CCST Report to the California-Mexico Commission on Education, Science and Technology:

Opportunities for Collaboration in High-Tech Research and Teacher Professional Development

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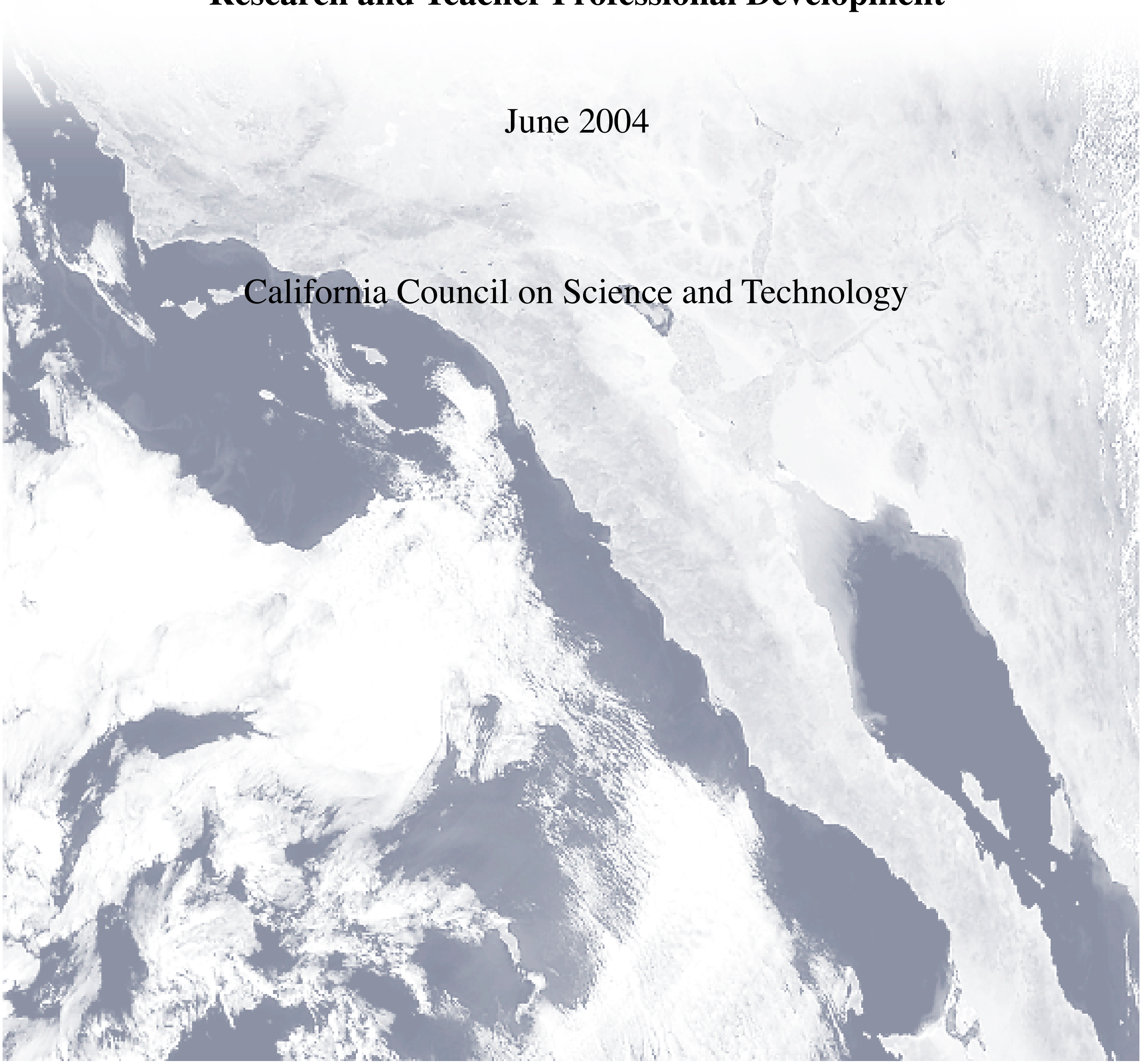
California Council on Science and Technology



CCST Report to the California-Mexico Commission on Education, Science and Technology: Opportunities for Collaboration in High-Tech Research and Teacher Professional Development

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CCST is a nonprofit organization established in 1988 at the request of the California State Government and sponsored by the major post-secondary institutions of California, in conjunction with leading private-sector firms. CCST's mission is to improve science and technology policy and application in California by proposing programs, conducting analyses, and recommending policies and initiatives that will maintain California's technological leadership and a vigorous economy.

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1. Introduction

The California-Mexico Commission on Education, Science and Technology was formed in 2002 with the goal of providing a high-level forum to determine vital areas in Mexico and California where joint investments could be made in research and education. The Commission stemmed from an agreement signed between the University of California and El Consejo Nacional de Ciencia y Tecnologia (CONACYT) in 1997.[1] The Commission acts as an intellectual and scientific advisory body to both UC and CONACYT, conducts in-depth analysis of critical issues at the request of UC and CONACYT, and issues reports on indicators of scientific and technological progress in Mexico and California. Membership includes representatives from academia and the government, including five members with affiliation to the California Council on Science and Technology (CCST).

CCST is a nonpartisan, impartial, not-for-profit corporation designed to offer expert advice to the state and provide solutions to science and technology-related public policy issues. The strength of CCST lies in the support and resources provided by its sustaining institutions, the University of California system, the California State University system, California Institute of Technology, Stanford University, University of Southern California, and the California Community Colleges. CCST also has strong connections to industry through its membership. CCST has a proven record of accomplishment in providing timely, impartial analyses of complex issues for the legislative and executive branches of government on issues ranging from nanotechnology to genetically modified foods to education. As an institution capable of bringing an impartial perspective to politically contentious and potentially wide-ranging in science and technology related issues, and as an institution with a close working relationship with the University of California, CCST was considered a logical organization to assist the Commission in accomplishing its mission.

At a March 2003 meeting, CCST was requested to help identify common science and technology research areas and suggest collaborative programs of mutual interest where a joint effort between California and Mexico could make a difference to the economies and education systems of both. It was noted that while California's research programs are much stronger than that of Mexico, both California and Mexico share poorly ranked elementary and high-school educational systems and produce inadequate numbers of skilled science, technology, engineering and math (STEM) baccalaureate graduates. In addition, Mexico is struggling to grow a larger research base in its universities and to foster the establishment of high-tech industries in the face of accelerating loss by the emigration of top scientists.

CCST was thus asked to pursue two lines of inquiry:

- How to foster small but important clusters of innovation in high-tech areas in Mexico and address the concern that Mexico loses top research talent to the United States
- How to address the lack of qualified science and math teachers in the K-12 systems by providing better, particularly online, in-service support

These are intended as focused fact-finding inquiries providing the Commission with a snapshot of data enabling further discussion and possible recommendations for productive collaboration between California and Mexico.

