Organizational Change in an Institution of Higher Education: Improving K-20 Math and Science Education through a University-School Partnership

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System-wide Change for All Learners and Educators
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Introduction

The System-wide Change for All Learners and Educators (SCALE) project is a large national Math and Science Partnership project funded by the National Science Foundation for the years 2003-2007. The partnership includes three institutions of higher education (IHEs) and four urban school districts across the country. The primary objective of the SCALE project is to improve math and science teaching and learning for all students in its partner organizations through systemic reform. Within that overarching objective, one of SCALE's principal goals is to involve institutions of higher education in sustained efforts to improve the entire continuum of math and science education, K-20, including the preparation of teachers. Indeed, IHE involvement in systemic math and science education reform has been identified by several national science education policy making bodies as a critical, but as yet largely untapped resource for change.[1] SCALE's theory of change maintains that in order for IHE involvement in K-20 math and science reform efforts to be sustainable, significant changes must take place in the ways science, technology, engineering, and mathematics (STEM) and education IHE faculty participate in teacher preparation, both as individuals and in collaboration with other faculty and with K-12 districts at various organizational levels.

In the spring of 2005, SCALE's Research and Evaluation team began conducting a set of IHE case studies to determine (a) whether positive and sustainable improvements are underway to facilitate the provision of high-quality professional learning opportunities in math and science to pre- and in-service K-12 teachers by STEM and education faculty and the IHEs (as organizations), and (b) whether these improvements can be attributed, at least in part, to SCALE implementation of the above-stated theory of action. Two research questions were developed to address these goals:

1. Are SCALE IHEs changing their support for reform-oriented teaching and for alignment of pre-service, induction, and in-service curriculum and pedagogy, and if so, are these changes associated with changes in (a) faculty attitudes and behaviors pertaining to collaboration across departments within individual IHEs, across IHEs, and between IHEs and K-12 districts, and (b) high-leverage change factors (such as leadership at faculty and larger organizational levels, new funding, and new tools, practices, and policies) that temporarily enable the typically loosely-coupled IHEs to function in a tightly-coupled manner in order to implement organizational change?
2. How, if at all, and why has the SCALE project resulted in change in IHEs such that STEM and education faculty (a) better understand and meet the needs of the K-12 teachers they serve, particularly in the SCALE districts, and (b) participate more effectively in reciprocal systemic efforts within and beyond their institutions to improve science and math education at K-20 education levels?

[1] A highly relevant example of these reports is *Educating Teachers of Science, Mathematics, and Technology: New Practices from the New Millenium* (2000), a report of the National Research Council's Committee on Science and Mathematics Teacher Preparation (CSMTP) (Washington DC: National Academies Press). For a more recent example of these reports, see *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.* National Academy of Sciences, National Academy of Engineering, Institute of Medicine (2005): Washington, DC. Available at www.nap.edu.

This case study report presents an initial description and analysis of institutional change efforts underway at one of SCALE's IHE partners, California State University, Dominguez Hills (CSUDH). At the time data were collected for this report, change efforts related to math and science pre- and in-service teacher preparation at CSUDH were relatively young. Consequently, this report can only provide early and tentative findings related to the research questions. Over the next two years, as the change initiatives mature, more data will be collected to determine the extent and sustainability of improvements being undertaken at CSUDH.

The first section of this report outlines the methods used to conduct the case study research. The second section draws on key policy analyses of math and science education reform written by the National Research Council and the National Science Foundation in order to provide a framework for envisioning how the involvement of institutions of higher education could be structured and utilized to affect improvement in K-20 math and science education. Using that framework as a backdrop, we then move to the case study of California State University, Dominguez Hills. The third section presents a brief profile of the university, specifically its organizational characteristics, and student and faculty demographics. Section Four describes how teacher preparation in math and science has been organized at the university and some of the strengths and challenges associated with that system. Section Five provides greater context for understanding institutional change at CSUDH by describing a new campus-wide initiative being developed by the CSUDH leadership to significantly improve the university's approach to teaching and learning. Section Six then provides a brief overview of how the SCALE project, in partnership with Quality Educator Development (QED), a project funded by the U.S. Department of Education Teacher Quality Enhancement Program, is attempting to change the K-16 math and science teaching and learning system at multiple points in the continuum. Section Seven follows with a more detailed analysis of these projects' activities and intended outcomes using the narrative data collected from CSUDH faculty and administrators involved in these efforts. The final section of the report provides an evaluation of the changes underway as a result of the partnership work in light of the research questions and the policy framework that frame the study. Future updates to this case study report will document the extent to which these changes actually take root in the everyday business of the university.

Methods

Interpretive case study methodology involving the collection and analysis of qualitative data was used to develop findings related to the study's major research questions. This methodology is particularly useful for research in which the main goal is to understand a bounded unit of study in a deep, complex, and holistic manner. Change within CSUDH related to math and science pre- and in-service teacher preparation represents the unit of analysis for this case study.

Data collection began with a key informant interview with the Co-Principal Investigator of the QED project. That individual, also a co-director of the SCALE project, has been a faculty member in the Math Department at CSUDH for many years, and has been involved in multiple grants and partnerships with schools, districts, and other institutions of higher education related to teacher preparation and professional development. This interview was used to define the scope and limits of an initial round of interviews with CSUDH faculty and administrators involved in change efforts. Subsequently, 22 individuals were interviewed on a face-to-face basis. In order to triangulate data, a common interview protocol was developed and then

customized prior to and during the interview to take advantage of individuals' expertise and knowledge in particular areas. For example, STEM faculty were asked specifically about issues relating to undergraduate math and science education, while College of Education faculty were asked specifically about issues relating to postbaccalaureate teacher preparation. The interview protocol focused primarily on the following areas of interest:

- Faculty members' teaching approaches and past involvement in collaborations around k-20 math and science education;
- Faculty members' assessment of CSUDH's pre- and in-service teacher preparation system;
- Faculty members' specific involvement in the QED- and SCALE-related collaborative working groups; and
- Faculty members' assessment of the quality, value, and anticipated impact of those groups' efforts.

Audiotaped interviews were conducted in the late spring and early summer of 2005. The interviews were then transcribed and coded, using Nvivo software, according to major themes outlined in the research questions. Specific attention was paid to the following categories of data: a) CSUDH organizational context; b) SCALE/QED workgroups; c) STEM faculty involvement in K-12 curriculum development and teacher professional development; d) collaborations between STEM departments and the College of Education; e) CSUDH collaborations with Los Angeles Unified School District (LAUSD) and other SCALE partners; and f) recruitment, tenure, and promotion policies for faculty engage in K-12 math and science education. Additional data on the university were collected from the CSUDH website, including the campus strategic plan and student enrollment data. Findings were developed through iterative analyses of the data and through discussions with colleagues on SCALE's Research and Evaluation team.

Framework: IHE Involvement in K-20 Math and Science Education Reform

In its Request for Proposals for the Math-Science Partnership (MSP) Program, the National Science Foundation placed great emphasis on the participation of institutions of higher education in K-20 educational reform efforts. NSF argues that K-12 educational institutions cannot be expected to make significant improvements in math and science education in isolation and without the significant involvement of higher education faculty. Furthermore, the NSF believes that improvements in math and science education need to happen not just in K-12, but also in higher education settings themselves through changes in undergraduate math and science education, as well as through improvements in pre- and in-service teacher preparation taking place at IHEs. The NSF cites as critical the need to improve math and science education across these traditional institutional boundaries. In particular, it argues that change efforts must not only involve IHE schools of education, as has traditionally been the case, but also faculty from their science and math departments. Thus, in its MSP Request for Proposals, the NSF stated the following vision for a successful MSP project:

> *K-20 education organizations (that is, K-12 schools and school districts, and institutions of higher education) are critical partners in all MSP projects.*

Specifically, administrators, mathematics and science teachers and guidance counselors in K-12 partner organizations join forces with disciplinary faculty in mathematics, science and/or engineering, education faculty and administrators in higher education partner organizations in activities developed to effect deep, lasting improvement in K-12 mathematics and science education. Furthermore, K-20 partner organizations commit to implementing the coordinated K-20 institutional change necessary to sustain partnerships' successes in the long-term; this includes the continued participation of mathematics, science and engineering faculty in work that clearly results in improved K-12 student and teacher learning…. Mathematicians, scientists, and engineers, particularly mathematics, science and engineering faculty in higher education partner organizations, play substantial roles in MSP-funded projects; it is their substantial involvement in these projects that distinguishes the MSP program from others seeking to improve K-12 student outcomes in mathematics and science.[2]

Similar calls for institutional change at the higher education level have come from other stakeholders as well. In 1998, the National Research Council established a Committee on Science and Mathematics Teacher Preparation (CSMTP) and "charged it with identifying critical issues in existing practices and policies for K-12 teacher preparation in science and mathematics."[3] The resulting report, released in 2000, synthesizes a broad body of research on teacher preparation in these disciplines and outlines recommendations for improving math and science education through teacher pre- and in-service preparation. The CSMTP report argues for a significant restructuring of the relationship between K-12 schooling and higher education, and devotes considerable attention to discussing how IHEs could contribute to efforts to improve math and science teacher preparation and education throughout the entire K-20 continuum. According to the Committee, key components of IHE involvement in such efforts should include:

1. *Entering into ongoing and sustainable partnerships with local school districts* with the goal of improving "the knowledge base and skills of all practicing teachers of science, mathematics, and technology in the K-12 and higher education sectors that are involved with the partnership."[4] These partnerships would involve the IHE in substantial and recurrent cross-institutional planning efforts related to pre- and in-service teacher education based on the needs of the local districts.
2. *Promoting greater collaboration across departments and colleges within the IHE with respect to teacher preparation.* Teacher education, traditionally viewed as the sole responsibility of colleges of education, would become a priority of the entire campus. In particular with respect to math and science teacher preparation, greater active collaboration between STEM faculty and education faculty would provide current and future teachers with the content and pedagogy necessary to teach in the K-12 schools.

[2] National Science Foundation. (2003). Math and Science Partnership Solicitation. Program. Retrieved March 10, 2006, from http://www.nsf.gov/pubs/2003/nsf03605/nsf03605.htm.
[3] Op cit. *Educating Teachers of Science, Mathematics, and Technology: New Practices from the New Millenium*, p xiii.
[4] Ibid, pg 91.

3. *Increasing the level of awareness and understanding on the part of STEM faculty about K-12 education.* STEM faculty would become better informed about K-12 math and science education and more knowledgeable about K-12 teacher needs through activities undertaken as a result of the partnership. This understanding would then allow STEM faculty members to be more responsive to the needs of future teachers in the courses they teach.

4. *Restructuring undergraduate STEM courses to promote active learning on the part of students, many of whom are future teachers.* The CSMTP committee is clear on this point: "Learning through inquiry and active engagement with subject matter should be a primary feature of all courses that prospective teachers take—disciplinary as well as pedagogical."[5] The report further states that by using such active learning strategies in their undergraduate courses, STEM faculty not only help their students understand the content more deeply but also model effective pedagogy that future teachers can use in their own instruction.

5. *Building rewards into faculty support systems—including the recruitment, tenure, and promotion system—for those faculty involved in K-12 education outreach.* In fact, the CSMTP cites the current widespread lack of such support systems as a substantial obstacle to getting STEM faculty involved in K-12 education: "Current tenure and promotion policies at many colleges and universities may not sufficiently recognize the contributions of faculty in science mathematics, engineering, and in education departments to the improvement of teacher education through such partnerships."[6] By rewarding STEM faculty members' involvement in K-12 math and science teacher preparation, IHEs can create systemic incentives for ongoing faculty engagement in educational change.

