotechnology, MEMS, and Advanced Manufacturing Jobs

Executive Summary

Prepared for

Workplace Learning Initiative
Economic and Workforce Development Program
California Community Colleges

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"For the overwhelming preponderance of human history,
humans have lived in societies that were characterized by 80% continuities, 15% cycles, and only 5% novelties at best. Now I believe the figures are reversed: 80% of our futures may be novel, 15% cyclical, and only 5% continuous with the past and present."
Professor Jim Dator, Hawaii Center for Futures Studies

The Evolving Mission of the Workplace Learning Initiative

The California Community Colleges Workplace Learning Initiative's mission is to:[i]

> …utilize a network of twelve regional community college Workplace Centers to serve the emerging needs of the public and private sectors with a variety of customized workplace learning services including occupational-specific skills assessment, needs and task analysis of requirements of the job, basic skills instruction, vocational English as a second language, analytical and problem-solving skills and customer service training. The Centers continuously realign their services in order to provide a flexible response to the changing needs of the business community. In a highly coordinated effort, these centers serve not only the needs of their local region, but provide technical assistance throughout the state to funded and unfunded centers.

California has the opportunity to create a 21st Century multi-ethnic workforce to meet the evolving and complex challenges of converging technologies—particularly nanotechnology, Micro-Electro-Mechanical Systems or "MEMS," and advanced manufacturing technology—that will dramatically change the state's manufacturing sector by 2015.[1] The 2010 to 2015 workforce will be ethnically mixed but predominantly young, and Latino. The Economic and Workforce Development Program stands right at the crossroads of these profound developments. The Initiative, with its emphasis on basic skills training, is critical to preparing the new workforce for this evolving sector.

[1] Micro-Electro-Mechanical Systems or "MEMS" are microscopic or smaller systems which have a moving part and utilize some form of electronics. In terms of a measurement, anything under 100 nano meters (nm) is nanotechnology; and anything above is microtechnology or MEMS. In a way of speaking, we can say that MEMS involves the flea on the ant; nanotechnology involves molecular processes that regulate the flea's cells. Nanoscience is a broad term used for the study of materials and/or processes at the molecular level integrating a variety of disciplines. Biology, chemistry, and physics have all independently converged into nanoscientific research areas. Nanotechnology is the technological realization of the direct manipulation of materials and processes at the molecular and atomic levels as it builds molecule by molecule, or bottom up. Advanced manufacturing uses digital links to achieve the simultaneous digital integration of design, manufacturing, and marketing activities in real time.

A Turn-Key 21st Century Workplace Learning Training Program

This report describes and proposes a turn-key Workplace Learning Nanotechnology-MEMS-Advanced Manufacturing Program. The program is based on existing, tested training programs in Pennsylvania, New York, California, and Mexico. Resources

include:

- Key nano-technology and advanced manufacturing contacts and advisers;
- A sample list of potential clients, including California nanotechnology business, and Latino/Hispanic manufacturers;
- Ethnically based high-technology training programs;
- Nanotechnology/MEMS programs in California and other states;
- Nanotechnology/MEMS curriculum development experts, including experts at training ethnic minorities;
- Recommendations for working with and aligning Adult Education with the Workplace Learning Nano/MEMS Advanced Manufacturing Program; and a list of educational consultants and nanotechnology associations willing to partner with the Initiative to pursue funding and to create the new program.

California's Challenge to the Community Colleges Economic and Workforce Development Program, and the Workplace Learning Initiative

The immediate and continuing economic challenges being faced by the United States and California have been described in a joint 2005 study by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine of the National Academies. Their joint statement deserves a lengthy quote:[ii]

> Having reviewed trends in the United States and abroad, the committee is deeply concerned that the scientific and technical building blocks of our economic leadership are eroding at a time when many other nations are gathering strength. We strongly believe that a worldwide strengthening will benefit the world's economy—particularly in the creation of jobs in countries that are far less well-off than the United States. But we are worried about the future prosperity of the United States. Although many people assume that the United States will always be a world leader in science and technology, this may not continue to be the case inasmuch as great minds and ideas exist throughout the world. 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 nation must prepare with great urgency to preserve its strategic and economic security. Because other nations have, and probably will continue to have, the competitive advantage of a low-wage structure, the United States must compete by optimizing its knowledge-based resources, particularly in science and technology, and by sustaining the most fertile environment for new and revitalized industries and the well-paying jobs they bring.