[1] *Agreement of Cooperation in Higher Education and Research,* ucmexus.ucr.edu/agreements/agreement_eng.pdf.

2. Developing a Framework for High-Tech Research Collaboration

Although at different levels of development, the future of high-tech industry is a key concern for both California and Mexico. In California, changes are being effected as a result of the intersection of the "new economy and the new demography" – increasing dependence on high-tech innovation and industry growth coupled with growing Latino and other minority populations which to date have a lower participation and success rate in STEM education. Mexico, in turn, is struggling to develop a high-tech industry base, principally due to a lack of high-tech investment and support of research. It faces challenges in retaining its top STEM degree holders, many of who leave the country for more lucrative opportunities abroad. In the past, CONACYT has worked to counteract this "brain drain" by attracting some of these workers back with attractive academic positions, but these are increasingly unavailable and for many there is less interest in returning.

One goal of the California-Mexico Commission on Education, Science, and Technology is to catalyze research collaborations to help ensure that Mexico's loss of top research talent is stemmed. If successful, this collaboration will help jump-start clusters of innovation in high-tech areas in Mexico, that in turn can contribute to economic growth. Currently, while Mexico does have some world-class research centers, they have not led to the kind of innovation clusters that have been sparked in areas such as Silicon Valley or San Diego.

With the understanding that Mexico's research community is much smaller than California's, the goal for the project is to look at research areas of common interest to California and Mexico and develop peer-to-peer connections.

Goals of the project:

1) Establish a list of top science and engineering research programs in Mexico.
2) Identify California research programs focusing on comparable research areas to those identified in (1).
3) Prepare an overview of Mexican programs and possible California connections for presentation to the Commission.
4) Make suggestions for high-tech collaborative framework.

2.1 Peer-to-Peer Collaboration

Public and private collaboration among peers has been identified as a vital component of high-tech cluster growth.[2] Importing ideas from another country or region does not result in technological innovation and high-tech industry growth in the target region. Institutions fostering collaboration enhance productivity and innovation in a number of ways, including the development of common economic or cluster agendas. Previous analysis has suggested that

[2] Porter, Michael, *Clusters of Innovation Initiative: San Diego* (Washington, D.C.: Council on Competitiveness, 2001) p. 36.

collaboration is most likely to take place and succeed when there is an infrastructure in place to support and promote such activity.[3]

Key components of such collaboration are trust and mutual benefit. Moreover, this collaboration is most effective and most readily achieved at the individual level. Therefore, in establishing a potential framework for collaboration between Mexican and Californian research programs, individual programs and faculty members need to be identified as potential collaborators. For this reason, CCST focused on individual programs rather than entire institutions.

2.2 Methodology

In examining the programs in greater detail, CCST began by requesting the program criteria used by the National Research Council to compare graduate programs in the U.S. This was not an attempt to rank Mexican graduate programs, but simply a means of identifying possible matches for collaboration. In addition to assistance from CONACYT, UC MEXUS provided significant assistance in establishing contact and translating both email and telephone conversations with officials at CONACYT and at Mexican universities.

CCST requested that CONACYT provide data on programs identified as internationally competitive in its own evaluation using the following criteria listed by the NRC in its index of research-doctorate programs.

Faculty

1. Total faculty
2. Percentage of full professors
3. Percentage with federal research support
4. Percentage of total faculty publishing in previous five years
5. Ratio of total number of program publications to total faculty
6. Gini coefficient for program publications (reflects distribution of publications among faculty)
7. Ratio of total program citations to total faculty
8. Gini coefficient for program citations (reflects distribution of citations among faculty)

Students

1. Total graduate students enrolled as of most recent academic year
2. Percentage of female graduate students enrolled as of most recent academic year
3. Number of Ph.D.s produced by the program in previous five years

Doctoral Recipients

1. Percentage of Ph.D.s awarded to women
2. Percentage of Ph.D.s awarded to underrepresented minorities

[3] Ibid, p. 60.

3. Percentage of Ph.D.s awarded to U.S. Citizens and permanent residents
4. Percentage of Ph.D.s primarily supported by research assistantships
5. Percentage of Ph.D.s primarily supported by teaching assistantships
6. Median time to degree

Conversations with individuals at CONACYT and at UC MEXUS indicated that some of these criteria were not applicable or comparable when applied to the Mexican programs because of differences between the Mexican and American higher education systems, and because of differences in the way the data were collected. The distribution of publications among faculty (Faculty criteria 6 and 8), were not available at the time this report was prepared. The number of publications per faculty member is lower in Mexico than in the United States due to different emphases in the respective academic cultures. Enrollment and degree data were not available by gender or ethnicity, which excluded Student criterion 2 and Doctoral Recipient criteria 1, 2 and 3. In addition, funding is awarded differently and teaching assistantships are not a common means of support for Mexican graduate students. Teaching assistantships are very important towards helping groom future professors, and help provide more laboratory experiences for graduate education which is often weak in Mexico. However, data were provided on recipients of CONACYT scholarships.

We also contacted individuals at CONACYT involved in the preparation and management of data on the Mexican institutions, and contacted high-level officials at each of the institutions identified by CONACYT as being internationally competitive to discuss the results and gain additional perspective on the research strengths in the programs identified and elsewhere in the institutions. The results of the previous joint UNAM/National Academies analysis were also used.

2.3 Previous Analyses and R&D in Mexico

Mexico has invested much less in R&D in relation to its GDP than the United States, but its R&D spending has been average (approximately 0.4%) in relation to other Latin American countries.[4] Proportionately more of this spending in Mexico has gone to the government sector (over 70%), largely in the form of Public Research Centers (PRC) than in other Latin American countries. Conversely, the United States, most R&D spending (over 74%) goes to private industry,[5] and more R&D dollars are spent in California than in any other state by a wide margin.[6]

Partly because of the differences in research support, Mexico faces obstacles in developing high-tech innovation clusters around its research institutions.[7] While interdepartmental

[4] Bortagaray, I., and Tiffin, S., "Innovation Clusters in Latin America," presented at *4th International Conference on Technology Policy and Innovation.* (Curitaba, Brazil, Aug. 28-31, 2000).

[5] National Science Board, *Science and Engineering Indicators – 2002.* Arlington, VA: National Science Foundation, 2002 (NSB-02-1), p. 4-9.

[6] DeVol, Ross; Koepp, Rob; Ki, Junghoon; and Fogelbach, Frank, *California's Position in Technology and Science: A Comparative Benchmarking Assessment* (2004) Milken Institute: San Diego, p.18.

