Advances in Engineering Education

SUMMER 2010

Prime: An Integrated and Sustainable Undergraduate International Research Program

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ABSTRACT

Recently we have seen an increase in the calls for universities and the education community to re-think undergraduate education and create opportunities that prepare students as effective global professionals. The key motivator is the need to build a research and industrial workforce that works collaboratively across cultures and disciplines to address major global challenges.

At the same time, computing, information, and communication technology facilitates a comprehensive 'cyberinfrastructure' on which new types of scientific and engineering knowledge environments and organizations can be constructed. We describe our four-year pilot experience with the Pacific Rim Experiences for Undergraduates (PRIME) project.

The goals of PRIME are to: develop an integrated and sustainable undergraduate international research program that serves as a model for 21st Century undergraduate education; prepare students to become effective global professionals and citizens; and, give students a head-start on careers in science, engineering and technology research. We discuss the design and motivation for the scheme, salient implementation details, outcomes to date and discuss challenges of scalability and sustainability.

Keywords: International Curricula, Undergraduate Research, Cyberinfrastructure.

INTRODUCTION AND MOTIVATION

"What nations don't know can hurt them. The stakes involved in study abroad are that simple, that straightforward, and that important. For their own future and that of the nation, college graduates today must be internationally competent."[18]

> "Most of the major problems facing our country in the 21st Century require every young person to learn more about the world's regions, cultures, and languages.", C. Powell, Former U.S. Secretary of State.
>
> "Fewer than 1% of U.S. college students are studying abroad each year. Most of these students choose destinations in Western Europe," [26]

The past several years have seen a dramatic increase in the calls for universities and the education community to engage actively in international activities [29] [10] [16]. The calls for better preparing students to become effective global professionals have been direct and uncompromising [18, above]. There are many There are many motivations for these calls, including: globalization is driving demand for an internationally competent workforce; access to good jobs will require new skills and competencies, especially *global* knowledge and skills; solving new national security challenges, and increasingly complex humanitarian crises brought about as a result of chronic conflict; sudden and developing large-scale natural disasters as well as existing and potential new pandemics will require increased knowledge of other world regions, histories, cultures and languages; increased diversity in our nation's classrooms, workplaces, and communities, including new immigrants from many different parts of Asia and Latin America, requires greater understanding of the myriad cultures and histories students bring to school. As an example, the University of California at San Diego (UCSD), where some of the authors work, is itself a microcosm of this diversity, with 23% of the undergraduate students immigrants, 43% of the students speaking a language in addition to English (of those more than 50% a language from the Asia Pacific Rim) [34]. This profile is typical of many Universities both in the US and abroad.

At the same time, a United States (US) National Science Foundation (NSF) Blue Ribbon Panel on Cyberinfrastructure [9] stated "a new age has dawned in scientific and engineering research, ... [where advances in technology] make possible a comprehensive 'cyberinfrastructure' on which to build new types of scientific and engineering knowledge environments and organizations, and to pursue research in new ways and with increased efficacy." In addition, to have this cyberinfrastructure interoperate internationally, there is a "need for a new workforce – a new flavor of mixed science and technology professional –... who are trained to understand and address ... working across disciplines, cultures, and institutions using technology-mediated collaborative tools." The recent report "2020 Vision" by the National Science Board emphasized three strategic investments for the NSF: infrastructure, in particular cyberinfrastructure; a world-class workforce, and a *global* frontier of fundamental and transformative research, emphasizing areas of greatest scientific opportunity and potential benefit.

To address the need articulated in the Lincoln report (among others [13]), to prepare undergraduate students for the global research and industrial workplace, and to take advantage of the "revolution in science and engineering through cyberinfrastructure," the UCSD, with NSF support, and partners in the Pacific Rim Application and Grid Middleware Assembly (PRAGMA), launched a pilot program in 2004 called Pacific Rim Experiences for Undergraduates (PRIME). Under this program, UCSD students worked on summer research projects at eight international sites, as shown in Table 1.

The overarching goal of the PRIME program is to develop an integrated and sustainable undergraduate international research program, that prepares students to become effective global professionals and citizens. PRIME gives students a head-start on careers in science and technology research, and serves as a model for undergraduate education in the 21st Century.

Features of the PRIME student experience include the conduct, presentation, and dissemination of research; immersion in an international host site as an apprentice researcher; experiential training for cultural awareness; and learning to become an effective member of an international research team.

In this paper we describe the PRIME model in Section 2, and give an assessment of the success of the program in Section 3. We discuss the sustainability and scalability in Section 4, and describe other international programs in Section 5.

Cybermedia Center (CMC), Osaka University	Osaka, Japan
National Center for High-performance Computing (NCHC)	Hsinchu, Taiwan
Monash University	Melbourne, Australia
Computer Network Information Center (CNIC) of the Chinese Academy of Sciences	Beijing, China
National Center for Research on Earthquake Engineering (NCREE)	Taipei, Taiwan
Universiti Sains Malaysia (USM)	Penang , Malaysia
University of Auckland	Auckland, New Zealand
University of Waikato	Hamilton, New Zealand

Table 1. Location of PRIME target sites (June – August 2008).

THE PRIME PROGRAM

Background

The PRIME program was started in 2004, with support from the US NSF and California Institute of Telecommunications and Information Technology (Calit2) as well as the international partner institutions mentioned above, as a pilot activity to prepare students for the global workforce of the 21st Century through experiential research and immersive cultural learning. PRIME builds on the strength of four key units or research organizations on the UCSD campus. Sixth College is an undergraduate college whose educational vision is that culture and technology are interrelated and that all students must develop cultural competency through experiential learning opportunities (practicum) such as spending an extended period abroad as part of an educational program/opportunity. The Academic Internship Program (AIP) [4] is authorized and has the administrative infrastructure to support credit-bearing undergraduate research internship programs. The Programs Abroad Office of the International Center identifies study abroad opportunities and prepares more than 1,000 UCSD students per year to live and study abroad.

"I can say without question that my involvement with PRIME, more so than any course I took, helped give me the level of professional understanding and maturity that I believe will be necessary for success in graduate school, a professional career, and beyond. The leadership skills and firsthand technical experience gained through working in international collaborative environments are invaluable assets to our generation of engineers and scientists, who must learn to function on the ever-growing stage of global research." – 2004 PRIME student

PRIME leverages an existing collaborative platform called PRAGMA, the Pacific Rim Application and Grid Middleware Assembly, for the participating international partner (host) sites and many scientific and technological development projects. PRAGMA, established by an US NSF award in 2002, provides the technical and human network for the students. Since inception PRAGMA has grown to more than 30 institutions around the Pacific Rim, with both application scientists and technology developers working collaboratively to make the Grid usable on a routine basis [8] [3] [35]. PRAGMA, in its grass-roots approach to community building, recognized one of the key transformation aspects of cyberinfrastructure, namely building virtual communities. As stated by the US NSF Director Arden Bement, "cyberinfrastructure enables distributed knowledge communities that collaborate and communicate across disciplines, distances and cultures, … [to become] virtual organizations that transcend geographic and institutional boundaries" [14]. Importantly, the PRAGMA sites that host students co-invest in PRIME by providing mentoring, local support, space and equipment and assistance with issues such as housing.

The PRIME Program Experiential Learning Model

PRIME is an immersive, hands-on international educational advancement and research internship program for science and engineering students. PRIME is distinct from traditional education abroad programs because it allows students to participate in research, working side-by-side with the researchers at the international host sites. In contrast, traditional education abroad programs almost all involve students in traditional lecture style courses.

The program's two distinctive elements are research apprenticeship and a cultural competency learning experience. The components, the logistics, inputs, outputs and outcomes are shown in Figure 1 below.