Clearly, the CSMTP report presents a vision for change that is, in most IHEs, far from reality. IHE partnerships with K-12 education tend to be time-limited connections between individual faculty members and individual teachers, rather than broader partnerships aimed at sustainable and reciprocal improvements. Within IHEs, teacher preparation is viewed largely as the responsibility of schools of education; collaboration between STEM departments and schools of education is infrequent. STEM faculty often are not aware that they have future teachers in their undergraduate disciplinary courses, and if they are, do not understand the implications of that fact for their own instruction and pedagogical approach. The undergraduate math and science courses, most often taught in traditional lecture style, are primarily designed to provide maximum coverage of many topics. They are rarely designed to engage students actively in the development of deep conceptual understanding. STEM faculty rarely have an understanding of K-12 education, the math/science standards that districts must cover in their instruction, teachers' level of content knowledge, or their professional development needs. When STEM faculty do become involved in teacher education, they are rarely rewarded in the recruitment, tenure, and promotion process of their department or institution. In addition, IHEs are not well-known for their ability to plan for and effect deep and lasting organizational change. Change tends to happen slowly and incrementally and often only through the application of both external and

[5] Ibid, pg 119.
[6] Ibid, pg 105.

internal pressures that force change. So, effecting change at the IHE level is a difficult, complex and often very slow process.

CSUDH certainly faces the constellation of conditions described above that make sustained institutional change difficult and complex. Recently, however, two parallel but interrelated and promising change processes have been introduced. One initiative is a campus-wide strategic planning effort to shift the university more strongly towards a "learner-centered" approach to teaching and learning. The other is the joint work being undertaken through the SCALE and QED grants to improve math and science teacher education K-20. These change efforts are described in later sections of this report. First, however, we provide basic profiles of CSUDH and the role of teacher education at the institution.

Profile of California State University, Dominguez Hills (CSUDH)

California State University, Dominguez Hills (CSUDH), initially named South Bay State College, was founded in 1960 as part of the California State University system. Over the next several years, the college underwent a number of name and location changes. In 1965, following the riots in Watts, the university settled on its current location in Carson, as the site offered the "best accessibility to minorities who want a college education." Now, the university serves a highly diverse population of students and defines its central mission to be responsive to the higher education needs of the surrounding local communities.

In the fall of 2004, CSUDH had a total enrollment of about 12,500 students. Of that number, 38% was Mexican-American or other Hispanic, 31% was African American, 20% was White, 11% was Asian/Filipino/Pacific Islander, and 1% was American Indian. Overall, the university has many more undergraduate transfer students than it does first-time freshman. In the fall of 2004, new freshman represented just 27% of the first-time students on campus, while students transferring to the campus from other two- and four-year institutions represented nearly 50% of the new enrollees. In addition, just over one in five new CSUDH students enrolled in postbaccalaureate professional programs or graduate degree programs. CSUDH is a "commuter campus." Approximately 40% of undergraduates are part-time students[7], and while the university does have some housing for students, the vast majority lives and works in the community. Many courses are held in the late afternoon and evening to accommodate their schedules.

The CSUDH faculty—comprised of 124 full professors, 37 associate professors, 63 assistant professors, and 48 lecturers—is not as racially and ethnically diverse as the student population. Approximately 70% of the faculty is white, 11% is Asian, 9% is African American, 8% is Hispanic, and 1% is American Indian. Faculty at CSUDH have a heavy teaching load; they are typically responsible for four courses each semester. Research and service activities are squeezed into remaining time faculty have.

The university is organized into six academic colleges: Business Administration and Public Policy, Education, Liberals Arts, Health and Human Services, Extended and International Education, and Natural and Behavioral Sciences. The School of Education has an undergraduate "Liberal Studies" program, a post-baccalaureate Teacher Education program, and a Graduate

[7] Retrieved 2/22/2006 from http://www.csudh.edu/admfin/proposal/NTC-Final%20EIR/Vol1-Final%20EIR/4.5%20Employment,%20Housing,%20and%20Population.PDF (CSUDH website)

program. The core STEM departments are located within the College of Natural and Behavioral Sciences, and include the Departments of Mathematics, Biology, Chemistry, Earth Sciences, and Physics. The university does not have an engineering program.

Role of Teacher Education at CSUDH

Teacher education is, and has always been, an important part of the university's mission. At one time, College of Education enrollment, measured in terms of full-time equivalents (FTE), reached about 40% of the total CSUDH enrollment. According to university data, College of Education enrollment has fallen significantly in the last few years and currently hovers around 18% FTE. However, 32% (4,021) of the people enrolled ("headcount") at CSUDH in fall 2004 were in the College of Education, indicating that a disproportionately high percentage of education students are part-time.[8]

According to CSUDH administrators, the drop in FTE enrollment is due largely to external forces. The No Child Left Behind legislation emphasized the need for all teachers to be "highly qualified" and thus, credentialed. The (then) Dean of the School of Education indicated that, in order to be eligible for Title 1 federal funds,

> *our larger school districts that were feeding us with non-credential teachers, realized that within a couple of years they had to have all of their teachers credentialed. So they went out and really searched for credentialed teachers so they did not need to have their teachers prepared. They were already qualified. So that pipeline has been closed.*

In addition, a state initiative designed to reduce class size in schools was eliminated, thereby reducing the need for new teachers. Finally, districts in the areas surrounding CSUDH have had lower student enrollments than projected, thus reducing the need for teachers. At the secondary level, there is now an oversupply of teachers, except for teachers of math, science, and English language learners.

Despite this drop in College of Education enrollment, teacher education continues to be a high priority task of the university.

> *Teacher education is part of the fabric of this place. I mean it's in the DNA. Dominquez Hills has always been known for the college that supports teacher prep programs. It's a very large program, one of the biggest in the system and one that has served the needs of this part of the Los Angeles basin for a long time. So it has been and will continue to be a very, very important part of what we do at Dominquez Hills. [Provost]*

Teacher preparation in California is organized somewhat differently than it is in many states. In the 1970s, in an effort to increase emphasis on subject area mastery, the state eliminated undergraduate teacher credential programs and began requiring that teacher candidates have a four-year undergraduate degree in a subject area (i.e., not education). Teacher candidates must demonstrate their subject matter proficiency by taking a California subject exam or by completing a state-approved subject matter preparation program. To complete credentialing

[8] Retrieved 3/14/06 from http://www.csudh.edu/oir/QuickFacts2004/Major_College.htm (CSUDH website)

requirements, individuals must then complete a post-baccalaureate teacher education program that provides them with the pedagogical training and classroom student teaching experience necessary to teach at the elementary or secondary level. Often, individuals with four-year degrees are hired as teachers prior to earning a credential. In other words, they may enter their teaching career with no specialized training in education or pedagogy. However, once hired, they must complete education coursework focusing on teaching methodology, and often additional subject area courses, in order to earn teaching credentials.

CSUDH teacher preparation programs are built around the state's teacher credentialing system. For example, the College of Education's undergraduate Liberal Studies program is designed specifically for students intending to become elementary school teachers. While Liberal Studies majors do not earn a teaching credential on completion of the program, graduates have a broad-based education that allows them to enter a teaching career at the elementary level and follow up with post-baccalaureate coursework to become credentialed (see below). In the fall 2004, about 37% (~1500 headcount) of the College's students were enrolled in that program as undergraduates.[9] The College of Education also offers several master's degree programs through its Graduate Education division. Students enrolled in one of these programs accounted for 38% of the College's total enrollment in 2004. The balance (25%, or about 1000 headcount) of the College of Education's students were enrolled in CSUDH's "Teacher Education" division, a post-baccalaureate program that provides the coursework and student teaching/internship opportunities a person requires to be recommended for a "first-time" teaching credential. The bachelor's-trained students enrolled in the Teacher Education division work solely toward a teaching credential, taking coursework in a disciplinary subject and/or education, depending on their background and the type of certification sought.

However, many people who take courses in order to obtain a teaching credential do not enroll in the College of Education's Teacher Education division. Some of these people, already credentialed in one subject area, take courses needed to complete subject matter requirements in a new subject area,[10] and are recommended for a "new" teaching credential by the College of Education. For this reason, the number of students officially enrolled in the teaching credential program understates the number of individuals that CSUDH recommends annually for either a "first time" or "new" teaching credential. For example, during academic year 2003-04, CSUDH recommended 1,444 people for first time or new teaching credentials, a typical number for the last few years.[11]

People who have been hired as classroom teachers by a district in the area, and who do not have teaching credentials and are unable to meet California subject matter standards in their teaching area, also take courses (primarily in mathematics and science) without enrolling in the College of Education's Teacher Education division. These "pre-interns" need these courses in order to obtain an "internship credential" from the College of Education, which certifies that they have met the subject matter standards and a few other requirements, and allows them to enroll in the College for a teaching credential. Because granting the internship credential does not indicate

[9] Data provided by the College of Education, March 2006.
[10] This division also provides "intern" credentials to several hundred individuals each year. As CSUDH generally provides this credential to an applicant prior to actually working with these individuals, the College of Education does not include them in their counts of annual credentials recommended.
[11] Data provided by the College of Education, March 2006.

College of Education coursework taken, the College does not include these in their counts of annual credentials recommended.

The many pre-interns and "interns" (e.g., 820 internship credentials were granted in 2002-03[12]) on campus significantly influence the faculty. According to the Associate Dean of the College of Education, many of these students face the twin challenges of enhancing their subject matter knowledge and meeting the demands of being a new and inexperienced teacher. This requires both College of Education and subject matter faculty who work with them to be particularly responsive to the students' needs. According to an Associate Dean in the College of Education,

> *People are often hired before they finish their credentialing program, and most of the student teachers that I've worked with have been in that situation. They're hired, but they have minimal subject matter academic confidence. They're put into their own classroom and then they're taking our classes at the same time. We [in teacher education] spend a lot of our time on triage. If your content is weak, it's harder to maintain command of your classroom because you're struggling with the content in addition to struggling with behavioral issues and organizing your classroom and everything else. So their needs are enormous. (Associate Dean, College of Education)*

Through its teacher preparation programs, CSUDH's College of Education has worked closely with many of the schools and school districts in the Los Angeles basin to provide current and future teachers with practical, on-site professional development experiences. Some of those initiatives have entailed the establishment of professional development schools for CSUDH teacher interns to complete their student teaching or internship experiences. According to the (then) Dean of the College of Education, LAUSD has been the university's largest partner in such initiatives, and CSUDH has developed strong working relationships with the district.

> *LA Unified is the largest district here. The bulk of [enrollment in] our teacher preparation programs would be people from LA Unified. So we've always had to work very closely and we've had a real good relationship with them, setting up programs to meet their needs and having our faculty work closely with them, as well as other districts, but LA Unified primarily. (Dean, College of Education)*

In addition, CSUDH has developed partnerships with other universities in the area to support teacher recruitment, preparation, induction, and in-service professional development. A few partnerships have involved individual STEM faculty in in-service professional development activities for math and science teachers. Such partnerships generally have been developed as a result of grant funding, and when the funding period is over, the initiatives end. However, these partnerships have provided the College of Education with important connections both to other IHE faculty and institutions, as well as to the local communities from which it draws teacher candidates.

While teacher preparation represents a critical element of the CSUDH mission, it has not always been viewed as the responsibility of the entire university. Often, teacher preparation has been viewed largely as the responsibility of the School of Education, despite the fact that many of CSUDH's undergraduate students—not only those enrolled in the College of Education's Liberal Studies major—go on to teaching careers. These students, destined to teaching careers, represent

[12] Retrieved 3/14/06 from http://www.asd.calstate.edu/scripts/cctc/cctc_02_03.asp (CSUDH website)

a significant percentage of the students enrolled, for example, in undergraduate math and science courses. The Chair of the Mathematics Department reported that while a large number of their students identify teaching as a career path for themselves when they first enter CSUDH, an even larger number of CSUDH graduates actually go on to become teachers.

