The Multiple Faces of Agency
NEW DIRECTIONS IN MATHEMATICS AND SCIENCE EDUCATION
Volume 11

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Scope

Mathematics and science education are in a state of change. Received models of teaching, curriculum, and researching in the two fields are adopting and developing new ways of thinking about how people of all ages know, learn, and develop. The recent literature in both fields includes contributions focusing on issues and using theoretical frames that were unthinkable a decade ago. For example, we see an increase in the use of conceptual and methodological tools from anthropology and semiotics to understand how different forms of knowledge are interconnected, how students learn, how textbooks are written, etcetera. Science and mathematics educators also have turned to issues such as identity and emotion as salient to the way in which people of all ages display and develop knowledge and skills. And they use dialectical or phenomenological approaches to answer ever arising questions about learning and development in science and mathematics.

The purpose of this series is to encourage the publication of books that are close to the cutting edge of both fields. The series aims at becoming a leader in providing refreshing and bold new work—rather than out-of-date reproductions of past states of the art—shaping both fields more than reproducing them, thereby closing the traditional gap that exists between journal articles and books in terms of their salience about what is new. The series is intended not only to foster books concerned with knowing, learning, and teaching in school but also with doing and learning mathematics and science across the whole lifespan (e.g., science in kindergarten; mathematics at work); and it is to be a vehicle for publishing books that fall between the two domains—such as when scientists learn about graphs and graphing as part of their work.
THE MULTIPLE FACES OF AGENCY

Innovative Strategies for Effecting Change in Urban School Contexts

Alberto J. Rodriguez (Ed.)
San Diego State University

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This book is dedicated to the contributing authors whose strong commitment to advancing knowledge through scholarly collaboration made this project possible.

This book is also dedicated to all the teachers and students who generously share their lived experiences with us in our multiple agency roles as researchers, teacher educators and partners in education reform.
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FOREWORD

This timely edited volume examines the education of children and youth in urban settings and offers compelling alternatives for successfully engaging them in school learning. Urban schools serve a large proportion of students who are poor, of color, and speakers of languages other than English. For example, of all students attending schools in the large urban districts comprising the Council of Great City Schools in 2006, more than 80 percent were of racial/ethnic minority backgrounds, 26 percent were eligible for free/reduced price lunch (a proximal indicator of poverty), and 16 percent were English language learners. This demographic profile characterizes the student population in urban districts across the United States. Historically, factors such as race, ethnicity, social class, and language status have been forceful predictors of the benefits students are apt to reap from their school experience. It is widely known that compared to their White, middle-class, native English-speaking peers, students from low-income, racial/ethnic minority groups, and immigrant backgrounds generally attain lower scores on achievement tests, are overrepresented in special education programs and lower academic tracks, are more likely to repeat a grade and/or drop out of high school, and are less apt to enroll in and graduate from college. Arguably, reversing these disturbing trends is the most critical challenge to American education today, particularly within urban schools. The studies reported in this thoughtful volume suggest clear and tangible strategies for making schools responsive to the student population historically left behind.

The innovative instructional practices featured in this volume reflect current theories of learning. Recent work in cognitive science depicts learning as an active process by which learners infuse new ideas with meaning. In this interpretive activity, learners are said to draw on their prior knowledge, experiences, and interests as they strive to make sense of new concepts. As this suggests, children’s preexisting knowledge, derived from their personal and cultural experiences, is what gives them access to learning. Such insight permeates the research reported in this book. The contributing scholars offer powerful images of urban school students successfully building on their interests and funds of knowledge—essential resources generally ignored in schools—as a bridge to learning science. In so doing, the authors challenge deficit views of urban school students widely held by educators and others today. While the focus of the works in this volume is on science learning, the innovative strategies depicted are easily transferable to learning in other subject areas.

Implicit in the collection of studies presented in this volume is the recognition that schools are intricately linked to the broader society and, therefore, can never be politically neutral. As institutions in society, schools mirror the language,
culture, values, and interest of the dominant group, thereby placing children who differ from the mainstream norm at a disadvantage in the learning process and systematically obstructing their development. While acknowledging the conservative function of schools, contributing authors keep the focus on the potential for schools to serve as sites for social transformation. Their optimism is derived from a deep understanding of human agency. As they remind us, institutional structures and practices do not exist in a vacuum. Instead, they are built and sustained through human action. Such a perspective opens up new possibilities for educators and others to envision strategies for altering inequities deeply ingrained in the fabric of schools.

True to its title, the book offers readers insight into the multiple faces of agency. The authors probe the meaning of agency in the context of learning science in urban sites. They present detailed examples of social actors—teachers, students, community members, and others—working collaboratively in different settings to disrupt entrenched inequitable forms of schooling with the goal of rendering the education process more democratic and just. In doing so, they stretch our understanding of the meaning of learning as well as what constitutes responsive teaching. The inspiring images motivate and challenge the reader to take an active role in reforming urban schools in the service of student learning.

A salient feature of this volume is its unique organization. The book is structured around six research papers. Each paper is followed by a commentary written by one or two author(s) of other research papers that puts into sharp perspective central issues introduced in the original paper by raising questions, extending ideas, and/or suggesting alternative interpretations. The paper author(s) then respond to questions and concerns raised in the commentary, often elaborating or clarifying ideas already presented. These rich and engaging dialogues both extend the readers' understanding of concepts explored in the papers and pull them into the ongoing discussions. The presentation, critique, and response sequence that structures the work in this volume is a model of scholarly exchange that is worthy of attention.

The multiple faces of agency: Innovative strategies for effecting change in urban school contexts is a new and significant addition to the literature in urban education. The editor of the book and contributing scholars are to be commended for assembling such an exciting collection of innovative research for publication. The volume’s central message—the power of human agency—may help transform teaching and learning in urban schools. If this happens, urban school children and youth, who deserve better than they have received to date, stand to benefit the most from this work.

Ana Maria Villegas
Montclair State University
The data at hand cannot supply the solution; they can only suggest it. What, then are the sources of the suggestion? Clearly, past experience and a fund of relevant knowledge at one’s command. (Dewey, 1933, p. 15)

Various theoretical frameworks inform the work of the scholars contributing to this volume, but they all have one thing in common. Namely, they perceive learning as a social enterprise that is shaped by the stakeholders who breathe meaning into it. The contributing authors are also interested in exploring more effective ways to enhance the participation and achievement of all students. While the calls for educational reform are abundant, it is evident that more empirical and conceptual studies are needed to illuminate the complexity of factors that prevent teachers from using more student-centered, culturally relevant and inquiry-based approaches to teaching. Similarly, more research is needed to illuminate the sociocultural, historical and institutional codes that may obstruct or facilitate students learning for understanding in urban school contexts.

In response, the contributing authors make agency a central construct in their research work. Agency is defined here as the voice (or “speaking consciousness,” Bakhtin, 1981) that an individual uses to accommodate into or resist against established norms within specific communities of practice. The individual’s culture of course plays key roles in this process, as our learned cultural norms provide certain guideposts that help us navigate the established expectations imposed by the prevailing culture.

Therefore, the research work presented in this edited volume moves beyond rhetorical notions of good intentions and generalizations about the need for change in our schools. We see teacher professional development and student learning as processes that are not (cannot be) done for the other or to the other. Instead, by taking into account the individual’s agency, we seek to better understand the conscious and/or subconscious choices individuals make to accommodate into, resist against or seek compromises within the dominant discourses of their communities of practice. To this end, the contributing scholars are actively engaged with experienced teachers, pre-service teachers, and/or students in the common pursuit of investigating what accounts as meaningful learning and what is responsive and relevant teaching. While, we do not claim to have all of the answers, we believe that this kind of scholarly and positive exchange begins to uncover new ways of thinking about the multiple faces of agency and the roles this construct plays in effective teacher professional development and student learning.
In the next sections, I briefly describe how we came together to collaborate on this project, as well as how the book is organized. I close with a series of questions that arose from the discussion of the authors’ papers. Readers may find these questions useful and they are encouraged to keep them in mind as they engage with each chapter.

A MODEL FOR INTENSIVE AND FOCUSED SCHOLARLY COLLABORATION: 
THE INSTITUTE ON SCIENCE EDUCATION

In early January of 2006, I organized the first one-day institute on science education research (ISER) at the Hawaii International Conference on Education. The theme for the ISER was on agency and science education in urban school contexts, and prominent and emerging scholars in the field were invited to present a research paper. Each paper presentation was followed by a focused critique prepared by another of the institute’s participants. After each critique, the floor was then opened for a full discussion that included institute participants, as well as audience members. Thus, this book is based on the collection of revised papers and critiques resulting from this intensive scholarly collaboration. In order to enrich the dialogue that we started at the ISER, each of the chapter critiques is also followed by a response written by the original chapter author(s). We hope that this type of scholarly conversation will provide readers with more opportunities to engage deeply with the ideas being presented and to stimulate more meaningful conversations about effective teacher professional development and student learning.

Although the curriculum subject focus of this volume is science, the strategies and insights offered can be applied across grade levels and subject areas. We believe this because this book provides much needed new insights and strategies for effecting positive change in urban school contexts through a better understanding of what agency is, its multiple faces, and the roles this powerful concept plays in mediating teaching and learning.

For example, in Chapter 1, Pauline Chinn provides an excellent example of how indigenous knowledge, the National Science Education Standards, and teacher agency can productively intersect to make the science curriculum more culturally relevant and meaningful to all high school students. The next chapter, which I co-wrote with my colleagues Cathy Zozakiewicz and Randy Yerrick, is part of a three-year longitudinal project similar to Chinn’s study in terms of our interest in closely working with teachers and their students. However, our chapter focuses on the notion of students as change agents. In other words, we describe a variety of action components—or ways in which we enlisted the students’ assistance—to implement several intervention strategies in their teachers’ science classrooms. Our goal was also to make the science curriculum more culturally relevant and inquiry-based through the use of high end learning technologies, such as probeware, wireless laptops, and different kinds of web-based and laptop-based educational software.

While the projects conducted by Chinn and my colleagues and me have a more ecological emphasis (i.e., we examine how the interactions between teachers and researchers, teachers and teachers, teachers and students, and student to student influence teacher professional development and student learning), the chapters
written by Ken Tobin and Wolff-Michael Roth, respectively, have a more micro focus. Their approach is extremely interesting because they do not only provide alternative ways to appreciate the construct of agency in action, but they also allow us to immerse ourselves in the students’ everyday discourses. More specifically, in Chapter 3, Ken Tobin documents how some culturally diverse high schools students supported one another during laboratory activities and in essence, as Tobin explains, “expanded their collective agency to meet individual and collective goals.” Similarly, in Chapter 4, Wolff-Michael Roth uses a student’s environmental project as a springboard to articulate the ethico-moral dimension of agency. This important aspect of agency is rarely discussed, yet, as Roth explains, with the sense of power to act that agency imbues, the individual should also strive to use that power responsibly for the benefit of the collective.

Jerome Shaw provides a different perspective in Chapter 5 by describing how the leaders of a large-scale teacher professional development materials project used their sense of agency to guide the progress of the project and to keep it more closely connected to its goal of better serving their English Language Learner’s community. The final chapter, written by Angela Barton and Louiza Ortiz, take us back to the microcosm of student-to-student interactions in a grade 5 classroom to illustrate how culturally diverse girls enact their sense of agency to co-opt science. That is, Barton and Ortiz, suggest that youth find multiple ways to appropriate normative practices in the science classroom and modify them to suit their own purposes and interests.

As mentioned earlier, the accompanying commentaries and responses that follow each of these chapters, add a new level engagement with the authors’ findings and arguments that I am sure readers will find useful.

SUGGESTED QUESTIONS FOR DISCUSSION AND FURTHER RESEARCH

Since all good arguments always raise even better questions, the following questions emerged during the ISER paper presentations and discussions. These questions are meant to stimulate discussion, and we hope that readers will revisit these questions as they read each chapter:

- To what degree should researchers take the participants intent and self-awareness into account in order to name the participants’ actions/choices as expressions of agency?
- How do we capture the actual participants’ intentionalities? That is, how do we ensure that what the participants share with us (their espoused beliefs) are really what they intend to do (their beliefs in action) in their given contexts?
- As researchers hear the participants’ voices, how should our roles change in order to support positive change in the classroom?
- In what ways is place-based literacy (culturally and locally relevant-based literacy) a key entry point to work with participants to appropriate the standardized curriculum and make it more culturally and socially relevant?
- In what ways should student assessment change to meet the alternative forms of scientific literacy being suggested?
REFERENCES


1. CONNECTING TRADITIONAL ECOLOGICAL KNOWLEDGE AND WESTERN SCIENCE

The Role of Native Hawaiian Teachers in Sustainability Science

INTRODUCTION

Hawaii’s students have a unique natural laboratory to explore fundamental biological questions involving evolution, adaptation and interactions of humans and the environment on isolated island systems. A newly described endemic caterpillar, *Hyposmocoma molluscivora*, that wraps a snail in silk before eating it was recently described (Rubinoff & Haines, 2005) in Science and Hawaii newspapers (Altonn, 2005). But science classes focusing on science relevant to Hawaii tend to be targeted towards non-college bound students while college bound students take the mainstream biology, chemistry, and physics courses recognized by colleges. Meaningful science learning connected to students’ cultures and immediate environments is further compromised by the federal No Child Left Behind (NCLB) Act leading to curricular restructuring, even school takeover if students perform below expectations on standardized tests of reading and mathematics. In Hawaii, schools likely to be affected by NCLB are those serving low income, high immigrant, rural, and indigenous populations.

Test-driven policies leading to top down curricular control run counter to sociocultural theories of learning (Lave and Wenger, 1991; Gee, 1992; Garcia, 1999) and indigenous studies (Cajete, 1986; Chinn, 1999a, b; Kawagley, 2001) that stress the inclusion of students’ funds of knowledge in their learning. School policies driven by mainstream standardized tests also contradict Science Education Standards (National Research Council, 1996) directing teachers to:

Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students (p. 4).

Relying on standardized tests as a primary assessment tool leads to situations where teachers are obligated to use mainstream science curricula against their professional judgment and training. An elementary teacher prepared through the author’s class to teach Hawaii relevant, standards-based science lessons critiqued her school’s mandating of a mainland curriculum as being irrelevant to students living on a subtropical island, absorbing scarce school funds and teacher time, and undermining her professional training to teach to the lives and issues of her...
students. Restricting science to mainstream textbooks reduces opportunities for teachers and students to study and think through tough, complex real world science issues. Implications extend beyond teacher and school issues.

Sternberg’s (2003) research on instruction and learning suggests instruction “must relate to real practical needs of students” to yield the intelligence essential to making decisions “toward the attainment of a common good” (p. 7). He worries that conventional teaching methods aiming for the analytical thinking emphasized on tests have negative implications for educational equity, quality of learning, and application in the world outside of school. Instruction involving a combination of analytical, creative, and practical thinking enables students from more diverse ethnic, educational and socioeconomic backgrounds to be successful learners. In contrast, the analytical approach reduces diversity. He writes:

Conventional methods of teaching may, at best, create pseudo-experts—students whose expertise, to the extent they have it, does not mirror the expertise needed for real-world thinking inside or outside of the academic disciplines schools normally teach (p. 5).

The emphasis on texts and tests foregrounds issues of authentic learning and the balance between content and process. Place and problem-based learning are fundamental to scientific inquiry and environmental literacy. Thus teaching to tests through texts that establish boundaries around what is important to know in science do more than trigger struggles over curriculum and pedagogy. A science education system driven by tests that allow comparisons across schools, districts, and states must exclude the variability introduced by local and culture-based knowledge. In Hawaii, this disconnects teachers and students from their familiar environments and indigenous ecological knowledge developed through living on small, isolated islands.