California's challenge is to cultivate the competitive advantage of its manufacturing sectors and its current and future workforce. Succinctly put: *Competitive Advantage = An Innovative Workforce + Advanced Manufacturing + New Materials + Global Logistics + Ubiquitous Information Technology*. The core of California's competitive manufacturing advantage in the future is the use of new nanotechnology, MEMS, and other materials based on biotechnology for example, applied through advanced manufacturing techniques to produce innovative products that are moved across global electronic and surface logistics, just-in-time, to customers anywhere in the world. Information technology penetrates and ties together every element of this process. An innovative, highly trained workforce working with these technologies invents and applies the proprietary knowledge that generates a firm's competitive advantage. (Each element of this "equation" is developed in this report, serving as a foundation for the proposed Workplace Learning Program.)

Clearly, the California Community College's Economic and Workforce Development Program's challenge is to pull together its Workplace Learning, Biotechnology, Applied Competitive Technologies, Small Business Development Centers, Advanced Transportation Technology, Environmental Technology, International Trade Development, Multimedia and Entertainment Initiatives to creatively and agilely address each element of the global challenge to California's future prosperity. Kay Ferrier, Dean of the Economic and Workforce Development Program has defined the program's theme as "Stability with agility focusing on growth and relevancy," and its goal as a program that realizes continuous initiative development by balancing stability and change.

Forecast of Size of Workforce to be Trained

Almost 45 percent of California's workforce will be Latino/Hispanic in 2010 compared to about 37 percent white. Of all of the students taking and *passing* the high school math and English exit exam in 2005, over 50 percent (32,000) were Latino/Hispanic. This, in addition to other students passing the test, totaled about 62,000 in 2005 alone. In 2001-02, the total enrollment of adult students in adult education was 1,171,780. Another quarter, or 292,795, of the students at adult schools reported having a high school diploma. Adult education statistics indicate that in 2001-02, 50% of students enrolled in adult schools were of Hispanic origin. In 2003-04 (the latest available figures), Latinos made up 53% of enrolled adult school students.[iii] Of the 1 million minimum wage workers in California, about 334,000 have a high school diploma. A very substantial number of laid-off manufacturing workers with at least a high school diploma need to be retrained.

Nano/MEMS Job Forecast

According to a study by the California Economic Strategy Panel, more than 62 percent of the state's job growth from 1993 to 2002 came from newly formed small companies. Another 37 percent came from expansion of existing firms. Less than 1 percent came from businesses moving into the state. Ethnic entrepreneurs' start-ups have generated a

significant portion of high technology jobs in Silicon Valley. The ethnic ownership of small businesses and start-ups has been increasing over the past decade and will continue to increase.

Scientific and technical occupations already employ a significant number of not only Whites, but also ethnic minorities. For example in 2000, a large number of Hispanics and Asians were employed as technicians (113,000 or 36 percent of all technicians), production workers (711,000 or 69 percent), and as scientists, engineers or computer specialists (268,000 or 32 percent). California's workforce demographics are already changing to look like 2010.

It is very difficult to forecast jobs in industry sectors that are not fully developed let alone for technologies that enable revolutionary production and products in many other sectors as nanotechnology and MEMS do. The following table uses various sources to roughly

New Technology:	***2004 or 2005***	***2006 to 2008***	***2010 or 2012***	***2015***	***Total Job Growth***	***Percent***
Existing Manufacturing Sectors (LMID)			1,665,000		26,800	1.6%
MEMS	18,000		22,000	30,000	12,000	66.7%
Nanotechnology				226,800		

forecast the number of manufacturing, nanotechnology and MEMS jobs that could be created or influenced due to these new technologies. The projections far exceed the number of expected manufacturing jobs showing the significance of the two sectors to California's future. The challenge will be not only to train workers to fill job openings created by retiring, highly skilled older workers, but to retrain incumbent workers to the technical and innovative requirements of the new enabling technologies.