> *If you look at what our students say initially when they come here, probably about 60 percent of them will say that they're interested in becoming high school teachers, and maybe 40 percent will say that they're interested in going on to graduate school, or they want to go into industry, or they don't know. A lot of them really don't know. By time they graduate, it's probably more like 75 or 80 percent of them become high school teachers. (Chair, Mathematics Department)*

The level of collaboration between the College of Education and the science and math disciplinary faculty at CSUDH around teacher preparation has varied substantially over the past few decades. According to the Associate Dean of the College of Education, the teacher preparation and credentialing system that was put into place in the 1970s had the side effect of driving the College of Education and STEM departments apart. By de-emphasizing education methodology in teacher preparation and highlighting subject matter competence, STEM and education faculty had little reason to collaborate in preparing teachers.

> *In California, as a way to increase emphasis on subject matter in the early 70s, education majors were eliminated, so that every teacher candidate had to have a major in a content area. The intent, of course, was to have people that were prepared in their subject matter. It was also probably an implied criticism of methodology classes—that they weren't as essential. One very serious consequence was that it pretty much built a wall between colleges of education and the content areas, including STEM faculty. They offered no education classes. We offered no content classes. So structurally, there were more disincentives for collaboration than there were incentives. A lot of STEM faculty didn't even think of themselves as preparing teachers, even though if they'd looked at the data in their own enrollment, they would've seen that in some cases eighty percent of their students, in some of the sciences in particular, were teacher candidates, mostly at the elementary level. But they didn't see themselves as teacher preparers, so there wasn't much that happened in the content areas that enhanced teacher preparation. [That was] an unintended consequence of the design. There were some committees that met together, but there was not much day to day collaboration at all. And that was pretty much the norm. [Associate Dean, College of Education]*

The wall that emerged between the College of Education and STEM departments as a result of this teacher preparation system has at times been evident in faculty members' lack of understanding of the other's discipline. Several STEM faculty members indicated in interviews for this case study that education often is not viewed by their colleagues as a rigorous academic subject.

> *The Doctorate of Education is not considered by scientists to be the same as a PhD and so I think there are at least little rivalries and opportunities for misunderstanding. When I got my PhD, you'd go to a science class and you'd talk about things that are extremely obscure and mathematical, quantifiable and required a great deal of effort and then you'd go sit and sleep through an education*

class and get an A. In the interim, there has been tremendous progress in what is taught to educators. But I think some of that resentment, some of that misunderstanding, still exists a lot. (Faculty Member, Biology Department)

Likewise, College of Education faculty members believe that while mathematicians and scientists may know their subject well, they often do not know how to engage students in learning the subject. So relations between STEM and education faculty have been characterized by misunderstanding and distrust.

In addition to these divides, the CSUDH College of Education dean in the late 1990s and early 2000s actively chose not to work with the College of Arts and Sciences (now "College of Natural and Behavioral Sciences"), thereby closing down opportunities to build collaborative relations with science and math faculty.

We had a dean for five years who pretty much cut off relationships with Arts and Sciences. So the wall became even higher and thicker, I think in that case due to an administrator's personal approach. (Associate Dean, College of Education)

Despite the difficult relations between the School of Education and the STEM departments that typified CSUDH until recently, some individuals in the College of Education and College of Arts and Sciences did engage in productive collaboration. One faculty member from Earth Sciences described the need for interactions of this type between education and STEM faculty to be ongoing and sustained:

I have participated in doing educational opportunities with the School of Education for the last six or seven years. The start of it was a program that NASA put out called the ALERT program. This grant was to support activities for K-12 for science to get kids interested in science at an early age. It was a great opportunity for some of our faculty to do some research. But what really happened was we [science faculty] got introduced to the College of Education and the College of Education got introduced to us. So the outcome of that was we learned a lot about each other…and got an understanding of what each other does. I don't think that happens over night. (Associate Dean, College of Natural and Behavioral Sciences)

According to the interviewees, relations between the College of Education and the STEM departments have improved substantially in recent years, due largely to the installation of a new dean in the College of Education and the development of the SCALE and QED projects. Later in this report, we discuss how and why these projects are leading to improved collaborations between the College of Education and STEM departments on campus. However, before turning to institutional change efforts being undertaken around math and science teacher preparation, we describe a campus-wide initiative to improve undergraduate students' learning experience.

Campus-wide Institutional Change Efforts

CSUDH is beginning to plan for some significant institutional changes with the goal of becoming a "model urban communiversity." In the most recent strategic plan for the years 2003-2008, the university writes that it aspires to be a teaching university with high academic standards that provides students with a supportive learning environment, emphasizing diversity and cross-cultural understanding. The four main goals outlined in the plan are to 1) strengthen

and assess student learning for academic excellence and social responsibility; 2) construct and implement a sound process of planned enrollment; 3) build upon and take full advantage of CSUDH's unique cultural and demographic diversity; and 4) engage in interactive partnerships that promote educational, economic, and social development of the communities the university serves to make CSUDH an indispensable resource.

In an extended interview for this case study, the Provost described how this strategic plan was being put into place. As he explained, the university is undertaking to become a "learner-centered campus" that promotes greater student engagement in the university and active learning. This shift was occasioned by two key conditions. First, the university became a participant in the Building Engagement and Attainment for Minority Students (BEAMS) project. This project, an initiative undertaken by the Alliance for Equity in Higher Education and the National Survey of Student Engagement, works with Historically Black, Hispanic Serving and Tribal Institutions to "analyze the scope and character of students' engagement in their learning and to implement well-designed action plans for improvement of engagement, learning, persistence, and success."[13] Initially, the work of the BEAMS project was not well integrated with the university's work and thus did not immediately lead to change efforts. However, a second condition—that the university has entered a significant period of faculty turnover—set the BEAMS initiative in motion and tied its work with a campus-wide strategic plan to become a learner-centered campus. Many faculty are approaching retirement age and significant numbers of new faculty are needed to fill those positions. According to the Provost, CSUDH has hired nearly 100 new tenure-track faculty in the past three years, and that trend is expected to continue over the next several years. All told, the university anticipates that there will be almost 100% faculty turnover within the next five years, representing an opportunity to make significant cultural change with respect to teaching and learning on the campus. In fact, the Provost stated that the initiative to change to a learner-centered campus would be impossible without this faculty turnover.

> *It is impossible to change the culture. You have to change the people. And when the people change, the culture changes. So we believe we can change the culture because we have so many new people coming in. (Provost)*

With the faculty turnover, the BEAMS work aimed at improving student engagement and active learning took off. In 2004, several of CSUDH's top leaders spent a week with staff from the BEAMS project and developed a five-year plan to do the work. Since that time they have begun several related initiatives.

First, greater emphasis is now being placed on recruiting faculty who are open to using active learning strategies in their instruction. For example, a member of the Biology Department admits that while the teaching style of most faculty members in the department is, at the moment, primarily lecture-based, the department is attempting to move to more active and inquiry-based instructional styles as new faculty members are hired. When recruiting new faculty, this department now asks about teaching philosophies, and is looking to their new hires for new ideas and vision, and for knowledge of how to use, or willingness to learn to use, approaches to teaching that incorporate student input, cooperative learning, inquiry-based learning.

[13] Alliance for Equity in Education website. Retrieved 2/22/2005 from http://www.msi-alliance.org/beams/index.asp

In addition, the Provost stated that the university is specifically recruiting faculty who are actively engaged in research and who involve their students in that research. The Provost believes that these measures will help shift the campus toward being a learner-centered campus.

> *It says right in our recruitment materials now that preference will be given to hiring faculty who involve their students with them in the research. One of our faculty members and now our graduate dean, her research has to do with vision. [She] involves students in her research. Her students publish with her, and they go to conferences routinely and present with her. We're going to take that whole model, and we're going to export that throughout the whole university, encouraging that for all faculty where it's appropriate. (Provost)*

Because of the large numbers of new faculty on campus, CSUDH has initiated a "new faculty success" and mentoring program designed to help new faculty become oriented to the university, their role within it, and the learner-centered model at its core.

> *Last year was the first year of my new faculty success initiative. The new faculty members all get one course off in the fall and they attend five or six workshops, one of which is dedicated to active learning. So they will also be a cohort, and they get mentors. The goal is to keep them together and focused and maybe some of them will graduate to take what we're just simply calling for lack of a better term the "Monday morning workshops" on engagement and active learning. Then ultimately the hope is that you have about 150 faculty doing this. That's a significant choir. Most campuses would be satisfied to have a third that many. We're hoping to have 150 of the 300 full time tenure tracked faculty committed to what we're trying to accomplish. (Provost)*

Overall, the Provost's office has sponsored numerous workshops for faculty with the goal of improving how faculty teach. CSUDH has a number of faculty experts on cooperative learning and the use of active learning strategies who have worked with other faculty to expand their teaching styles beyond the traditional lecture approach. Moreover, the university has brought in many consultants on student engagement to work with them.

In addition to the focus on changing the faculty culture of teaching and scholarship, the university is attempting to recruit more new freshman. As mentioned earlier, just over one in four new CSUDH students are traditional aged freshman (age 18-20), while nearly half are undergraduate transfers. The university wants to increase their enrollment numbers overall, and specifically increase enrollment of new freshman, in order to encourage greater engagement in campus life.

> *We're a commuter campus with students that are roughly average around 29, two-thirds women students and mostly part-time, so lots of evening students and mostly upper-division transfer. So we were looking to increase the 18- to 20- year old population because that changes the campus quite a bit, and we want to appeal to them because the other market is a tough competitive market and because we have room. (Provost)*

As new students enroll, the university is developing a cohort model whereby students are grouped together for their first two years. In the 2004-2005 academic year, about half of the new students were assigned to cohorts, and took a new course, University 101, designed to orient

students to the university and prepare them for the type of learning they are expected to do at CSUDH.

> *[University 101] is geared around helping them become students and to engage in critical thinking and improve their skills, time management, learn more about the campus, study skills. They have to go and see an advisor, it's required. Each group will eventually have peer tutors that will support them. It's the center piece of my initiative to move to be a learner-centered campus so a lot of us are teaching the course. I'm teaching a section of freshmen. The vice provost, the undergraduate dean, the graduate dean, a lot of us are teaching sections of University 101. And each of those sections are linked up with a course. Our section on teaching is linked up to a biology class. So the biology professor and the two of us are involved in a dialogue about how we will integrate what they learn in 101 with what they are going to learn in Bio 101. The goal ultimately is to link up the first two years…and for them to stay together as a cohort for two full years. (Provost)*

As part of the effort to provide greater support to new students and actively engage them in academics and campus life, the university has set aside funds for 80 faculty members to receive training and support for redesigning their introductory undergraduate courses to engage students in "critical thinking and active learning, learner-centered teaching, cooperative learning" (Provost). This major effort at course redesign is intended to facilitate the implementation of the "first-year-experience" for new students.

Taken together, these campus-wide efforts are intended to effect a substantial transformation of the university's culture and practices, such that faculty and students become more actively engaged in the teaching and learning process. Because the faculty turnover will ultimately be so extensive, the Provost has high hopes that this cultural shift can take root and fundamentally change the institution. He has made this initiative a priority.

> *It's very transformative, what we're proposing. We're investing a lot of human energy in this….If I am successful in trying to get this initiative completely installed in how we do business, we will have a learner-centered campus with a community of teacher scholars who believe in active learning and who involve students in research. If [faculty] are engaging [students] in classes and involving them in research, I think it would be apparent to anybody that that will change the nature of the teaching and learning dyad and swing it far more in the direction of the learner being the center of what happens, not the teacher. It's moving from a teaching model to a learning model, and I think that's pretty key to what we're trying to accomplish. There is an integrated well thought-out strategy to have this permeate the whole campus over the next five years…I think there is widespread commitment to that. I think over time it will, in a very fundamental way, transform the institution. I think it will be a movement that will really take the campus by storm. (Provost)*

Clearly this initiative is in its early stages, and institutional change of this scale can be exceedingly slow and fraught with setbacks. Future updates to this case study will attend specifically to documenting the extent to which the initiative unfolds as planned and within the defined timeframe.