[7] Ávila, Salvador H. *Collaboration, Innovation and the Building Blocks of Social Capital Formation in the Technology Sector: A Comparative Analysis of Knowledge-creating Institutions.* Dissertation: Stanford University, July 2003.

and interdisciplinary collaboration are an important part of developing such clusters, one analysis performed by Salvador Ávila suggests that the demands made by the system's central administration to increase such collaboration have met with resistance as researchers view the demands as an imposition. According to Ávila, key incentives are lacking, and social factors such as differences in perceived rank of individuals and institutions and entrenched distrust of the academic and governmental system must be dealt with. In short, Ávila suggests that there is not sufficient confidence in the ability of the government to enforce the incentive framework and prevent violations of regulations governing collaborative research. This analysis used survey results from researchers, policy experts and external users, and also analyzed organizational issues at the systemic and institutional levels, including the incentive structure of the centers. Ávila also points out the difficulty of connecting industry to university research.

A limited external peer review was conducted of selected programs at the Universidad Nacional Autónoma de México (UNAM) by the National Academy of Sciences (NAS) and the Academia de la Investigación Científica (AIC) in 1995 and 1996.[8] Four separate teams composed of members from the NAS and the AIC assessed graduate engineering, chemistry, biomedical, and science programs. The teams visited UNAM and compiled data on equipment, faculty, and degrees offered. The assessments were geared towards "response to national needs in the context of a vision for the future."

The NAS/AIC reviews provided overall assessments of the graduate programs in question and gave specific advice on physical facilities, faculty allocation and degree production, among other things. Some statistics and quantitative criteria, such as time to degree, were mentioned in passing; but the report does not contain specific data on any of the programs evaluated, nor does it provide any means of comparing or matching the programs in question with other programs in the country or abroad. The fourth assessment, which covered the Faculty of Sciences, identified the UNAM institutes of astronomy, cellular physiology, ecology, mathematics, nitrogen fixation, physics, and earth sciences as able to compete at an international level.[9] However, issues with cooperation among faculty and other institutions were also noted.

The most comprehensive overall evaluation of Mexican research universities was conducted in 2002, when CONACYT issued the National Census for Graduate Programs (Padrón Nacional de Posgrados (PNP)) as part of the Program for the Reinforcement of the National Graduate Programs (Programa Para El Fortalecimiento del Posgrado Nacional (PFPN)). The primary objective of the PFPN was to evaluate existing graduate programs (certificates, master's and doctoral degrees) and provide an overall assessment of graduate research centers in the country.

Out of 4,500 graduate programs in Mexico, 1,128 programs in various disciplines agreed to be evaluated. This is low in comparison with the nearly 95% agreement rate for U.S. institutions invited by the National Research Council to take part in its 1993 survey of research doctorate

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[8] National Academy of Sciences and Academia de la Investigación Científica de México, *UNAM Graduate Programs Assessment: Biomedicine, Chemistry, Engineering, and Sciences*. Mexico: 1996.

[9] Ibid, p.33.

programs, but may simply be a reflection of a wider range of programs and departments in Mexico.[10] There is also evidence that there are members of quality graduate programs who chose not to participate in such evaluation procedures as a political statement (see below).

The evaluations were carried out by a committee consisting of representatives from the scientific and technological community of Mexico, and members invited by SEP (Mexican Ministry of Education) and CONACYT. Criteria considered in the evaluation of graduate programs included:

- Overall evaluation of the program, including whether the program is oriented toward research or professional or managerial degrees
- Program operation
- Curriculum and program structure
- Evaluation
- Faculty and their productivity
- Tracking of students and alumni
- Academic results
- Infrastructure
- Institutional and academic links
- Financial support

Of the 1,128 graduate programs which agreed to participate in the PNP, 204 were judged by CONACYT to be either competing at the International Level (30) or at a High Level (174). Note, however, that the number of doctoral programs is much smaller (221) and that more than half of these are described by CONACYT as being in the process of "consolidation." Twenty of the thirty internationally competitive programs are doctoral programs.

An initial look at this survey provided a valuable overview of graduate programs in Mexico, and represents the most complete evaluation of such programs to date. Several of the programs listed as "competente a nivel internacional" are doctoral programs in disciplines that could potentially serve as appropriate matches to California institutions. These include[11] programs at the Centro de Investigación y de Estudios Avanzados del IPN (biomedical sciences, physics, math, chemistry, and biology); the Colegio de Posgraduados (agricultural science and genetics); and the Universidad Nacional Autónoma de México (UNAM) (astronomy, biomedical sciences, biochemistry, math, biology and chemistry). Both these and those programs rated as high level were examined to locate the best possible potential matches for collaboration. (See Table 1.)

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[10] National Research Council, Research-Doctorate Programs in the United States. Goldberger, M.,Maher, B. and Ebert Flattau, P., eds. Washington, D.C.: National Academy Press (1995) Appendix D.

[11] Data from the Padrón Nacional de Posgrado index on the CONACYT website, accessed 11/21/03 http://www.CONACYT.mx/dafcyt/pfpn/pnp/contenido.html.

2.4 Findings

CONACYT applied the NRC criteria identified above to the degree programs identified in the 2002 PNP as being internationally competitive (Appendix A). Nineteen graduate programs were identified by CONACYT as potentially appropriate matches for collaboration in science and technology related disciplines, twelve of which are doctoral programs and hence eligible for comparison with the NRC index of U.S. programs. The doctoral programs are as follows:

Universidad Nacional Autonoma de Mexico
• Doctorado en Ciencias Biomédicas
• Doctorado en Ciencias Químicas
• Doctorado en Ciencias Bioquímicas
• Doctorado en Ciencias Astronomía
• Doctorado en Ciencias Matemáticas
Centro de Investigacion y de Estudios Avanzados del IPN
• Doctorado en Ciencias Químicas
• Doctorado en Ciencias Física
• Doctorado en Genética y Biología Molecular
• Doctorado en Ciencias Fisiología Celular y Molecular
• Doctorado en Ciencias Matemáticas
• Doctorado en Farmacología
Colegio de Posgraduados
• Doctorado en Recursos Geneticos y Productividad

Table 1: Mexican Ph.D. identified by CONACYT as internationally competitive.

These programs range substantially in size and scope. Nonetheless, all contain faculty who publish regularly in international journals and are considered highly competitive. The programs that offer the most promise for potential collaboration include biochemistry, molecular biology, and genetics (represented at all three institutions). It was not possible to obtain more specific research foci for all of these degree programs due to time constraints and highly varying degrees of information available online for these programs. Narrowing down the specific research strengths of these programs will be a logical next step.

However, conversations with senior officials at UNAM indicate that the CONACYT suggestions only cover a portion of potential matches.

"We have a great many competitive research programs which did not appear on this list," said René Drucker Colín, Coordinador, Investigacíon Científica, UNAM, which conducts 40 percent of the country's scientific research.[12] "At the moment we are in fact in a strategic planning process and are discussing where to focus existing and new research centers throughout UNAM." Drucker indicated that nanotechnology and stem cell research are areas where UNAM will be focusing its efforts, noting that the university already contains several

[12] Personal communication, 5/17/04.

notable materials sciences programs. He also pointed out that engineering programs were not represented in the CONACYT results but constitute a significant portion of UNAM's research and development.