The study presented in this paper suggests that cultural narratives containing the values and ways of understanding the world and how one should act within it affect the way teachers understand and address science curriculum and pedagogy, especially sustainability, a systems concept seeking best current and future outcomes for humans and natural environments (http://encyclopedia.thefreedictionary.com/sustainability). According to Rao (2000), views of sustainability are grounded in ecocentrism or anthropocentrism. Anthropocentrism places humans as “the central feature of planet Earth” and holds “that environment and ecology should be valued in terms of their utility or lack of it for humans” (p. 379). Ecocentrism “views human activities in terms of their implications for the ecological ingredients, their relative effects, and balances.” Rao emphasizes the need for ecocentric approaches due to the “imperative that a totally anthropocentric approach will sooner or later reach a critical stage (in which) ecological and biogeophysical limitations form impediments to the continuity of human survival and stability itself” (p. 70). Public school policies and science programs that de-emphasize learning located in the real world are essentially anthropocentric in emphasizing learning that meets institutional objectives without regard for human-ecosystem sustainability.
This paper presents a case study of five Native Hawaiian teachers who lead ecocentric, place and culture based science programs on Maui, O‘ahu, and Kaua‘i. Though there are local variations, each teacher involves scientists, students, and community members in authentic, culturally relevant, science inquiry and problem-solving. Their approach addresses state and national science content and teaching standards while unstandardizing pedagogy and curriculum. Their place-based programs involve monitoring and restoration of the commons--forests, beaches, and bays--suggesting that connecting sustainability-oriented, indigenous knowledge, practices and values to science knowledge and practices creates the context for teacher agency and empowerment.

‘Olelo No‘eau: Glimpses of Hawaiian Worldviews

The intersection of traditional Hawaiian and mainstream American values in schools sets the stage for the research questions explored in this ethnographic, multiyear case study of Native Hawaiian teachers who emerged as school and community-based leaders through a professional development program oriented to sustainability. The cultural values that ground their approach to science teaching and learning may be glimpsed in the proverbs of ka po‘e kahiko, the people of old.

The history of western science suggests that knowledge-building and technological innovation are driven by the interests of dominant elites (Gould, 1993; Takaki, 1993) and shaped by Descartes’ view that knowledge of reality is gained through intellect instead of the senses. The separation of nature and culture is antithetical to a Hawaiian worldview that connects humans and nature in spiritual and familial relationships. The voices and values of Native Hawaiians may be heard in nearly 3,000 proverbs and sayings, ‘olelo no‘eau, collected and translated by cultural expert Mary Kawena Pukui (1983). Many convey the responsibility of everyone, beginning with the mo‘i, the highest chief and representative of gods, to care for the lands and sea. The Hawaiian proverb, He ali‘i ka ‘aina; he kaua ke kanaka; the land is a chief, man is its servant, recognizes human responsibility for active care (malama ‘aina) and respect/love (aloha ‘aina) for that which sustains life (p. 62, Pukui, 1983).

Prior to western contact, most Hawaiians lived and married within ahupua‘a, self-contained political units extending from mountaintop to the edge of the reef containing all necessary resources. Those living upland, mauka, exchanged products with those living makai, seaward, a relationship captured in the sayings ko kula uka-ko kula kai; Those of the uplands, those of the sea (Abbott, 1992). The saying Ho‘okahi no ‘ohana, mai uka i kai, mai kahi pae a kahi pae; There is one family, from the uplands to sea, from one boundary to the other boundary holds the deeper meaning that people are part of the family of nature (Maly, 2005). A lower ranking chief, the konohiki, served as a human-resources manager with the authority to direct human behavior towards the conservation of resources. According to Handy and Handy (1991), “In addition to his responsibility as an overseer of the lands and their use in the ahupua‘a, the konohiki was also in charge of along-shore and offshore fishing rights” (p. 321).
The name for the common people, maka’ainana, interpreted as eyes (maka) of the land (‘aina) or those who live on (ma) the (ka) land (‘aina), suggests their role as caretakers of that which provided sustenance (‘ai). Close attention to the environment is revealed in sayings connecting land and sea, e.g., *Pua ke ko, ku ka heʻe*; When the sugarcane tassels, the octopus season is here; *Pua ka wiliwili nanahu ka mano*; When the wiliwili blooms, the sharks bite; and the naming of places after winds, rains, and springs (Pukui, *et al.*, 1974). *Punaluʻu*, a place name found on Oʻahu and Hawaiʻi, indicates one could dive down (luʻu) to an underwater spring (puna). A subsistence lifestyle that connected environmental, personal, and cultural knowledge and behavior for sustainability suggests universal environmental literacy among traditional Native Hawaiians.

Maly, a contemporary Hawaiian language translator and cultural resource emphasizes the human-in-ecosystem orientation of traditional Hawaiian culture:

> (I)n the Hawaiian mind all aspects of the land—all natural and cultural resources are interrelated, and that all are culturally significant. The integrity of a landscape and its sense of place depend upon the well-being of the whole entity, not only a part of it. Thus, what we do to one part of the landscape has an effect on the rest of the landscape1.

Place-based learning integrating humans and nature characterizes sustainable cultures (Orr, 1992; Cajete, 1999, 2000; Savagely, 2001). The humans-in-ecosystem understanding of Hawaiian and other sustainable cultures is now being recognized by mainstream society as human population growth and consumption-oriented economies reveal the limits of the ecosystem services that provide clean air, water and energy and nutrient cycling necessary for all life (Daily, 1997). Educating for a scientifically and environmentally literate citizenry is urgent in the light of evidence that human activities may be the most important evolutionary force in the world, associated with the rise of pesticide and antibiotic resistant organisms (Palumbi, 2001) and emerging diseases (Kaneshiro, *et al.*, 2005).

The place-based, local aspect of environmental issues supports the emergence of sustainability science, a transdisciplinary field in which environmentally literate citizen scientists “perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems” (Disinger & Roth, 2003).

*Indigenous Perspectives and Professional Development*

Hass (1992) writes that Hawaii’s schools served as a vehicle for monoculturism, “the practice of catering to the dominant or mainstream culture, providing second-class treatment or no special consideration at all to persons of non-mainstream cultures” (p. 161). Native Hawaiian children at 26% represent single largest ethnic group in public schools but experience the lowest school success of any group (Kanaiaupuni & Ishibashi, 2003). Kawakami and Aton (2000) suggest conventional mainstream classrooms and instructional approaches do not provide the authentic,
personalized, experience-based learning considered a critical factor for success in the schooling of native Hawaiian students.

Gruenewald (2003) includes ecological disruption along with social justice and educational equity in his critique of dominant culture and schooling:

[D]ecolonization involves learning to recognize disruption and injury and to address their causes. From an educational perspective, it means unlearning much of what dominant culture and schooling teaches, and learning more socially just and ecologically sustainable ways of being in the world (p. 9).

Until the 2005 revision, Hawaii’s science content standards included the only state standard directly related to a Hawaiian view of the relationship of humans and nature, *Malama I Ka ʿAina, Sustainability*. Kanahele (1986) explains its significance:

If we are to be truly consistent with traditional Hawaiian thought, no one really owned the land in the past...The relationship was the other way around: a person belonged to the land...We are but stewards of the ʿāina and kai, trusted to take care of these islands on behalf of the gods, our ancestors, ourselves, and our children (pp. 208, 209).

EDCS 433 Interdisciplinary Science Curriculum, *Malama I Ka ʿAina, Sustainability*, a course underwritten by a federal grant (Chinn & Sylva, 2000) takes its name from this content standard. School and community-based culture-science immersions establish place and culture as contexts for science teaching. In contrast to conventional classroom and textbook learning, science is learned in the context of Hawaiian cultural practices and traditional ecological knowledge. Service learning in taro pond fields (*lo‘i kalo*) and fishponds (*loko i‘a*) familiarizes teachers with traditional practices that retain soil and nutrients on land, increasing food production and protecting coral reefs. Teachers’ lived experiences give meaning to the ethic of care, *malama*, and personal responsibility, *kuleana*, embedded in the science standard *Malama I Ka ʿAina, Sustainability*. Teachers are tasked with developing culturally relevant, standards-based science lessons (http://malama.hawaii.edu/schools/index.html) connecting students to the place where they live.

Personal connections and tools to study one’s place support transformative environmental learning defined as “learning...which is linked to changing the root causes of environmental destruction or damage” (pp. 170-171, Hall, 2004). Going beyond translating science goals “into a curriculum...that helps students make sense of their world and understand the fundamental ideas of science” (p. 4, NRC, 1996), it recognizes the importance of traditional cultures, elder knowledge, a sense of place, biodiversity, connecting with nature, and understanding social networks and power-knowledge relationships (Hall, 2004).

**Research Questions and Theoretical Framework**

The tension between place-based, indigenous ecological knowledge oriented to environmental literacy and sustainability and mainstream, school science knowledge oriented to test performance and demonstration of knowledge sets the stage for the research questions addressed in this paper. The research centers on the
community-based science programs of five female Native Hawaiian teachers and asks the questions:

What provides the contexts for their science activities?
What ways of learning and doing science are illustrated in their programs?
How and why do teachers establish networks of knowledge connecting indigenous and western science knowledge and practices?
Could their programs provide a model for engaging underrepresented students in meaningful science learning?

A theory of learning embedded in social practice best fit the data and themes that emerged over the four years of this study. Based on naturalistic research associated with Lave and Wenger (1991), Gee (1992, 1996), and Wenger (1998), social learning theories acknowledge the role of modeling, observational learning, subjectivity, intentionality, and a plurality of socio-cultural contexts, producing multiple literacies. Learning is understood as a social process, occurring continuously over an individual’s lifespan, both intentionally and unintentionally in formal and informal situations. Lave and Wenger’s (1991) theory of knowledge acquisition is based on studies of learning situated in communities of practice engaged in activity towards a shared goal. A community of practice has the characteristics of joint enterprise, mutual engagement, and “communal resources (routines, sensibilities, artifacts, vocabulary, styles, etc.) that members have developed over time” (p. 9, Smith, 2005).

Study Population

The case study focuses on Sabra, Kalei, Napua, Johanna, Michelle, five Native Hawaiians of 11 lead teachers (See Table 1.1) in Pikoi Ke Kaula Kualena, Focus on the Essential Core, a science curriculum and professional development project underwritten by the Native Hawaiian Education Act (Chinn & Sylva, 2002). Another objective of the project was development of at least six culture-science centers connecting K-12 science learning to local environments. (See http://pikoi.hawaii.edu.)

<table>
<thead>
<tr>
<th>Ethnicity of Pikoi Teachers</th>
<th>Lead Teachers</th>
<th>Native Hawaiian</th>
<th>White</th>
<th>Japanese</th>
<th>Filipino</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female (n=7)</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Male (n=4)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>45%</td>
<td>27%</td>
<td>18%</td>
<td>9%</td>
<td></td>
</tr>
</tbody>
</table>

Lead teachers at science learning centers on the islands of Maui, Hawai‘i, O‘ahu, and Kaua‘i, are tasked with developing cultural, standards, and place based programs and providing school and community outreach. Teacher selection is based on evidence of leadership and willingness to develop and provide outreach.
programs. Ten were students or peer instructors in EDCS 433 Interdisciplinary Science Curriculum, *Malama I Ka ‘Āina*, Sustainability; one was a Peace Corps teacher. The subgroup of Non-Hawaiian teachers holds baccalaureate or master degrees and certifications relevant to science. They teach in environmental and secondary science, university, and community college settings on four islands and range in age from late 20s through 50s.

In contrast, four of the Native Hawaiians teach in elementary schools and none have science backgrounds. Two recently completed associate degrees, plan to become elementary teachers, and teach Hawaiian Studies in the *Kupuna* (elder) Program. The third recently completed her M.Ed. The fourth works as a *Kupuna* Program Resource Teacher for the Hawaii State Department of Education and as a Hawaiian Studies teacher in a private school. The fifth is a physical education teacher in a public high school Polynesian Voyaging program. Each has adult children, two are grandmothers. Hawaii’s population is 20% Native Hawaiian, an ethnic group underrepresented in science as well as the largest (26%) and fastest growing segment of the public school population. The five women represent 45% of the lead teachers.

The author-researcher is Chinese-American, from a family with roots in Hawaii from the late 19th century. As a public school secondary science teacher she taught courses spanning Plants and Animals of Hawaii to Advanced Placement Chemistry. Her involvement with teachers in the case study is due to her roles as an instructor of EDCS 433 and principal investigator of *Pikoi Ke Kaula Kualena*.

**METHODOLOGY**

The multi-site case study employed constant comparison of naturalistic, ethnographic data to develop grounded theory (Glaser & Strauss, 1967) as key themes emerged over the four years. Constant comparison data was continually collected and analyzed to detect emerging patterns that suggested how the teachers constructed meaning, acted deliberately, and shaped their culture-science programs (Cohen, Manion, & Morrison, 2000; Stake, 2000). Data sources include field notes acquired over three to four years of participant-observation at each site; archival e-mails and learning center documents including evaluations and fiscal records; photographs taken by the author, teachers, students, and participants at site activities. Participant-observation included overnight, multiple day contacts during EDCS 433 classes and culture-science immersions, school and community site visits to observe project activities, co-presentations at national and international conferences, and numerous grant meetings where learning center teachers presented and discussed their projects. Overnight sites included rural fields; libraries, gymnasiums, and classrooms; rural church and YMCA camps; environmental education centers; and participants’ homes.

Teachers were invited to collaborate in the inquiry (Heron & Reason, 2000) by providing comments on drafts of the manuscript. Two teach on Maui, two on Kauai, and one on O’ahu. In addition to the meetings noted above, each hosted EDCS 433 preservice and in-service teachers during the culture-science immersions held at
teachers’ schools and field sites. Teachers served as co-planners and hosts of the immersions enabling the author and teacher colleagues to observe and participate in each other’s programs. Teachers communicated frequently with the author and each other by e-mail concerning their activities, budgets, purchases, and local educational, political, and science issues. The need to build a project website resulted in numerous e-mails and transmission of photographs, lessons and other texts. Documentation of activities, including conference presentations may be seen on the project web site http://pikoi.hawaii.edu.

Extensive reporting of incidents in the following section is intended to give transparency to the process of theory generation.

FINDINGS

The five teachers work on three different islands in roles ranging from Hawaiian Studies kupuna (elder) to community-based educator/home schooling mother to teacher in a high school Polynesian voyaging program. Cases are clustered by island and learning center: the two Maui teachers are sisters co-coordinating the same Learning Center and working in the same rural ahupua’a. The two teachers on Kaua‘i teach in different communities and ahupua‘a, one in a public the other in a selective private school; they view the entire island as their learning center.

Case Study 1. O‘ahu: Living in the Maunalua Universe

Michelle teaches at a high school program in an urban, highly developed, and densely populated marina community that once was the largest precontact fishpond in Hawaii. Her vision for her interdisciplinary Project Ho‘olokahi Learning Center is a metaphor for learning and moving into the future based on traditional Polynesian values and navigational skills:

We acknowledge the traditional navigational skills of our ancestors who sailed Voyaging Society, Na Kalai Wa‘a Moku o Hawai‘i and E‘ala who set sail, rediscover the islands of the Polynesian Triangle and voyage in the wake of our ancestors. With the help of the community or village we set the course of study as they navigate into the future. Our vision is to develop a culture based navigational learning center that addresses Department of Education standards and provides students with culturally specific, project based, experiential learning. The curriculum will address standards in Science, History, Technology, World Languages and Physical Education and focus on three major themes: Ahupua‘a: ‘Aina - land, Ke Kai - coastal/ocean and Ka Lani- sky activities.

Michelle is a longtime member of a Hawaiian canoe club and advisor of the school’s canoe paddling team. As a student in EDCS 433 she expressed interest in initiating a monitoring and restoration program dedicated to the memory of the club’s founder, a prominent Hawaiian educator. Her desire to restore the bay where her professional and personal lives intersect was seen by colleagues and marine educators in her K-12 complex as a way to develop a thematic, place-based K-12
integrated science program. This expression of interest led to an invitation, which she accepted, to be a teacher-leader of a culture science learning center.

Early in 2003 an informal meeting with teachers in Michelle’s K-12 complex and the author was held to identify issues and teacher commitment. This led a month later to a meeting of scientists, K-12 complex teachers and community at the nearby Hanauma Bay Education Center. Teachers of Japanese, Chinese, White, and Native Hawaiian ethnic backgrounds articulated a vision shaped by Hawaiian cultural values of caring for children from the time they entered school until they graduated they named L.I.M.U., Living in the Maunalua Universe. Their diagram showed the community as three fronds of seaweed labeled K-12 schools, community, and university growing on a rock labeled na keiki, the children. The acronym has deeper meanings, as do many Hawaiian sayings, being the Hawaiian word for seaweed, the base of coastal ecosystems.