Description of SCALE and QED Initiatives

The second institutional change initiative at CSUDH is being carried out under the auspices of the SCALE and QED grants. As mentioned in the introduction, the primary objective of the SCALE project is to improve math and science teaching and learning for all students in its partner organizations through systemic reform. Within that overarching objective, SCALE has five interrelated goals:

> Goal 1. Core STEM Instructional System: Implement strategies to transform core STEM teaching system-wide in each of the four partner school districts so that every student experiences deep, conceptually based instruction on core mathematics and science concepts on a continuing basis.
>
> Goal 2. Immersion Units: Develop and implement immersion STEM learning experiences to ensure that every student in our partner districts experiences the process of engagement in an extended (e.g., four-week) scientific investigation at least once a year.
>
> Goal 3. Coherent Teacher Preparation: Design a new environment for and implement new teacher preparation and development programs that give teachers a deeper grasp of STEM content and effective pedagogical strategies for engaging students in learning.
>
> Goal 4. Equity: Increase the participation of minority and female students in high school mathematics and science courses and send more of them to college as students in these fields, thus building a more diverse pool of potential STEM teachers.
>
> Goal 5. Research and Evaluation: Ensure that a culture of evidence permeates all lines of work in the partnership through a program of research and evaluation.

Building on the work of one of SCALE's key partners, the Institute for Learning (IFL) at the University of Pittsburgh, the SCALE project began working with LAUSD in 2003 to build capacity for meeting these goals in math and science. The bulk of the SCALE work with LAUSD during 2003 and 2004 was developed along two parallel but separate lines. One was the development of Goal 1 in the area of math, undertaken exclusively by the IFL, whose representatives worked with LAUSD district representatives to plan strategies for improving teacher professional development and student performance on interim math assessments. The other line of work was related to the development of Goal 2. That effort involved scientists and science outreach staff, located primarily at UW-Madison, in the initial design of a strategy to develop science immersion units for use throughout the district.

CSUDH was formally involved with SCALE from its beginning in 2003 through an agreement between Goal 1 and the (then) Dean of the College of Education. However, CSUDH did not actively participate in SCALE until spring of 2004, when a member of the Mathematics Department, who also led that department's Center for Mathematics and Science Education, began working with the SCALE Principal Investigator (PI), at the UW-Madison (UW-Madison). The partnership with both SCALE and LAUSD gained further momentum later that year when CSUDH won a state-funded five-year Math Science Partnership grant. The Quality Educator Development (QED) project was awarded to the Associate Dean of the College of Education, and is co-led by an LAUSD administrator and the CSUDH mathematician who was working with the SCALE PI. The strength of the SCALE partnership work in LAUSD was critical in leveraging the human and material resources needed to develop and implement the QED project.

The QED project proposal states that there are three challenges that individuals interested in teaching face: 1) finding sufficient social and organizational support to enable students to persist in the certification program; 2) learning sufficient disciplinary content and pedagogical content knowledge to implement reform-oriented curriculum with expertise; and 3) "learning the ropes," through apprenticeship, from model, expert teachers who have bridged the gap between theory and practice in their own classrooms.

In light of these challenges, QED's overarching goal is to "increase the pool of highly qualified mathematics and science teachers who are willing and able to serve the poor, minority, and limited English proficient students in LAUSD and other urban schools." Within that goal, the QED proposal states that five objectives structure the work of the project:

> Objective 1: Lower structural barriers and provide social support for undergraduate math and science teacher candidates.
>
> Objective 2: Improve undergraduate curriculum and instruction for mathematics and science teacher candidates.
>
> Objective 3: Improve post-baccalaureate professional education and professional development.
>
> Objective 4: Strengthen and expand the partnership for scale-up and stability.
>
> Objective 5: Produce and disseminate research findings and field-tested processes and products.

In order to achieve these objectives, the education and STEM faculty leading the QED grant began by focusing on several clusters of activities (see Figure 1, p. 39):

- Recruiting cohorts of undergraduate freshman and transfer students interested in becoming math and science teachers, and supporting them in their cohort groups by fostering the development of strong learning communities;
- Revising the introductory math and science courses for undergraduate students;
- Developing and implementing state-approved subject matter programs for teacher candidates in biology, chemistry, earth science, and physics;
- Providing sustained professional development support for STEM faculty to integrate the use of active learning strategies in their instructional practice;
- Working with SCALE to develop math and science immersion units;
- Training LAUSD math and science teachers/coaches in content and coaching techniques; and
- Creating collaborative working relationships with SCALE, other local IHEs, and district partners to improve local capacity to scale up and sustain improvements in K-20 math and science education in the LA basin.

As seen in Figure 1, several of the clusters of activity at CSUDH are joint SCALE/QED initiatives; collectively, the efforts are designed to reinforce each other. The STEM faculty professional development is intended to provide faculty with the foundation in active learning necessary to redesign the core STEM courses, including those for science subject matter, and to participate effectively in the science immersion unit development and related K-12 teacher

professional development. The intention is that those units and the related professional development will provide the grist for a stronger and more sustainable partnership with LAUSD. The redesigned science courses at CSUDH will incorporate aspects of the immersion unit approach and will be offered to the cohorts of undergraduate students interested in teaching science. The development of a state-approved science program will allow undergraduates to fulfill the subject matter requirements for their credential. When science teacher candidates graduate and start a teaching assignment in LAUSD, they will then have been exposed to the inquiry-based curriculum and instructional approach developed through the immersion units.

Both the SCALE and QED projects share similar approaches to change, and both are trying to effect systemic change throughout the continuum of K-20 math and science education in the LA area by working at multiple points in the teaching and learning continuum. Together, these initiatives are in line with the components of higher education change that the National Research Council's CSMTP identified as critical to making significant improvements in math and science education: creating partnerships between IHEs and school districts, engaging STEM faculty in K-12 education, improving undergraduate math and science education for teacher candidates, and fostering greater collaboration across the university around teacher preparation.

The following section provides a more detailed analysis of these projects' activities and intended outcomes using the narrative data collected from CSUDH faculty and administrators involved in the QED and SCALE efforts. It is important to reiterate that interview data for this report were collected in the spring and summer 2005, just six months into the joint SCALE and QED initiatives at CSUDH. The data presented here represent individuals' early perspectives on these institutional change efforts and on the possibilities for sustained improvement in math and science education at the K-12 and higher education level in the L.A. basin.

Baseline Findings on the SCALE and QED Initiatives

Faculty and Administrator Awareness of the K-20 Educational Cycle

One of the most consistent and striking findings in the spring/summer 2005 round of interviews with faculty and administrators involved in SCALE and QED was the keen awareness that these individuals showed of the interrelatedness of K-12 and higher education. Although these institutions most often operate as separate systems and have distinct, even conflicting, cultures, the CSUDH faculty and administrators we interviewed—both those in education and those in STEM departments—saw a strong and cyclical connection between the teachers that the university prepares, the quality of K-12 education in the community in which the university is located, and the math and science abilities and motivation of the students who then enroll at CSUDH. CSUDH students come from the schools and communities surrounding the university, and they return to live and work in those communities. If those students become teachers, they prepare the K-12 students who later go on to take courses at CSUDH.

> *If you're going to complain about our students, then complain about us, because we prepared those teachers. If you look at the research, people stay where they get a degree, and they go and teach very close within that area, very often back in their own neighborhood. (Faculty member, Mathematics Department)*

CSUDH faculty members are highly aware of the effects of the K-12 system in their classrooms. In particular, math and science faculty feel the results of a K-12 system that does not prepare

students well in these disciplines. The CSUDH Office of Institutional Research, Assessment, and Planning reports, for example, that in the Fall 2003, 84% of all first-time freshman were assessed on their basic math skills and determined to be unprepared for college level math.[14] As a result, the university does a lot of remedial education, and faculty organize their classes to account for students' lack of preparation. The Associate Dean of the College of Education spoke to the self-perpetuating nature of this cycle:

> *I did some early work on the child abuse cycle, where abused kids become abusers and so on. I think probably if you look at math and science education, there's a similar cycle. I don't know if I'd call it math and science abuse, but maybe I would, you know. People come through, they have poor science instruction, they come to college, they avoid it as much as they can, they take the minimum. Faculty complain about the poor quality of high school seniors that they get, but then they don't encourage their bright kids to go into teaching. (Associate Dean, College of Education)*

A number of STEM faculty indicated that the low motivation and interest they see among students for math and science education is particularly distressing because they see how engaging these disciplines can be. Several STEM faculty echoed the words of an earth sciences professor:

> *We're in the sciences because we enjoy it. And we want to have others enjoy it. We realize that when our students get here, they don't know much about the sciences…They don't even know what it is. They don't have the background. Well, they don't have the background because of how was it taught.*

The faculty we interviewed were also keenly aware of the part that they, as higher education faculty, have to play in breaking that cycle by preparing teachers who not only are highly competent in their subject area, but also have the instructional practices that promote student interest in and ability to persist in math and science.

> *A lot of the stuff I've been doing in the last couple of years has really made me think that we're not doing a good job. We're not doing a good job of educating teachers, and they in turn are not doing a good job of passing on what we think they should be passing on to their students. So we see them as freshmen and we think, 'Oh my god, what happened here?' Ultimately, we're the ones that are responsible for it because we're training the teachers. So if we can improve the quality of what we do and get the teachers to do more of what we think they should do in preparing their students, I think it would benefit everyone. (Faculty member, Biology Department)*

The faculty and administrators we interviewed perceived SCALE and QED's teacher preparation and professional development initiatives as critically important efforts aimed at breaking the negative math/science educational cycle and creating a pipeline of students interested in these disciplines and capable of teaching the next generation of students.

> *What we [in SCALE and QED] hope is that we can improve the quality of the education of all of our students, including the ones that go on to become teachers. I think one of the deficiencies that students have when they come to us—and I don't*

[14] The picture is the similar in English: 78% of first-time freshman were assessed and determined to be unprepared for college level English.

think we do a good job of remedying it right now—is that they've not been trained to think scientifically, to think logically in a scientific sense. I think really the big challenge is to help them do that and to help them learn that, especially the ones that are going to be teachers, learn that in a way so they can teach their students. Maybe have it be sort of a chain reaction. They go out and do these inquiry-based learning activities in their classrooms and then when students come to us, they already know about that so we can go on beyond that. That would be what I hope would happen. (Faculty member, Biology Department)

I think there's a pipeline that we [in SCALE/QED] are creating ultimately for students and then maturing adults in science. We're starting with youngsters in the classroom. We're developing the teachers, giving them professional development, and helping to nurture the science instruction in the classroom. Then ultimately what that will do is produce a cohort of students that have better science experience than their predecessors. They will then march on through the ranks. More people will be interested in science and teaching science and so forth. So of course for the teachers at the schools through their professional development… that's directly feeding back into the elementary students. For the college faculty, it's feeding back in that they are refining their instruction to college students, who are still students, just at a different stage of the game. The idea is that theoretically there's a feedback here, that we enrich the science experience for students and, in doing so, we also enrich it for the faculty that are at the universities and for the teachers that are at the schools. (Faculty member, Earth Sciences Department)

Strengthening Undergraduate Math and Science Teacher Preparation

As mentioned in the previous section describing the SCALE/QED initiatives, CSUDH is attempting to strengthen its undergraduate math and science education and teacher preparation by: 1) providing ongoing professional development and support to STEM faculty with the goal of increasing their capacity to use active learning strategies in their classes; 2) recruiting and supporting cohorts of undergraduate future teachers; 3) redesigning some of the core math and science courses that future teachers take; and 4) developing a state-approved science program. Below we present the baseline findings on these initiatives.