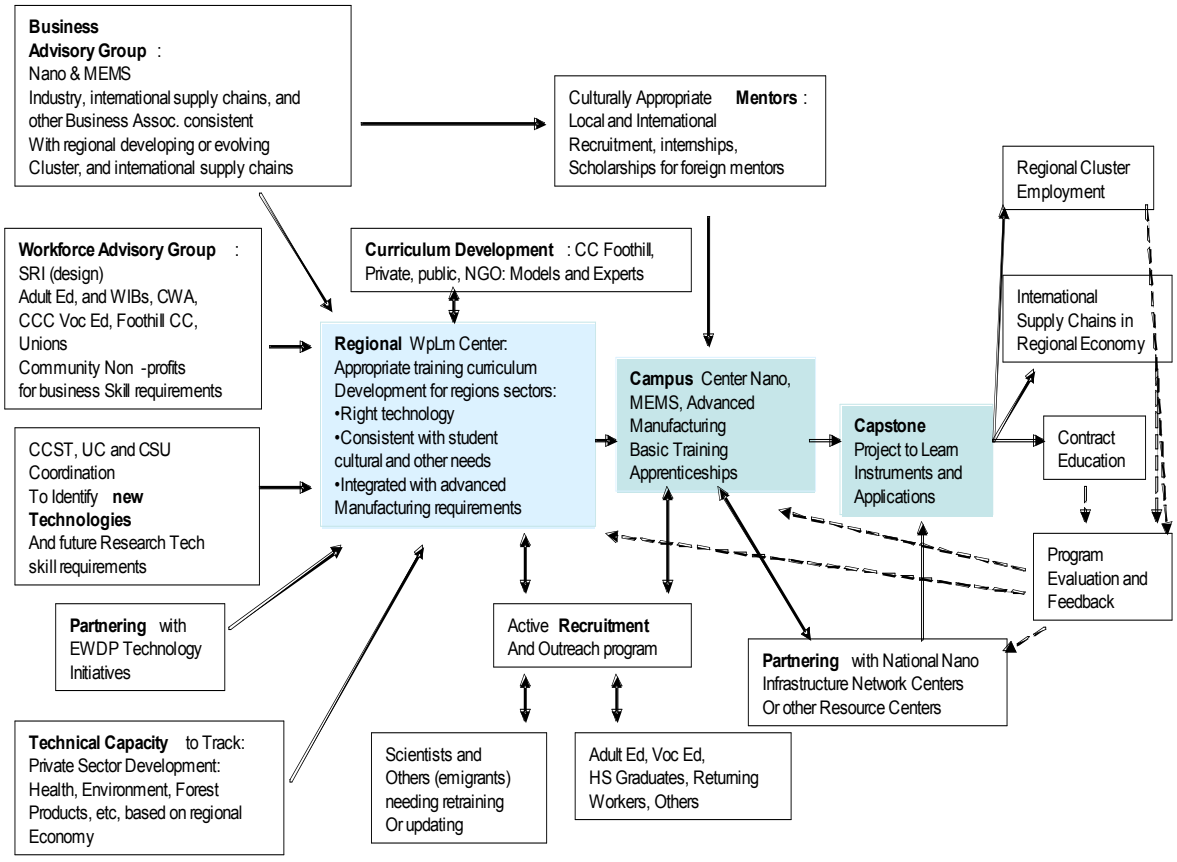
Globalization involves the use of advanced manufacturing technology and logistics systems to develop and produce products for markets anywhere in the world. Due to demographic projections indicating Latinos will comprise a majority of California's workforce by 2010, this study chooses to look at Latino/Hispanic high technology manufacturing as an example of these developments. Mexico has initiated a MEMS initiative and is working with companies and universities in New York, New Mexico and Arizona. California could become part of this initiative in the future. The state already has multiple high technology supply chains that extend across the border. The owners and employees of the firms could also serve as mentors to encourage Latinos and Hispanics to consider a technical occupation. This model could apply to other ethnic groups as well, particularly Chinese and South Asian immigrant owned firms.

Proposed Actions to Make Workplace Learning Visionary, Evolving, and Agile

According to California's Regional Economies Project, California Economic Strategies Panel, the "…current workforce investment system is a hybrid based on both a cyclical model of unemployment, which assumes either explicitly or implicitly that jobs that have been lost within an industry are likely to come back, and categorical training programs that are aimed at helping disadvantaged groups find employment."[iv] These conditions call for a growth-oriented workforce training strategy. It requires a shift away from the current workforce training assumptions to one of continuous transition, linked to life-long learning. Such a continuously adjusting strategy must be driven by two inextricably linked customers: the worker and business.

The following diagram provides one option for how the Workplace Learning Program might organize itself to continuously respond to the emerging challenges of nanotechnology/MEMS and advanced manufacturing technologies.

One Option for Organizing a WpLrn Regional Organization



Source: Time Structures

The three shaded boxes at the center of the diagram are the major, highly integrated, proposed Workplace Learning Nano/MEMS Training Program components. The three components are: the regional Workplace Learning Center (other colleges in the region participate in the consortium[2]); the regional CACT; and a regional nano/MEMS technology center. The Workplace Learning Center develops, in partnership with various businesses, technical, community and other advisory groups, and the local CACT, the appropriate training curriculum to respond to the needs of nano/MEMS and advanced manufacturing businesses in a region. Based on the skill requirements developed by the consortium, Workplace Learning then assesses the needs of high school graduates, using community based organizations and appropriate experts, in the geographic area and develops the necessary basic science, math, technical English, and other training necessary to prepare the students for the more advanced CACT training program. Once students have passed a basic nano/MEMS knowledge test, they receive a stipend to travel to a regional nano/MEMS technology center to complete their Capstone Project. The Capstone project involves developing the necessary instrumentation and other technical skills to qualify for a nanotechnology degree or certificate. After receiving a degree or certification, they are then prepared to be hired by a nano or MEMS company. As noted above, this report provides the necessary contacts and resources to implement this option.