In this model, there are three key contributors to and beneficiaries of the outputs and outcomes: the students, the home (i.e. UCSD) mentors, and the host mentors. In considering issues of sustainability (discussed in section 4) all three groups are considered. However, for the most part, this paper focuses on the students.

Research Apprenticeship

Research is a process that includes the identification, formulation and contextualization of a research question, and the determination of the methods and tools most likely suitable for solving the research question. PRIME makes students aware of this by involving them in all of those steps. Students must initiate contact with the UCSD mentor as well as the host site mentor to discuss research possibilities, and develop a proposal as part of their application. Students who have been selected prepare during the quarter before leaving the US. Under the guidance of both mentors, students acquire the necessary background knowledge of the research topic and, if applicable, acquire the skills to use the cyberinfrastructure tools. At the host site, students are then immersed

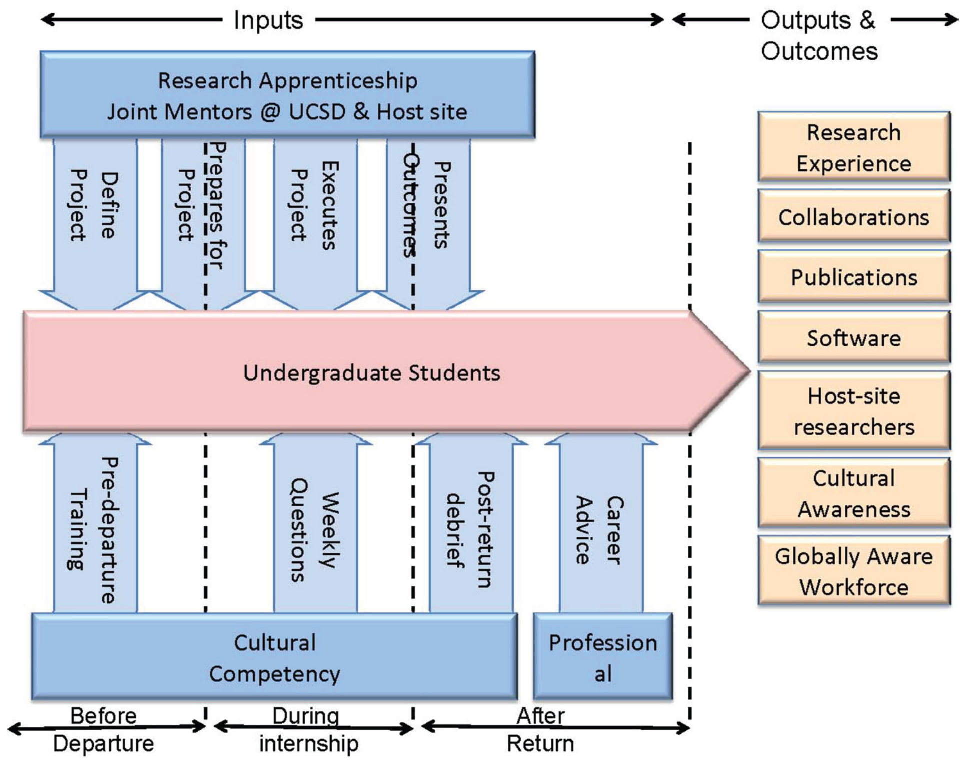

Figure 1. PRIME and its components.

in a research team for nine weeks. This provides sufficient time to make reasonable progress on the research topic.

The internship culminates in a presentation by the students at their host site, emphasizing the value and need for communicating their results to a broader audience. In addition, upon their return to UCSD, students often present their research at a workshop organized by PRIME and/or at professional meetings. For example, in 2004 the students presented at the PRAGMA 7 workshop, and in 2005 at iGRID2005 (co-incidentally) both held at UCSD. Some students continue their project with the UCSD mentor and then present results either at international conferences (four each in 2004, 2005, 2006, and 2008, and six in 2007 participated in the IEEE Supercomputing conference, one of the premier symposia in cyberinfrastructur, or in peer-reviewed papers (see section 3.2).

Cultural Competency Learning

We introduce students to the four stages of cultural awareness: blissful ignorance of cultural difference and behavior (unconscious incompetence); realization of difference but little knowledge of how to behave (conscious incompetence); realization of the difference and with effort knowledgeable about action (conscious competence) and cultural awareness and action as second nature (unconscious competence).[1] Recognizing that students come to the program with different levels of awareness of the host culture, PRIME tries to move students towards "unconscious competence". We use this model to raise awareness of cultural differences, and to begin changing students' attitudes and behaviors.

The pre-departure training, currently a two-hour workshop, begins with a definition of culture, and explores verbal and non-verbal behaviors that reveal cultural attitudes and values. We define and give examples of "critical incidences"[2]. Using the Describe-Interpret-Evaluate process we analyze several critical incidents that lead students to ask "what happened?" and "why?" and encourage students to use cross-cultural thinking and vocabulary that describes the incidents. We discuss different types of communication, such as direct/indirect, with and without eye contact, and physical proximity, demonstrating each to illustrate the points. The addition of cross-cultural incidents and ways to analyze them is considered an integral and important part of the "learning how to learn" process, including how to recognize, characterize and respond to meaningful cultural differences. The sessions' format is a full group activity, followed by discussion and activity in small groups. Finally, perspectives are shared with all participants. Subsequent to the workshop, new participants interact with prior years' students to better understand possible cultural and logistical challenges that await them.

While abroad, students reflect about their experiences (critical incidences) in their new environments by answering weekly questions based on material in "What's Up With Culture". Students learn to discern knowledge about cultural differences and similarities without assigning values, i.e., better or worse, right or wrong, to those cultural differences. The materials are based upon 'cultural-general' models and theories of intercultural communication that are applicable across a wide range of human societies, and are illustrated with global examples of communication mistakes. Especially useful are cultural 'contrast" sets that allow students to place general cultural patterns into non-stereotypical categories on a continuum (e.g. 'individualist" societies vs. "collectivist" so-

[1]From LaBrack presentation on May 18 2005: Unconscious incompetence ("…the state of blissful ignorance… unaware of cultural differences … or that you may be making cultural mistakes or misinterpreting much of the behavior going on around you. You have no reason not to trust your instincts); Conscious incompetence ("You now realize that differences exist between the way you and the local people behave, though you understand very little about what these differences are, how numerous they might be, or how deep they might go."); Conscious competence ("You know cultural differences exist, you know what some of these differences are, and you try to adjust your own behavior accordingly. It doesn't come naturally yet") and Unconscious competence ("You no longer have to think about what you're doing in order to do the right thing. Culturally appropriate behavior is now second nature to you; you can trust your instincts because they have been reconditioned by the new culture.").

[2] As defined by La Brack "a 'critical incident' is an occurrence that in some way raises questions and leads the participants to wonder 'What just happened?' and 'Why?' Everyone who goes abroad is, eventually and inevitably, faced with some kind of a situation we could call a critical incident, even if s/he is unaware of it at the time or can't immediately figure out what was going on. Such encounters illustrate the tricky nature of interpreting everyday events in a different culture."

cieties or a preference for "direct vs. indirect communication" styles). These types of models can then be supplemented by "culture specific" material appropriate to country and setting. Using a general framework makes it easier to understand macro cultural patterns and allows subsequent micro 'culture specific' knowledge to be placed into a broader context.

Upon return to their home institution (UCSD), these online contributions are enhanced in a face-to-face "re-entry" meeting using exercises that explore issues such as concept of time, gender roles, professional hierarchy, communication styles, international lab procedures and techniques, different thought processes and approaches to scientific questions and social interactions with peers in the host country. Through this, PRIME participants learn to appreciate (rather than judge) that different cultures have developed their own specific ways of carrying out or expressing behavioral patterns that are shared by all of humankind collectively.