Teachers and paddlers were concerned about the quality of the water in the bay following the conversion of a 500 acre traditional fishpond into a marina and housing development less than 50 years ago. Students as young as 10 years old paddled where heavy rainfall triggered occasional spills of raw sewage into the marina. Paddlers complained of boils, likely caused when salt crystals opened breaks in the skin while they paddled. Instead of being seen as a traditional purification agent, seawater was now a potential health hazard. Paddlers were directed to shower off with soap. Long time residents familiar with the coastal ecosystem were also concerned about the appearance of alien seaweed.

Since that meeting, teachers have been studying their own community from mountain to the sea, mauka to makai, interviewing elders, taking field trips to test water when streams flow during the rainy season and studying native and invasive plants and animals. During the first year, community-based limo removal and restoration projects led by the Waikiki Aquarium (http://www.hawaii.edu/cgi-bin/uhnews?20031009125039) and a Hawaiian practitioner at Ewa Beach provided models of practice. Michelle and her students participated in invasive seaweed removals in Waikiki and learned to restore native limo by weaving fronds into lei to weigh down with rocks. University scientists and botany graduate students taught limo identification and classification on site at Maunalua Bay; others taught water-testing.

With the support of the canoe club, a USGS scientist, graduate students and environmental organizations these first steps by Michelle and her students have evolved into a long-term study to remove invasive seaweeds, identify fish and record ecosystem changes using GPS and underwater photographs to monitor 18 sites in the bay (see Figures 1.1 and 1.2). Seaweeds are weighed then taken to the canoe garden for composting. Science learning occurs in the context of cultural practices—students learn about the land by cultivating plants brought by Polynesians; learn meteorology and astronomy in the context of sailing; and learn marine science by caring for marine resources. As part of their program, Michelle’s students become life-guard certified, prepare print and audiovisual presentations, and serve as peer teachers to visiting students and teachers.
In past years students made canoe paddles, learned to sail, planted the canoe garden, learned to identify *limo*, and prepared meals in a traditional underground cooking oven (*imu*) on campus. As this is being written, with the support from Pikoi and the shipping and trucking community, Michelle and her students are working with a master canoe carver on a double hulled canoe. Their goal is to launch the canoe in 2006 and to invite students from neighboring schools to work on, maintain, and use the canoe in a “Ten Thousand Hands” outreach project. To replace trees that provided the 45 foot long, 4.5 foot diameter logs, students planted *Acacia koa*, an endemic tree traditionally used for canoes, last fall.

Table 1.2 shows the agenda of a 24 hour culture-science immersion, the last of 3 held on sequential weekends in the 2005-2006 school year. Activities and supporters illustrate the diverse community of practice that has formed around Michelle’s problem and place-based culture-science program. I joined a group of 30 or so high school students, teachers, graduate students, canoe club members, and scientists after the opening *pule*, prayer connecting participants, place and purpose of the gathering. I met the new aquascience teacher who was eager to meet Matt, who leads Project *Koko 'Ula*, a high school ag-science program. Michelle provided overviews of protocols for alien *limu* removal, fish identification, data collection, and water safety. When the canoes returned with bags of *limu* from the study sites, the sorting process—invasive species to the compost pile, native species to return to the ocean—provided opportunities for teaching. A student’s announcement, “A pregnant crab!” led to a short lesson on crab anatomy and sexual dimorphism.
As students sorted, identified, and recorded masses of alien limu, I chatted with the young Hawaiian man seated next to me. He was a canoe club member who lived on the other side of the island where Native Hawaiians are the largest part of the population. He had dropped out of middle school and home and alternative schooling had failed. He said this was the best way to learn, instead of from books, caring for the environment, malama `aina, in ways that were scientifically, personally and culturally meaningful. Being part of a learning community composed of Native Hawaiian teachers, high school and graduate students validated the type of learning he said he would benefit from but never personally experienced. He told a story about coming across dead pigs abandoned by hunters while out with his brother and said the senseless slaughter affected his thoughts about his life direction. His brother had recently enrolled in a conservation biology program; he said he was ready to go back to school. Later I checked with a senior member of the canoe club who knew of his academic record and said he would follow up.

At lunch the group on the walkway outside the canoe house included a representative from the Department of Fish and Wildlife and five master and doctoral students in botany and resource management. They were Native Hawaiian and White, from Hawaii and the mainland U.S. Two graduate students, Dawn and Kim had been associated with the limu program from the start, had connected their research to school programs and supported teachers on Maui and Kaua`i with their limu programs. They supported community-based citizen science and were committed to helping schools to develop their science programs.
Table 1.2 Twenty-Four Hour Immersion, Maunalua Bay

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00-8:00 a.m.</td>
<td>Meet at Halau, Pule, Agenda</td>
</tr>
<tr>
<td>7:30-8:00</td>
<td>Paddle overnight gear to Hokule’a return for activities</td>
</tr>
<tr>
<td>8:00-8:30</td>
<td>GPS activity (USGS scientist)</td>
</tr>
<tr>
<td>8:30-9:30</td>
<td>Alien limu removal (graduate students)</td>
</tr>
<tr>
<td>9:30-10:00</td>
<td>Break, snacks</td>
</tr>
<tr>
<td>10:00-12:00</td>
<td>Fish &amp; Coral ID (Nature Conservancy)</td>
</tr>
<tr>
<td>12:00-1:00 p.m.</td>
<td>Lunch (Students)</td>
</tr>
<tr>
<td>1:00-2:00</td>
<td>Water Quality Testing (marine science teacher)</td>
</tr>
<tr>
<td>2:00-2:30</td>
<td>Prepare for Sail, Meet at Boat Ramp</td>
</tr>
<tr>
<td>2:30-6:00</td>
<td>Sail on Hokule’a (Hawaiian navigator)</td>
</tr>
<tr>
<td>6:00-6:30</td>
<td>Lv Hokule’a</td>
</tr>
<tr>
<td>6:30-7:30</td>
<td>Prepare Dinner, Showers</td>
</tr>
<tr>
<td>7:30-8:30</td>
<td>Pule, Dinner (Students)</td>
</tr>
<tr>
<td>8:30-9:30</td>
<td>Clean Up</td>
</tr>
<tr>
<td>9:30-10:00</td>
<td>Paddle to Hokule’a</td>
</tr>
<tr>
<td>10:00-11:00</td>
<td>Star Gazing w/ Nainoa (Hawaiian navigator)</td>
</tr>
<tr>
<td>11:00-1:00 a.m.</td>
<td>Crew I - Canoe Watch</td>
</tr>
<tr>
<td>1:00-3:00</td>
<td>Crew II - Canoe Watch</td>
</tr>
<tr>
<td>3:00-5:00</td>
<td>Crew III - Canoe Watch</td>
</tr>
<tr>
<td>6:00-6:30</td>
<td>Clean Hokule’a, return to shore</td>
</tr>
<tr>
<td>6:30-7:30 am</td>
<td>Clean Hui Nalu Halau, Pule, Students Lv for Home w/Parent</td>
</tr>
</tbody>
</table>

Three weeks later, on Sunday, November 20, 2005, 100+ members of the Maunalua community assembled for a party, pa’ina, at the Marine Technology Education Center, Honolulu Community College where the Hokulea, the first double hulled canoe using traditional navigational skills to sail between Hawaii and Tahiti was in dry dock. Posters of student work lined the hall leading to room where Nainoa Thompson, the Hokulea’s Native Hawaiian navigator, educator and member of the Polynesian Voyaging Society, Hui Nalu Canoe Club and Maunalua community spoke about the importance of sustaining school and community efforts to care for Maunalua Bay. The pa’ina celebrated the establishment of a non-profit organization, Malama O Maunalua dedicated to continuing the community-based educational and outreach efforts initially expressed by teachers in their LIMU presentation nearly three years earlier.

The smell of frying blue line snapper (taape, Lutjanus kasmiri) a fish introduced from Tahiti in the 1950s filled the air. In the audience were teachers, students, canoe club and community members, and the captain of the first voyage of the Hokulea to Tahiti. The teachers’ vision of Living in the Maunalua Universe had been taken up.

Long range, Michelle recognizes the need for collaborators within her school and a teacher to continue her program. Science colleagues have not found sufficient common ground to invest the time necessary for interdepartmental collaborations. Michelle plans to enter a master program and taking a sabbatical but has a set of skills, knowledge, and social contacts that few possess. The
establishment of the non-profit *Malama O Maunalua*, its goal of curriculum development relevant to the bay and the canoe that is being carved are hopeful indicators that Michelle’s program will continue to be a training ground and model for transdisciplinary programs connecting school science, culture, and community-based learning.

**Case Study 2. Maui: Kupuna as Leaders of Communities of Practice**

Napua and Johanna, Hawaiian Studies *kupuna* who enrolled in EDCS 433 Interdisciplinary Science Curriculum in 2002 were at first put off by the science content of the course. Their family lands are planted with taro and they augment their diets by fishing and gathering edible seaweed (*limu*), but they did not at first see how practitioner knowledge related to science until they experienced the culture-science immersion in Waipi’o Valley that linked traditional water use and *kalo* farming to science indicators of high water quality. Since that time, they completed associate degrees, co-instruct courses with former community college instructors, plan to acquire degrees in education to establish a charter school, want to form a non-profit in connection with proposals they are writing, and are working towards establishing a site in the community to perpetuate Hawaiian culture.

Napua and Johanna use cultural frameworks in instruction on native plants, water cycle, geology, and astronomy. They both recognize that incorporating science adds academic value and greater depth to their Hawaiian Studies lessons. Napua’s place-based lesson on the water cycle employs Hawaiian terminology and locates her students in a water cycle they see occurring in the mountains, clouds, rain, and streams of their own community. Her lesson on *limu* and coral reefs may be viewed on the project website [http://malama.hawaii.edu/schools/lessons2005/napua.pdf](http://malama.hawaii.edu/schools/lessons2005/napua.pdf). Johanna found that taxonomy and plant families could be taught through parallels to Hawaiian extended families, *ohana*, and developed interdisciplinary lessons centered on families of culturally important Hawaiian plants.

After learning about Michelle’s *limu* program in 2003, Napua began thinking about her community’s formerly rich beds of *limu* and fishing grounds. Though raised on Oahu, she married a man from Maui and returned to the island where her grandmother once taught. In the summer of 2006, she shared with her Pikoi colleagues the insight that connected science to her personal and cultural worlds. Her grandmother had asked her many years ago to “get educated to help her people.” Years passed as she raised a family and worked as a Hawaiian Studies *kupuna*. In 2002 she was still working towards her community college degree. When teachers carried out the first alien *limu* removal at the Hawaii Institute of Marine Biology in Kaneohe Bay she recognized that from a Hawaiian perspective, removing something from the environment required replacing it with something else.

Napua’s statement of personal responsibility to establish a reciprocal, righteous relationship with nature was not unique. When Michelle planned to carve a double-hulled sailing canoe for her program, she and her students planted *koa* seedlings before the trees for her project were even selected. A Native Hawaiian colleague helped me understand the ethic of responsible being in the world conveyed by the
Hawaii state motto *Ua mau ke ea o ka ‘aina I ka pono*; The life of the land is preserved in righteousness. Just a slight revision of the final word transforms attitude to action: The life of the land is preserved in right-useness. This is the active ethic of care, *malama*, motivating those who understand sustainability and environmental literacy from a Hawaiian cultural perspective.

With this guiding perspective, Napua requested help from botany graduate students she had met through Michelle then involved her community, family, and elementary students in a study of *limu* at their beach at Waihe’e. They conducted transects to map *limu* distribution and began to restore edible and non-edible native *limu* from a nearby site to improve the habitat for fish. Cathy, a Pikoi colleague and ethnobotany instructor at Maui Community College included her students in monitoring and bio-restoration activities. Together, Cathy, Johanna and Napua developed a mountain-to-sea *ahu‘pua‘a* unit integrating ecosystem science and Hawaiian culture.

In 2004, Derek Masaki of the United States Geological Service (USGS) joined the Maui and Pikoi teacher network to teach GPS techniques useful to recording the distribution of native and invasive species. He has since taught teachers and students on Maui, O‘ahu, Hawai‘i and Kaua‘i to establish marine and terrestrial transects using global positioning systems (GPS), geographic information systems (GIS) and digital photographs. (Derek describes the cultural contexts of this work at http://www.nbia.gov/about/pubs/factsheet/pdf/PBIN-CitizenScience.pdf.)

Napua and Johanna are becoming leaders in a Hawaiian Homestead community that seeks to preserve a rural, semi-subistence lifestyle in an area being eyed for high income housing. They lead researchers, students, family and members of the Hawaiian community in the study of seaweeds, fish, streams, native plants, and land use in their *ahu‘pua‘a*. A *limu* restoration project that occurred during the celebration of Napua’s school’s 100th anniversary in 2005 brought the project to the attention of Maui’s mayor, a graduate of Waihe’e. They intend increase their community’s environmental knowledge and pride of place towards the goal of returning local residents to their traditional role of *maka‘ainana*, those who live on, watch over, and care for the land. To this end, both are writing proposals, intend to establish their own non-profit, and ultimately want to establish a culture-based public charter school. In March 2006 Johanna’s wrote in her Letter of Intent for a research proposal:

The proposed monitoring site for this project *Waihe’e, Maui*, is one of the few remaining intact *ahu‘pua‘a* with a predominantly Native Hawaiian, part-Hawaiian population. It is an older established community with some families who have been there before [Western] contact (1790) when *kalo*, fish, *limu*, and water were abundant. Critically impacted by non-native agriculture crops for more than 100 years, the effects on estuarine and coastal waters beg study, monitoring, and documentation as encouraged by Hawaii Department of Land and Natural Resource biologists and local residents, especially fishermen and gatherers.
The relationships among Johanna, Napua, Kim, Derek, and researchers are supportive, warm, and shaped by indigenous Hawaiian understandings of extended family and reciprocity. On Maui for presentations at the National Marine Educators Association Conference in 2005, O‘ahu and Kaua‘i Pikoi teachers, scientists, and agency biologists were hosted by Dr. Isabella A. Abbott, an algae expert and Maui-born Hawaiian scientist. We chatted about research projects, invasive species, and updating old transects with new GPS and GIS data while weaving limu lei for Napua’s project. The next morning, Napua picked up Kim and a freshwater algae scientist from the airport and went directly to the beach to “plant” the limu. Kim did not have a swimsuit but Napua immediately offered her the wetsuit and shorts she wore over her swimsuit. Soon they were placing stones tied with limu lei in the water as fast as we could tie them to stones Matt brought to us. Dr. Abbott watched, the new scientist videotaped, and Johanna told stories that reveal how unwritten knowledge is conserved and transmitted in Hawaiian communities.

Johanna spoke of an elderly neighbor who knew stories of astronomical heiau (temples) on Maui and described a visit from a state aquatic biologist who chanced upon a longtime resident able to describe fish and stream life from decades past. The short visit stretched into hours. On hearing this, the freshwater algae scientist asked Johanna who lives in the midst of stream-fed taro fields for permission to study her stream. Permission was granted without hesitation, with the unstated expectation that what would be learned would be shared. These informal transactions reveal how knowledge networks form and how science-indigenous community connections are established through informal, peripheral participation in community-based activities (Lave & Wenger, 1991).

Two weeks later Napua reported that tying the limu lei to rocks appeared to be more successful than simply weighing the lei down with rocks, the technique used by O‘ahu projects (see Figure 1.3). There was less chance of limu washing away and holdfasts were seen to be developing. She told me she understood this technique was used when Hawaiian royalty wanted favorite limu planted close by. Though her formal role is that of an elementary school Hawaiian Studies kupuna, Napua’s teaching has shifted to science. Purchases for her project include PVC tubing for quadrates, GPS units, a digital camera with underwater housing, underwater fish identification cards and slates. She increases her science knowledge through courses, workshops and collaborations with scientists. Being a grandmother does not slow her progress--she acquired SCUBA certification in spring 2006, was invited to participate in a month-long research cruise sponsored by the National Oceanic and Atmospheric Administration (NOAA) to the Northwest Hawaiian Islands, and co-instructs science classes with some of her former Maui Community College instructors.

Napua’s 2006 grant report illuminated how her school and community-based program involves human resource networks. In the prior 6 months she participated in 12 programs affecting nearly 700 students and community members spanning Hawaii Nature Conservancy, Maui CC programs, a hula conference, Derek’s GPS/GIS project, an archeologist/former MCC instructor and her Hawaiian community. In her own school, she instructed 525 K-2 students and worked with a
range of people including her librarian and 5 students on a video project in which she “related stories of Waihe’e and the work with the limu restoration…with the traditional cultural practice of managing our resources. Waihe’e, Waiehu and Wailuku were and still are rich in the natural resources. The people knew this fact then but not so today.”