Professional Development for STEM Faculty

As part of the SCALE/QED projects during spring 2005, a series of four half-day professional development sessions for STEM faculty were developed and facilitated by a faculty member in the College of Education with expertise in active and cooperative learning strategies. The sessions covered the following topics: 1) classroom management, 2) active learning strategies, 3) teaching for transfer, and 4) cooperative learning. The goal of these sessions was to improve the professional teaching practices of STEM faculty at CSUDH by helping them develop strategies for engaging students actively in their own learning. Of the 22 individuals interviewed for this case study, eight had participated in these sessions. During the interviews, those faculty members were asked whether they were finding the sessions valuable, and if so, how. In addition, they were asked if and how they were incorporating the information into their teaching.

All eight faculty members had highly positive comments about the value of the sessions. They reported that the techniques presented had practical, immediate applicability to their teaching

practice. The facilitator's suggestions were concrete and could be incorporated relatively easily into participants' existing course design. According to the faculty participants, many of the techniques that were presented were particularly useful because they addressed teaching concerns with which faculty members were already grappling (e.g., quick methods of formative assessment, encouraging productive student interactions, making more efficient use of class time).

> *She has some very specific things that she's brought up that we could try. And some of them I've tried with some real success. I mentioned the example of turning questions you ask into a little ungraded quiz, which isn't really a big change. It may sound very minor, and that's because it is. But the way you use it can be big. Another little twist related to that was to do that with your questions you ask at the beginning when you remind people what happened last time. I hadn't done it that way before; it works a lot better. I always would refresh about last time in my lectures. That seemed obvious to me that you need to do that. But to do it as a little ungraded assessment was one of the little ideas she brought up that I think would work very well, and now I do it much more often. (Faculty member, Physics Department)*

> *I've gotten a lot out of [those sessions about] how to make tasks real clear, so that students understand what they are doing, how to ensure that groups are working together as opposed to four people sitting and working by themselves. All of those sorts of detail type things, they are really what makes an activity take off as opposed to stagnate. (Faculty member, Mathematics Department)*

The practical applicability of the active learning techniques presented was important even for those faculty members who had had a long-standing interest in education and pedagogy.

> *I've thought of education issues for a long time. I think what [the facilitator] is offering is something that people at different levels can still take away from. She covers a lot of ground in each session, so I would expect that in each session, people found some things that they could take away from. So I've thought about education a lot, I've thought about my courses a lot, and I'm seeing a lot that I can take away from here. (Faculty member, Mathematics Department)*

Most participants reported that they had already tried using some of the techniques presented. However, even when they had not incorporated any of the strategies yet, faculty members said they were considering how to do so in the future.

Several participants also mentioned that the facilitator was respectful of their own teaching styles, offering a variety of techniques to pull from, and emphasizing that each individual faculty member would need to find the strategies that work best for him/her. For some STEM faculty members, the facilitator's openness to exploring the fit between a faculty member's personal teaching style and a set of teaching techniques was an important feature of the sessions. Some STEM faculty even implied that their interactions with education faculty in the past had not always been so positive.

> *[The PD sessions have] really made me think about a lot of what I am doing. [The facilitator] is really great. One of the things that I respected most about her, early on in that series, was that she told us up front '…not all of these techniques are*

going to be important for everyone of you, depending on your style, and how you can deal with things in your classroom,' which was, I thought, refreshing to hear from that corner of campus, since a lot of people tell us that this is the new way to do things, and everyone should do them that way. (Faculty member, Physics Department)

I've been allied with education long enough to know that not all methods that are popular or current at the moment work for all instructors… There are people who can make lecture work for students better than other people can. So I think part of it is attitude and finding the styles that easily fit with my own personality, with my own training, but also it requires a willingness to look at it fresh. So I think the major breakthrough is attitude. And [the facilitator] is just someone with a drawer full of ideas. Pick up the shiny ones and try them out. If they work, they work. If they don't, pick out another and maybe some of the ones that aren't so shiny work better. So I look at it as an on-going process. (Faculty member, Biology Department)

In addition, faculty participants reported that they highly valued the opportunity to engage on a regular basis with other STEM faculty around issues of teaching and learning. Several said that although teaching is central to their day-to-day work in their departments, they rarely have the time or opportunity to talk with their colleagues about teaching strategies and approaches.

[In my department] we never actually have a chance to talk to each other about research or anything else….That's the way things go on this campus. But when we meet with [the facilitator], she forces us to sit at tables of three. She introduces an idea and then forces us to work together and explain together why this does or doesn't work. And then, she calls us to be responsible for the ideas, and then table to table argue it out: does this or does it not work, and under what circumstances? And can you give an example of that? She's just a wonderful person to work with. She's the one that induces us to do all this reading, and then come back to her and say, 'What do you mean by pedagogy?' (Faculty member, Physics Department)

The meetings with [the facilitator] are opportunities for all of us to come together and kind of share about these issues and hear different points of view from different content areas, which always help people reflect on your own area. (Faculty member, Mathematics Department)

The attention [we have during the sessions] is pretty striking. Wow. The level of focus [is amazing]. It's all just beautifully laid out. We always sit with different people. So I've had conversations with one of the physicists, one of the biologists. And sometimes after the sessions are over, we're still sitting here talking about stuff that came out of the session. She's engaging people in conversations about this stuff and modeling. (Faculty member, Mathematics Department)

Many faculty members expressed a desire for the sessions to continue and to involve a broader segment of faculty members. One faculty member suggested that providing incentives for faculty, such as release time, would encourage them to participate.

I would like to see [those sessions] continue. I would like to see more faculty be involved in that outside of the School of Education, and I would like to see some way of incentivizing that with the faculty, especially new faculty. It would be nice if

they had some additional time off during their first year to attend these workshops. (Faculty member, Biology Department)

Many of the STEM faculty who participated in these professional development sessions were participants in other aspects of the SCALE and QED initiatives, such as the development of the immersion units, the redesign of undergraduate STEM courses, and the development of a state-approved science program for prospective high school teachers. The facilitator intended the professional development sessions to have an impact on these other efforts by influencing the teaching practices that faculty members would draw upon as they participated in the broader SCALE and QED work. Future iterations of this case study will document the continuation of the professional development sessions and the extent to which they influenced participants' other SCALE/QED activities.

Recruitment and Support of Teacher Candidate Cohorts

The goal of the cohort recruitment effort is to identify graduating high school seniors, as well as community college students who express an interest in becoming math and science teachers, enroll them in CSUDH, and group them into cohorts to provide them with social, academic, and advising supports necessary to enable them to persist throughout the teacher preparation continuum. Faculty involved in this effort note that while many CSUDH students show an initial interest in teaching, they often leave teacher preparation programs because they do not have an adequate support and mentoring system.

The goal is to get up front some people who would want to get into the teaching profession, especially math. We want to recruit them and support them, creating cohorts and a mentoring structure that will help them to move along. Most of the time, teachers drop out because they encounter lots of bottlenecks. They leave teaching angry. So you [need to] provide a support system that will help them pull through, and then actually go into teaching. So this is something that started as a result of not having math teachers. We are looking for a way to catch them early, and then help them to go into the profession without losing them.(College of Education faculty member)

The effort aims to recruit 60 students each year for entry into a math and science teacher preparation cohorts. These students would take courses together, have access to faculty mentors and advisors, attend social events with other members of the cohort, receive financial assistance, and have the opportunity to receive academic tutoring.

At the time the interviews for this case study were conducted, this QED effort was only just underway. A small team of STEM and education faculty members were working together with representatives from LAUSD to recruit high school students who have an interest in teaching K-12 math and science. This collaborative relationship between CSUDH and LAUSD is one that has been fostered over many years through the work that the College of Education has done to support teacher preparation for the district. The working group had developed a flyer for distribution to local high schools outlining the program and the benefits of the cohort model. The group also developed selection criteria for students interested in participating and were beginning to look at applications from new freshman.

The working group knows that recruiting students and developing the appropriate supports for these cohorts will not be an easy task. The Associate Dean of the College of Education admitted

that CSUDH *"is not a place where a lot science and math people spontaneously come,"* so the working group will have to take steps to increase the university's reputation in the community for providing high quality math and science education. In addition, such efforts typically take an extended period of time to develop and mature. The Associate Dean says, however, that once a program is built, the recruitment of students could be institutionalized through the creation of an interdisciplinary unit that brings together STEM departments, the College of Education, and the Admissions Office. Future updates to this case study will document the progress of the working group in recruiting and supporting pre-service teacher education students through the cohort model.

Redesigning Undergraduate STEM Courses

Linked with the recruitment of student cohorts is an effort to redesign some of the core STEM courses that cohort students and others would take during their time at CSUDH. The first set that will be redesigned is the pre-calculus and calculus series, as it encompasses the gateway courses that students (including future teachers) need to continue on with math or science. These are also the courses that many students drop or fail.

> *We're working on the idea of cohort. We're working on the idea of a better prepared student coming in. But most importantly we're working on the idea of not killing them off. Everybody who becomes a teacher, either math or science, takes a year of calculus. So if they kill them off at calculus, they're not going to be secondary teachers. They'll not get to physics. They'll never get to chemistry. So we're trying to hit those killer courses. Not that people intentionally do it, but we have got to look at how we're teaching it. How can we make it so that these kids are successful? And yeah, it's not going to be just the courses; it's also going to be the cohort model, but the changes we're looking for are not changes necessarily in the students, but the changes in how we do business. That's the important part. (QED Co-PI)*

The QED project supports release time for faculty involved in overhauling the courses. The QED Co-PI stated that changing the instructional approach by using problem-based approaches combined with active learning strategies is key to the redesign of these courses.

> *The first thing we're going to do is use a different textbook in calculus. We're going to use Harvard textbook instead of the standard Stewart textbook which is a pretty traditional approach. I used to teach out of that, and man, I put myself to sleep. So what we're really focusing on is changing how we teach that course. It'll be very problem based, rather than just textbook based. (QED Co-PI)*

After the math courses are redesigned, QED will turn to the redesign of some of the core science courses, as well. Several faculty members involved in QED indicated that redesigning these courses across the math and science departments would substantially improve the teacher preparation process at CSUDH.

> *I think the change in courses is an important thing that's coming out of this. That is our opportunity to redevelop the way we teach certain courses. I think it's going to be a big deal that's happening not only in math but in the other sciences: the more we have a common experience of how to do things with the students, then there is a common benefit of them experiencing these redesigned courses. If they took a*

redesigned physics course while they are math major, then that enhances rather than detracts from their experience in math. So there can be a synergy between the different departments if all of them have these redesigned courses and they are all trying to train teachers in a conscious way. (Faculty member, Mathematics Department)

Other STEM departments are reconsidering how they teach their core courses, indicating a heightened awareness that many of their students are future teachers. For example, the (then) Chair of the Biology Department reported that the department is reviewing its curriculum model with an eye toward integrating more inquiry-based approaches into the courses, and designing courses that take future teachers' needs into account.

The department is looking at its own curriculum. So each model will have a retreat, where we will be discussing our own departmental curriculum. So we will be looking at our own core courses for the first two year's courses, and then we will also be looking at the upper-division, or concentration, courses. We will definitely introduce a few new upper-division courses that we're not offering now. We have hired three new faculty members, so they will be bringing in new course development and so on. So, when we discuss our curriculum to revise it, one of the objectives that we will have in mind is also developing courses for future teachers. (Chair 2005, Biology Department)

Developing a State-Approved Science Program

In order to earn a "single subject credential" to teach in a secondary school in California, individuals must either complete a state exam in the content area (California Subject Examinations for Teachers (CSET)) or get a waiver from the exam by completing coursework in a subject matter program that has been approved by the state. These programs, often called "waiver programs," allow undergraduate students who want to become secondary school teachers to satisfy the state's subject matter proficiency requirement as they complete their four-year degree. CSUDH is currently trying to strengthen its state-approved single subject programs for undergraduates.