Students are encouraged to use their new awareness to begin understanding the cross-cultural situations they encounter in their everyday lives, and use this knowledge to work more effectively and harmoniously with colleagues of backgrounds different than their own.

Program Logistics

Student Preparedness and Programmatic Requirements

To ensure that students are academically prepared, and that they are mature enough to deal with the challenges of living and working in a foreign country, they must be in good academic standing (i.e., a grade point average of at least 3.0 out of 4.0) and must have earned credit equivalent to completing their first two college years. Students must also return to UCSD for at least one quarter (see: Return to UCSD after Nine Weeks)

Application Process

The application process consists of two steps. The first step is a pre-application, which allows the program directors to help indentify potential UCSD and host site mentors and to sketch out a project. The second step consists of a rigorous application process. Students discuss projects with one or more mentors already associated with PRIME (or new mentors students persuade to participate in the PRIME). Students' final project and mentor decision is based on their interest in a specific project, positive interactions with the mentors and host site location. If a particular host site is "oversubscribed", we help the students to modify the projects so that they fit the interests of different host sites. We believe that the students need to be involved in the definition of the project's scope and goals by formulating a project plan.

Applicants prepare a curriculum vitae through which they demonstrate how and why their educational and personal skills make them a good applicant, an essay describing why they are interested in PRIME, what they hope to gain educationally from participating, a project plan, and two named references. A review panel, consisting of the PRIME PIs, some UCSD mentors and the host lead mentors, review all applications to identify the best qualified students. The inclusion of the host site mentors in the review process ensures that the project fits the expertise at the host site and that the applicants are welcomed enthusiastically. The finalists are interviewed to determine their maturity and interpersonal communication skills, and finally, references are consulted. Table 2 shows the acceptance rates since 2006, showing a dramatic increase in applications in 2009.

Host Site Contributions

Host sites contributions are critical to the success of PRIME. They typically provide mentors, space, and access to equipment required for research and, importantly an overall safety net by assuring that local logistics are provided (e.g., meeting students at the airport, finding housing, helping the student adjust to the new location). We send a minimum of two students to any given site. This allows students to share their experiences together and provides a built-in safety network to explore their new location. See section 2.5 for why the host sites participate.

To support the cultural competency component of the program, the host site often provides funds for sponsoring social activities and encouraging members of the research team to accompany the students on excursions to explore the local culture.

Return to UCSD after Nine Weeks:

Students must return for at least one quarter, for a variety of reasons:

1. Cultural re-entry: PRIME provides the students a re-entry seminar to help them put their experience in context.
2. Assessment: The re-entry meetings allow us to assess aspects of the program.
3. Program improvements: Discussions with students improve the program. For example, after the second year we required students to spend time in the UCSD host labs before traveling to the host site.

Year	Applied	Accepted
2006	39	14
2007	33	14
2008	38	21
2009	73	33

Table 2. Acceptance rates for PRIME students.[3]

[3]Applied is number of pre-proposals. We implemented this in 2006, thus do not present data for 2004 and 2005.

4. Project continuation: Returning allows the students to continue their work in the UCSD mentors lab, in some cases giving them time to produce a paper on their work.
5. Recruitment of new students: Former students help recruit future students. This happens both by word of mouth, as well as by involving previous students in information sessions. At those sessions returning students play a prominent role by talking about their research, cultural, and living experiences.
6. Mentoring new students: Former students mentor new students for their upcoming experience in a pre-departure meeting, and often prepare them on aspects of the project
7. Career advice: Upon return, students are invited to participate in a career advice seminar. Attendees receive guidance on how to prepare a curricula vitae (CV) and resumes that reflect and highlight their international experience.

Program Data

During the first five years of the program, PRIME supported 71 students from a variety of majors, though mostly from Engineering (see Tables 3 and 4). The program was extended to include CNIC in China as a partner site in year 2. It developed a cultural awareness component that year as well.

	2004	2005	2006	2007	2008	Total
CNIC	–	0|**2**	3|**3**	0|**3**	0|**2**	3|**10**
Monash	0|**3**	3|**5**	3|**4**	4|**5**	5|**7**	15|**24**
NCHC/NCREE	0|**3**	1|**3**	1|**3**	1|**2**	1|**3**	4|**14**
Osaka U	0|**3**	1|**3**	1|**4**	3|**4**	1|**3**	6|**17**
USM	–	–	–	–	3|**3**	3|**3**
U Auckland/U Waikato	–	–	–	–	3|**3**	3|**3**
Total	0|**9**	5|**13**	8|**14**	8|**14**	13|**21**	34|**71**

Table 3. Number of Students (Female|Total) by Host Institution and Year.

Major	Number Students Years 2004–8
Bioengineering	27
Compt. Science, Compt. Engineering, ECE	19
Aero, Mech, Struct, Eng Phys	10
Science (list majors here)	14
Other (Visual Arts)	1

Table 4. Distribution of Students by Major.

PRIME has involved 21 UCSD researchers as mentors, roughly half from departments, and the other half from interdisciplinary research units. We added a resume-writing component in fall (northern hemisphere) 2006 to improve students' ability to present their experiences to potential employers and/or post-baccalaureate admissions programs.

In the first five years of the program, of these 71 students, 29 have enrolled in graduate school, 12 have entered professional position in the private sector and 11 are still students at UC San Diego. Ten of the students have co-authored 11 research publications with their mentors.

Sample Research Projects

Because PRIME leverages the PRAGMA initiative, all PRIME projects either apply or develop cyber-infrastructure [9]. The projects are defined both by the interests of the students and mentors. As such, some projects build on results of prior projects, whilst others bring in new areas and researchers [5]. The interests of the UCSD mentors are diverse and include drug design, image processing, cardiac modeling, molecular simulation, sensor networks, scientific visualization facilities (typically tiled display walls) and earthquake engineering. By engaging new host sites, we expect to broaden the research topics even further, including areas such as lake ecology, geoscience, and grid computing.

PRIME research projects exploit unique attributes of the (remote) host site and therefore would not have been possible if done solely in the US. Specific examples include learning from the authors of a key middleware, such as Nimrod that was developed at Monash University; using data from the host site, such as Malaysian natural compounds available at the Universiti Sain Malaysia; studying earthquake engineering at a world center such as at the National Center for Earthquake Engineering in Taipei; or studying aspects of a specific lake or coral reef on site, such as at University of Waikato. Importantly, none of these opportunities would be available if the host site was at another US University. It highlights the benefits of choosing host sites from other PRAGMA members. In all cases students are immersed in the research hierarchy and sociology at the local site, which can help them in future interactions with scientists from that culture.

Projects require students to learn new technologies which are either conveyed to their host institutions (e.g. display technology made from regular flat paneled screens that have been arrayed into a larger one, with the appropriate software to allow the collection of screens to act as one, i.e. tiled display wall technology) or brought back to their UCSD mentor's lab (such as the use of specific software). We give some examples of recent projects:

1. One set of students used the Nimrod cyberinfrastructure tools (developed at Monash University in Australia) [2] in the development of more stable ionic models in rabbit and human ventricular myocytes. One of the interesting scientific outcomes of this work was that the single cell model for the rabbit predicted calcium and action potential 'alternans' at high frequencies above the

point where the model was physiologically stable, i.e., the model behaved as a real cell behaves, which was not predicted.