Napua helped a Hawaiian friend with his family history and found him willing to support her dream of a site for learning: “[W]e have dug up many interesting facts about the area of Waihe’e, Waiehu, and Wailuku. [He] agreed to let us use his property…to build a halau (traditional structure)…for our project.” Her anthropology instructor, a former state archeologist helped with the history project. Halau builders were located in her Waihe’e community: “[T]hey wanted to build a halau with the emphasis of teaching our native children and then adults. Unfortunately, we couldn’t get Waihe’e school to take on this project. Now we have a location.” The director of the Hula Conference, a member of group that has acquired property in Waihe’e for perpetuating the Hawaiian culture asked her present her work to 65 participants in 2005. People, projects, skills and knowledge are connected in ways that are mutually supportive. (See Appendix 1. for Napua’s description of her program.)

Case Study 3. Communities of Practice on Kaua’i

On Kauai, a program to restore native edible seaweed, limu manauea was begun in 1999 by a Hawaiian elder and his granddaughter, an intern with the state
Department of Land and Natural Resources. The agency was interested in community-based management and elder knowledge and supported several projects on the island at that time. Daughter Kalei, a fourth grade teacher, kept the program alive by connecting it to her school science program. Unlike programs on Maui and O’ahu in which *limu lei* are tied to rocks or weighted down, the Kaua‘i project placed bundles of highly desirable, edible *limu manauea*, *Gracilaria coronopifolia* in mesh bags in wire cages placed offshore in shallow water. The *limu* grows in the cages and releases reproductive bodies into the water, ideally settling and growing on solid surfaces. Fourth graders set out cages and retrieve and monitor mass monthly with the help of community members (see Figure 1.4). Growth can be rapid with gains of over a pound per month per cage.

Students observed that weight gains fluctuate over the year and color of the new growth may differ from the old, and were asked to develop testable hypotheses. Observations over the course of restoration show more *limu* is growing on the outside edge of the reef and more fish in the area. Recently, a new kind of algae appeared, from Kalei’s description, the invasive *Gracilaria salicornia* that is being removed from Waikiki and Maunalua Bay and is spreading through the islands since its introduction for potential use in aquaculture. In a potential setback, *limu* and cages were stolen at the end of the 2005 school year. The cages were later returned. Kalei and her father continue undaunted. He continues to work with students and she now incorporates water testing to monitor how water conditions (salinity, temperature, nutrients) might affect *limu* growth. Her students designed and built their own cages as part of a geometry project in 2006, but now also apply Napua’s practice of tying *limu lei* to rocks as an alternate way to reestablish *limu*. They will incorporate invasive *limu* removal if the need arises.

Sabra, Kauai District’s Resource Teacher for the *Kupuna* Program and an elementary Hawaiian Studies teacher at a private school entered the program as a leader in Hawaiian Studies and indigenous issues. She already had access as a cultural practitioner to Nualolo Kai, an important archeological site accessible only by sea during the calm, summer months. Sabra involves community, students, colleagues and archeologists in learning about and caring for the site by clearing debris, removing alien species, and restoring native plants. Visits by Dr. Abbott’s botany class a decade ago produced surveys of land plants; a visit by Pikoi teachers in summer 2005 yielded a preliminary assessment of the *limu*. A visit in summer 2006 of teachers and researchers is intended to add to the growing database of Hawaiian biota.

Over the 2005-2006 school year Sabra’s students collaborated with a doctoral student who lived on O’ahu to collect data on shearwaters, seabirds that raise their young in burrows from late summer through mid-November. While the parent birds are out fishing at sea, students gather data on the developing chicks. Each accessible nesting colony on Kaua‘i was studied by students at three different elementary, middle and high schools, enabling students to participate in authentic inquiry and providing the researcher with maximum data.
Evidence of Benefits to Researchers

I met the shearwater researcher and his wife on Kaua‘i in November 2005 when EDCS 433 students were staying in seaside cabins for their immersion. Sabra had asked them to stay with us instead of in a tent at the beach. He could not afford lodging or frequent travel to his study sites. The research collaboration with teachers and students solved his need to collect data at multiple sites during the nesting months.

Multiyear collaborations have developed among teachers and their science partners. Kim (Peyton, 2005) reported at the NMEA conference that partnering with teachers and students leveraged her ability to acquire data at multiple sites. She is currently studying 18 sites in Maunalua Bay with students’ help. In an informal, on-site interview she told the author that an unexpected finding is that native seagrass is first to colonize the bare areas when alien limu is removed. She noted that teacher-scientist collaborations not only enable access to study sites and communities but lead to changes in communication styles and ways of thinking on both sides. She said that as someone who grew up on the U.S. east coast, she had to alter her interaction patterns to work effectively in Hawaiian communities.

Derek, USGS scientist and co-principal investigator of a project to teach citizen-scientists how to acquire and post environmental data useful for monitoring ecosystems works with project teachers because of common interests in monitoring and maintaining marine and terrestrial ecosystems. An excerpt from the abstract of
his September 2005 presentation “Spatial Tech Talk: Integrating GIS and GPS Applications into K-12 and Undergraduate Science Programs” describes this work:

USGS Pacific Basin Information Node (PBIN)…has been working in the field with MCC Ethnobotanist Cathy Davenport and instructors associated with the Pikoi Ke Kaula Kualeana native Hawaiian science education program. The students … have been using GPS and GIS to georeference restoration efforts on land and in the ocean.

DISCUSSION

The following section discusses the four research questions addressed in this case study and concludes with a commentary on the grounded theory that emerged from the study of teachers’ programs.

What provides the contexts for teachers’ science activities?

A consistent theme that emerged from each teacher’s program is the applicability of pre-indigenous cultural values, practices, and roles to current environmental situations.

The Native Hawaiian teachers’ science activities are set in the context of knowledge of local resource issues gained through cultural transmission and place-based, practitioner experiences. The desire to learn about and to care for (malama) community resources grows out of core cultural values of learning from and respecting elders, connecting with nature in a familial way, and caring for resources for future generations. This ecocentric, sustainability-oriented cultural perspective enabled precontact Hawaiian society to adjust to demographic and environmental changes through widespread environmental literacy and a management system embodied in konohiki authority to control human behavior in response to ecological information.

The acceptance of personal responsibility, kuleana, is a cultural imperative and term used and understood by longtime residents in Hawaii, Native Hawaiian or not. Even in highly urbanized and altered environments, Hawaiian communities continue their subsistence practices and seek to maintain sustainable lifestyles. Western science and its technologies are valued for contributing to understanding and caring for that which sustains, ka ‘aina.

The teachers in this study are alike in being 21st century konohiki, integrating traditional and current science knowledge towards monitoring, restoring, and maintaining communal (in contrast to privately owned) resources for future generations.

What ways of learning and doing science are illustrated in their programs?

Their programs and approaches suggest that despite variation in their academic backgrounds, schools, teaching lines and emphases, these teachers’ visions and implementation of culture science programs share culturally shaped characteristics:
knowledge and experiences based in their indigenous communities, knowledge gained as cultural practitioners, and western science knowledge informed and guided by indigenous values. A culturally shaped way of seeing the world and understanding how to act in it supported the development of school-community sustainability programs in public areas such as beaches, bays, and archeological sites where their work would benefit the community at large. In contrast, Pikoi teachers who were not Native Hawaiian developed sustainability programs primarily within their school grounds and other clearly defined areas.

The report by the Maui teachers of being put off by the classroom science presentation even with its Hawaiian context indicates that learning about science has less value than doing science in a context of problem-solving and application in the real world. As practitioners, these teachers place high value on hands-on learning and invite schools, families and local community to participate in authentic problem solving. The Maui teachers’ were empowered by the realization that much of what they taught as Hawaiian Studies kupuna could be integrated with science.

Johanna sent an e-mail March 13, 2006 to Pikoi teachers to announce Mali’o, dawn light, as the name of Maui’s learning center. In her message she related how the program led all three site teachers to pursue further education and thanked each teacher colleague and member of the team by name. The following excerpt charts the pathway of her growing agency.

Malama immersion and Pikoi brought light to our path(s). For myself, it has brought a housewife, mom, and Hawaiian Studies makua-kupuna to a realization of some pretty lofty dreams. Napua and I have both returned to college, something we detoured from a lifetime ago, got our associates degrees which set us on the BA path. [The program] has networked us with some pretty hefty University type folks…sent us on wonderful field trips and workshops all over the state, introduced us to researchers, specialists, professional, state and federal government types and a wealth of exciting and engaging people…So for us here in Maui, the years in malama and pikoi have “cast the shadows” from our night and allowed our personal lights to emerge.”

Culture-science partnerships and immersions experienced during the EDCS 433 class became models for teachers’ programs. Teachers’ access to the Hawaiian community supported mutually beneficial collaborations with researchers who gained access to community sites and environmental knowledge and reciprocated by sharing their science knowledge and technical skills. Social factors such as trust, reciprocity, communication styles, and taking the time for personal interaction were recognized as playing critical roles in learning and doing science in school and community settings.

How and why do teachers establish networks of knowledge connecting indigenous and western science knowledge and practices?

The overrepresentation of 5 Native Hawaiians among 11 teacher leaders and the scope of their culture-science programs is an unexpected outcome of the program.
given their non-science academic backgrounds. Though Pikoi Site Coordinators were selected for their initiative and vision, it was not anticipated or expected that teachers would center their programs in caring for public spaces such as beaches, reef flats, and bays. In contrast to the Native Hawaiian teachers, other Pikoi site teachers developed their school sites and/or worked with partners who had jurisdiction of clearly defined areas.

In conversations with the author, Native Hawaiian teachers recognized they had entered the pre-existing, currently vacant role of konohiki or resource manager. Such a role authorized the mobilization of students and community towards caring for land and sea, malama i ka ʻaina, malama i ke kai. Professional development provided by Pikoi Ke Kaula Kualena and scientists associated with the program helped bridge western science with indigenous knowledge, practices, and values. The project goal of establishing teacher-led culture-science learning centers explicitly supported teacher agency, empowering them to develop programs, curriculum, and networks of human resources and knowledge oriented to action.

These teachers, none of whom were science majors, actively sought scientists able to contribute to the learning community. The relationship was mutually beneficial--as gatekeepers to place, culture and community-based knowledge and human resources, teachers’ relationships with university-trained researchers were egalitarian and collegial. In return for access to community resources, on multiple occasions such as described in this paper, the author observed researchers share their knowledge in formal instructional and informal, beach and trailside conversations leading to increased student and community knowledge. At the National Marine Educators Association Meeting, Pikoi-related presentations were given by 10 individuals ranging from 4th graders to scientists and teachers. At the gathering hosted by Dr. Abbott, these individuals and other faculty and scientists mingled informally. Participating, even being present at colleagues’ activities enable face-to-face meetings that build the familiarity and trust that support personal and professional networks. Derek who teaches GPS mapping and Kim, a limu researcher are now part of a statewide knowledge network grounded in personal contacts.

The pattern of establishing networks through peripheral participation in activities led by colleagues (Lave & Wenger, 1991) shows the value of bringing teachers, scientists, and community members together. Teacher-led learning communities of individuals who share a common objective provide long term stability to sustainability efforts involving ecosystem mapping, monitoring and restoration for participants realizing mutual benefits.

*Could programs provide a model for engaging underrepresented students in meaningful science learning?*

Each teacher incorporated her community-based environmental programs into school science programs with the support of practicing scientists. Though the monitoring and restoration programs do not lend themselves to traditional pencil and paper measures of student learning, they do meet state standards of scientific
inquiry, habits of mind, sustainability, and interdependence of science technology and society. Written evaluations, anecdotes of student success, and reports of the number of parents, students, and community members participating in restoration and monitoring efforts suggests that science done in the context of real world environmental issues is engaging and meaningful to a broad learning community.

Pikoi programs tend to have higher proportions of Native Hawaiian students than school or statewide proportions (26%). The following project data sent to the US Department of Education in January 2006 was reported by Kalei and Napua for their elementary students and by Matt and Manuel for their high school students. Schools on four islands are represented.

– Kapa’a School, Kauai: 88% Native Hawaiian students; 0 failures.
– Waihe’e School, Maui: 75-80% Native Hawaiian students; 0 failures.
– Kealakehe High School, Hawai’i: 44 Native Hawaiians/91 students in program, 48% vs. school 30%; 14 Native Hawaiians/19 SPED in program, 74%; Native Hawaiians received 10/29 total As, 34%; 0 Native Hawaiian students failed.
– Kahuku, O’ahu: 74 Native Hawaiians/142 students in program, 52% vs. school 38%; 72 Native Hawaiians received 72/108 As, 67%; 0 Native Hawaiian students failed.

This data indicates place-based, real world science learning congruent with Native Hawaiian knowledge, values and practices supports indigenous students’ academic success. Evidence for student success is important as school administrators worry that science content assessed by standardized tests will not be adequately covered in locally and culturally relevant curricula. These fears already restrict teachers to mainstream texts covering content likely to be tested.

Who gains and who loses? McNeil (2003) notes that accountability measured with standardized tests benefits those in the business of producing tests and textbooks, but conflicts with teaching standards promoting student-centered pedagogy, collaboration, problem solving and inquiry. Sternberg’s (2003) research suggests that test-driven schools produce pseudo-experts unable to make decisions for the common good. Scientists are concerned that a growth and consumer oriented society is ecologically unsustainable.

This study suggests that dominant, anthropocentric, cultural narratives that view humans as separate from and superior to the natural world might be countered by place and culture-based lessons grounded in authentic science and cultural narratives of sustainability and connectedness. Such an approach effectively un-standardizes science curriculum to address local contexts and student cultural diversity. This study suggests that professional development connecting culture, place and science has a positive impact on teacher agency, especially that of Native Hawaiian teachers.

CONCLUSION

For the five Native Hawaiian teachers in this study, having a personal sense of place, knowledge of traditional practices oriented to sustainability, and access to western science and scientists appears to support environmental literacy and
teacher agency. The vision and scope of their programs suggests the power of indigenous practices and values in supporting a 21st century environmental literacy in which teachers and scientists are konohiki and students and community are maka 'ainana, using traditional and western science knowledge to malama i ka 'aina, malama i ke kai, care for the land and sea. Their programs demonstrate current ways to understand and act on traditional cultural frameworks expressed in the Hawaiian proverb “He ali'i ka'aina, he kaua ke kanaka, the land is a chief man is the servant (Pukui, 1983).

In a manner that parallels the loss of biodiversity due to exploitation and habitat change for human benefit, society stands to lose cultural, linguistic, and knowledge diversity under current educational policies oriented to capitalism and globalization. The anthropocentric emphasis in mainstream schools and society marginalizes ecocentric indigenous practices oriented to sustainability of communities and resources. This study suggests that science teaching leading to communities of learners engaged in the study of locally relevant science issues holds promise for educational equity and environmental literacy. These programs and their real world concerns un-standardize mainstream science curricula, empower teachers as curriculum developers, value traditional knowledge, and support the development of ecocentric, transdisciplinary literacies.

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NOTES

1 Hawaiian customs and practices demonstrate the belief that all portions of the land and environment are related, like members of an extended family, each environmental zone was named, and their individual attributes were known. Acknowledging the relationship of one environmental zone (wao) to another is rooted in traditional land management practices and values. Just as place names tell us that areas are of cultural importance, the occurrence of a Hawaiian nomenclature for environmental zones also tells us that there was an intimate relationship between Hawaiians and their environment. The native tradition of Ka-Miki (in Ka Hoku o Hawaii, 1914-1917), provides readers with a detailed account of Hawaiian land divisions and environmental zones. These traditional wao or regions of land, districts, and land divisions include:

1–Ke kuahiwi; 2–Ke kuahonu; 3–Ke kuamana; 4–Ke kuaiahoe; 5–Ke kaulo; 6–Ka wao; 7–Ka wao ma'u kele; 8–Ka wao kele; 9–Ka wao akua; 10–Ka wao la'au; 11–Ka wao kanaka; 12–Ka 'ama'u; 13–Ka ‘apa’a; 14–Ka pahe’e; 15–Ke kula; 16–Ka ‘ilima; 17–Ka pu‘eone; 18–Ka po‘ina nalu; 19–Ke kai kohola; 20–Ke kai ‘ele; 21–Ke kai uli; 22–Ke kai pualena; 23–Kai popolohua-a-Kane-i-Tahiti.