In fact, it is notable that CONACYT did not identify any engineering programs as internationally competitive, confirming this assessment when CCST asked that this apparent omission be double-checked. Partial answers to this may lie in the 1996 UNAM/National Academies assessment. This assessment made engineering one of its focus areas; while it determined that many areas, including mechanical engineering, electrical engineering, and computational science boasted strong programs, the report observed that "…[while] the faculty are making significant contributions to Mexican education and the solution of Mexican problems…only a fraction of the faculty have published in international peer-reviewed journals or have achieved international recognition…Not enough full-time faculty are qualified to do world-class research."[13] This may explain the discrepancy between the programs identified by CONACYT and those singled out by Dr. Drucker.

A matrix of possible collaborations is included in Table 2. Note that this is not an exhaustive list and additional programs exist in the university systems of both Mexico and California that could offer similar opportunities. In particular, we have not had the opportunity to discuss the CONACYT data with representatives from Centro de Investigacion y de Estudios Avanzados del IPN (CINVESTAV) or the Colegio de Posgraduados. The California programs listed are selected from those which ranked among the top 25 programs in each respective discipline identified by CONACYT, according to the 1993 NRC index. As the goal of this project was to identify research collaboratives that could lead to successful commercial ventures, we have focused on doctoral programs that represent these disciplines. This list can be augmented if necessary.

It should also be noted that this matrix also does not include interdisciplinary research centers, such as the Red de Grupos de Investigación en Nanociencias at UNAM and the California Nanosystems Institute, or other prominent California institutes such as the Center for Information Technology Research in the Interest of Society (CITRIS), at UC Berkeley; the Quantitative Biomedical Research center (QB3) at UC Berkeley, UC Santa Cruz, and UC San Francisco; or the Integrated Media Systems Center at the University of Southern California. In particular, we anticipate that there are likely to be strong interdisciplinary candidates for collaboration in various engineering disciplines, and believe that this may be an area to focus on in future analysis of potential collaborations.

[13] *UNAM Graduate Programs Assessment,* pp. 11-13.

Subject Area	Mexico	California
Biochemistry & Molecular Biology	UNAM CINVESTAV – IPN	UC San Francisco Stanford University UC Berkeley California Institute of Technology UC San Diego UC Los Angeles
Biomedical Engineering	UNAM (Ciencias Biomédicas)	UC San Diego UC Davis
Genetics, Cell & Developmental Biology	Colegio de Posgraduados (Recursos Genéticos y Productividad) CINVESTAV – IPN (Fisiología Celular y Molecular)	UC San Francisco California Institute of Technology UC San Diego UC Los Angeles
Pharmacology	CINVESTAV – IPN	UC San Diego Stanford University

Table 2: Matrix of comparable research-doctoral programs in Mexico and California.

3. Professional Development of In-Service Teachers in California and Mexico

Both California and Mexico face challenges in assuring that the quality of students' education is consistent throughout their respective educational systems, especially in science and math. Science and math teacher production and retention are major priorities for both California and Mexico. Because of their "shared population," they have many related issues concerning teacher professional development. California's teachers are 50% more likely to be under-prepared or unqualified to teach science and math than other subjects, and are disproportionately clustered in districts with high percentages of low socio-economic status students who are often Latino.[14] Teacher quality varies widely by school in Mexico as well. Student performance on international measures such as the Trends in International Mathematics and Science Study (TIMSS)[15] and Program for International Student Assessment (PISA)[16] shows wider variance between schools than in other participating countries.

While changes are clearly called for in both California and Mexico in the education and induction of new teachers, there is also an apparent need to improve the quality of the existing corpus of teachers. Professional development is seen as a priority by both California and Mexico, but is generally expensive and labor-intensive. In addition, it is difficult to maintain homogeneous standards among the large numbers of programs and teachers enrolled in the programs. It is speculated that adoption of a computer-based professional development program with a focus on math and science could provide a cost-effective means of disseminating and administering a high-quality professional development program or programs to a wider section of the teaching population in both California and Mexico.

The goals of this study were to:

- Inventory math and science professional development programs in California and Mexico which use computers and/or the Internet as a central component
- Analyze the parameters of the programs and determine whether any are potential candidates for widespread adoption in both California and Mexico, either as is or with modification

3.1 Methodology

Research associates at CCST and the Academy of Learning through Partnerships for Higher Achievement (ALPHA) Center at the University of California, Riverside[17] examined computer-based science and math professional development programs in California. The Mexican Ministry of Education provided data on programs being run in Mexico. UC MEXUS assisted in coordinating the research associates between California and Mexico and provided translation services as needed.

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[14] Shields, Patrick M., Humphrey, Daniel C., Wechsler, Marjorie E., Riehl, Lori M., Tiffany-Morales, Juliet, Woodworth, Katrina, Young, Viki M. & Price, Tiffany. (2001) The status of the teaching profession 2001. Santa Cruz, CA: The Center for the Future of Teaching and Learning, p.18.

[15] http://nces.ed.gov/TIMSS

[16] http://www.pisa.oecd.org

[17] http://www.alphacenter.ucr.edu/

In order to obtain meaningful comparisons of the various programs surveyed, the following information was solicited:

- Who runs the program? (i.e. university, government, private or independent non-profit)
- When was the program started (and, where applicable, when did it end)?
- How many teachers participate in the program?
- Budget for the program.
- Program goals – what are the teachers supposed to learn, what outcomes are desired among teachers, their students, and their schools?
- What do teachers study in the program and how was the curriculum established?
- What measures of success does the program use.
- How well has the program performed according to its own criteria?
- Has any third party evaluated the success of the program?
- What equipment, hardware and software does the program use?
- Was the program intended as a pilot for a larger effort, and if so, how and when will it expand?

Principal concerns in the evaluation and selection of these programs were measures of success and portability. Measuring success of professional development is difficult, particularly as many systems are open-ended and do not include specific evaluations of teacher skills. While some of these programs have been shown to provide valuable mentoring and post-induction support in California,[18] measuring this effect requires surveying teachers and is difficult to quantify. It is very important to decide on where and how to invest. It is also difficult to draw correlations between participation in open-ended programs and success in teaching science and math at the primary or secondary level.

Portability is important because access to computer equipment and software varies widely by district (within California) and between California and Mexico. A system dependent on acquiring specific high-end equipment, or which requires a high-speed Internet connection, would be less portable throughout the target areas.