2. A team of students worked on a study of the avian influenza virus, subtype H5N1, screening neuraminidase and hemagglutinin proteins, respectively, against two libraries of compounds. They used AutoDock and DOCK, software tools designed to predict how small molecule drug candidates bind to a receptor of known 3D structure, to screen the NCI diversity library representative set of 2,000 compounds, and 1,000,000 ZINC library compounds. Students identified certain receptor residues that were especially important to ligand binding and future drug design. One of the students continued her work in an international research group, and on a new model that was released at the end of summer 2007
3. A single student created a pipeline between the Nimrod cyberinfrastructure and two programs that calculate various physical properties of molecules, namely General Atomic and Molecular Electronic Structure System (GAMESS), which uses quantum chemical theories, and Adaptive Poisson-Boltzmann Solver (APBS), which uses electrostatic theories. These computer simulations allow scientists to predict, for example, how a small molecule might interact within a protein, or what types of functional group alternations could cause differences in structure and property behavior. The project generated a database of amino acid properties that researchers can access globally, and provided valuable infrastructure for another student's PhD program.
4. Another student used image analysis as a computational tool in identifying functional biological neural networks. These networks provide the framework for constructing three dimensional representations of the dynamics of cells. She successfully determined the number of cells present in a still image taken from a movie of astrocytes, the largest and most proliferate of glial cells in the central nervous system. The astrocytes she observed were tagged with calcium sensitive dye, and the still image captured calcium transient signal propogation after the cells were stimulated with ATP signal.
5. Two students worked as a team on a visualization project using tiled display walls. They employed COVISE, the COllaborative VIsualization and Simulation Environment, and added features to make it more usable. Specifically, the students added a File Browser "Plugin" with a suite of image processing functions, which displays all files in a directory, navigates to other directories, and loads any COVISE file to their respective plugins.
6. A student assessed the durability of decommissioned elementary classrooms at Ruei-Pu Elementary School in Taoyuan, Taiwan. The team studied the responses of the classrooms using four different tests: push-over—exerting physical force to a building from its side, explosives—blowing up a column and noting the response of the other columns, pseudo-dynamic testing—pushing the building and then essentially pulling it to simulate a one-direction earthquake, and cyclic testing—repeated push-over, back and forth. The student used the structural analysis

program GISA3D (Graphical Interface of Inelastic Structural Analysis for 3D Systems), and created visualization "plug-ins" with indicators for monitoring and analysis. His modifications allowed the research team to analyze and interpret their data more efficiently so that they did not interface strictly with a column of numbers, and it provided NCREE a foundation for implementing further changes to GISA3D for future experiments.

Importantly, a number of these projects have resulted in publications in peer reviewed conferences [32][1][5][6] or software such as Cytoscape. All of them have generated outcomes of interest to the mentors, and have underpinned further research and collaborations. Importantly, the projects leverage the international flavor of PRAGMA, and provide opportunities that are not available in the US as noted at the beginning of this section. In some cases this is because the software environment and expertise at the remote site is unique. In others, it is because the local culture is a key component in the research. Finally, exposure to the local culture (and language in many cases) is a critical component of the research experience.

Host Sites

Host sites play an invaluable role as partners, mentoring students and providing local logistical support, investing staff and research time, with no compensation from PRIME. So why are our Pacific Rim partners willing to host students? In all cases, the host sites identified that their participation in the PRIME program:

- *exposes and trains their staff to work in an international context.* This was uniformly the first response. PRIME students build local workforce experience, by exposing host site students and staff to new ideas and different ways of thinking, training host site students and staff to work in an international setting and training host sites students and staff to give better presentations;
- *builds collaborations to new labs.* Students serve as ambassadors to international research groups, and to inspire different approaches and applications to problems;
- *improves the* depth and quality of research because of the intellectual exchange brought to the lab via the students; and
- *internationalizes their own institution*, by bringing in international students and their U.S. mentors, which motivates the intellectual culture of the campus to embrace problem-solving and creativity through multi-disciplinary and multicultural collaborations.

PRIME ASSESSMENT

As outlined in Figure 1, PRIME has a number of tangible outputs and outcomes, namely: research experience, collaborations, publications, software, host-site researchers, cultural awareness and a globally aware workforce. Clearly, PRIME has not been operating long enough to perform a full longitudinal study and assess the performance of the scheme against these outcomes. However, here we provide preliminary data (both quantitative and qualitative) that suggests the program is effective. We address each of the outputs in turn and evaluate the performance of that output against a range of performance metrics. These assessments allow us to monitor student growth, improve the PRIME program, and build connections to promote research and scholarly collaborations.

The data presented here was gathered by a number of different methods. Some of the more quantitative results are available by simply gathering the statistics. However, additional data is available through various other instruments. For the first two years of the PRIME program we used evaluation forms based on "Looking Beyond the Borders: A Project Director's Handbook for Best Practices for International Research Experiences for Undergraduates" [28]. We received evaluations for students, UCSD mentors, and host sites. In addition, during the first two years the PRIME directors visited many of the sites while the students were there, to conduct informal assessment of their research progress and of their acculturation. In addition, we required feedback from the host mentors to identify any issues that they had seen. Anecdotally, we observed that host sites that had not been used to undergraduate students (i.e. both local and from the United States) were less certain what could be expected of the students. The visits helped explain what was possible and what the host mentors could expect.[4] Finally, we engaged in a number of small focus groups to tease out details not gained from these other methods.

Research Experience

Recently, we examined the qualitative long-term impact of the program on participants with a small focus group of students. The students in this group were from the first two years of our program (two from year 1, two from year 2). Three of them are currently pursuing higher degrees (MD/Ph.D, CS Ph.D, Computational Chemistry Ph.D) and one works in industry. Each of them acknowledged PRIME's influence on their use of computing, its immersive experience working at an international lab and the effect on their thinking, and often their career path (one is now studying abroad). Also, several mentioned the opportunity to work on projects with different cultures was important to their profession, and how the experience helped them develop independent problem solving abilities.

Generation of new collaborations

Long-term research collaborations have been enabled by PRIME and the students that have been shared between labs. In Table 5 we give five examples, indicating the specific collaborations. There are several explanations for these ongoing collaborations, ranging from the interests and dispositions of the specific UCSD mentors and the host mentors, clearly defined projects, and building upon the works of previous students and other activities.

[4]After the first four years we developed a set of practices and expectation of the students, called Agreement of Release of Liability. It also helped articulate what the host sites could expect of the students.

Publications

As shown in Table 5, there have been a number of publications produced directly from the PRIME program, Of the 11 publications (including 1 posters), nine involve mentors from both UCSD and host sites.

CMRG: Computational Mechanics Research Group; VBL Vascular Bioengineering Laboratory; NBCR: National Biomedical Computation Resource; Vis@Calit2: Visualization Effort at the California Institute for Telecommunications and Information Technology; CompChem: Computational Chemistry Lab, initially at the San Diego Supercomputer Center, later at the University of Zurich.

Software and new products

Several software components have been developed and distributed as shown in Table 6

Other outcomes include new products or services. For example, the Global Lake Ecological Observatory Network (GLEON) is a grass roots network of limnologists, ecologists, information technology experts, and engineers who have a common goal of building a scalable, persistent

UCSD Lab	Host Site	# Yrs of Shared Students	# Students Shared	# Shared Publications
CMRG	Monash	5	11	1
VBL	Osaka	4	5	4
NBCR	CNIC	3	7	3
Vis@Calit2	Osaka/NCHC	2	6	1
CompChem	Monash	5	7	2

CMRG: Computational Mechanics Research Group; VBL Vascular Bioengineering Laboratory; NBCR: National Biomedical Computation Resource; Vis@Calit2: Visualization Effort at the California Institute for Telecommunications and Information Technology; CompChem: Computational Chemistry Lab, initially at the San Diego Supercomputer Center, later at the University of Zurich.