Additional Nanotechnology/MEMS, and Advanced Manufacturing Training Options

There are a number of supplemental options that could be considered along with the proposed training program.

1. Develop a communication and outreach strategy to California companies receiving a U.S. Small Business Innovation Research grant[3] to market the resources existing through the Workplace Learning Initiative partnership with the California Community Colleges Centers for Applied Competitive Technologies, to support rapid prototyping and product design using digital media, with a particular emphasis on firms engaged in high technology manufacturing including nanotechnology and MEMS.[v]
2. Consider developing a Nano College by working with the Molecular Foundry to design "Nano College," as a replicated model of "Nano High" to be operated at the California Community Colleges. Scientists and post-doctorate experts could be invited to community college campuses to offer a series of talks and forums on what they are doing in nanotechnology, the nature of nanoscience and the implications for career opportunities in the workplace in the future. Such an initiative should be launched in concert with a nanotechnology technician program so that interested students could enter an academic pathway leading to a nanotechnology career.[vi]
3. Consider developing a Nanotechnology Apprentice Technician Program.[vii] Work with interested nanotechnology employers and unions to:[viii]

[2] The emphasis is on partnering to pursue joint resources and to prepare workable curriculum. Credit for developing the regional effort should go to the joint consortia leadership.

[3] President's Executive Order on U.S. Small Business Innovation Research dated February 24, 2004.

a. Make them aware of the existing capacity of the California Community Colleges to deliver apprenticeship training programs for nanotechnology industries.
b. Develop an apprenticeship curriculum and program plan to be certified and approved through the Division of Apprenticeship Standards.
c. Establish employer and union linkages with appropriate community colleges across the State to design and deliver academic and applied science components of the Nanotechnology Apprentice Technician program.

4. Considering developing a model career ladder project leading to life-long learning for advanced manufacturing and nanotechnology/MEMS related careers.

Options for Improving the Alignment of Adult Education with Economic and Workforce Development Program Initiatives

Adult Education, as noted above, provides basic skills to a large number of adults, including high school graduates who could move through the CACT or other more advanced training programs. The Adult Education system could be better aligned with Economic and Workforce Development Program, and the Workplace Learning Initiative, to provide basic skills necessary to train workers for emerging high technology manufacturing jobs. Here are some options that could realize this opportunity.

1. The Comprehensive Adult Student Assessment System (CASAS)[ix] **c**urrently works in collaboration with thirty states in support of data collection, evaluation and assessment for adult education (and noncredit) programs. CASAS is presently engaged in a consortium among fifteen states involved in developing a workforce (basic) skills certification guided by industry needs. CASAS and consortium partners are in the process of developing pilots for that certification. Although California is one of the fifteen states engaged in this effort, no pilot basic skills certification projects have yet been established here. The Workplace Learning Initiative may elect to develop and propose, in collaboration with the State Department of Education and other interested parties, a model certificate of basic skills reflecting: the state's strategic education and workforce needs required to support a 21St century economy and meeting literacy needs, including basic literacy in science and math. A component of this effort could be inclusion of general and introductory curriculum focusing on nanotechnology and underlying scientific concepts such as that already developed in other states.

2. Potential resources for development of model certificate of basic skills include:
    a. SRI International has launched the Center for Technology in Learning,[x] whose mission is to improve learning and teaching by prototyping new interactive learning environments and tools, including uses of technology in assessing learning in mathematics and science. A related SRI International Project, "NanoSense"[xi] is developing and testing 5 – 6 high-school curricular units focusing on real-world examples of nanotechnology, drawing on concepts from physics, chemistry and biology.

b. The National Hispanic University (NHU),[xii] located in Silicon Valley, offers an Associate of Science degree in Mathematics and Science. The National Hispanic University, a 4-year university, offers this AA degree requiring a minimum of 69 units with an average grade of 2.0 or higher. In addition, NHU offers an Associate of Science degree in Mathematics and Science with an Engineering emphasis, requiring a minimum of 73 units.