1–The mountain; 2–The region near the mountain top; 3–The mountain top; 4–The misty ridge; 5–The trail ways; 6–The inland regions; 7 and 8–The rain belt regions; 9–The distant area inhabited by gods; 10–The forested region; 11–The region of people below; 12–The place of ‘ama‘u [fern upland agricultural zone]; 13–The arid plains; 14–The place of wet land planting; 15–The plain or open country; 16–The place of ‘ilima growth [a seaward, and generally arid section of the kula]; 17–The dunes; 18–The place covered by waves [shoreline]; 19–The shallow sea [shoreline reef flats];
20–The dark sea; 21–The deep blue-green sea; 22–The yellow [sun reflecting– sea on the horizon]; and 23–The deep purplish black sea of Kane at Tahiti. (Kīhe in Ka Hoku o Hawai‘i, September 21, 1916; Maloy, translator).

REFERENCES


APPENDIX 1

Program Goals and Instructional Strategies at Waihe‘e School

A. Napua Barrows, Co-Coordinator, Mali’o Culture-Science Learning Center

Main Goals:
– Students develop a great sense of who they are.
– Students develop knowledge of the history of where they live.
– Students learn that the Hawaiian people were very knowledgeable and skilled.
– Students learn that they have the same ability as their ancestors.
– Students have the ability as their ancestors to excel in any field of studies.

I first introduce historical events or legends that occurred in their community. Students are encouraged to point out where these places are located in their community. Their awareness of places in their community acknowledges they know or are familiar where certain places in their community. New materials are now introduced to enhance the old ones. This is when learning begins as they absorb the new information.

The following example is a story related to the “the kissing place” at Waihe‘e Beach.

Students are quick to acknowledge they know where Waihe‘e Beach is located by sharing their stories. We proceed with the story of “the kissing place.” Students are informed of the battle of Iao. After the battle Kamehameha received Keopulani as his wife. This arrangement was an acknowledgement that he was now the new ruler and that fighting would cease. The students are learning about their community and surrounding communities where they live.

Now that I have brought the students home to explore their community, we look even deeper into marine life found on the reef where they live. Students are recognizing the native limu and invasive algae. They can identify where they have seen the invasive algae. Students can recognize a he’e (octopus) and relate the story I shared. They can describe the physical characteristic of the he’e. They can describe the preferences of its habitat and its behavior when someone tries to catch them. They can touch it and see pictures of the he’e being caught. The idea is bringing the students home to learn to everything that is in and around where they live. Students are comfortable and familiar with the subject at hand and can easily learn new materials.

Source: January 2006 Learning Center Evaluation Report
A COMMENTARY ON PAULINE CHINN’S
CONNECTING TRADITIONAL ECOLOGICAL
KNOWLEDGE AND WESTERN SCIENCE

KENNETH TOBIN

CULTURAL RELEVANCE AND ALIGNMENT IN SCIENCE EDUCATION

Hawaii is a cluster of islands that is ecologically rich. Glimpses into the evolution of the islands and the life they support are available through archeological studies and in the culture of the islands’ inhabitants, the latter being most evident in the actions of those who have lived on the islands for a long time and in the local knowledge passed on by their ancestors. Pauline Chinn makes it clear, not just here, but also in her other writings about Hawaii, that many native Hawaiian inhabitants adhere to traditional lifestyles that acknowledge a connection with and harmony between people and the physical and living environment (Chinn, 2006). Rather than the environment serving the people’s needs, many native Hawaiians regard themselves as stewards, enacting collective agency by assuming roles to protect and maintain Hawaii’s health and authenticity. These traditions, the minority status of native Hawaiians, and the rapid influx of the West into Hawaii produce contradictions, including dichotomies associated with exploiting the environment to support consumer-oriented lifestyles and enacting stewardship roles to protect the ecosystem. An increasing population and its energy-gorging lifestyles create numerous problems. For example, the development of a tourist industry in Hawaii opened the door for the introduction of invasive species of plants and animals.

The destruction of Hawaii’s ecosystem and failure to enact science curricula to address problems created by mainstream lifestyles are dubitable facts emerging from a history that includes colonization of native Hawaiians and the production of minority status for them. Serious questions arise about the purposes of schooling and the extent to which issues having local significance can and should be included in science curricula. Who will and can step forward to do what is right? This is a question about collective and individual agency (Sewell, 1992)—about power, status, and politics. Can native Hawaiian’s voices inform policy? To what extent do the descendents of native Hawaiians have individual and collective agency—that is, the power to act—to preserve the islands’ ecosystems and educate inhabitants to live in equilibrium with fragile ecosystems?

According to Chinn, profound inequities are reproduced within an anthropo-centric perspective. She proposes an ecosystems perspective that situates people within a network of living and non-living parts; enacting social life with conscious

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awareness of the necessity for humans to maintain fragile equilibria within an interactive web of being. Adopting an ecosystems perspective in lifestyle takes courage and sacrifice because the needs of humans cannot be seen as more important than sustaining other life forms and the physical environment that supports them. Simply put, the ecocentric perspective is awkward for most of us to accept because it challenges our ways of living and requires us to make uncomfortable changes in lifestyle. Also, political and economic structures that support the distribution of power and wealth will likely have to change, not just in Hawaii, but also globally. Such changes seem unlikely since the will of the mainstream to change its energy-gorging lifestyle is absent. Without an imminent crisis it seem doubtful that the political will exists for the necessary changes in lifestyle and it seems just as unlikely that the mainstream is ready to initiate changes in science curricula that could educate the citizenry and provide a foundation for changed lifestyles.

Is a switch possible to science curricula that embrace an ecocentric approach to social life? Teachers, students, and school level administrators do not have the power to make such changes through their individual or collective agency (Tobin, 2005). Would policy makers and politicians consider changes to science curricula to include ecocentric perspectives? Perhaps tinkering is possible at a local level, but national efforts seem to fall short and rarely extend beyond exhortation. Macrostructures silently erode the individual and collective agency needed to enact essential changes. For example, as the evidence of global warming becomes apparent to the public at large the motivation, even among science teachers, does not seem sufficiently strong to change curricula to connect local issues to global problems such as species destruction and global warming. Recently the National Science Teachers Association (NSTA) refused to accept a donation of 50,000 free DVDs of the movie An Inconvenient Truth (Guggenheim, David, Bender, Burns, & Chilcott, 2006). Refusal of the NSTA to accept these resources for teachers has been attributed by some to the possibility that sponsors would not provide economic resources they had pledged or that were being negotiated (David, 2006). Is this evidence that economic forces shape what seems rational? The contradiction of the NSTA refusing to place An Inconvenient Truth in the hands of many science teachers is a salient reminder of ever-present macrostructures that limit power to pursue other valued interests (i.e., truncate individual and collective agency), such as protecting the global ecosystem. Walking the walk is a primary challenge for those who are positioned to change macrostructures. It takes commitment, courage, and sacrifice to embrace an ecocentric perspective, even for national institutions such as the NSTA to enact collective agency—for such purposes as foregoing donations from energy producing corporations and educating the public about the science of alternative lifestyles. The reluctance of the NSTA to step up to the plate is probably an aberration. A preferred optimistic view is that opportunities like these will become more prevalent and institutions to which science educators belong (including NSTA) will enact collective agency to establish new macrostructures in support of ecocentric lifestyles and educate the public about the need to change structures that destroy fragile ecosystems.
Chinn provides thick descriptions of the natural and cultural resources that abound in Hawaii. Furthermore, she provides examples of effective collaborations between educators, scientists, and native Hawaiians with deep knowledge of the culture and natural resources of the island. Through these examples she shows how a both/and approach to science education can build on knowledge systems that include cultural understandings of ecosystems and canonical science. Native Hawaiians, who regard themselves as stewards of the land, exercise individual and collective agency to cure the ecosystem of which they are part, assuming a responsibility to coexist and protect its longevity. If this perspective were incorporated into a science education curriculum students would learn from a scientific perspective how to maintain a productive and balanced ecosystem in which living and nonliving resources are healthy, coexist, and resist invasion.

Active environmental literacy assumes that science learners can do more than show success on paper and pencil tests. The idea of activism implies fluency in enacting culture in the fields of the lifeworld; in ways that are appropriate, timely and anticipatory. These three criteria are the essence of what I have referred to as science fluency, foregrounding the salience of science, as a form of culture, being enacted in fields. The key notion is that what is done in a field fits and creates structures that support not only individual but also collective attainment of goals. Implied in science fluency is that participants have a sense of the other and participate in ways that align with and are adaptive to what others do (and are anticipated, though not necessarily at a conscious level). Hence, culturally adaptive practice would imply that all participants would enact forms of culture, that is, particular roles that support the actions of others—opening the possibility of differentiation of roles. Enacting culturally sensitive roles is agentic because the collective acts in accordance with articulated schema to attain goals to which all participants ascribe. That is, the agreed to schema allow for divisions of labor that are complementary and entrained and, which could be along the lines of interests and preferences based on expertise and personal goals. If this is to occur a teacher has to know what students know and can do and act in ways that expand collective agency and participation of all learners. Hence teaching needs to be fluent in the sense previously described with the teacher’s actions being anticipated, appropriate, and timely. Because the structures of fields are dynamic all actions are contingent—a requirement that suggests that as interactions occur there will be times when one person’s actions truncate the agency of others, unintentionally shutting them down and acting to disadvantage them. When unintended actions oppress others it seems highly desirable that critical pedagogy is enacted to identify and eliminate the sources and associated examples of oppression.

Cogenerative dialogues appeal as ideal fields in which to identify examples of oppression and create plans to eliminate them (Tobin & Roth, 2006). These dialogues involve representatives from all stakeholder groups from a field and consist of conversations in which enacted culture is described in terms of patterns of coherence and associated contradictions. Collective responsibility among the participants leads to resolutions on how to remove contradictions and strengthen
desirable patterns of coherence, thereby increasing the quality of learning environments. Over time what happens in science education can become culturally adaptive in the sense that all stakeholders build an increasing awareness of the capital of others and create roles to support others’ learning. When culturally adaptive teaching and learning occur all participants enact roles that are responsive to the unfolding uncertainties of productive activity, fluently enacting some roles and being more deliberative about others as efforts are made to maximize success in a give and take community where collective goals are valued. Regular review of what happened and why it happened (i.e., interpretive research through cogenerative dialogue) raises awareness on what might be done in efforts to minimize disadvantage and maximize learning for all participants.

Chinn uses the phrase culturally relevant teaching to mean something different than what I refer to above as culturally adaptive pedagogy. She takes the ecosystems view whereby the focus of the science curriculum is tailored to active environmental literacy. This involves much more than the betterment of humankind—positioning above such goals the idea that the primary purpose of social life on the islands of Hawaii is to maintain the ecology of the environment in a pristine form, leading to active environmental literacy, whereby what is learned is used to protect the fragile equilibrium within an ecosystem of which human life is part. Being part of a fragile equilibrium is a challenge for all participants in a field and, as Chinn has shown, scientists with wide ranging expertise can have a hand in science curriculum design, professional development of teachers, and perhaps coteaching in public schools.

**AUTHENTIC TESTING AND HOLDING TEACHERS ACCOUNTABLE FOR THE LEARNING OF OTHERS**

As I have written elsewhere, one of the most pervasive myths about teaching is that effective teachers can control their students (Tobin, 2006). The focus on control over students leads teachers to create classrooms in which forms of coercion are widespread and students experience truncated agency through the well-intended actions of teachers. What is meant by truncated agency in this context is that students are prevented from enacting what they know and can do because a more powerful other, in this case a teacher, establishes rules and practices (i.e., structures) to prevent them from participating in ways that do not conform to what is anticipated, expected, and approved. Efforts to establish control over a group of others will often be met with resistance from the others who prefer to self-determine the course of their social lives. In classrooms in which teachers endeavor to get control over students there might be resistance to the teacher’s efforts and struggle to maintain identities that are trampled by well-intentioned efforts of a teacher who is doing what she considers to be best practices. Classrooms in which such resistance and struggle occur may be characterized by asynchrony in the actions of participants, negative emotions, and a build up of negative emotional energy. An alternative to control over students is cooperation with them. Instead of enacting teaching as a form of imperialism in which all participants must align
their practices with (presumably) mainstream culture and suppress much of what they can do fluently, teachers and students can negotiate new culture built around the capital of all participants with the goal of learning mainstream culture as a part of activity (which is the collective counterpart to individual action).

A test of whether or not an individual knows science is whether or not that individual can enact culture within fields in ways that are anticipatory, appropriate, and timely. In so doing success would be evident in individual and collective goals being attained and cooperative spirit in enacting culture in ways that expand individual and collective agency and thereby maximize the productivity of the field. It is conceivable in such fields that participants would find ways to participate that would allow them to produce through transformation and reproduction, sometimes teaching and at other times learning—always with an eye to optimizing his or her roles in relation to the practices of others. Much of what happens in productive fields is unconscious, however, as I discussed earlier, critical dialogues about what happens and why it happens can lead to collective agreements on changes to be enacted, deliberate strategies needed to improve the learning of all and especially to assist the learning of others who cannot readily help themselves.

Issues that arise in relation to the assessment of knowing in a field are the extent to which an individual enacts culture that is anticipatory, appropriate and timely. Since there is a dialectical relationship between conscious and unconscious practices, much of what can and is done is beyond the awareness of participants, including the actors. Any efforts to raise consciousness about what happens during enactment, often by changing roles to enact equitable practices, as occurs in critical pedagogy, also introduces unconscious practices (that are hopefully equitable). This is a challenge for assessors since there will always be practices enacted fluently and unconsciously, which are not represented easily or fully in discursive ways (Schutz, 1967).

In Chinn’s paper she addresses high stakes tests and reasons that they cannot be authentic measures of achievement. I regard testing as a field in which participants produce culture, as transformation and reproduction, based on what they are required to do—usually with a pencil and paper. Presently public schools devote a lot of time to preparing students for success in the field of testing and as Chinn states, some of the impetus for this is that test producers lobby for their tests to be used as ways to measure student success in science and to hold teachers accountable for science achievement—which amounts to success on their tests. Chinn’s focus on this issue is a stark reminder of the economic and political underpinnings of education policy and the challenge of ever making meaningful changes to the status quo.

Paper and pencil tests are not authentic measures of science knowing and emphasizing them in the enactment of science curricula distorts the curriculum in ways that are inconsistent with the goal of students becoming actively environmentally literate and learning science in ways that are relevant to social life. Instead, performance on paper and pencil tests functions as a gatekeeper to particular fields and tends to reproduce society with inequities that reflect minority
status in respect to ethnicity, social class, language and gender. The measures obtained undoubtedly reflect production, usually reproduction of forms of science culture, but in a very limited way that does not address whether or not science is or can be used productively in the fields that define an individual’s lifeworld. Given the alarming extent to which high stakes paper and pencil tests continue to focus enacted science curricula worldwide, there is an urgent need for a policy shift that addresses the creation of assessments that are authentic in fields in which science might reasonably be enacted by a literate citizenry.

Teachers, students and school administrators do not have the power to decide not to use high stakes tests, which may be mandated by politicians and national, state and district level officials. Hence, all participants in a school system are swamped by macro structures that they are not absolutely free to change without greatly disadvantaging themselves. Individuals and collectives can agitate for change while working within the existing structural frame and also they can endeavor not to elevate the importance of the test such that it becomes the “only game in town.” Agitating for reform and endeavoring to pursue multiple goals also are examples of individual and collective agency. As is the case with hegemony in all of its forms, those who are most victimized will likely accept their oppression as normal, accepting responsibility for their own failure to perform at the required level, and exhort a necessity for greater personal effort to succeed.

Briefly Chinn addresses curricula relevance in relation to tracking. Somewhat sadly and surely ironically non-college bound students were able to study science courses with relevance to Hawaii, whereas students who were college bound studied the traditional fare. Hence, the scientists of tomorrow were tracked away from science courses that had local relevance into those focused on traditional canonical science—presumably selected because of its abstract and universal applicability.

THROUGH THE LENSES OF URBAN EDUCATION

Many of the problems addressed in Chinn’s paper seem particular to education in Hawaii. As an urban educator who has spent a professional lifetime in science education, I can see readily the applicability of much of her paper to students learning in urban environments. I am certain that Randy Yerrick would argue that Chinn’s paper also has implications for rural science educators. In the remaining part of this paper I connect some of the issues Chinn has raised to urban schools.