Table 5. Outcome Statistics on Collaborations, Data from 2004–2008.

Software Developed	Context
Hyperbolic Focus Layout Plugin	Cytoscape Plugin, that allows viewers to see relationships via a hyperbolic focus, bringing into focus relationships of greater interest, http://cytoscape.org/plugins2.php.
ThumbnailBrowser	A file browser plugin for Covise, for ultra-high resolution images, which can run on a tiled display wall or in the Starcave at Calit2
Enhancements to Image Viewer	A plug in to Covise, with added functionality to allow for the viewer to lay out a number of image files on a grid so that multiple images can be compared side by side on a tiled display wall.

Table 6. Software Components that have been developed by PRIME students.

network of lake ecology observatories. Currently there are more than 150 individual members and more than 20 sites around the world interested in sharing data. A PRIME student developed a controlled vocabulary for data from sensors from two lakes, one in New Zealand and on in Wisconsin. In this case, key words and phrases were developed that can be shared among lake scientist for comparing measurements. This list has been adopted by the Global Lake Ecological Observatory Network (GLEON) and will be a basis for being able to share data.

Host site researchers

Section 2.5 noted several qualitative benefits for host sites. There are benefits in terms of collaborations over several years and publications (Table 5); new projects started (e.g. MURPA and PRIUS – see section 5.3 for Monash and Osaka respective; GLEON – see section 3.4 for NCHC); and staff exchanges – Osaka, CNIC. These all indicate benefits for host site researchers.

Cultural awareness

To assess the impact of the cultural experience, we use the What's Up with Culture and four stages of cultural awareness model from La Brack, as well as the Intercultural Development Inventory of Bennett and Hammer.

Throughout the cultural training sessions we stress that major factors in a successful adjustment to another culture are a combination of knowledge and attitude towards difference. We also assume that students enter the training with different levels of experience and intercultural awareness. We deal with this directly in the curriculum by introducing them to La Brack's model that characterizes four commonly encountered 'stages of cultural awareness': blissful ignorance of cultural difference and behavior (unconscious incompetence); realization of difference but little knowledge of how to behave (conscious incompetence); realization of the difference and with effort knowledgeable about action (conscious competence) and cultural awareness and action as second nature (unconscious competence). Recognizing that students come to the program with different levels of awareness of the host culture. Our goal is to move students towards "unconscious competence".

The What's Up with Culture website contains questions of 75 long-term impacts (Section 2.4.1 of [23]) during our first year. Subsequently we asked the students to respond to weekly questions during their time at the host site (see Weekly Questions – also based on questions in What's Up with Culture. A summary of the responses has been compiled for the years 2 through 4 (2005–2007).

Although we do not expect them to attain "conscious competence" given the limited length of the summer immersion, we believe that both "conscious incompetence" and "conscious competence" represent significant progress towards attaining the ability function in a new environment. We use this model to raise student awareness about their own reactions and to motivate students to examine their own stage of awareness. This is the beginning of a mental process that is aimed at eventually changing students' attitudes and behaviors that might be inappropriate or counterproductive if displayed in another culture. This conceptual framework is linked with training providing culture general information that supports culture learning and allows students to increase their ability to interact effectively (and appropriately) while doing research overseas.

These questions are used to help students think more deeply about their cultural experiences, helping to guide their thinking about cultural issues. For the directors this was a way to monitor issues during the summer and to improve the program in subsequent years. In addition, the responses to these questions provide input into discussions at the re-entry workshop the students attend.

In addition to students' stage of cultural awareness, we employed a more detailed assessment instrument (IDI) that directly measures their attitudes towards difference. As part of the preparation for the orientation every student takes the Intercultural Development Inventory. This instrument is based upon the Developmental Model of Intercultural Sensitivity (DMSI). The content and categories of the IDI have been addressed elsewhere, but what is salient here is that the 'stages of cultural awareness' are conceptually related to the IDI categories which rates a student's degree of sensitivity along a continua from 'ethnocentric' to 'ethnorelative' attitudes. The IDI is a much more rigorous and nuanced inquiry, which creates a detailed student profile that reveals their current degree of intercultural sensitivity. In comparison, the 'stages of cultural awareness' only asks students to consider that they might not be open, flexible and/or appreciative towards different cultures. Both can be used at different points to raise student awareness that many of their assumptions and attitudes they consider 'natural' are actually cultural constructs and that successful intercultural interactions will frequently depend upon their ability to understand and adapt to systems quite different from those they are familiar with. Each of these activities hopefully makes students more curious and willing to pursue intercultural learning even if it moves them outside their comfort zone.

Beginning with the 2008 cohort, we administered the Intercultural Development Inventory (IDI) prior to departure and again after return [19]. The IDI measures intercultural competence on a six point scale of orientations from ethnocentric to ethno relative. These include *denial, defense, minimization, acceptance, adaptation, and integration*. IDI is theory-based, meeting the scientific criteria for a valid psychometric instrument. It has been in use since 1986, it has been validated extensively, and is widely used [36].

Twenty one PRIME students took the IDI pre and post departure. Evaluation of the pre departure group indicated *minimization*, which is the tendency to minimize difference between cultures. This is a common finding among groups of university students preparing for a study or internship abroad experience. After nine weeks abroad, the students were re-evaluated. The results showed that the students remained in *minimization*, albeit with a slight though statistically insignificant shift from 2.49 to 2.42. This movement is not large enough to indicate a shift towards ethnocentrism. However, they did experience an increase towards *reversal*, from 3.57 to 3.17, which is the tendency to be more critical of their own culture. Another important finding was that students advanced in the *acceptance/adaptation* range from 3.12 to 3.44. Bennett and Hammer found that people taking the IDI "...develop their sensitivity on each of the stages simultaneously. That is they do not have to completely resolve the issues involved in one stage e.g. reversal) before moving on to the next stage e.g. *minimization*)" [7]. So it is completely consistent for the group to remain in *minimization* while developing greater *adaptation* after their experience.

The IDI measures a moment in time. Our hope is that students will remain engaged with international research and global interests in order to continue developing their intercultural competence. In the future, we plan to administer the IDI to this cohort one and two years after their return. We also intend to administer the IDI to each new PRIME cohort to develop linear data across several years of students to measure trends. While the sample size for the first year is small, further testing will improve our research. We may also do comparison studies with similar programs at other institutions.

Globally aware workforce

It is not possible to provide quantitative assessment of this criterion so early in the program, and evidence will only emerge after many years of operation. As outlined before, we created PRIME to prepare students to become effective members of the global workforce. We know that leading high technology companies increasingly value international experience when recruiting and hiring new college graduates. For example, Google makes hiring decisions based on whether an applicant has worked or studied abroad because they require diverse, multi-lingual, inter-culturally competent workers who can function effectively on international work groups and with international clients. US engineers must understand a multiplicity of cultural approaches to engineering design because they work as system integrators on fast changing international functional teams [12]. PRIME's cultural competency program has been created to develop and hone these soft skills.

SUSTAINABILITY AND SCALABILITY

Here we discuss our strategies for scaling and sustaining PRIME and steps we have taken thus far. However, whiles the strategies are based on our observations, we are still implementing and revising them.

Table 7 shows the various PRIME participants, their contribution and the benefits they derive from their involvement. It is clear that almost all of the current participants derive benefit, either directly (D) or indirectly (I) via others. Direct beneficiaries, namely those who receive tangible results, include students and mentors, whereas indirect beneficiaries gain value through a better-educated student body or through furthering a mission. By understanding the participants and the benefits they derive, it is possible to understand the issues that affect both sustainability and scalability.