In addition, the very technology that enables online learning can also create stumbling blocks to successful implementation. Issues of users' technological literacy combined with technology support considerations must be addressed carefully in planning for activities online.[19] This will be a particularly important consideration in attempting to import a technology-based professional development system to the underprivileged school districts in both California and Mexico, which are least likely to have experience with such systems.

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[18] *The status of the teaching profession 2001,* p.122.

[19] Carter, Kim, "Online Training: What's really working?" Technology & Learning Volume 24, No. 10 (May 2004): p. 35.

3.2 Findings

Over two dozen computer-based professional development programs were identified in California. No comparable wide-scale programs were identified in Mexico, although a science and math professional development program was identified which uses computers as a component of the program. In general, the more centralized nature of Mexico's teacher preparation and professional development system has not led to the proliferation of programs evident in California, where individual districts are free to adopt different programs, or devise their own if resources are available. In addition, the private and non-profit sector in California (and the United States) appears to be much more active in this regard.

There exists a wide range of technology-based professional development resources, which are managed by educational institutions, corporate partnerships, and various other organizations.[20] Two programs were identified as the most likely candidates for meeting the requirements set forth by the Commission in its original mandate: the California Learning Interchange (CLI) and Teachscape. The principal Mexican program identified, La Ciencia en tu Escuela (Science in your School), did not meet the criteria established at the outset of this study, and would not be portable into California; while this program is a laudable and significant effort to improve science education in Mexico City, it employs computer technology as a supplemental resource rather than a means of implementing professional development. The principal relevant programs located in California are listed in Table 3.

Of these programs the two most promising in terms of meeting the original parameters suggested by the Commission seem to be the California Learning Interchange and Teachscape. The programs are very different and offer different benefits. These two programs are detailed further below.

[20] There are several indices of these resources, such as the website Techlearning.com (http://www.techlearning.com/content/profes/articles/resources.html).

California Learning Interchange (CLI) (detailed below)
• Online professional development resource.
• Video case studies and other teaching resources.
California Virtual Campus, California Community Colleges (http://www.cvc.edu)
• Offers hosting for online classes to promote virtual learning.
• Offers training, conferences, etc. to assist staff/faculty in technical skills & knowledge to successfully run online courses.
• This program is directed mainly to college faculty/staff.
California Technology Assistance Project (CTAP), California (http://www.ctap.k12.ca.us)
• Technology assistance project offered by California to provide assistance to schools in technology infrastructure, staff training, and funding.
• Offers technology training and assistance to teachers so they can effectively incorporate technology into the classroom.
• Offers resources from which teachers can extract technology based lessons that are aligned to content standards.
Folding @ Home, Stanford University (http://folding.Stanford.edu/education)
• Allows teachers and their students to participate in scientific research at Stanford University on the folding of proteins.
• Teachers can join the website and download a free program which they can use to participate in and also create interactive lessons in chemistry which are aligned to the standards.
The JASON Project (http://www.jasonproject.org)
• Online resource/program for teachers – used for professional development, and as a curriculum resource.
• Gated web community (pay for services). CSU and California school districts participate.
Lesson Lab/El Centro Elementary School District (no web address available)
• They are currently developing an online teacher professional development program under Stigler's Lesson Lab website.
• Currently collaborating with the California Subject Matter Projects, San Diego State University, Imperial Valley Campus and NSF funding.
• This program is in its early planning stages. Lesson Lab currently offers digital videos of teaching practices and database of relevant research in teaching.
North Bay Science Project, Sonoma State University (http://nbsp.sonoma.edu/resources)
• Supplemental to the California Science Project which offers face-to-face teacher professional development.
• Offers resources, links, and access to teacher materials/lesson plans for continued use after program participation.
Tapped In, Stanford Research Institute (SRI) (www.tappedin.org)
• Online community of educators offering workshops, support, and mentoring.
• Widespread system, funded in part by the National Science Foundation.
• System is very open-ended; a mentoring system rather than a linear course of study.
Teachscape (detailed below)
• Professional development resources tailored to district needs.
• Face-to-face and online components.
Technology & Outreach Project, UCOP (http://www.ucop.edu/sas/techoutreach)
• UCOP initiative to explore how technology can be incorporated into outreach services provided by the UCs.
• Sponsored conferences with UC campuses to explore the use of technology for outreach initiatives.
UC Nexus, UC (http://www.ucop.edu/ucnexus)
• UC wide technology initiative to improve technology capabilities of schools and for integrating technology into outreach efforts.

Table 3: Technology-based professional development programs in California.

CALIFORNIA LEARNING INTERCHANGE (CLI)

The California Learning Interchange is an online professional development resource developed in conjunction with Apple Computer that focuses on providing best practice examples in specific subject areas and mentoring. The online component offers video case studies and teacher resources. CLI is currently managed by Joan Bissell, Dean of Education at California Polytechnic University Pomona. At this point, CLI has a library of math-related materials, but not science. Presumably, additional funding would be needed to develop and produce master teaching resources in science.

1. Who runs the program? (i.e. university, government, private or non-profit)

   CLI was designed by the University of California, Irvine (UCI); the Orange County Department of Education; Apple Computer; the University of California Office of the President; California State University Bakersfield; and California State University Fresno. The program is now run by the School of Education at Cal Poly Pomona.

2. When was the program started (and, where applicable, when did it end)?

   CLI began in 2000.

3. How many teachers participate in the program?

   To date, CLI has been used primarily on an experimental basis with prospective teachers at UCI and candidates in the UCI teacher credential program. Over 1,000 participants were involved in the experimental project examining the impact of CLI experiences.

4. Budget for the program?

   Research and evaluation have cost $100,000, and an additional $100,000 in goods and services were donated by the Orange County Department of Education and Apple Computer. The current projected annual operating cost of the program is less than $20,000.

5. What are the specific goals of the program - what are the teachers supposed to learn, what outcomes are desired among teachers, their students, their schools?

   The primary goal of the CLI is to provide a foundation for a statewide digital compendium of resources and materials to support teacher training and professional development connected to the state's content standards that is easily accessible via the Web. It is also intended to test the Internet as a vehicle for delivering, illustrating and electronically publishing examples of best teaching practices.

6. What, exactly, do teachers study in the program, and how was this curriculum established?

   The content of the CLI is not a curriculum but rather a prototype of video-based professional development. The video cases are designed to reflect the California Standards for the Teaching Profession, the State's standards for new teachers (including content-specific pedagogical knowledge) established under SB 2042, and the standards of the National Board for Professional Teaching Standards.

7. What measures of success does the program use?

> One study of the CLI examined the impact of experience in improving teachers' understanding of teaching and their ability to generate teaching and learning ideas. The specific measures used were new teacher's ability to identify effective teaching, interpret effective teaching, and analyze effective teaching. A second study examined the impact of experience with the CLI on improving prospective teachers' analyses of instructional practice.