Consider the demographics and trends in New York City. Little wonder education is such a challenge. The diversity and magnitude of the system exceed what many states and just a few cities experience. According to the latest data available from the New York City Department of Education website (http://schools.nyc.gov; 2006), more than 54,000 teachers and a million students teach and learn in New York City public schools. The ethnic composition of the students is approximately 35 percent African American, 34 percent Hispanic, 17 percent White, 14 percent Asian and less than 1 percent American Indian. Almost 13 percent of the students are English Language Learners (ELLs) and 26 percent are former ELLs. Nearly 20
percent of the students are recent immigrants to the United States, coming from more than 140 different countries, almost all entering the US during or after grade 7. About 70 percent of students graduate from high school, and of those who graduate, 63 percent earn the lowest level of pass, 26 percent receive a certificate endorsed by the State Regents, and 10 percent graduate from high school through the completion of a Graduate Education Diploma. A question that arises immediately is whether or not a basic pass from high school is worth much in terms of a better social life? These data are indicative of trends sustained for many decades, signs of great disparities in the potential of education along the boundaries of ethnicity. More than 80 percent of the Asian and White students graduate compared to a little over 60 percent of the African American and Hispanic students. There are gender differences too, with more females than males graduating (61 compared to 54 percent).

Even within a city as diverse as New York there is a system of public schooling that allows tracking. There are six basic types of public high school, more than sufficient to allow for different programs based on aptitude, interests and needs of students. The provision of choice affords contradictions arising. To be admitted to a specialized public high school, students must pass entrance examinations. Specialized public schools seek and get the best students (in terms of test taking) and, not surprisingly, specialized high schools graduate more than 96 percent of the students in the expected four years of high school—a contrast to comprehensive high schools where the graduation rate is almost 60 percent. Some of the alternative schools for students with special needs have even worse graduation rates varying from about 60 percent down to 18 percent. It would not be desirable for school choice and the associated policies and practices to be associated with resegregation of schools in New York City. Yet this appears to be exactly what has happened. Special elite schools consist mainly of Asian and White students, minorities in the public school population. How could racial segregation like this happen? For example, Science High¹, an elite school for science achievement, has a racial distribution of approximately 40 percent White (15 percent), 3 percent Black (35 percent), 3 percent Hispanic (36 percent) and 54 percent Asian (14 percent). District wide percentages are provided in parentheses. Similar analyses based on whether or not the schools such as Science High receive Federal title I funding and the percentage of the students eligible for free lunch support an hypothesis that specialized high schools are tracked on the criterion of economic means. Compared to a 54 percent citywide eligibility for free lunch Science High has only 15 percent of its students eligible for free lunch and it has not received title I funding from the Federal government. In addition, in a context of a high level of immigration and a need to educate students with limited proficiency in the use of English, it is noteworthy that, compared to citywide averages, Science High has very low levels of each.

Patterns such as these are signs of systemic problems in the education systems of cities such as New York City. Knowing how and having the time to find out about specialized schools and how to gain entry to them might reflect an understanding of how to navigate and having convenient access to high-speed
Internet connections and/or how to communicate effectively with middle class bureaucrats. Alternatively, the social networks of some racial groups and immigrant families might not support participation in the application process. Ethnic and language minorities may be less inclined to discuss and pursue admission to special schools such as Science High, preferring to enroll students in schools in which the process requires less agency. Although this is conjectural, it might be necessary to explore such possibilities if special schools are to be desegregated. Also, if students are aware of the admission tests and know where and when to take them, it is important that they have studied the content needed to prepare them for success. To what extent do elementary and middle schools citywide prepare students for success on examinations that, by law, determine whether or not students can attend specialized high schools? Does the curriculum prepare students with the necessary verbal and mathematics knowledge needed to do well on the tests or do only certain segments of the public school system make it a priority to educate students for success on the entrance tests? Just which public schools are feeders for special schools like Science High and are the curricula different at such schools? For as long as paper and pencil tests remain as gatekeepers to special elite schools a paradox will exist. Although paper and pencil tests have doubtful claims to authenticity and focusing on them narrows the curriculum in ways that are deleterious for learners—good things come from high performance on these tests and therefore there is a press for teachers to align enacted curricula with doing well on these tests; a tendency Chinn describes as depprofessionalizing.

Frequently I am asked what I mean by urban education and research in urban schools. To me the defining issues extend beyond ethnicity and class. Just as the issues above are more than simply issues of ethnicity and class, urban education involves identifying and resolving contradictions associated with size and diversity. Complex contradictions arise in regard to the distribution of resources when the magnitude of the student population is large and the diversity is great. Widespread differences in ethnicity and class between the types of schools in New York City suggest that within schools there may be policies and practices that produce and reproduce disadvantage over time and, at the school district level, policies and practices might also produce disadvantage for groups of students along the boundaries of ethnicity, class and gender and for recent immigrants and students without mastery of English. Despite efforts to overcome such forms of disadvantage and the oppression they represent, trends like those described above are apparent over long periods of time; even as the flux of our times produces new waves of immigrants who seem unable to benefit from education equitably.

Questions can be raised about whether or not teachers are certified in the areas in which they are to teach, and perhaps whether or not they have a relevant master’s degree. In New York City’s public schools 82 percent of its teachers are certified to teach. But what does this mean in terms of their qualifications to teach what they are assigned to teach? For example, do physical education teachers teach science courses? If trends to teach out of the field of certification exist in public schools, are they stronger in comprehensive high schools than in specialized high
schools? Also, when a student in a comprehensive school goes to one of her three required science classes, does she have a teacher who can communicate with her effectively, with knowledge of her ethnicity, class, gender, and age? Does she have a teacher who can assess and tailor the enacted curriculum to take advantage of what she knows and can do? To what extent do teachers have the experience of the youth culture of their students and to what extent do the students know how to successfully interact with their teachers across the same boundaries that challenge their teachers? It is not just for teachers to be educated to interact successfully with students, but also for students to learn to interact successfully with their teachers, especially when the homes they live in are markedly different than those of their teachers. Do the racial and class distributions of teachers in a school align with those of students? All too often they do not. The particular challenge for all participants is that so many cultures are involved, exacerbated by the steady volume of immigrants into high schools, from more than 140 countries. On any day high school students would have 6–8 teachers, hence the chances are slim that a given teacher has first hand experience of an immigrant student’s country or that the teacher has the same racial background as most of his students. Accordingly, establishing and maintaining successful communication chains across the boundaries of ethnicity, class, and language are significant challenges for teachers and students.

Just how can teachers be adequately prepared for teaching successfully in urban schools? That learning to be an effective teacher is a life long commitment almost goes without saying. Also, that teachers should be researchers of their own practices is accepted as a viable component of initial certification and professional development programs. However, in urban school districts, in comparison to other places in the US, there are the challenges of educating the teachers to see and build upon the resources students bring to the classroom, to use the resources of the city in their teaching, and to reduce the incidence of macro workforce indicators of problems, such as the high levels of out of field teaching, high rates of teacher turnover, and high levels of teacher absenteeism. Rarely can the approach to issues such as those I have identified involve policy only and seldom can accountability measures solve the problems. Successful solutions will require more than blaming, simplistic solutions such as doing away with Colleges of Education, and rewarding those who gain the highest test scores. Can ways be found to expand the agency of students, teachers and school level administrators? In New York City and Hawaii there is appeal in the slogan of think global and act local. Perhaps the solutions to a better science education are situated locally. However, the agencies of individuals and collectives do not float freely, but are dialectically related to structures, including macrostructures—which include forms of hegemony that reproduce a status quo of inequities, oppression of minorities, advantages of the mainstream, and destruction of fragile ecosystems.

Because the problems and their probable solutions are complex and highly situational, there is dire need for more research, visionary policy and curriculum development aligned with the needs of students and the communities in which they live. Few would disagree with the sentiments expressed in the previous sentence. Where the disagreements occur though are in the details of what counts as
research, what counts as evidence, what counts as appropriate policies, what should be taught, and how best to ascertain whether or not students are learning and that teachers and schools are effective. The differences that inform alternative perspectives on these issues run deep along epistemological and ontological boundaries.

Elsewhere in this volume, Wolff-Michael Roth draws attention to a dialectical relationship between agency and passivity. Roth exhorts science educators to consider this relationship in their professional activities. Salient to science educators in New York City and Hawaii are macro schema and the practices of powerful others that restructure local fields and thereby change the nature of resources to support action and even the motives of participants within a field. Accordingly, solutions to the problems of curricular relevance or of misaligned lifestyles may not be available locally. At the same time, local actors can burn out as repeated efforts to exercise agency fail to produce worthwhile goals. If macrostructures need to be changed—and most certainly they do, it becomes imperative for such changes to become conscious goals and this likely necessitates widespread adoption of critical methodologies like cogenerative dialogue and forms of collective action that involve participation in macro fields.

LOOKING AHEAD

Chinn has raised important issues that have salience to many of the priorities of science education. Her chapter exposes the shortcomings of dichotomous ways of thinking; for example, whether scientists or native Hawaiian teachers should inform curricula. Clearly, science curricula can be informed by both and have relevance to local culture, history, and ecosystems. It is clear too that the professionalism of science teachers has to be central to teaching science in ways that have relevance to place, culture, and local environments. Teacher education programs need to prepare teachers in ways that allow them to become cultural brokers with respect to their students and the locale in which the school is situated, while reaching out to a community that includes scientists, technicians and the equivalent of what would be considered native elders—those with deep knowledge of the culture of local inhabitants of the land. In a symmetrical way, students also should be cultural brokers and learn to communicate effectively with and learn from their teachers—many of who will differ from them in terms of ethnicity, native language and gender. Finally, in making a case for authentic forms of curricula and assessment of learning Chinn also argues for teachers, students and other school-based personnel to undertake research on their own practices as they engage forms of critical pedagogy to overcome oppression and the destruction of the world’s natural resources and ecosystems—by human progress. Through necessity the roles of teachers and students (and other stakeholders) will change, expanding their agency and, in so doing, policy makers will need to create new models of accountability and education progress—models that reflect sociocultural theory, the creation of communities of learners, and the both/and nature of goals and accomplishments for individuals and collectives.
NOTES

1 A pseudonym.

REFERENCES


PAULINE CHINN

A RESPONSE TO TOBIN’S COMMENTARY

Culture, Place, And Teacher Agency: Empowerment Through Transdisciplinary Communities Of Practice

I introduce this response to Kenneth Tobin’s comments with an edited excerpt from the footnote from my paper (this volume) describing the Hawaiian landscape from an indigenous perspective. A careful reading reveals that traditional Native Hawaiians experienced life through an ecocentric worldview that integrated place, nature and culture. Familiar zones where people farmed, fished, and sailed were part of a cultural landscape where gods dwelt and the ancestral islands of Tahiti lay beyond the horizon.


The excerpt grounds my response to Kenneth Tobin’s thoughtful comments on the challenges of aligning science education with an ecocentric approach that respects place, culture, and sustainability. How might science educators help learners acquire and develop ecocentric understandings that recognize the strengths of indigenous knowledge and support evidence-based critique of dominant, anthropocentric culture? Tobin (this volume; Tobin & Roth, 2006) suggests that cogenerative dialogues enable all stakeholders from a field to “identify examples of oppression and create plans to eliminate them.” Cogenerative dialogue has much in common with Habermas’ communication theory which holds that people are able to engage in “social interaction in which the plans of action of different actors are coordinated through an exchange of communicative acts, that is, through a use of language oriented towards reaching understanding” (p. 4, Habermas, 1981).

My experiences with K-12 science students and teachers (Chinn, this volume and in press) suggest that open communication among stakeholders is an important step towards rethinking instructional practices. The sharing of personal experiences provides the emotional, physical, and cognitive basis for transforming mainstream
anthropocentric views of science to ecocentric understandings that recognize the sociocultural contexts in which science occurs.

For the past decade, I have asked my science education students to carry out one or both of the following assignments: to interview grandparents/elders about their lives and/or to research and report on the *ahupua‘a* in which they live or teach. This reconnects them to the lives and values of earlier generations and models a lesson they can use with their students. A Caucasian student reported her grandmother used different water sources for cooking and washing hair or clothes; a Filipino student said her grandmother planted a tree after the birth of each child. Each student’s story is a personal starting point to explore ecocentric lifestyles across cultures, places, and times.

But understanding ecocentric lifestyles does not necessarily translate into culturally relevant, place-based instruction if teachers are unfamiliar with local places and cultures. Beginning in 2001, with support from a federal award, I included culture-science immersion as part of a professional development course, EDCS 433 Interdisciplinary Science Curriculum. Whether in Hawai‘i or elsewhere, active environmental literacy is gained in communities of practice (Lave & Wenger, 1991; Wenger, 1998) composed of diverse stakeholders who develop shared ways of understanding issues and producing new knowledge.

In the problem solving systems of teachers, scientists, students, and community members described in my paper, cognition is situated in socio-cultural contexts relevant to particular places and issues. Knowledge is distributed among members who contribute expertise in their own areas—marine biology, water quality, canoe paddling and steering, and knowledge of place. Michelle’s students learn and master science and skills relevant to their tasks at different levels of sophistication and at different rates. Skilled and rapid sorting of native from non-native seaweeds can occur without knowledge of classification and life cycle, but over time, participation in a community dedicated to monitoring and restoring a coastal ecosystem supports the learning of scientific ways of understanding, analyzing, and communicating ecological information.

Evidence for multiple literacies is seen in a student video of activities in Maunalua Bay. Topics and terminology reveal multiple ways of learning about and relating to the place: as students learning from scientists, as young Hawaiians carrying on sailing and navigation traditions, as youths learning from elders. The students’ narratives reveal a complex interweaving of ways of understanding and acting in the world from both Hawaiian and western perspectives. Multiple literacies develop in the context of authentic settings and issues. When cross-cultural knowledge informs a shared vision of ecological sustainability, individuals traditionally underrepresented in science learn through observation, modeling and application how western science complements indigenous values and practices.

Thus Michelle’s current project, the carving a traditional, double-hulled voyaging canoe from two 40-foot non-native *Albizia* logs from trees harvested on the island of Hawaii has a dual educational purpose: the canoe as a traditional sailing and modern scientific research vessel. But the framework in which the project is conceived and carried out is guided by cultural values of responsibility,
A RESPONSE TO TOBIN’S COMMENTARY

kuleana and malama i ka ‘āina, caring for the land. Students replaced the Albizia by replanting endemic Acacia koa, carrying out the wisdom of a Hawaiian saying, Hahai no ka ua i ka ululā‘au; Rains always follow the forest (No. 405, Pukui, 1983). Knowing this, Hawaiians cut only the trees that were needed and made sure that native stocks were not depleted.

Western science explains this saying as occult precipitation, condensation on trees from clouds, fog, and mist that increases the amount of water received in forested versus treeless zones by 20-40% (Thompson, 2001). Beyond value-free scientific knowledge, Native Hawaiian teachers bring to their environmental projects culturally relevant ethical contexts for restoration that link removal to replacement, an understanding not uniformly modeled in all environmental efforts.

LEARNING AS ADAPTIVE REORGANIZATION AND CULTURAL ENACTMENT

Lave and Wenger (1991) and Hutchins (1995) studied human learning and cognition in authentic situations, a methodology Hutchins calls “cognition in the wild.” His studies of western and Micronesian navigation lead him to conclude that:

The proper unit of analysis for talking about cognitive change includes the socio-material environment of thinking. *Learning is adaptive reorganization in a complex system.* (sic) (p. 289).

EDCS 433 Malama I Ka ‘Āina, Sustainability provided teachers with a framework to connect culture and science in meaningful, community-based science activities. All have continued to strengthen their community-science networks towards goals of sustainability and local resource management and 4 of 5 are pursuing higher education. Agency is seen in their initiative in forging local partnerships with scientists, particularly the growing number of Native Hawaiians with degrees in natural science and resource management.