Participant	Contributions	Direct or Indirect benefits	Benefits
Students	Time, some funds	D	Research Understanding; Cultural Awareness; Transcript notation and credit; Establishing track record (through publications); Help build mentor network.
UCSD Mentor	Time and effort	D	Publications, Software solutions, Funding, Collaborations; Professional satisfaction
Host Mentor/Staff	Time and effort; Administrative Coordination	D	Publications, Software systems, Funding, Collaborations, Exposing staff to international perspective; Professional satisfaction
PRIME Admin Staff	Time	D	Salary and professional satisfaction.
UCSD: Academic Internship Program	Academic Credit, Prof. Dev'l Sem.	I	Contributions to their core mission; Promotes opportunities to students
UCSD: International Center	Administer IDI, Cultural Training Seminar: Pre-, Post.	I	Uses IDI to improve cultural orientation and re-entry programs for all study abroad students.. Uses PRIME to promote academic integration with all majors and increase study/intern abroad participant rates among undergraduate students.
UCSD: BioEngineering	BioEngineering Seminar. for Returning Students	I	Provides opportunities for Bioengineering majors
UCSD: Bio (6th)	Educational Coordination	I	Professional satisfaction, Promoting international experiences
PRAGMA	Framework, Scientific Coordination	D	Strengthen collaborations
Other contributing. projects	Funds	D	Advance goals of project; new funding
Calit2	Funds	I	Advances Calit2 Technology to other sites via PRIME program
NSF	Funds	I	Supports Mission of Agency
UCSD		I	Recruiting material (unrealized)
Industry/grad school		I	Globally aware workforce
Society		I	More competitive, globally aware workforce

Table 7. Participants and the benefits they derive from PRIME.

Our basic premise is that the scalability and long-term sustainability of the program requires a strong commitment at the institutional level. In particular, faculty and research staff need motivation and reward for mentoring students; departments need incentives for developing new courses and seminars; and supporting units require dedicated personnel to handle the extra program administering and for evaluating the programs.

Supporting the concept of institutional commitment for scalable and sustainable programs is the position of NAFSA, the Association of International Educators, with respect to the Senator Paul Simon Study Abroad Foundation Act, that aims to increase over the next decade the number of US college students who study abroad to 1 million. "Such a dramatic increase in the number of students studying abroad each year cannot be accomplished unless changes are made at the campus level to make study abroad more accessible to each student." In particular need to "bring about necessary reforms to address the various barriers – curriculum, faculty involvement, institutional leadership, and programming." [22]

Effective institutional support should promote curricular changes, i.e., academic integration of programs abroad into the curriculum of each undergraduate major. This benefits all students, especially those in science and engineering majors, who often feel that they must choose between graduating on time in four years, or pursuing a valuable international educational experience.

Financial aid is another area where institutional leadership is crucial. As the PRIME program expands, and NSF grant funding ends, it may become necessary to require a greater student financial contribution. Streamlined access to all forms of federal, state and institutional financial aid will be essential to promote access for all students regardless of their financial resources.

In the next two sections we discuss Sustainability and Scalability in the context of the PRIME program.

Sustainability

A program is sustainable when its benefits outweigh its costs. This requires continual improvement to the program. When the number of the participants grows, the focus must continue to be on maintaining highest programmatic standards. This can be achieved with dedicated individuals, explicit institutional appreciation of the educational value of the program, and funding from direct (students, faculty) and indirect (funding agencies, institutions) beneficiaries.

Furthermore, the sustainability of the program increases if it successfully engages new mentors (both at UCSD and at host sites); adds new host sites, to provide an ever growing list of projects to interest students; engages new partners on the UCSD campus (e.g. Academic Internship Programs, International Center, BioEngineering Department) to take advantage of their expertise and the processes they have already set up; maintains interactions of the administrative staff at UCSD and the host sites; and maintains or grows the funding stream through additional support from already contributing agencies or by bringing in new funding via projects that have specific goals that overlap with those of the PRIME students. Core funding streams need to be expanded to areas of preparing students for intercultural communications and assessment, at a minimum, to ensure appropriate materials are prepared and the impact of the program is measured.

NAFSA, Association of International Educator, recommends the following best practices for international internship programs [30]:

- Hire dedicated staff to manage the program.
- Obtain support from and develop partnerships with academic departments and the campus career center and the study abroad office.
- Remember that economies of scale may be less evident with internships than with study abroad because they do not achieve the same scale at each site.
- Selecting sites can be time consuming, so more resources may be needed to maintain an international internship program.

Finally, in addition to engaging the institution as noted above, programs such as PRIME need to engage industry. This has been demonstrated by the MIT International Science and Technology Initiatives (see Section 5), which has had more than 500 internships since its establishment in 1994.

Scalability

Scalability, that is the ability of the program to scale (up) its "inputs and outputs", to benefit a broader group, requires a commitment on the part of an organization. There is no one program that suites all students. The program we discuss, PRIME, is just one of several that can be employed for an organization to offer a diversity of international experience opportunities.

In this section we outline our thoughts on scaling PRIME. Our goal is to engage between 40 and 60 students annually. This is a number where students can still know the other participants, and the program would have a significant size to begin draw conclusions from assessment data.

In addition to institutional commitment and support of such a program (mentioned above), there are several other considerations in scaling, which may require compromises on current amount of student flexibility. These considerations include:

Costs imposed on the students: What is reasonable to expect for student buy-in to this program? Currently PRIME pays for airfare, lodging and food (earlier we also paid a small amount for additional expenses). Can we lower the program contribution and increase the expectation on the student? Can we ensure that needs-based students are not excluded?

Agreements with host sites: For a scaled program, we need agreements that provide incentives for the hosts. Either hosts accept more students, or we need more hosts. One approach would be to provide a reciprocal agreement between institutions, where students are actually exchanged, as is done for other abroad programs.

Logistics of the program: What we currently do for 20 students will not scale to 50 with the same budget. Processes that require modification include the selection process, where projects may be predetermined, or where projects require teams of students; travel arrangements either could be made with less modification by students or become the responsibility of the student, which would add different burdens to the program if students do not act in a timely manner; budgeting to ensure that key added-value activities such as assessment and cultural awareness training are more than volunteer efforts.

OTHER INTERNATIONAL PROGRAMS

General Trends in Study Abroad

Overall participation by US college students in study abroad has increased from nearly 100,000 to around 250,000 annually over the past decade. It is estimated that approximately 50,000 students pursue international internships annually, however this data is not tracked systematically, and no data is provided by study major. The Institute of International Education (IIE) publishes the annual Open Doors report that provides the most comprehensive national data for study abroad rates and trends. Over the past decade, science and engineering students have lagged other fields of study in the rate of participation in international educational experiences such as study or internship abroad. In the 1996/97 academic year, 6.8 % of US study abroad students majored in physical or life sciences, 1.9 % were engineering majors, and 1.6 % were math or computer science majors. A decade later, 7.3 % were in physical or life science majors, while 3.1 % were majoring in engineering and 1.5% were math or computer science majors. While the participants rate held steady for physical/life science as well as math or computer science majors, engineering students did increase their participation by 61% [21] However the absolute number remains very low compared with other fields of study, and compared to the increasingly global nature of science and engineering. However some universities have much higher participation rates. At UCSD, participation rates are higher. For the 2006–07 academic year, 23.7% of study abroad participants were math, science and engineering majors [20].

Specific Programs

International internships programs for science and engineering students exist at a limited number of institutions. While not exhaustive, we report on several programs that offer different models and approaches to the challenge of sending science and engineering students abroad for internships. The programs highlighted here are not the only options available for students at these institutions. For example at some schools, students have the opportunity to go on outside internships or study/

intern abroad programs such as the International Association for the Exchange of Students for Technical Experience (IAESTE) or Deutscher Akademischer Austausch Dienst (German Academic Exchange Service) Research Internships in Science and Engineering (DAAD/RISE), or they might have an individual opportunity arranged by a faculty member. However the programs share an institutional base that sends students to locations in a coordinated manner.