Options to Equip Workplace Leaning Leadership with the tools to Address New Training Challenges

Workforce Learning leadership development should go beyond technical expertise. Workforce Learning leadership could imitate successful large corporations by training them to be flexible and capable of taking calculated risks to align well with the complex way the future is approaching. The training could include guidance in how to establish the proper mix of slow and rapid change that includes strategic realignment with the past combined with an adaptive orientation towards the future. Of course opportunities to develop key competencies consistent with the challenges of advanced manufacturing, information technology, emerging materials, and other factors is necessary.

The Economic and Workforce Development Program and the Workplace Learning Initiative could develop the capacity to anticipate and track nano/MEMS and advanced manufacturing and other manufacturing competitive advantage developments by systematically collecting related data and by expanding participation in key government and private industry-based planning groups. The goal of this activity is to track a highly complex, evolving system that is not fully realized in the present.

Workplace Learning Initiative and the CACTs could partner with the University of California, the California State University System and other universities to anticipate and develop new academic and training curricula as new nanotechnology/MEMS and advanced manufacturing technology transfers produce opportunities for new workforce career ladders.

Options for Working with the Community College System

Resolve various Community College and system-wide policy issues that limit the Economic and Workforce Development Program, Workplace Learning and other initiative's ability to hire instructors, to fund successful centers, and to disburse and/or integrate key programs amongst campuses. Time Structures believes that the following focused options, drawn from a survey of College administrators and conducted for this series of Economic and Workforce Development Program studies, begin to flesh this out:

Option 1: Work toward building bridges to full-time faculty.

Option 2: Complete the removal of the statutory sunset clause from the California Community College's Economic and Workforce Development Program's enabling legislation.

Option 3: The Economic and Workforce Development Program could create or facilitate a strategy that will satisfy the California Community College system making possible the rapid hiring of qualified part-time and full-time instructors for the Centers by examining limitations imposed by the "25%/75%" rule on program growth.

Option 4: The Economic and Workforce Development Program could investigate a strategy and develop options for a plan to facilitate movement of mature programs onto campus throughout the system without loosing their essential capacity to generate new curricula in response to changing industry and workforce needs.

Option 5: Consider using the college administrator's survey[4] to continue the current positive dialogue and to strengthen relationships with college administrators.

Option 6: Develop a communication and outreach strategy that identifies and communicates with California companies receiving a U.S. Small Business Innovation Research Grant. The outreach effort could market CACT resources to support rapid prototyping and product design using digital media, with a particular emphasis on firms engaged in high technology manufacturing including nanotechnology and MEMS.

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[i] Kay Ferrier (2005). *California Community Colleges Economic and Workforce Development Program: Annual Report for Fiscal Year 2003-04*.

[ii] The National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine of the National Academies (2005) *Rising Above The Gathering Storm Energizing and Employing America for a Brighter Economic Future, Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology.* Committee on Science, Engineering, and Public Policy. http://books.nap.edu/catalog/11463.html

[iii] Patricia DeCos, "Educational Opportunities for Adults in California" (2004), California Research Bureau, CRB 04-004, p. 4, and the State Department of Education, Adult Education Division.

[iv] Regional Economies Project, California Economic Strategy Panel (2004). *Creating a Workforce Transition System in California.*

[v] Notes from Marshall Gartenlaub: Many companies will bring in hard sketches and want them in digital form – 3d models drawn to facilitate development in a digital way. Allows 3 dimensional printing and rapid prototyping.

[vi] Contact: Dr. Mark Alper, Deputy Director of Material Science Division of the Lawrence Berkeley National Laboratory and Deputy Director of Molecular Foundry. (510) 586-6581; mdalper@lbl.gov Dr. Alper believes NSF may be receptive to funding a proposal of this nature for the community colleges. Industry could be contacted for donations of equipment.

[vii] See California Education Code Sections 79146 and 79148 authorizing development of "innovative Apprenticeship training demonstration projects in high growth industries in emerging and transitioning occupations that meet local labor market needs and that are validated by current labor market data. "

[viii] Contact: Barry Noonan, California Community Colleges Educational Services Division, Career Technical Education (916) 445-8026.

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[4] The survey results are available from Kay Ferrier, Dean, Economic and Workforce Development Project, Chancellor's Office, California Community Colleges.

[ix] Patricia Rickard, Executive Director, Comprehensive Adult Student Assessment System; rickard@casas.org; www.casas.org

[x] SRI International, Center for Technology in Learning; http://ctl.sri.com/about.jsp; contact: Nora Sabelli. (650) 859-3599; nora.sabelli@sri.com

[xi] NanoSense Project, NSF Grant # ESI-0426319, SRI International; contact: Patricia Schank; patricia.schank@sri.com

[xii] The National Hispanic University, Dr. David P. Lopez, President, dlopez@nhu.edu; www.nhu.edu