CSUDH currently has a state-approved single subject waiver program for mathematics. In fact, the Math Department has a significant number of faculty with doctorates in mathematics and strong interest in math education. Five of the 17 tenure-track faculty in the department were hired for their research and work in math education. Together with a faculty member from the College of Education with a mathematics specialization, they form a "math education group" that is involved in pre-service and in-service teacher preparation activities, including teaching courses for CSUDH students who plan on becoming secondary math teachers.

Many years ago, the university also had a state-approved program for science, but then lost that approval when the state's program requirements shifted. This means that CSUDH undergraduate students who know they want to become high school science teachers must either be prepared to take the state exams or complete coursework at another university that has such an approved program in the sciences.

The QED project includes an effort to develop a state-approved science subject matter program. A group of faculty from the STEM departments, in consultation with faculty from the College of Education, will be working to draft the program proposal and gain approval from each of the

governing bodies required, including department- and university-level approvals. The program will include general science coursework with concentrations in biology, chemistry, physics, and earth sciences.

A number of STEM faculty members interviewed for this case study indicated that there is a great need for such a program at CSUDH. The university in general, and the STEM departments in particular, hope to increase their student enrollment numbers by attracting students who might otherwise go to other local universities.

> *We have trouble with our enrollment right now. [Having a science waiver program] would increase enrollment because people wouldn't leave Dominquez Hills to go to Long Beach or L.A. to take an education class; they'd do it here. (Dean, College of Natural and Behavioral Sciences)*

In addition, increasing the numbers of students taking courses in the sciences would bring more resources and support to those departments, particularly by drawing students into the upper division courses which are often sparsely populated. According to the Chair of the Math Department, this would enable the science departments to build their programs for both teacher candidates and for other students as well.

> *It's a program that I think would be enormously beneficial to our science departments. Our physics department currently has 12 majors and they offer little tiny classes because there are very few people participating in it. But I think if you got a science waiver program, there would be a real track for people to become physics teachers. You would get more physics students. The same thing with chemistry. It would just enlarge their programs. I think that will have a big effect on the College [of Natural and Behavioral Sciences]. It will enable the programs, both the teacher programs and the non-teacher programs, to become stronger, simply because you have more students there, which means you can offer the classes more frequently and on a more regular basis. And you just get better support. (Chair, Mathematics Department)*

According to STEM faculty, developing a state-approved science program will not be an easy task. The science departments have submitted program proposals a number of times since losing their previous approval from the state, and have been denied approval each time. One science faculty member reported that he believes the program proposal was deemed inadequate because it was not written using the appropriate education jargon.

> *[The science waiver] was something that we've tried to do over the years. We've done a number of submissions, and it always comes back saying that it's inadequate, but I don't feel that it's inadequate. I think it's not in 'credential-ese.' We're just not saying it in the right way. That's something we learned early on: there is different vocabulary for educators as opposed to scientists. And they may be saying exactly the same thing but you would never know it. I think it's a major problem. You've got people who speak these two languages and what you need is somebody in-between to translate. (Faculty member, Earth Sciences)*

The process is an extended one that involves getting the appropriate approvals at the department, college, and university levels before being submitted to the California credentialing office. Several faculty members stated that collaboration between the STEM departments and the

College of Education will be necessary to prepare a proposal that is approved by the state. The QED Co-Principal Investigator has taken steps to promote such collaboration by inviting the participation of the Chair of the Teacher Education Department who has experience in the proposal development and approval process.

Strengthening In-Service Teacher Education

Another set of initiatives within the QED and SCALE projects are related to strengthening in-service teacher education by developing rigorous, inquiry-based math and science curricular units and by providing corresponding and ongoing professional development for teachers in the use of these units. Ultimately, the QED and SCALE projects hope to promote the development of a strong and sustainable partnership between LAUSD and the local IHEs—CSUDH, as well as the other state universities in the LA basin. Below we describe this series of initiatives.

Science Immersion Unit Development

One of the goals of the SCALE project is to "develop and implement immersion STEM learning experiences to ensure that every student in [SCALE's] partner districts experiences the process of engagement in an extended (e.g., four-week) scientific investigation at least once a year."[15] In immersion units, "students deeply investigate a topic over an extended period of time, experience putting disparate bits of knowledge together into a systematic conjecture or hypothesis, gather data that tests a hypothesis, confront conflicting evidence, draw conclusions, and consider those conclusions in the context of a broader body of knowledge."[16] The leaders of the immersion unit initiative intend to provide students with experience engaging in the scientific inquiry process and to promote deep conceptual learning on the part of teachers and students. The immersion unit design process is meant to involve representatives from IHEs and from school districts in a cross-institutional collaboration: IHE STEM and education faculty along with administrators, math and science specialists from the school district and teacher leaders.

Early in the SCALE project, a small team of immersion unit developers from the UW-Madison began meeting with central office science staff at LAUSD. After much effort to define the scope of the immersion work, the district and SCALE staff agreed that a series of units would be developed and written into the district's science instructional guides, and that teachers then would be provided with professional development in the use of these units. Between January and June 2005, SCALE and QED joined forces to coordinate the development of these units. SCALE's immersion unit design team from the UW-Madison (consisting of curriculum writers and scientists with expertise in teacher professional development) headed up a joint collaboration involving the UW-Madison team, CSU faculty, and LAUSD science administrators and specialists. In particular, three immersion unit teams developed middle school units during that period of time:

- A "plate tectonics" unit for 6th grade;
- A "variation" unit for 7th grade; and
- A "buoyancy and density" unit for 8th grade.

[15] System-wide Change for All Learners and Educators (SCALE). (2002). Proposal to National Science Foundation.

[16] System-wide Change for All Learners and Educators (SCALE). (2002). Proposal to National Science Foundation.

While only three STEM faculty and four education faculty from CSUDH were involved in these teams, the unit design work was very intensive. Participants from the different institutions met together on the CSUDH campus every two weeks during this period to define the scope of the units' learning objectives and to develop curriculum and instructional activities to support those objectives.

Those CSUDH faculty who were involved in the project had much to say about the value of the work. In particular, faculty members reported that the collaboration was particularly rich, as it brought together over a sustained period of time representatives of educational institutions that typically have had little interaction. Representatives from each of the institutions brought to the curriculum design process a different knowledge base which proved valuable to the task at hand. The science experts from the school district brought knowledge about the students, the teachers, and the working conditions in schools. The CSUDH College of Education faculty brought attention to pedagogical issues such as curriculum planning and assessment. And the CSUDH science faculty brought expertise in the content area.

> *I think the collaborations [in developing the immersion units] have been the most thorough of any project that I've participated in. I'd say they're very extensive, actually. There's always active participants representing each of the institutions, and they're not token participants. They're very much bona fide members of the team. On paper, it represents an idea that you have people from different disciplines coming together;[in reality] everyone has the same goal. (Faculty member, Earth Sciences]*

> *That's a very dynamic group and that's the strength of it. This is cross-institutional in terms of what experiences people have and what kinds of information, textbooks and other things, demonstrations, equipment people have been introduced to in the past, and what they designed themselves. We had a mixed group and we all got to know each other really well, what our strengths were. The district people know the teachers inside and out. They know what the teachers' strengths and weaknesses are. They've taught before; they know the student base really well. Without that you can't do anything. (Faculty member, Physics Department, participant on the Buoyancy and Density Immersion Design team)*

> *[The district staff talk about] standards and situational issues like the condition under which the teachers work, the timing, the time that they have, those housekeeping things that would impede implementation of these inquiry units. They keep reminding us of the administrative problems that might prevent the teachers from implementing. They also talk content too, because they're specialists. They're able to also contribute in that area too. We [the Teacher Education faculty] talk about content, pedagogy, especially pedagogy. At what point should we present? How should we start this? Where should the assessment be? What kind of assessments? How should the assessment tie into the activity? And the content people say what they think about the content and how they think it will impact learning. They will explain how to work better and do it in a different kind of way. (College of Education faculty member)*

The CSUDH science faculty admitted that they themselves were most often focused on content issues, and had to learn about and take into account pedagogical and logistical issues that K-12 teachers face in the classroom.

At the college level, we find ourselves very concerned with how the ideas get presented, a clear logic and flow for ideas, so one idea builds on another. What's the most elegant way to present the idea, the most transparent? We also are very interested in it being technically correct. But you have to step back a little bit when you're dealing with elementary kids. If you want them to get that idea, you can't present it in the same way. There's been many times where I've thought of a sequence of ideas and someone would say, 'Timeout. These are sixth graders.'…So engagement is very important, this idea of having students pick topics and explore things that are of interest to them. So you give them a choice, and let them pursue that challenge. That's not something I'm really as familiar with. (Faculty member, Earth Sciences Department)

Many of the faculty who participated in the immersion unit work said that they had not collaborated in the past with individuals from such diverse backgrounds and fields. They reported that the collective thinking of representatives from different institutions and with varying backgrounds ultimately produced a unit which was higher quality than could have been produced otherwise. Many echoed the words of this Earth Sciences faculty member:

That's one thing that's been very striking to me, how you can take sixteen people in a room, all educated, but all people that would have different ways of doing it, collectively assembling their ideas, mapping them into some sort of logic, having groups study them in subsets, and then everyone collectively comes to an agreement that this is the best way to do it. That's very powerful, because it really shows that the collective intellect is a superior product than any one person could develop on their own. It's a great way to channel all that intellectual energy. So it's something new for me. I hadn't seen that ever done before. It's been impressive to see how there's a whiteboard with nothing on it and three hours later there's this very elaborate scheme proposed. It's somewhat exciting to see that created out of nothingness. (Faculty member, Earth Sciences Department)

CSUDH STEM faculty all admitted that they learned a lot about K-12 education in the process of participating in this collaborative effort.

It's really interesting. I've learned a lot, not only about the details, but also some general things about the culture of teachers, stuff I never thought to ask about before. It wasn't important to what I was doing at the time. [Like] how much teachers have to think about classroom management issues. It's just not something you would have thought about, unless you tried to do it yourself, and now I have to think about classroom management issues. It's a heck of a lot different with adults than it is with kids. And how much [teachers] have to think about it, and how they think about it. I've learned a lot. (Faculty member, Physics Department)

In addition, one CSUDH College of Education faculty member reported that the immersion unit design work has fostered closer working relationships between the education faculty and the STEM faculty.

I think it's a high quality discussion… It's very respectful, very collegial. I think we are working well. So I think that it's creating an atmosphere of collaboration that I think would extend beyond what we are doing now. Because we are beginning to talk, even outside this program. For example, I am beginning to discuss with [one

of the physics faculty members] about how [we] are going to work together around inquiry activities that we can do in my methods class here on campus. So that's extending beyond what we are doing in the immersion work. It simply shows how we are getting to work together more (Faculty member, College of Education)

The QED Co-Principal Investigator intends for the immersion units to have a visible impact on the disciplinary and teacher preparation courses that CSUDH students take at the university. STEM faculty could use the immersion unit approach in their undergraduate disciplinary courses, while education faculty could use it in their methods classes. When teacher candidates then graduate to teaching positions in LAUSD, they would already be familiar with the inquiry approach.

The intention is, when [the science faculty] recreate [their own] physics course, that they take those same ideas and put them into their physics course as an immersion unit for the future teachers at a freshman physics level. So what's going to happen to a future teacher, ideally, is that they see it in an undergraduate physics course, they experience it. They go to their methods course and [see it there]. Then they go out and teach 8th grade science, and boom, there it is. It's part of the instructional program at LA Unified. (QED Co-PI)

During the summer of 2005, several of the CSUDH faculty who had participated in the development of the immersion units also played key roles in a series of summer institutes on the immersion units for LAUSD teachers and teacher leaders. The institutes were run jointly by UW SCALE scientists on the immersion unit design team, CSU science and education faculty, and district science leaders. While data for this case study report was collected before the institutes took place, SCALE researchers are studying the continuing collaboration between CSUDH faculty and district staff in the rollout of the immersion units and the related professional development.