8. How well has the program performed according to its own criteria?

> A report of the studies conducted above is underway, and the results show positive impacts of experience with the CLI video cases on the teachers' ability to teach mathematical concepts in the elementary grades.

9. Has any third party evaluated the success of the program?

> The research has been subject to peer evaluation and accepted for publication in The Journal of Experimental Education.

10. What equipment, hardware and software does the program use?

> The CLI requires a computer connected to a moderately high-speed modem or a high-speed network. Quick Time, Media Player, or comparable software required for viewing is available at no cost.

11. Was the program intended as a pilot for a larger effort, and if so, how and when will it expand?

> CLI has to date been in the testing stages. There are plans to disseminate it more widely, but these have not been specified as program director Bissell moved from UCI to Cal Poly Pomona in 2003.

CCST and ALPHA center research associates visited Dr. Bissell at Cal Poly Pomona for an overview and demonstration of the program.

TEACHSCAPE

Teachscape is a professional development program that focuses on assisting three types of teachers/issues: new teachers, experienced teachers, and alternative certification. Teachscape custom designs a program for a particular district or university (i.e. client) based on their specific needs. Teachscape has both face-to-face and online components, with the online component serving to enhance face-to-face professional development. The online component offers video case studies and teacher resources. Teachscape is located in NY, San Francisco, and Los Angeles. The direct contact is Jon Denholtz in San Francisco.

Teachscape is a successful commercial program that is not subsidized by a university at this time. It is likely to go public this year. It was originally created at SRI; Roy Pea, a former CCST Council member, is on the board of directors.

1. Who runs the program? (i.e. university, government, private or non-profit)

Teachscape is a private company and works collaboratively with districts or universities to offer teacher professional development.

2. When was the program was started (and, where applicable, when did it end)?

Teachscape has been running since 1998.

3. How many teachers participate in the program?

Teachscape has worked with more than 5,000 teachers in approximately 29 school districts in California this past year.

4. Budget for the program?

The budget for the program depends on the specifically tailored program Teachscape designs for its clients. On average, districts and universities pay $300-$500 per teacher/ user license.

5. What are the specific goals of the program - what are the teachers supposed to learn, what outcomes are desired among teachers, their students, their schools?

The goals of the program depend on the client. Teachscape has a broad array of offerings and each program is designed to meet the specific needs of its client based on their objectives.

6. What, exactly, do teachers study in the program, and how was this curriculum established?

This again depends on the specific structure of the program designed for the client. The curriculum is aligned with the standards. The Teachscape approach is based on findings from current research in education—specifically, on five main principals:

1. Teachers need opportunities to understand the theory and rationale for new forms of instruction and to become intellectually engaged with subject matter.
2. Learning should be situated in authentic contexts.
3. Teachers need opportunities to try new approaches in supportive environments.
4. Learning takes place in discourse communities.
5. Learning is supported and sustained through reflective habits of mind.

7. What measures of success does the program use?

Measure of success depends on the needs of the client. In general, success is measured by usage (hours, completion of online work, etc.) and qualitative feedback. As a private venture, Teachscape also measures success by the renewal rate among its clients.

8. How well has the program performed according to its own criteria?

Results from the above mentioned measures of success suggest positive, encouraging effects. Teachscape is interested in establishing a more rigorous and quantitative approach to assessing the effectiveness of the program. Some considerations are pre- and post-testing of teachers who participate in the program and tracking student performance. These have not been implemented.

9. Has any third party evaluated the success of the program?

There has not been any formal third party evaluation of the program.

10. What equipment, hardware and software does the program use?

Participation in the program requires a computer with Internet access. Only small runtime programs such as Quicktime and Flash are needed to operate the program properly. A fast internet connection is not required but would greatly enhance access to the site and those with slower internet connections have the option to view the "best practices" videos on CD which they can receive through mail and load directly onto their computers.

11. Was the program intended as a pilot for a larger effort, and if so, how and when will it expand?

Teachscape is not a pilot program—the size of the Teachscape program will depend largely on the number of clients who are interested in utilizing the program.

3.3 Conclusions

These programs offer both short and longer-term possibilities for the Commission to consider in promoting a technology-based math and science professional development program or programs. CLI has master teaching math resources available now (though not science) which conform to state curriculum standards and which have been tested in a university study; access is free, as the program is being subsidized by Cal Poly Pomona. Teachscape is a successful enterprise which offers custom systems which can be tailored to specific needs. It would be capable of designing and implementing a technology-based professional development system to meet the specific focus of the Commission, provided the resources could be procured to pay for the contract.

Online professional development remains in the early stages of development; the most effective emerging models appear to be a convergence of different delivery methods, including face-to-face, video-conferencing, and online technologies.[21] However, provided there is adequate oversight, online learning resources have become a successful component of local districts around the country. Customization to the needs of the target districts and programs is a critical element of developing a successful program, and both CLI and Teachscape offer such capacities.

[21] Carter, p. 36.

4. Next Steps

The data presented here are not a comprehensive survey of the research and education programs in California and Mexico, but a representative sampling. However, we believe that they represent a good set of starting points from which to build effective collaborations between the research and professional development communities in both Mexico and California.

The most effective way to encourage collaboration is to provide an infrastructure that enables it.[22] In order to develop meaningful partnerships between the research community in the Mexican programs identified and corresponding California programs, an environment must be created in which the benefits of collaboration are reinforced. Ávila's survey of Mexican faculty members noted that prestige frequently interferes with collaboration;[23] it is therefore important, in connecting the best researchers in Mexico to California, to ensure that appropriate level matches are made. Emphasizing the benefits of collaboration and providing a high-profile impetus behind the broader effort of bringing these research programs together could be an effective way for the Commission to proceed.

It will be even more important to stress and explain the benefits of collaboration with regards to the professional development systems. Mexico's highly centralized system does not afford much opportunity for international collaboration; California's educational system has no effective central strategy for continuing professional development, adopting instead a variety of programs at the district level.

Our findings suggest the following broad goals as appropriate for the Commission:

- Create venues to bring people together (high-tech researchers and educators)
- Identify funding sources and ways to leverage existing resources to support both efforts

There are two aspects to this strategy. First, the present strengths of the Mexican and California research communities need to be connected. We suggest that a series of meetings between key members of the research-doctoral programs identified in the matrix in section 2.4 and the funding entities be arranged, coordinated and perhaps facilitated with the assistance of a subcommittee of the Commission. A major meeting aim should be to identify the hurdles that need to be overcome by whom and how with what resources.

The second aspect is planning for the strengths which are in development. This should be a follow on activity once the former gets underway. It would be advisable to arrange meetings between members of the Commission and high-level research officials at UNAM, CINVESTAV, and the Colegio de Posgraduados (e.g. Dr. Drucker at UNAM) to discuss potential matches between nascent research programs and/or interdisciplinary research centers which may not have met the particular criteria of the present study, but which could offer strong opportunities for potential collaboration.