Tobin writes that an authentic test of whether or not an individual knows science is her ability to “enact culture within field in ways that are anticipatory, appropriate, and timely.” In addition to their community-based projects, some teachers are beginning to engage in the political and legal aspects of resource management. When teachers and I were on Maui for the NMEA conference in 2005, a Department of Land and Natural Resources scientist showed us a bucket containing juvenile o‘opu (endemic goby) and ‘opae (endemic shrimp). He had collected the animals as they milled about where the waters of I‘ao Stream normally would flow into the ocean and intended to release them above the diversion that sent water through aqueducts to sugar plantations, resorts and developments. Taro cultivation, subsistence fishing and the lifecycles of native, catadromous stream animals that must return to the ocean to spawn have been affected. For the Maui teachers, agency based on increased science knowledge now extends to political and legal action to return water to the stream to restore mountain to sea ecosystems. This summer Napua will visit New Zealand as part of study group; her primary interest is to research Maori land rights as a model for
Hawai‘i. There are no pencil and paper assessments for this kind of knowledge demonstration, the authentic enactment of culture in ways that are, as Tobin writes, “anticipatory, appropriate, and timely.”

In fall 2006 Michelle received the Hawai‘i Coral Reef Initiative’s Educator of the Year award for her Maunalua Bay project. In spring 2007, she and her Nature Conservancy partners, both Native Hawaiian, will conduct 3 invasive algae cleanups with students and community. They plan to employ a suction device to increase collection efficiency and will use two canoes with a fine mesh net suspended between them to contain the algae. Students will take the algae to shore to weigh, sort and record data. Alien algae will become mulch for the Hawaiian garden. They will restore native algae by staking out cages containing limu following the method employed by Kalei at her Aliomanu Beach restoration project. Managers of a fishpond on the other side of O‘ahu will help grow out native limu for restoration.

Monitoring by underwater remotely operated vehicles (ROV) will be undertaken through a partnership with Kapi‘olani Community College which has an NSF TCUP (Tribal Colleges and University Program) that aims to prepare Native Hawaiians to enter 4-year science, technology, engineering, and mathematics majors. Members of the engineering group will be invited to go out on the canoes to observe their activities. High school and community college students and faculty will co-design and build ROVs appropriate for the research. As a teacher educator with my university’s NSF Center for Microbial Oceanography: Research and Education (CMORE), I anticipate working this summer with teachers to establish a learning community focused on issues of water quality. Fixed probes at various sites in the bay and marina will send data directly to participating classrooms.

Michelle recently wrote a proposal to support her canoe project. Meanwhile, the non-profit Malama Maunalua established a year ago to support and extend her education and restoration efforts is exploring community-based management of an adjacent wildlife refuge.

Her school of just over 1000 9-12th grade students is diverse: 19% indigenous Hawaiian, 40% Asian American, 33% Caucasian, and 7% other. The higher percentage of Native Hawaiians in the school than the community indicates students from neighboring communities choose her school over their home schools (geographic exceptions). Nine per cent of students are classified as special education, 8% receive free or reduced lunch, and 2.4% are Limited English Proficiency. Michelle reports that Native Hawaiian and special education students are 2 -3 times more likely to be in her programs than in the general school population.

Michelle’s project has been a teaching site for EDCS 433 since 2003 and will be a site for this summer’s students. Michelle plans to enter a master in education program in the fall with the goal of developing interdisciplinary science curriculum and science credit for her developing program. Ironically, her students receive credit for physical education, not science though they conduct research with graduate students, engineers, and scientists.
Unfortunately, despite a state science standard requiring students to engage in science inquiry, Michelle’s science colleagues are not involved in her project. Only the aquascience teacher is interested in sustainability, specifically in raising fish, a Hawaiian technology developed centuries ago that reveals deep knowledge of trophic levels and life cycles. Her program does not fit neatly into content areas, textbooks, or learning structured as 5-6 classes per day between 8:00 a.m.-3:00 p.m. Monday through Friday. Other teachers do not have Michelle’s set of culture and place-based skills, values, and social networks and perhaps the willingness to be with students in other than well-defined classroom contexts. Nor do mainstream schools have a system to reward teachers such as Michelle who successfully engage underrepresented students in meaningful learning.

I wonder as Tobin does if ecocentric cultural values and practices will someday be aligned with science education. I think there is growing reason for optimism.

EMERGING POSSIBILITIES

Hawai’i’s legislators and business community realize development strains freshwater resources and compromises fragile terrestrial and coastal ecosystems. The general public knows that Hawai’i’s natural beauty and host culture drive tourism, the main industry. Sustainability is a term that is used widely. Yet many well-educated and well-meaning people, including educators, rely on simple solutions to complex educational problems. Tobin describes the myth of control that holds that effective teachers are those able to control their students. High stakes tests, controls over schools allowed by the No Child Left Behind Act, and tracking of children as early as kindergarten and first grade create a climate of control over students, teachers and curriculum. As a result, learning is decoupled from local issues, communities, and students’ lives.

Tobin writes that even “as the evidence of global warming become apparent to the public at large the motivation, even among science teachers, does not seem sufficiently strong to change curricula to connect local issues to global problems such as species destruction and global warming.” Those in power fear loss of control as communities begin to monitor and critique practices from eco-justice, sustainability, and human health standpoints. But the business and political climate is changing as states, businesses and non-governmental organizations acknowledge the evidence for human contributions to global climate change and support ecocentric perspectives. Even though educational macrostructures do not actively support teacher agency, professional development can and should prepare teachers to establish community-based science networks, especially when such programs appear to support student success. Evidence that underserved students are academically successful in these programs (Chinn, this volume) deserves the attention of relevant publics.

As science educators we can research and refine our practices towards the development and dissemination of critical, place-based science education oriented to environmental stewardship, student learning and aligned with National Research Council (2005) recommendations that science instruction be learner-centered,
knowledge-centered, formative assessment-centered, and community centered, “encouraging a culture of questioning, respect, and risk taking” (p. 13.)

Teachers know that professional development that supports teacher-led, transdisciplinary communities of learners can lead to personal and professional agency (Chinn, this volume). Maui’s culture-science learning center is named Mali’o after the dawn light that throws off night’s shadows. Johanna, Napua’s sister, describes how the name was chosen:

Malama immersion and Piko brought light to our path(s)...networked us with...researchers, specialists, professional, state and federal government types and a wealth of exciting and engaging people...So for us here in Maui, the years in malama and piko have “cast the shadows” from our night and allowed our personal lights to emerge.”

REFERENCES


2. STUDENTS ACTING AS CHANGE AGENTS IN CULTURALLY DIVERSE SCHOOLS

The Need for Intervention Studies In Teacher Professional Development

The literature has well documented that many elementary school teachers do not feel well prepared to teach science and many still rely on traditional and non-engaging methods of teaching to their students (Appleton, 1995; Weiss, Banilower, McMahon, & Smith, 2001). Harlen and Holroyd (1997) explicate an array of strategies teachers utilize to overcome their uneasiness and lack of confidence when it comes to teaching science, including such strategies as only teaching the content in which they are the most confident, relying heavily on the textbook and worksheets, and avoiding using any equipment that might lead to mistakes.

To make this situation even more problematic, particularly given the diversity of our student population in the United States, is that research makes it clear that many teachers do not feel well prepared to teach effectively within culturally diverse populations (Moore, Harrison & Donaldson, 2005; Rodriguez & Kitchen, 2005). Given these challenges, researchers advocate that for professional development experiences to enhance teachers’ content area knowledge and skills in working with culturally and linguistically diverse students, teachers must be provided with multiple opportunities to reflect upon and work to change their beliefs about academic content, children’s abilities to learn, the role of language and culture in instruction, and their own sense of self-efficacy (Lee 2004; Thompson, 1992).

Although, as researchers, we continue to accumulate a body of knowledge on professional development, educators, such as Borko (2004), argue that “each year, schools, districts, and the federal government spend millions, if not billions of dollars on in-service seminars and other forms of professional development that are fragmented, intellectually superficial, and do not take into account what we know about how teachers learn” (p. 3).

This tension is furthered complicated by the fact that, according to Rodriguez and Kitchen (2005), some teachers may resist learning to teach for diversity (resistance to ideological change) or resist to teach in student-centered and inquiry-based approaches (resistance to pedagogical change) due to a multitude of real or perceived factors (standardized testing, content knowledge, confidence, experience, school culture, students’ abilities, parent involvement, and so on).

Given these challenges, several scholars are making the case for the creation of “culturally congruent” science instruction that promotes more equitable treatment
of diverse students (Lee, Hart, Cuevas, & Enders, 2004). We searched the literature for instances in which investigators had identified science learning equity issues and addressed them directly in an intervention kind of approach. Herein, we define intervention study as a teacher-centered approach to professional development by which the researchers and teachers collaboratively explore areas in need of improvement (e.g., pedagogy, content knowledge, curriculum) and take steps to systematically evaluate and address the identified areas. Our review of the literature revealed that only a few researchers have completed intervention studies that have lead to promising results in the field in terms of helping us better understand how to change school practices on-site in ways that positively and directly impact science understanding and achievement for culturally diverse students.

For example, Lee (2004) implemented and studied a model for developing culturally responsive science teaching practices with a cohort of teachers who were bilingual and Latinos/as that did influence their classroom instruction. The authors contextualized the process of change however, as being slow, difficult, and taking a long time. The research study also demonstrated that participating teachers reported developing an increased knowledge of subject matter and more positive attitude towards working with culturally diverse learners (Lee, Hart, Cuevas, & Enders, 2004). In a previous study, we implemented an intervention professional development research project (Maxima) that focused on assisting teachers make better connections between teaching for understanding (using inquiry-based and social constructivist pedagogical approaches) and teaching for diversity (making the curriculum culturally and socially relevant). To this end, we used three guiding concepts in our collaborative work that proved to be very beneficial in helping teachers to change their practices. These guiding concepts were (a) being responsive and theoretically explicit; (b) providing on-going and on-site support; and (c) facilitating reflexive approaches to collaboration. (Zozakiewicz & Rodriguez, 2007). Findings from this research project indicated that most of the teachers responded positively to the proposed guiding concepts and significantly changed their teaching practices to be more culturally responsive and gender inclusive in their science classrooms.

As with Lee’s study, this project was a two-year study that was multi-layered, complicated, and time-consuming, but did yield positive and promising results with a diverse pool of elementary and middle school teachers. Still, given the small number of intervention studies available in the teacher education and education reform literature, there is a dire need for more studies that focus on investigating how to assist teachers in implementing the many proposed changes in curriculum and instruction that educators and others suggest are needed in our culturally and linguistically diverse schools.

Our current project reported herein begins to address some of these concerns by investigating what happens when all the necessary elements and support for professional development and school reform in the area of science are present in a culturally diverse and urban school context. What deeper understandings do we gather as researchers by implementing an intervention study; that is, a study that enables us to work alongside with teachers and their diverse students in the field,
and struggle with them to make the changes in classroom practices that they themselves agreed are needed to lead to better participation and higher achievement for all students? What are the factors that obstruct or facilitate the integration of innovative learning technologies with culturally relevant and social constructivist teaching practices when the required technology and support is being provided? How does the expectation of using learning technologies to enhance student learning impact teachers’ already complicated professional lives? What are the overall challenges that may emerge in our collaborative work together and what intervention strategies are the most promising to help address the challenges encountered in these types of school contexts? One of the intervention strategies we found to be most promising for the addressing the above questions was working with students as change agents. In other words, we decided to also explore what professional development might look like if it included working with the students as change agents in their own schools contexts? Instead of students being individuals only “acted upon” by teachers who are challenged with learning new content and pedagogical strategies, what if the students were also to become a part of the reform story themselves in a more active manner?

Therefore, while the central focus of this chapter is on teacher professional development, we report herein only on how we worked with students as change agents to meet the project’s goals. We start by explaining how sociotransformative constructivism is the guiding theoretical framework for the overall project, and how we are using this framework to inform our interest in using learning technologies as tools to make the science content more inquiry-based, culturally responsive and socially relevant. Given the complexity of the study, the context of the project and methods used are explained in detail in the methodology section. Finally, we report in the findings section the various action components through which the intervention strategy of students as change agents was manifested during the first two years of the project. We close with some questions for further study and some recommendations for implementing intervention studies that look at the process of teacher professional development through a non-traditional lens.

**USING LEARNING TECHNOLOGIES AND SOCIOTRANSFORMATIVE CONSTRUCTIVISM TO ENHANCE TEACHERS’ PEDAGOGY AND STUDENTS’ LEARNING**

There is a continual stream of research that demonstrates the value of constructivist teaching in improving student learning (Wenglinsky, 1998) and in enhancing student engagement in classrooms (Sivin-Kachala, 1998). Study after study also demonstrate that it is not the technology tool that makes the difference, but instead the willingness of the teacher to change his or her classroom practices that causes the greatest impact on learning (Quinn & Valentine, 2001). Despite the reports that teachers are open and willing to try technological innovations in their science teaching (Pedersen & Yerrick, 2000) studies show relatively low rates of classroom transformation (Rakes, Flowers, Casey, & Santana, 2002).
These findings have been well documented by several researchers, who in addition argue that when it comes to infusing learning technologies in their classrooms, teachers have more difficulties making changes towards a constructivist orientation (Becker & Reil, 2000). So, putting computers in the classrooms of teachers who are eager to use them is not enough. Similarly, providing technical and/or professional development support is not enough to effect long lasting change even in the classrooms of teachers who self-report to be constructivist teachers (Rakes, Flowers, Casey, & Santana, 2002).

As we investigated ways to provide more effective support for teachers, we used relevant information from other studies to overcome commonly reported obstacles, such as lack of resources and funding, lack of planning and collaborative time, and lack of sustained professional development and teacher support (Cuban, 2001; Pflaum, 2004; Yerrick & Hoving, 1999). Therefore, in this intervention study, we sought to provide ongoing, onsite, and responsive technological and pedagogical professional development support while carefully studying teachers’ practices and students’ participation in learning over an extended period of time.

One key component to the design of our intervention study was to allow students’ voices and cultural backgrounds to become integral parts of the curriculum planning, teaching, and assessment. We felt that this approach was necessary because our review of the teacher professional development and learning technologies literature also indicated that there was a conspicuous absence of how the students’ voices, cultural backgrounds, and sense of agency come to bear on research directed at them. We also argue that this approach may serve to bridge the digital divide between the have-nots by conducting a study that seeks to listen to what students think and feel about science and learning technologies, as well as exploring how they learn complex science content using these tools. To conduct a study of this nature we needed an alternative theoretical framework; a framework that would allows us to be responsive to the participating teachers’ professional development needs, the students’ voices, and at the same time allows us to implement an intervention approach that uses suggestions from recent research and from various reports that call for education reform. This approach is called sociotransformative constructivism.

Sociotransformative Constructivism and Teaching for Diversity and Understanding

Sociotransformative constructivism (sTc) is a theoretical orientation to teaching and learning that affirms that knowledge is socially constructed and mediated by cultural, historical, and institutional contexts (Rodriguez, 1998). Therefore, having a better understanding of how the interactions of these contexts influence what is taught to whom and how creates multiple opportunities for meaningful learning. As such, sTc is an orientation that draws from multicultural education (as a theory of social justice) and social constructivism (as a theory of learning). Therefore, through sTc teachers and students can work collaboratively to move beyond covering the prescribed curriculum to create a sense of praxis; that is, a space where teachers and students feel enabled to deconstruct the official knowledge and
the structures of power that serve to sustain its production and reproduction. In this way, all learners could ultimately see themselves as critical consumers and producers of knowledge to advance social justice goals instead of seeing themselves as spokes in a wheel that keeps rolling and over which they have no control.

For more information on sTc, see Rodriguez and Zozakiewicz (2005), Rodriguez and Kitchen (2005), and Rodriguez (2002). These manuscripts include more detailed examples of how sTc was applied in elementary, high school and college-level classroom settings. In these previous studies, we have found that sTc has had a positive impact on teachers’ practice and on students’ learning. For this project, we are particularly interested in finding out what kind of challenges arise when using an sTc theoretical framework that also has a focus on integrating learning technologies in culturally diverse science classrooms.

There are four closely connected components that make sTc possible: The dialogic conversation, authentic activity, metacognition, and reflexivity. We are not suggesting that these components be implemented in any particular order or “levels.” In fact, these elements may be implemented concurrently as appropriate in order to assist teachers and students to make more meaningful and socially relevant connections between content knowledge and how that knowledge is used to serve them (or not).

The dialogic conversation is a more complicated and deeper kind of dialogue because the goal is to understand not just what is being said, but the reasons (emotional tone, ideological and conceptual positions) the speaker may have chosen to say what he or she says in that particular context (Bakhtin, 1986). For Bakhtin (1986), “all words have a ‘taste’ of a profession, a genre, a tendency, a party, a particular work, a particular person, a generation, an age group, the day and hour. Each word tastes of the context and contexts in which it has lived its socially charged life” (p. 293). Therefore, the dialogic conversation enables the speakers to be more attentive to not only what it is being said but also to the ideological location(s) the speakers’ words reflect. For the dialogic conversation to be a fruitful and transformative process, trust amongst all participants is paramount.