In-service Professional Development for Math Teachers

As mentioned earlier, five faculty members in the Math Department, along with a faculty member from the College of Education, form a "math education group" that is involved in various in-service professional development activities for K-12 teachers. The Mathematics Department has been involved in numerous grants and projects that have supported workshops and summer institutes for teachers in the schools and school districts surrounding CSUDH. In fact, some faculty members from the Mathematics Department have been involved in running such professional development activities for math teachers for 20 years. Through those activities, they have learned much about teachers' needs and how to more effectively provide professional development that has a tangible impact on teachers' classroom practice. As a result of this, the faculty members have gained a lot of experience and have substantially changed how they conduct professional development in two ways. First, they have moved from presenting a random set of "fun activities" to focusing on essential concepts that teachers are expected to cover in their instruction and helping them plan units around those concepts.

We've been doing this for a long time, since 1986. I haven't met too many consultants that have been doing it as long as we have, so we have a lot of experience here. We are always learning. We moved away from fun activities that are all over the map in terms of topic to building teacher math background, trying to make the activities link into a theme so that we're revisiting math topics from

different points of view within the activities. So it became more focused over the years in terms of the content. It really pushes unit planning beyond just "What are the activities, and what's the task?" We're trying to look at these units in terms of "What are the big understandings that are involved in the unit?" Then trying to use the activities that we've been doing in the institutes so that we get into the teacher planning space. (Faculty member, Mathematics Department)

Second, the faculty members have shifted from promoting their professional development workshops to any interested teachers across a spectrum of schools and districts to working in partnership with particular districts, and sometimes even with teacher coaches who can then have an impact on all the teachers that they support.

The structure [of our PD] has changed too. [In the past] we had open invitations and anybody could come. Or we've had [programs] where you come in teams from your same school, from any district. So it's been wide open. But now in the last few years it's been more focused towards partnerships [with] a specific district or sub-district of LA Unified, either with their coaches, or some other arrangements. I started realizing more advantages of this unit than just helping teachers plan; it gave coaches something to do in terms of coaching, real life, what they were supposed to be doing. And then the coaches were able to go back with the teachers and help them in the classroom with those units. So we could see more things happening in the classroom through the eyes of the coaches. (Faculty member, Math Department)

Through these changes in the content and structure of the teacher professional development activities, Math Department faculty report that they have increased their own capacity to support in-service math teachers in the L.A. basin in ways that are aligned with LAUSD needs and priorities. In the summer 2005, as part of the QED and SCALE projects, CSU math faculty designed and conducted a series of three-week math institutes for LAUSD teachers. They were designed specifically for 6^{th} – 8^{th} grade math teachers of English Language Learners and with the goal of building teachers' content knowledge and pedagogical skills related to algebraic thinking.

Since that time, the SCALE and QED projects have been working to extend and deepen the partnership model such that the local IHEs in the LA basin become a significant and sustained resource for LAUSD in the area of math teacher professional development. The projects are promoting substantial connections among faculty at CSUDH, CSU Northridge, CSU Los Angeles, and UCLA. Moreover, at the time of these interviews, the SCALE PI and the QED Co-PI hoped to begin conversations with the district's instructional leaders on how best to develop an ongoing partnership to support teacher professional development. Future updates to this case study will document the nature and impact of those conversations on the developing partnership between CSUDH and LAUSD.

Collaboration across CSUDH Departments and Colleges

One of the changes most evident from the interview data collected in 2005 is the increasing collaboration between the STEM departments and the College of Education at CSUDH. Relations between the two entities were once severely strained and few faculty members collaborated with each other across these intra-institutional lines. Through the SCALE and QED initiatives, however, STEM and education faculty have begun to collaborate with each other. The professional development sessions on active learning that were developed by a College of

Education faculty member have been well received by STEM faculty. Other SCALE and QED initiatives have led to improved collaboration between STEM and education faculty as well, such as the development of the immersion units and the initial work toward developing a state-approved science program. Through the various SCALE and QED working groups, faculty and administrators from STEM and education departments have begun to develop a higher level of respect and trust for each other. Individuals interviewed for this case study spoke to this changing climate and the improvement in collaboration and trust that is beginning to develop as a result of these projects.

> *The Math Department for a number of years did not get along terribly well with the Education School. There was a while when the [departments] went off in different directions. And there were some personality conflicts. Those seem to have disappeared. I see the interactions nowadays as being hopeful and beneficial. For instance with this SCALE and QED project, there is a collaboration between [the Associate Dean of Education and a math faculty member]. They're now working very closely together. [The head of Teacher Education] and I have met on many occasions to talk about how we can bring the Math Department and the Education School together a little bit more. There's a greatly improving history here of collaboration, and I think now people are working quite well together. I've learned what's extremely important is for people to get together often and not simply sit alone in their own little islands and begin to form opinions about other people. As long as the people work together actively, then I think that you can accomplish things. And that's what's going on now. (Chair, Math Department)*

> *In the past, the science people didn't think that we in education know anything. They tended to think that we don't have any information, but now they are beginning to respect what we come in with. And we also respect them. They also realize now, we have content too. So I think that its really working; it's creating an atmosphere of collaboration. (Faculty member, College of Education)*

> *Our science faculty in our college [Natural and Behavioral Sciences] are working and talking with the people in the School of Education like they wouldn't be doing if we wouldn't have this project. (Dean, College of Natural and Behavioral Sciences).*

> *[Now] the dean over the STEM faculty is very cooperative. Our interim dean is very cooperative, and our incoming dean also is very committed to collaboration with undergraduate subject matter areas. So the climate is changing, administratively. (Associate Dean, College of Education)*

This increased level of collaboration bodes well for the university's efforts to make teacher preparation a campus-wide priority, not just one that is the responsibility of the College of Education. Key goals of the SCALE and QED projects are that collaborations between STEM and education will continue to deepen, and that math and science faculty will become increasingly aware of and responsive to the needs of future teachers. Interviews in 2005 indicated that the projects were on track to achieving these goals.

Incentives for Faculty Involvement in K-12 Teacher Preparation

For this case study, faculty and administrators involved in the QED and SCALE projects were asked to what extent the university provides incentives or rewards for faculty who engage in

teacher preparation activities. Their answers spoke to the complexity of this issue at the current time on campus.

As in all 4-year higher education institutions, faculty are expected to engage in teaching, scholarship (research), and service activities; however, at CSUDH teaching has always been the first priority. As mentioned earlier, faculty members have a heavy teaching load: four courses each semester. Research and service activities have been squeezed into the remaining time that faculty members have. Currently, the university is attempting to increase the scholarship requirements for faculty to gain tenure and promotion. However, tenure policy and the definition for what counts as "scholarship" is generally set at the departmental level. As a result, there is substantial variation among departments with respect to their definition of scholarly activities and the parameters for acceptable research.

> *CSU has been undergoing change in terms of expectations. If you go back far enough, people weren't expected to do research; it was basically teaching. If you did research, that was cool. Now Dominguez Hills is changing very fast because we're having a very rapid transformation of the faculty. In terms of professional growth and publications, this university is changing quite rapidly, we're expecting more from our faculty… When I came here a year ago I was told that each department has a policy on RTP [recruitment, tenure, and promotion]. I gathered all of those and I looked at them and they were all over the map. So the Council of Chairs wrestled with it all last year and came up with a provisional policy that basically says we expect two refereed articles and a refereed grant or three refereed articles or a monograph. (Dean, College of Natural and Behavioral Sciences)*

The increased expectation for scholarship, however, creates tensions because the faculty's teaching load remains high. Currently, faculty are being asked to continue a high level of teaching while also increasing their research activity.

> *[Faculty] are being told, you need to do research. We keep saying we've got to free these folks up [for more research] and there are ways to do that, but right now it's "No, we're going to throw it on top…." So one of the things we have to do is figure out a way that they can pack all of this in. You can't teach four classes and do the kind of research that we want now. Believe me this is not an eight-to-five job, the way it's set up right now. So if we're going to ask this from these folks, we've got to give them something and that's what we're going to have to work on. (Associate Dean, College of Natural and Behavioral Sciences)*

The Dean of the College of Natural and Behavioral Sciences reported that he will be trying to decrease the teaching load for faculty in order to allow them to engage in more substantial research activities.

> *I'm going to try as a dean to take that down to three classes from four. But we will have to enlarge some sections, bring in more money, get more of the federal grant "indirect" back that's not coming to us. My goal in two to three years is that for all of the faculty involved in research they would have a teaching load of three courses. (Dean, College of Natural and Behavioral Sciences)*

A critical related issue in the College of Natural and Behavioral Sciences is the question of what type of research is considered acceptable within departments—specifically, does research related

to teacher preparation carry as much value in the recruitment, tenure, and promotion process as does research in the disciplinary subject? The (then) Dean of the College indicated that he has been and will continue to be fully and actively supportive of scholarship related to math and science teacher preparation.

> *Improving the way science and math is delivered in our schools—I think that's one of the greatest things we [in higher education] can do. As a dean, articles having to deal with these kinds of issues—teaching, science delivery—are as important as a regular article on a scientific kind of project that has nothing to do with education. In fact, if all of that person's work was in that area, I would count it totally for tenure and promotion. (Dean, College of Natural and Behavioral Sciences)*

According to the Provost, across the university, deans are increasingly supportive of scholarship related to teacher education. He reported, in fact, that the SCALE and QED projects are

> *helping to stimulate a lot of that because you have a lot of faculty in the sciences in particular who are now writing articles and juried publications that are really about the pedagogy of science and math. Deans have been widely supportive, and I see it in the RTP reports. And of course, I think it's important so I also support it. So I think here it's widely accepted. (Provost)*

What is less clear at CSUDH is the extent to which faculty involvement in teacher preparation activities themselves will be rewarded. Grants can often be used to occasionally support release time for faculty to participate in teacher education activities; for example, faculty involved in the development of the immersion units received release time to participate in the work. However, if faculty are to be involved in teacher preparation activities on an ongoing basis, this work will need to be recognized and valued in the recruitment, tenure, and promotion process. Within the College of Education, teacher preparation work that brings education faculty into collaboration with teachers and schools in the surrounding districts is highly supported and is sometimes counted as scholarly activity. The Associate Dean of the College of Education reported, in fact, that within the College of Education, terms like "scholarship of service" and the "scholarship of teaching" are used to promote a deeper understanding of the value of these activities. He admits, however, that outside of the College of Education, teaching and service are undervalued as potentially scholarly activities.

> *I think [collaboration] with local districts is very well supported [in the College of Education]. In fact, we say if you go beyond the collaboration and you really document it and write it up well, we'll put that in a scholarship category. We've used terms here like the 'scholarship of service' and 'scholarship of teaching' because those are highly valued in our college. When it gets university-wide, it's a little harder to convince people that having an impact on three thousand children is more important than writing a paper and getting it in a juried conference somewhere where eight people come and listen to you. It's just a little personal opinion here, in case you didn't pick up on it. (Associate Dean, College of Education, QED Co-PI)*

A faculty member in the Mathematics Department echoed this opinion, noting that within the College of Natural and Behavioral Science involvement is teacher preparation is generally only valued in the RTP process if it leads to a publication.