For the professional development programs, it is suggested that representatives from CLI and

[22] Porter, p. 14.

[23] Ávila, p. 4.

Teachscape, and perhaps others be contacted to arrange a meeting with representatives from the Mexican Department of Education and the Commission to discuss further the possibility of using one or both systems, either directly or as a template, in the development and implementation of technology-based professional development resources for math and science teachers in California and Mexico respectively. Undersecretary Sylvia Ortega has indicated she is willing to lead such a meeting.

Lastly, it is also suggested that one significant resource which may prove valuable in promoting collaboration in both areas is the Mexican expatriate community in California. Preventing "brain drain" has long been a goal of the Mexican government, and California's research institutions have proved a substantial lure. Building on the network of expatriates, and using them as a bridge to broader collaboration with the research and education communities in California, may be difficult to accomplish but could prove an effective strategy.

Appendix A: Contact List

In pursuing the high-tech collaboration and professional development inquiries, CCST obtained the gracious cooperation of the following individuals:

High-tech research collaboration

Judith Zubieta, Former Deputy Director, CONACYT, currently with UNAM
Federico Graef, Director de Fortaliecimiento al Posgrado, CONACYT
Marlene de la Cruz, Former International Academic Officer, UC MEXUS, currently with UCI
Juan-Vicente Palerm, Former Director, UC MEXUS, currently with UCSB
Roberto Sánchez-Rodríguez, Director, UC MEXUS (2004)
René Drucker Colín, Coordinador, Investigacíon Científica, UNAM

We also contacted the following individuals for commentary, and are awaiting responses:

Luis R. Herrera Estrella, Director, Unidad Irapuato, CINVESTAV
Benjamín Figueroa Sandoval, Director General, Colegio de Posgraduados
José Antonio de la Peña Mena, Former Director of MAS, Instituto de Matemáticas – Director, UNAM

Professional Development

Sylvia Ortega, Undersecretary of Education in Mexico City (SEP)
Edmundo Salas Garza, Regional Director (SEP)
LeAnn Parker, UCOP – Office of the Provost, Academic Affairs-Educational Outreach
Brian Reilly, UCR – Professor, Graduate School of Education, Technology & Teacher Education
Michael Rettig, UCR – Professor, Chemistry Department
Herbert Brunkhorst, California State University San Bernardino – Professor & Chair, Science, Mathematics, Technology Education
Maria Freeman, UCLA, California Science Project Director
Kathy Bocian, UCR ALPHA Center, Director of Academic Research Initiatives
Lynn Cominsky, Sonoma State University – North Bay Science Project Faculty Advisor
Michael Klentsky – El Centro Elementary School District
Susie W. Hakansson – UCLA, Executive Director California Math Project
Pamela Clute, Director, UCR ALPHA Center

Judy Lee, research associate at the ALPHA Center, contributed much of the data compiled on California professional development programs.

Appendix B: Research Program Data received from CONACYT

	Name of the Graduate Program	Institution	Total Full Time Professors	Total Half Time Professors	Total Faculty	% of Full Time Professors	Full Time Professors who Published Refereed Articles (1998-2002)	Refereed Articles Published in 2002	Projects in 2002	Current Enrollment	Students Graduated in 1998	Students Graduated in 1999	Students Graduated in 2000	Students Graduated in 2001	Students Graduated in 2002	Students Graduated (1998-2002)	Students Graduated with Scholarship from CONACYT (1998-2002)	Median Time to get the Degree (Months)	Full Time Professors who Published Refereed Articles/ Total Faculty	Refereed Articles/Total Faculty	100/Full Time Professors who Published Refereed Articles (1998-2002)
1	Doctorado en Ciencias Biomédicas	Universidad Nacional Autónoma de México	252	23	275	92	208	279	98	450	56	32	44	38	44	214	32.24	52	0.76	1.01	0.48
2	Doctorado en Ciencias Químicas	Centro de Investigación y de Estudios Avanzados del IPN	17		17	100	17	23	15	61	6	7	11	7	11	42	14.29	73	1.00	1.35	5.88
3	Maestría en Genética y Biología Molecular	Centro de Investigación y de Estudios Avanzados del IPN	16		16	100	15	22	14	22	7	9	20	6	12	54	100.00	31	0.94	1.38	6.67
4	Doctorado en Recursos Genéticos y Productividad	Colegio de Postgraduados	60	19	79	76	53	75	63	143	13	14	21	15	26	89	84.27	48	0.67	0.95	1.89
5	Doctorado en Ciencias (Física)	Centro de Investigación y de Estudios Avanzados del IPN	52		52	100	49	69	0	57	9	13	10	9	12	53	45.28	50	0.94	1.33	2.04
6	Maestría en Ciencias (Física)	Centro de Investigación y de Estudios Avanzados del IPN	47		47	100	47	78	0	24	11	5	9	11	11	47	38.30	34	1.00	1.66	2.13
7	Maestría en Ciencias (Neurobiología)	Universidad Nacional Autónoma de México	37		37	100	36	36	33	34	6	6	7	9	14	42	88.10	36	0.97	0.97	2.78
8	Maestría en Ciencias (Física Aplicada)	Centro de Investigación y de Estudios Avanzados del IPN	28		28	100	27	28	16	24	6	1	3	1	0	11	72.73	31	0.96	1.00	3.70
9	Doctorado en Ciencias Químicas	Universidad Nacional Autónoma de México	133		133	100	132	226	42	207	18	8	20	29	28	103	31.07	56	0.99	1.70	0.76
10	Doctorado en Ciencias Bioquímicas	Universidad Nacional Autónoma de México	126	22	148	85	112	135	0	158	18	13	27	24	22	104	64.42	55	0.76	0.91	0.89
11	Maestría en Ciencias Bioquímicas	Universidad Nacional Autónoma de México	114	24	138	83	103	138	52	277	34	35	30	32	25	156	75.00	37	0.75	1.00	0.97
12	Doctorado en Genética y Biología Molecular	Centro de Investigación y de Estudios Avanzados del IPN	16		16	100	15	22	13	39	1	7	5	7	7	27	85.19	55	0.94	1.38	6.67
13	Doctorado en Ciencias Especialidad en Matemáticas	Centro de Investigación y de Estudios Avanzados del IPN	24		24	100	24	38	11	11	2	2	3	3	2	12	41.67	59	1.00	1.58	4.17
14	Doctorado en Ciencias (Fisiología Celular y Molecular)	Centro de Investigación y de Estudios Avanzados del IPN	29		29	100	28	28	22	35	3	7	7	4	4	25	72.00	75	0.97	0.97	3.57
15	Doctorado en Ciencias (Astronomía)	Universidad Nacional Autónoma de México	50		50	100	47	47	0	18	4	4	3	2	2	15	6.67	59	0.94	0.94	2.13
16	Doctorado en Ciencias Matemáticas*	Universidad Nacional Autónoma de México	113		113	100	85	94	0	41								11	0.75	0.83	1.18
17	Maestría en Ciencias Matematicas*	Universidad Nacional Autónoma de México	121		121	100	87	99	0	147								31	0.72	0.82	1.15
18	Maestria en Neurofarmacología y Terapéutica Experimental	Centro de Investigación y de Estudios Avanzados del IPN	16		16	100	15	19	7	9	5	2	2	6	4	19	100.00	27	0.94	1.19	6.67
19	Doctorado en Farmacología	Centro de Investigación y de Estudios Avanzados del IPN	15		15	100	12	12	9	7	1	3	2		1	7	100.00	37	0.80	0.80	8.33

* These programs did not deliver information about graduate students.