Our select sample includes: the Massachusetts Institute of Technology (MIT) MISTI program, one of several highly successful models of applied international engineering education; Georgia Institute of Technology (GIT) Division of Professional Practice's Work Abroad program provides international internship and co-op experiences for undergraduate and graduate students, supported by GIT's international plan for the first five years through 2010; and the University of Tulsa program, a collaboration with Rice University. These programs tend to be small compared to the total number of science and engineering students at a given institution. Funding sources, the number of student participants, the type of experience (work or unpaid internship), country locations, assessment of cultural and professional learning, language training, and staffing may vary (see Table 8). But each institution addresses the challenge in innovative and important ways. MIT, GIT and Tulsa have NSF funding, though for MIT this is for only the India and China programs. MIT uses a variety of funding models that include corporate and host government support, depending on the country. All three have professional staff dedicated to administering the programs.

Interest among students has been greater than the number of available positions. At Tulsa, for the most recent year there were 120 applications for 16 positions. At UCSD, 73 applied for 33 positions for summer 2009. These examples indicate that students are seeking international internships, but there are many challenges to expand opportunities to meet the demand. Individual science labs and corporate sites cannot handle a large number of students. A lab or site may only have the capacity for 1-4 students. Building connections between US and international faculty is time consuming process and this constrains the growth of the program. Finding ongoing sources of funding for faculty, students and administration is another impediment to growth. While some programs grant university credit, other universities will not grant credit because they are co-op programs. For the former, academic integration of international credit bearing internships into the engineering curriculum often encounters skepticism and/or opposition from faculty. Coop schools have an advantage here because they will take the internship whether it is in the US or abroad. Support from industry and academia, as well as the government is needed to increase student participation in international internships.

Universities differ on whether they require second language knowledge. Depending on the type of internship, fluency or at least strong language proficiency may be necessary, especially in a corporate setting. While many international labs use English, students may be at a disadvantage in developing closer cultural connections to the host culture if they do not speak the language. Many science and engineering

Program	PRIME	MISTI	GIT Work Abroad	NANO
Institution	UCSD	MIT	Georgia Tech	Rice U & U Tulsa
Started	2005	1984	2005	2005
Host Site Locations	8 Sites (see Table 3)	Europe, Middle East, Latin America, Asia	20 Countries	12 Universities in Japan
Host Site Industry		y (2/3 of students)	y	
Host Site Academic/ Research	y	y (1/3 of students)	y	Y
Level of Students	Juniors, Seniors	Undergraduate, Grad Students	Junior, Seniors, Grad Students	?
Number of Students (2008 data)	21	320	115	16
Language Requirement or Training	Encouraged	1-2 years required (for example, 1 year for Germany, 2 years for Japan)	Encouraged	Japanese
Cultural Activities	Organized by Host Sites	In country activities organized by programs, alumni, clubs, or hosts	Varies by employer and program	Y
Duration	9 week northern hemisphere summer		Northern hemisphere summer, 6 month, and year long	8 week northern hemisphere summer
Assessment	IDI pre and post	Assess Eng. Learning	IDI and other varying assessments	IDI pre and post
Return Seminar	y			Y
Funding	NSF, Calit2, other projects, host sites	NSF, Corporate and host government support	Georgia Tech	NSF
Dedicated Support			y	

Table 8. Comparison of Four Programs that Provide International Research or Work Internships.

students cannot incorporate a second language study into their already heavy course loads. A language pre-requisite might be difficult to implement and would require a much longer recruiting timeline so as to give first and second year students a chance to begin a language sequence. As an interim measure, a short pre-departure survival language and culture course might be offered.

In the case of PRIME, we do not require participants to speak the language to their host sites. We considered this, but felt it more important to provide initial exposure to an international culture and begin on a path to become culturally competent which may also include language skill acquisition.

Awarding credit for international internships is not universal among universities. UCSD awards one credit for the internship, but other universities such as MIT and GIT do not give credit. As co-op schools, MIT and GIT believe offering credit bearing internships would require their students to pay for credit that they would not need for graduation. UCSD believes the one unit PRIME internship provides several benefits. It provides structured faculty oversight and assessment, while also providing a transcript notation. At UCSD, students can also apply financial aid towards an internship that is credit bearing. It should be noted that some co-op schools provide transcript notations for non-credit internships. A credit bearing experience may also help to integrate the internship into the university curriculum and may lead to some form of departmental or institutional support.

Common among the programs is that the internship experience is placed at an international site, exposing students to working in another culture. As can be seen from the table, these programs range in scales of numbers of students, host sites and continents. Also we see a dichotomy of host sites: academic or research institutions, and industry. While not conclusive, programs with industry involvement have a greater numbers of sites (thus capacity) and students. We believe that this highlights that industry sees value in this type of investment.

Adapting and Extending the Model: PRIUS and MURPA

One measure of success of any model is its adoption by others. In this section we report on two universities that used the PRIME model as a starting point for their own programs, and have extended the model.

The success of the PRIME program motivated the creation of a new program at Osaka University. Funded by the Japanese government, the Pacific Rim International Universities (PRIUS), [15] was created. Modeled in part on PRIME, PRIUS provides a broad intellectual framework at the graduate level, combining:

- Lecture courses, taught by international experts, to stimulate student interest (many of who are PRAGMA members). During this last year more than 20 experts came to Osaka University, thus generation a great deal of interest in the other components of the program.
- Short internships abroad, to offer trial opportunities to live in a new environment Long internships abroad and to provide opportunities to build skills

Like PRIME, PRIUS's is to prepare graduate students for global citizenship and professional competence in a multi-cultural workplace through international immersive research experiences/internships.

PRIUS students have performed research at UCSD, other PRAGMA partner sites in Australia (Queensland University of Technology), Singapore (National Technological University), Taiwan (NCHC), and Malaysia (Universiti Sains Malaysia), and at additional sites in the United Kingdom (University of Oxford), Germany (Bauhaus University), and New Zealand (University of Canterbury). The extension of PRIUS to these additional sites has demonstrated the flexibility of the basic model to a broader, world-wide set of institutions. In addition, they too have published papers [33][25][24][27], and have had direct impact on improvement or extension of middleware used by the community. We note that in 2007 the success of PRIUS partly contributed to Osaka University's participating in Japan's Global Centers of Excellence program (MEXT). MEXT will establish education and research centers, to elevate the international competitiveness of the Japanese Universities.

Independently, Monash University has developed a similar program to PRIME, and has received seed funding to create MURPA (Monash Undergraduate Research Projects Abroad). MURPA delivers a PRIME experience for Monash undergraduates, and inherits all of these benefits discussed in this paper. MURPA students undertake an 8 week program across the southern hemisphere summer. The first MURPA intake occurred in 2008, and 8 students have spent an 8 week period at UCSD from January 2009.

MURPA expands PRIME by integrating an additional component that allows Monash students to attend 'virtual' seminars given by leading experts from the UCSD. These use the latest High Definition Video-Tele Conference equipment (HDVTC). (HDVTC is a meaningful enhancement on existing technology, and provides a significantly superior experience than existing H323 equipment.) Six seminars were delivered from the CalIT2 building at UCSD in 2008, and were be hosted in the Faculty of IT video conference facilities in Australia. In 2009 and 2010 this was extended to a complete semester seminar program, and integrated the seminars into the Computer Science curriculum at Monash University. Furthermore, we used this technology for the first four MURPA students to present from UCSD their final presentation to faculty at Monash University.