When it comes time to RTP, they don't always recognize [teacher preparation] as well as you'd like. The comment at the bottom is, 'So where are the publications for this?' Well gee, I was only spending 100 hours [a] week preparing teachers. When was I going to write up about this? Give me three months off and I'll write it up.' (Faculty member, Mathematics Department)

According to the Associate Dean of the College of Education, the California State Board of Trustees has asked all CSU campuses to consider faculty commitment to teacher preparation as an RTP issue. He said that the College is considering approaching the Academic Senate to gauge their level of support for advancing that policy at CSUDH by building in explicit RTP incentives for faculty in the content areas to participate in the preparation of teachers. This case study will continue to document the development of this policy, as well as the extent to which teacher education research and teacher preparation activities are supported in the recruitment, tenure, and promotion policies of the university.

Conclusion: Institutional Change at CSUDH as a Model for IHE Involvement in K-20 Math and Science Education Reform?

We now consider the findings presented here in terms of the research questions and national policy framework presented at the beginning of this paper. To review, the research questions informing this study ask:

1. Are SCALE IHEs changing their support for reform-oriented teaching and for alignment of pre-service, induction, and in-service curriculum and pedagogy, and if so, are these changes associated with changes in (a) faculty attitudes and behaviors pertaining to collaboration across departments within individual IHEs, across IHEs, and between IHEs and K-12 districts, and (b) high-leverage change factors (such as leadership at faculty and larger organizational levels, new funding, and new tools, practices, and policies) that temporarily enable the typically loosely-coupled IHEs to function in a tightly-coupled manner in order to implement organizational change?
2. How, if at all, and why has the SCALE project resulted in change in IHEs such that STEM and education faculty (a) better understand and meet the needs of the K-12 teachers they serve, particularly in the SCALE districts, and (b) participate more effectively in reciprocal systemic efforts within and beyond their institutions to improve science and math education at K-20 education levels?

On the basis of the information provided in this paper, the short answers to these two research questions are "yes, and yes, to the degree that these could be expected to occur in a two-year period."

The national policy framework, in terms of which we analyze this case study, includes the pointed emphasis that the NSF Math-Science Partnership program places on the participation of IHEs, and in particular STEM faculty, in K-20 math and science reform, and the recommendations of the National Research Council's Committee on Science and Mathematics Teacher Preparation (CSMTP), which argue that a fundamental restructuring of the relationship between K-12 and higher education is needed to make significant improvements in math and science education. Like the NSF, the CSMTP maintains that the participation of institutions of

higher education in this change process is essential. The CSMTP proposed that IHEs can contribute to this process by:

- Entering into ongoing and sustainable partnerships with local school districts with the goal of improving the math and science knowledge base of teachers;
- Promoting greater collaboration across departments and colleges within the IHE with respect to teacher preparation;
- Restructuring undergraduate STEM courses to promote active learning on the part of students, many of whom are future teachers;
- Increasing the level of awareness and understanding on the part of STEM faculty about K-12 education; and
- Building rewards into faculty support systems—including the recruitment, tenure, and promotion system—for those faculty involved in K-12 teacher preparation.

The information provided in this paper indicates that, for all intents and purposes, CSUDH is implementing with early success the CSMTP's recommendations for IHE participation in math and science education reform.

We consider at more length the question of what organizational factors are in play in support of the changes in K-20 science and mathematics reform underway at CSUDH. It is of note that CSUDH is simultaneously experiencing internally-initiated change efforts led by CSUDH administrators, and externally-initiated change efforts led by people within and outside of CSUDH. The latter are responding to the NSF's Math and Science Partnership policies—opportunities designed and promoted by national leaders, and implemented at the state level. As it happened, leaders positioned at various points within CSUDH (provost, deans, chairs, center leaders) and at various points outside of CSUDH (in LAUSD, at UW-Madison) held a largely shared vision for what should be accomplished, and are pursuing diverse, high-leverage, and complementary change strategies, including new funding, and new tools, practices, and policies.

First, we turn to the externally-initiated changes presented here—the SCALE and QED projects, which are enabling CSUDH to extend and deepen its partnership with LAUSD. A key goal of these externally-funded projects is to develop a stronger, more systemic, and more sustainable partnership with the district, such that CSUDH, in concert with the other IHEs in the LA basin, serves as an ongoing resource for LAUSD for curriculum and teacher development. The cross-institutional development of the science immersion units that was implemented by the SCALE and QED projects is a prime example of what a deeper partnership between CSUDH and LAUSD could look like. The school district asked for assistance in developing rigorous science units at the middle school level and the teacher professional development resources to implement the units. District science specialists, UW-Madison SCALE partners, and CSUDH faculty jointly developed the units, the district incorporated the units into their instructional guides for teachers across the district, and IHE and district educators together provided professional development in the use of these units. It is important to note that this model of partnership involved the significant participation of science faculty, many of whom had previously had little interaction with K-12 education. That partnership activity, thus, had benefits for both the district and for CSUDH, by bringing the content expertise of the science faculty to the work while also exposing those faculty to the realities of K-12 education. As SCALE and QED leaders continue meeting with LAUSD instructional leaders, they will be promoting the development of an

ongoing partnership between the two institutions to support teacher professional development in the area of math and science instruction.

Another key goal of the SCALE and QED grants is to improve CSUDH's undergraduate math and science programs for students interested in teaching. As described in the previous sections, these externally-funded projects are supporting several related efforts in this area:

- Professional development workshops for STEM faculty with the goal of improving faculty members' ability to actively engage students in the learning process;
- Recruitment and support of cohorts of students who express an interest in becoming K-12 math and science teachers;
- Redesign of some of the core STEM courses that future teachers take as part of their teacher preparation; and
- Development of a state-approved subject matter program in science.

The goal of these efforts is to provide specific supports to both faculty and students in changing how math and science teaching and learning take place on campus. Courses should be designed to provide learners with skills in inquiry-based instruction and should engage students actively and in cooperation with others in their own learning. Such instruction should serve as a model for future K-12 teachers to use in their own classrooms.

The SCALE and QED efforts run parallel to the broader, internally-initiated change process underway across the CSUDH campus that is aimed at improving undergraduate education and linking the services of the university with the needs of the surrounding local communities. Occasioned by a significant faculty turnover due to retirement, the university is attempting to change the culture of teaching and learning on campus by:

- Supporting professional development for new and existing faculty on the use of active and cooperative learning strategies in their instruction,
- Recruiting more new freshman, grouping them into cohorts, and providing them with a university orientation course,
- Promoting active student involvement in faculty research, and
- Supporting the redesign of many of the introductory undergraduate courses

According to the Provost, the campus-wide change initiative will benefit from the work taking place within the QED project.

> *I think that what QED is doing is a microscopic piece of what we as a campus are doing. They [QED leaders] have got such good support that they are helping by doing things with faculty through the grant that will have those faculty making a major contribution to the other effort. They will be players in both. So what they are doing at a micro level in QED can be stepped up to the macro level for the whole campus. I think it will have a very salubrious effect on what we do. It just is going to make it easier, and I think it will make it more effective. (Provost)*

In turn, the externally-initiated and funded QED work is more likely to become sustainable if it is part and parcel of this broader campus strategy to be more responsive to the needs of its students and to the communities in which it is located.

As mentioned above, faculty and administrators affiliated with the SCALE and QED projects at CSUDH are keenly aware of the interrelated nature of the K-12 and higher education systems because they feel the effects of that educational cycle at CSUDH. Many students educated in K-12 schools in the communities surrounding the university enroll at CSUDH and later return to those same communities as teachers. CSUDH faculty acknowledge that when math and science are poorly taught in the K-12 schools, undergraduate teaching is severely impacted. Likewise, CSUDH faculty believe that if they prepare pre-service math and science teachers more effectively, there will be a significant positive effect on the K-12 students. CSUDH faculty and administrators especially welcome the SCALE and QED projects because they are designed to intervene in the K-20 educational cycle at multiple points.

CSUDH's faculty recruitment, tenure, and promotion policies are currently undergoing change, and thus, it is not yet known whether teacher preparation work will be sufficiently rewarded outside the College of Education to attract faculty commitment to the efforts in a sustained way. Clearly, teacher preparation is an important mission of the university; however, it is unclear to what extent that translates into concrete reward structures and practices for STEM faculty engaged in partnerships with K-12 education. To date, there are small signs emerging within the College of Natural and Behavioral Sciences that faculty scholarship related to K-12 teacher preparation is being valued as highly as is scholarship in the discipline. As science and math departments continue to refine what counts as high quality teaching, scholarship, and service, and to assign relative value to each of those components in the RTP process, this case study will examine how STEM faculty respond to such policies when considering their involvement in K-12 education.

As described in the previous section, one of the most important impacts that the QED and SCALE projects have had thus far at CSUDH has been the increased level of trust and collaboration between faculty in the College of Education and the science and math departments. This represents a significant shift from past history when the College of Education and the math and science departments were largely estranged from each other. This currently improving relationship is a product of a number of the SCALE and QED initiatives, including the professional development sessions for STEM faculty run by a faculty member from education and the development of the immersion units. This improving relationship also is supported by the broader CSUDH changes in policies and practices intended to create a student-centered campus. These changes bode well for future collaborations among STEM and education faculty and for a shared approach to the preparation of math and science teachers after these externally-funded grants are over. In contrast to past history, teacher preparation could become a joint endeavor that involves STEM faculty in the pedagogy of teaching, and involves education faculty more deeply in the disciplinary preparation of teachers.

Overall, CSUDH is making a significant effort to improve its math and science teacher preparation system through the SCALE and QED work. Together these two initiatives comprise a well-thought-out plan to improve CSUDH's pre-service and in-service teacher development in math and science and to extend its partnership with LAUSD. These grants provide the university an infusion of resources to jumpstart this K-20 math and science work. However, whether or not the resulting initiatives become sustainable depends on the extent to which the intended changes actually take root and become embedded in the day-to-day practice of the university.

One way to assess this question of sustainability is to consider the following phenomenon noted by organizational theorists. Many organizations, IHEs among them, operate as loosely-coupled

systems. As such, they lack central coordination, are weakly regulated, use several means to produce similar outcomes, and have highly connected networks with very slow feedback times.[17] Loosely-coupled systems have many advantages, such as improving the organization's sensitivity to the environment, allowing local adaptations and creative solutions to develop, allowing sub-system breakdown without damaging the entire organization, and allowing more self-determination by their members. On the other hand, they are very difficult to systematically change. By contrast, systematic and sustainable organizational change is easier to accomplish in a tightly-coupled system. Bearing in mind these two types, we consider whether CSUDH leaders will be able to temporarily morph their organization into a tightly-coupled system by simultaneously altering a sufficient number of structural and cultural factors such that a new status quo can be maintained when the organization resumes its default functioning as a loosely-coupled system.

The findings in this report suggest that a temporary shift to a tightly-coupled system, in order to accomplish major organizational change, may be underway. We speculate that a critical mass of CSUDH leaders, from different levels of the organization, are working together on factors that are likely to cause change, including obtaining new sources of funding (e.g., SCALE, QED), engaging new members (a large body of new faculty, hired in terms of their fit with the provost's vision for a learner-centered campus), and developing and using new tools (e.g., science immersion units, redesigned STEM courses), practices (e.g., teacher professional development collaboratively offered by STEM and education faculty and LAUSD experts activities), and policies (e.g., professional development workshops for STEM faculty, use of students cohorts, early efforts to change RTP policies) that work together synergistically. Time will tell whether this university is operating in a sufficiently tightly-coupled manner to achieve the new K-20 status quo envisioned by leaders internal and external to CSUDH. The next three years (2006-2008) will be important in determining how the work progresses and the degree to which CSUDH becomes a model for IHE involvement in math and science education reform.

[17] Karl Weick, "Educational organizations as loosely coupled systems," *Administrative Science Quarterly*, 21 (1976), 1-9. Robert Birnbaum, *How Colleges Work: The Cybernetics of Academic Organization and Leadership*. 1988. San Francisco: Jossey-Bass.

Figure 1. California State University, Dominguez Hills: QED and SCALE Working Groups