Appendix C: CCST California-Mexico Project Reviewers

Alfonso F. Cárdenas

Alfonso Cárdenas is Professor of Computer Science in the Henry Samueli School of Engineering and Applied Science, University of California, Los Angeles; Vice-chair of the University of California Information and Technology Planning Board; Chair of the University of California-wide Academic Senate Information Technology and Telecommunications Policy Committee; and a consultant in computer science and management at Computomata International Corporation. Cárdenas is Principal Investigator of the NSF-supported Multimedia Stream System Project, Co-principal investigator of the recently completed NSF-supported KMeD Project and of the NIH-supported Research, Education and Patient Care Facilitated by PACS Project. He is also the Alumni Coordinator of the Computer Science Alumni Advisory Board.

He obtained a B.S. degree from San Diego State University and M.S. and Ph.D. degrees in computer science, at UC Los Angeles. Cárdenas has served as chairman and member of organizational and program committees for many conferences, and he has led many seminars and spoken to audiences in various countries.

Linda R. Cohen

Linda Cohen is Professor for the Department of Economics at the University of California, Irvine. Dr. Cohen has held positions at the Brookings Institution, the Kennedy School of Government, Harvard University, and the Rand Corporation. She was the 1998 Olin Visiting Professor in Law and Economics, University of Southern California Law School and is a member of the Irvine Research Unit in Mathematical Behavioral Sciences at the UC Irvine.

She received an A.B. from UC Berkeley in mathematics and in 1979, a Ph.D. from the California Institute of Technology in social sciences. She has advised numerous federal departments and agencies on science policies, including the Departments of Energy and Commerce, the Office of Technology Assessment and the Congressional Research Service and has served on several committees for the National Research Council.

France A. Córdova

France A. Córdova is the 7th Chancellor of the University of California, Riverside. She held previous appointments as Vice Chancellor for Research and Professor of Physics at the University of California at Santa Barbara, Chief Scientist for the National Aeronautics and Space Administration, Head of the Department of Astronomy and Astrophysics at The Pennsylvania State University, and Deputy Group Leader of the Space Astronomy and Astrophysics Group at the Los Alamos National Laboratory.

Dr. Córdova holds a B.A. from Stanford University, a Ph.D. in Physics from the California Institute of Technology, and an honorary doctorate of science from Loyola-Marymount University. In 2002, Dr. Córdova was given the lifetime designation of National Associate of the National Academies. Córdova has served on numerous policy, advisory, and review boards and committees for agencies of the federal government, the National Academy of Sciences, and university and scientific associations.

Carlos G. Gutiérrez

Carlos G. Gutiérrez is the President's Distinguished Professor of Chemistry at California State University, Los Angeles. He has participated in obtaining $35 million in research and research training grants over the past 25 years to support the activities of students in his research group and also 25 other laboratories on campus. He has directed the Cal State LA Minority Access to Research Careers program since 1978 and the Minority Biomedical Research Support program since 1992.

He holds a B.S. degree in chemistry from the University of California, Los Angeles and a Ph.D. in synthetic organic chemistry from the University of California, Davis. Gutiérrez has served on several standing and ad hoc peer review committees of the National Institutes of Health and the National Science Foundation. He has served on the National Research Council's Advisory Committee to the Office of Scientific and Engineering Personnel, and is currently a member of its Board on Higher Education Workforce. He is a member of the American Association for the Advancement of Science Committee on Opportunities in Science, the Arnold and Mabel Beckman Foundation Undergraduate Scholars Grant Advisory Panel, the Camille and Henry Dreyfus Foundation Grant Advisory Committee, the American Chemical Society (ACS) Committee on Professional Training, and the ACS Committee on Minority Affairs.

Susan Hackwood

Susan Hackwood is currently Executive Director of the California Council on Science and Technology and Professor of Electrical Engineering at the University of California, Riverside. Before joining academia, she was Department Head of Device Robotics Technology Research at AT&T Bell Labs. In 1984 she joined the University of California, Santa Barbara as Professor of Electrical and Computer Engineering and was founder and Director of the National Science Foundation Engineering Research Center for Robotic Systems in Microelectronics. In 1990, Dr. Hackwood became the founding Dean of the Bourns College of Engineering at UC Riverside.

Dr. Hackwood received a Ph.D. in solid state ionics in 1979 from DeMontfort University, UK. Dr. Hackwood is currently involved with science and technology development in California, the U.S., Mexico, Ireland, Taiwan and Costa Rica.

Miriam E. John

Mim John is currently Vice President of Sandia's California Division. Concurrent with her Sandia assignments, Dr. John has been recruited for a number of defense community efforts. She is a member of the Department of Defense's Threat Reduction Advisory Committee (for which she chairs the Nuclear Deterrent Transformation Panel), the National Research Council's Naval Studies Board and the Board on Army Science and Technology. She is a recent past member of the Air Force Scientific Advisory Board and DOE's National Commission on Science and Security. She is a National Associate of the National Academies of Science and Engineering

Dr. John received a B.S. in chemistry from Rice University, an M.S. in chemical engineering from Tulane University, and a Ph.D. in chemical engineering from Princeton University.

C. Judson King, Council Chair

C. Judson King is Director, Center for Studies in Higher Education and Former Provost and Senior Vice President, Academic Affairs for the University of California. He is the Former Provost and Senior Vice President-Academic Affairs at the University of California and also continues as Professor of Chemical Engineering, University of California, Berkeley, a post he has held since 1969. He served as Vice Provost for Research for the UC system and was Provost, Professional Schools and Colleges between 1987-1994. He was UC Berkeley's Chairman of the Department of Chemical Engineering between 1972-1981 and was Dean of the College of Chemistry from 1981-1987.

King graduated from Yale University in 1956 with a B.E. in chemical engineering and later received his S.M. and Sc.D. in chemical engineering from the Massachusetts Institute of Technology. Dr. King remains active with the American Institute of Chemical Engineers, the American Society for Engineering Education, the International Committee for Solvent Extraction, the American Chemical Society, and the American Association for the Advancement of Science.

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