CONCLUSIONS

Peace and prosperity around the world depend on increasing the capacity of people to think and work on a global and intercultural basis. As technology opens borders, educational and professional exchange opens minds."[26]

Here we outline some of the lessons we have learned, provide a view of the program from a student perspective, and provide some final conclusions and challenges for the program.

Lessons Learned

Through this pilot project we have learned a number of things, outlined below.

Aggressive recruiting is required to assure gender parity. Because no female undergraduates applied during the first year, we partnered with the Society of Women Engineers and key campus administrators to promote PRIME. Applications from women, and thus acceptance of women into the program, grew in years 2 and 3 until in year 3 more than half (8 out of 14) were women. See Table 3 for overall growth of the program and the gender balance.

Previous students are effective recruiters. We include previous program participants in all information sessions. Students gain confidence to apply when listening to peers. PRIME alumni are especially effective in encouraging other (especially female) students to apply.

Identifying a mentor and creating a project are application barriers. Many students told us that identifying a mentor and identifying a research question and projects are so daunting that they gave up before trying. We responded by instituting a pre-application process, in which the PIs advise the students on how to identify a suitable UCSD mentor and how to initiate a dialogue with a potential faculty mentor. In addition, we have published summaries of previous years' projects on the web, to give examples for students. The pre-application process, started in 2006, generated 39 pre-applications, resulting in 14 students being accepted into the program; in 2007 the numbers were 33 pre-applications and 14 acceptances. MURPA introduced the seminar series explicitly to help students find remote mentors.

The Spring Quarter is a crucial preparation period. Based on feedback from students of both first- and second-PRIME class (i.e. those student who went during PRIME's first and second year), PRIME acceptance decisions have to be made by the end of the Winter Quarter. This assures that students can use the Spring Quarter to better prepare for the summer, create a detailed plan, and to participate in the cultural competency curriculum.

Language is important. From students in PRIME's first class we learned that if they lacked basic language knowledge, they felt more isolated outside their laboratory setting. We therefore strongly encourage students to acquire a foundation of basic language skills prior to their departure. This increases the students' abilities to explore the host country and to gain insights into culture. We advise students about the numerous opportunities at UCSD to obtain fundamental language skills. As one PRIME 2006 student, noted: "I would like to be a part of that (i.e., China's growing economy) in the future. However, it will be impossible if I can't read or write the language."

Cultural competency is a process. In many cases, before students can observe cultural differences without judgment, they experience negative emotional reactions to certain cultural models they may not agree with or understand at first. This process occurs naturally, as students have pre-existing appraisal systems constituted in their own cultural upbringing. With proper guidance and support, students can learn to recognize when they are reacting negatively to cultural differences, and learn how to reframe their experiences and thus cognitively restructure their appraisal systems. By integrating the culture of their host country on a day-to-day basis and maintaining relationships with a network of people who are supportive of the program, students are given an invaluable opportunity to learn experientially how to transcend moral judgments, which impede the ability to understand and thus cooperate with individuals from other cultures.

Value of the Program to Students

It is worthy to also continue the program from the students' perspective, and we have gained the following insights.

Learning by doing facilitates true understanding. One student, said: "*Knowing about a culture and experiencing a culture are completely different things." Another student observed, "I heard a lot about living in Japan from Japanese friends at UCSD. It was not until I lived there that I began to understand what they were talking about.*"

Students return aware of and having experienced—often for the first time—what it is like to live and work in another culture. This builds confidence in their abilities to participate and excel in an uncommon environment. Many of the PRIME students have commented on this point.

Students are "often transformed by the experience: more willing–and able–to engage with the world beyond America's borders." [11][17] As one of our students stated: "*I understand now that I need to be able to accept failure, and build myself up again and begin the work with the same passion and energy that I originally had. I should not associate failure with disappointment, but think of it as a learning experience that causes me to seek other ways of approaching certain difficulties*."

This experience allows the students to be better collaborators in international teams. Students learn that "there are different ways of doing things in science, and it is good what we learn about science from being in another country—different approaches, different insights: that's what drives innovation in science." [31].

Being immersed in another culture distances students from the American culture, which gives them an opportunity to become aware of aspects of the American culture of which are usually unaware. Many students find that discussing stereotypes of America with co-workers and friends from their host country is educational, and that being a foreigner gives them a unique opportunity to think critically about culture. One student, reflects, "*In America, we have this great vision of* *independence. Our American hero is the stoic cowboy, riding alone into the sunset. In China, there is more of a group mentality … . I used to think that asking for favors was very bad, like admitting that I was weak and needed help, but my experience here has shown me that going at it alone is not always the best policy.*"

The values of the program mentioned above assist students in learning to identify aspects of different cultures they find meaningful to their own lives and personal success. As a result, they can create their own cultural context—one that informs their goals and values and at the same time allows them to understand and thus work with people with different cultural backgrounds. In essence, by having the opportunity to form their own identity, students can appreciate diversity.

The students' depth of cultural literacy provides them with the framework for understanding the formation and preservation of various cultural models, and they can recognize through experience that every cultural practice has a value. One student noted that "*however backwards a policy may seem (e.g. the one child policy), there is always logic behind it…Though there are political and cultural differences between different countries, reason and logic are common to all cultures*." When students learn how to recognize value in any cultural system, they develop a perspective of compassion, which is essential for global awareness and cooperation.

ACKNOWLEDGEMENTS

The direct support of the PRIME programs comes primarily from the National Science Foundation through awards NSF INT 0407508 and OISE 0710726. In addition, the California Institute for Telecommunications and Information Technology has been a consistent partner and has provided additional direct support for this PRIME. The PRIUS program received direct support from the Japanese MEXT framework of "University Education Internationalization Promotion Program". These programs would not have been possible without the support of all of the host sites to PRIME and PRIUS, including the Cybermedia Center of Osaka University in Osaka Japan, the National Center for High-performance Computing in Hsinchu Taiwan, Monash University in Melbourne Australia, and the Computer Network Information Center of the Chinese Academy of Sciences in Beijing China. MURPA is supported by the Monash International Strategic Initiatives fund.

The authors wish to acknowledge the significant input from Professor Bruce LaBrack, University of the Pacific and Professor Robert Sah, Bioengineering, University of California San Diego. Finally we wish to acknowledge the involvement recently of other host mentors and their institutions who are contributing to PRIME: Professor Keh-Chyuan Tsai, National Center for Earthquake Engineering; Professor Habibah Wahab, Universiti Sains Malaysia, Professor Poul Nielson, Professor Jason

Ingham, and Dr. Liam Wotherspoon, University of Auckland; Professor David Hamilton, University of Waikato; Professor Arun Agarwal,and Dr. Anand Kondapi, University of Hyderabad (new in 2009), Professor Jung Hsin Lin and Dr. Chih-hao Hsieh, National University Taiwan (new in 2009); Dr. Tony Fan, National Museum of Marine Biology and Aquarium (new in 2009), and Drs. Shinji Shimojo and Kaori Fukunaga, the National Institute for Information and Communications Technology (new in 2009).

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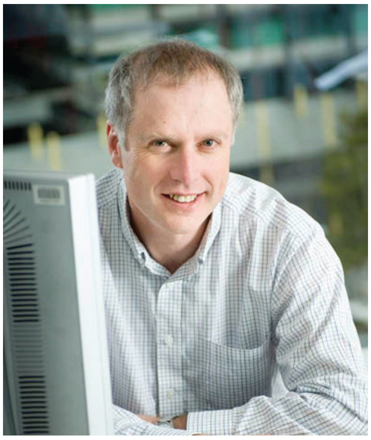

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