Authentic activity involves engaging students in hands-on, minds-on activities closely resembling the work that scientists do. At the same time, these activities are made to be more socioculturally relevant and tied to the everyday life of the learner. This means that it was not enough for us, for example, to highlight the importance of gender-inclusive curriculum in space exploration. We also needed to model how this curriculum could be enacted by engaging teachers in authentic activities and providing support for them to implement this curriculum in their own classroom contexts. The third element of sTc is metacognition. According to Gunstone (1994), “learners are appropriately metacognitive if they consciously undertake an informed and self-directed approach to recognizing, evaluating and deciding whether to reconstruct their existing ideas and beliefs” (p. 133). Thus, metacognition can be defined as the “knowledge, awareness, and control of one’s own learning” (Baird 1990, cited in Gunstone, 1994, p. 184). In our work, we extend this definition by encouraging teachers and their students to also ask
questions about the purpose for and the reasoning behind certain activities. In this way, learners could become more reflective about their preferred learning patterns and how these interact in preventing or assisting them in learning new concepts.

The final element, reflexivity, involves becoming critically aware of how one’s own cultural background, socioeconomic status, belief systems, values, education, and skills influence what one considers it is important to learn. In order words, through reflexivity one becomes more aware of how issues of power influence the prescribed curriculum (what we are required to learn), the standardized assessments (how we are required to demonstrate achievement), and how the curriculum and standardized assessment often drive the pedagogy. This new awareness encourages teachers and their students to explore more effective ways to be positive agents of change by acknowledging the role each person can play in maintaining or disrupting the status quo. To make the sTc components more clear, each one will be highlighted in the Findings section within the context of activities conducted with the participating teachers and their students.

Next, the qualitative research methods used for data gathering and analysis will be discussed.

METHODOLOGY

Design of the I²TechSciE Intervention Project

Integrating Instructional Technologies with Science Education (I²TechSciE) is a three-year longitudinal professional development research project that takes place in the Pacific Southwest of the United States. I²TechSciE is also a collaborative partnership formed between one local K–6 school which serves a culturally diverse student population and three university faculty members at a local state university. The principal researchers of the project are university professors with extensive experiences in multicultural education, teacher education, science education and learning technologies. As teacher educators/scholars, we bring different cultural and gender identities to this research study: one professor is an Anglo woman, one is an Anglo male, and one is a Latino who is bilingual in English and Spanish. The participating teachers include all the fourth, fifth and sixth grade teachers on-site at the school, including the special education, bilingual and regular education teachers. Ten teachers are involved in I²TechSciE: two Latinas, three Latinos, one Anglo male, and four Anglo females, with varying years of teaching experience from two to fifteen years. The school has a culturally diverse population of students including 56.5 percent Latino/a, 5.6 percent African-American, 18.8 percent Anglo students, 2.6 percent Asian, .6 percent First Nations and 16 percent Other (Such as bicultural). Each year, on average, the school population is 37 percent English Language Learners, with 37 percent of students being eligible for free lunch (students are eligible for the free or reduced cost lunch program based on their family’s annual income). Recruitment and selection of this school was also based upon the commitment of all the teachers to work collaboratively throughout the entire three years of the
project. During year one, teachers helped the research team recruit a representative sampling of twenty students from each grade 4, 5 and 6 participating classroom to be followed each year through grade 6. Each consecutive year the I2TechSciE students in grade level focus groups are placed in classrooms with the participating teachers to ensure continuity and to study the longitudinal influence the project has on the students' attitudes toward and achievement in science.

**I2TechSciE Professional Development Experiences**

Professional development experiences are continuously offered throughout the I2TechSciE Project. For example, a two-week professional development institute is provided each summer for the participating teachers, the first was during the summer before the first year of the project, and the second took place during the summer between the first and second year of the project. Each summer institute is collaboratively planned with the participating teachers and is designed to meet their professional needs based upon our on-going conversations and classroom visits and a written pre-institute survey. The institutes center upon modeling science learning activities that are sTc in orientation and focus on the integration of science content and learning technologies. During the institute, teachers develop science curriculum units that are multicultural, inquiry-based, and gender-inclusive (sTc), and will be implemented in their classrooms during the following year. In addition, during the regular school year, teachers are required to attend and actively participate in monthly meetings to share the classroom activities they have implemented with their participating colleagues and reflect together on how such curricular activities are impacting their students. These meetings are also used to troubleshoot any obstacles or challenges that arise in meeting the goals of the grant, and provide the opportunity for additional professional development experiences. Teachers receive financial stipends for their professional time during both the summer institutes and yearly participation in the project.

The budget for the project allowed for the purchase of state of the art learning-technology equipment that could be housed for easy access at the participating school site. This instructional technology included a cart of nine i-Books with an Airport station that allowed any classroom to become an Internet ready computer lab, printers, digital and digital video cameras, CD burners, scientific probes with software to collect and analyze scientific data, a school-wide subscription to Brain-Pop (a live website that displays informational movies on all subject areas specifically designed for public school teachers and students), and a variety of science-related computer software.

Two very unique facets of I2TechSciE as an intervention project are its longitudinal three-year design and its responsive, on-site and on-going support. In fact, in our other professional development projects we have found strong evidence that these factors are very successful in helping teachers to change their science teaching practices (Rodriguez & Zozakiewicz, 2005; Zozakiewicz & Rodriguez, 2007). In these cases, professional development must move beyond summer institutes and monthly meetings alone. Research staff make weekly visits classrooms to provide on-site support, such as: helping with classroom instruction, modeling learning activities with students, collaboratively planning with teachers, and
supporting teachers and students in the implementation of a variety of learning technologies. When visiting classrooms, we acted as both teacher supporters and researchers, helping with the teaching and learning process, and gathering data to better understand how the culturally relevant learning activities and technology being implemented were impacting students’ participation and achievement in science. This unique part of the design also allowed us to see, first hand, what challenges and struggles emerged for the teachers as they were working to change their science teaching practices. Being such insiders to the process of school reform gave us the opportunity to capture and better understand the contextualized and complex story of reform as it unfolded in actual classrooms with committed teachers and diverse students. This made us privy to particular challenges on-site that can slow or stop progress toward reform. By being there with the teachers and their students, we were also able to develop contextualized intervention strategies we hoped would help to manage the tensions and challenges in order to keep us moving forward with the progress we were making.

DATA COLLECTION AND ANALYSIS

We collected multiple data sets during year one and two of the project. To begin, the participating teachers were interviewed two times during the first year and three times during the second year of the project. These interviews were videotaped in order to capture the nonverbal nuances of communication in addition to the verbal transcripts. Beyond the teacher interviews, we held two focus group interviews with the fourth-, fifth-, sixth- grade students during each year of the project, one at the end of the fall semester and one at the end of spring semester each year. The focus groups were done in same gender groupings in order to ask questions about gender dynamics in the classroom. During year two, we had follow-up interviews with the same focus group of students, though they were now in new grade levels with different teachers (who were also participating in the project). In addition to such data sets, we completed and collected on-going surveys, transcripts and video clips of monthly meetings, classroom artifacts, field notes, district documents, and various school assessment artifacts. Finally, for each science unit, we collected lesson plans, assessment artifacts, and pre and post concept maps that were completed as tests at the beginning and end of each unit at each grade level. For this paper, we are concentrating on several sections of analysis within the larger research project that occurred during year one and two of the project. Our interest here is in sharing the analysis of the interviews, artifacts, concept maps and field notes that directly pertain to the strategy of Students as Change Agents, that emerged during year one and two of the project.

Using an ethnographic approach to data gathering and analysis (Spradley, 1979), all concept map data, interview and meeting transcripts, classroom artifacts, videos and photographs, transcripts and classroom field notes were reviewed multiple times by each member of the research team. As themes emerged, the team ascertained their validity and strength by triangulating surfacing claims across multiple data sets. Since multiple data sources and all three members of the
research team reviewed all data (Erickson, 1986), we were able to draw relevant insights about the impact this intervention project had on the participating teachers and researchers’ efforts to learn to teach for diversity and understanding with the integration of learning technologies during the first two years of I²TechSciE. We were also able to determine what strategies were emerging that proved beneficial to the participants as we were all collaborating toward making classrooms more culturally and gender inclusive learning spaces for science with the inclusion of learning technologies. One set of strategies that emerged, as being particularly useful for our project teachers and their diverse students was Students as Change Agents.

Though culturally relevant science and the integration of learning technologies are the focuses for this intervention project, we believe our findings reveal insights that will prove beneficial to the larger professional development and reform literature within and beyond these particular areas.

FINDINGS

Teachers in today’s culturally and linguistically diverse classrooms face a multitude of factors that impact their everyday professional and personal lives (e.g. standardized testing, overcrowded classrooms, lack of resources and professional development support, etc). Therefore, we realized that progress was going to be slow due to the competing demands teachers face; however, we were troubled by the slowness of our progress in most of the teachers’ classrooms (6 out of 8) and by the incongruence between the teachers’ espoused beliefs and their beliefs in action. Having the teachers follow through with their stated professional goals became one of the key challenges we encountered. In other words, all of the teachers were ideologically congruent with the social justice and social constructivist theoretical framework of the study, but most of them (6 out of 8) often did not implement the student-centered, culturally relevant and learning technologies-driven pedagogical strategies we modeled during the first summer institute and during the first year of the project unless we were in their classrooms to support them. This was puzzling to us because unlike our previous projects in which we often had a few teachers who resisted teaching for diversity (resistance to ideological change) and/or resisted to teaching in student-centered and inquiry-based ways (resistance to pedagogical change) [Rodriguez & Kitchen, 2005], none of the participants in this study displayed any overt resistance. In fact, the participating teachers often commented during informal conversations and interviews that they could really see how students were more engaged when they implemented the hands-on and multicultural activities we modeled during the two-week summer institute. Our numerous visits to the teachers’ classrooms and on our interactions with their students (which included formal focus groups interviews) validated the teachers’ comments. Furthermore, our analyses of the post-summer-institute surveys and five in-depth interviews with each teacher over the course of two years also showed that they were finding the project useful and relevant to their practice.
So, even though our visits to the teachers’ classrooms and our field notes and interviews indicated that all of them had shown substantial knowledge growth and confidence in the use of learning technologies to teach science in more culturally relevant and inclusive ways, we still felt that teachers could be using the available technology more frequently. That is, they could be using the laptops and other equipment available through the grant when we were not in their classrooms, calling on us for assistance more often and taking more initiative in pursuing their stated professional development goals. If the project was to have the kind of long-lasting impact on the participating teachers’ practice—and the kind of impact needed to significantly impact their students’ learning long after our three-year project expire—the teachers needed to take more initiative in infusing learning technologies and multicultural, social constructivist, and gender inclusive (sTc) strategies into their curriculum.

Despite this challenge, we must note here that we have no way of measuring what impact the project had on the teachers’ practices during science when we were not in the classroom, or the impact it has had or will have on their practices during other content area instruction. It might be that some of the seeds planted during the project did take hold during other times of the day, or will take hold after the project is over. We can only hope that such does occur. For example, one finding worth noting here is that at the end of year two, the faculty came together at the participating school and ordered a mobile laptop cart with ten laptops of their own. It arrived at the beginning of year three of the project for all the teachers in the school to use including the project teachers. We believe that the non-project teachers voted in favor of purchasing the computer cart because they saw how students and the project teachers were benefiting from the integration of learning technologies in their classrooms.

Even so, progress across project classrooms was still not going as well as we had hoped. This issue became another of the most difficult challenges we encountered—managing our own sense of urgency to effect change. This challenge raises related questions for all those interested in teacher professional development and school reform. For example, given funding agencies’ finite support and their expectations to yield results, how long does it to take effect positive and long-lasting change in teachers’ practices and in students’ learning? Should researchers and school administrators work only with teachers who demonstrate rapid professional growth regardless of the contexts in which they work?

We chose to continue working with all of the participating teachers to better understand the challenges encountered and how to manage them. Thus, findings from the analysis of multiple data sets for the first two years of the project are organized in Figure 2.1. Therein, the two key challenges we encountered and the three broad intervention strategies we used to address or manage these challenges are shown. As mentioned earlier, in this paper, we focus our discussion on one of those strategies, Students as Change Agents. As Figure 2.1 also indicates, each strategy involved a variety of action components through which the strategy was enacted. We have already reported elsewhere, the action components related to
STUDENTS ACTING AS CHANGE AGENTS

Prompted Praxis (see Rodriguez, Zozakiewicz, & Yerrick, 2005). The action components related to the strategy of Modeling and Demonstrating will be reported soon in a different manuscript. Below, each of the action components we used to enact the strategy of Students as Change Agents is discussed in more detail.

STUDENTS AS CHANGE AGENTS

It is important to note than none of the strategies and their corresponding action components indicated in Figure 2.1 were designed a priori. Since this is an intervention study in which the challenges we encountered arose as the project progressed, we sought to work with teachers to address the issues and obstacles we encountered to move toward achieving their stated professional goals and the goals of the project. Thus, for example, the strategy of Student as Change Agents involved encouraging students to enact their own sense of agency and/or use their voices to assist teachers transform their practice. We define agency here as the voice (or “speaking consciousness,” Bakhtin, 1981) that an individual uses to accommodate into, resist against or transform established norms within specific communities of practice. The individual’s culture of course plays key roles in this process, as our learned cultural norms provide certain guideposts that help us navigate the established expectations imposed by the prevailing culture.

Our analyses of multiple data sets indicate that we implemented the strategy of students as change agents through six interrelated action components: (a) student agency; (b) tech wizards; (c) tech coaches; (d) sharing students’ artifacts; (e) sharing preliminary analysis (pre- and post concept maps as assessment tools); and (f) students leading a parents’ night. Some of these action components involve the students directly using their own voices to effect change in their classrooms; while some action components involve the research team using the students’ voices to effect change (e.g. sharing students’ artifacts and sharing preliminary analysis). Each of the action components is explained in more detail below. 3 Table 2.1 also provides a list of the various learning technologies/skills students were expected to use in their science classes.

1. Student Agency

From the start, we were overwhelmed by the positive response we received from the parents and students at this school. We made a presentation during parent night at the beginning of the year and the majority of parents signed permission slips so that their children could participate, which allowed us to interview and videotape their children as part of the project. In fact, we had more students than we were able to include since we could only select a representative group 4 for our focus interviews in all of the participating teachers’ classrooms.

So, we did not encounter any problems in terms of students or parent participation; just the opposite, during the first semester of the project, students across grade levels would see us entering the school or passing between classes and they would greet us with cheerful smiles and invitations like, “Dr. ___, when can we do
science with you again?” or “Dr. ____, when will you be coming into my teacher’s class? We want to use the computers too.” Word traveled fast among the students about the work we were doing in one teacher’s classroom or another. So, the students began making requests of their teachers from what they heard was happening next door. One teacher admitted that his students had repeatedly pestered him to use the laptops because the mobile computer cart continued to pass through his class on its way to other teachers’ classrooms.

Table 2.1 Learning technologies used by participating teachers and their students

<table>
<thead>
<tr>
<th>Vernier Probeware (pH, dissolved O₂, salinity, temp., others)</th>
<th>iMovie</th>
<th>Global Positioning System (GPS) Portable Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Still &amp; Video Cameras</td>
<td>Brainpop</td>
<td>MS Excel</td>
</tr>
<tr>
<td>Earthbrowser</td>
<td>Worldbook Encyclopedia</td>
<td>Digital Microscope</td>
</tr>
<tr>
<td>iPhoto</td>
<td>Web-Based Equity Resources</td>
<td>Robotics (Rover)</td>
</tr>
<tr>
<td>MS Powerpoint</td>
<td>DV Minicams</td>
<td>Sound Studio &amp; iTunes</td>
</tr>
<tr>
<td>Video Projector</td>
<td>Pasco Probeware (magnetic field, light, others)</td>
<td>iBook Cart &amp; Airport</td>
</tr>
</tbody>
</table>

As part of our on-going analysis, we noticed consistently that six out of the eight participating teachers were not making use of our availability and of the computer equipment as often as we had hoped, or as often as they said they would. In other words, given the teachers’ espoused beliefs and commitment to the project, we were expecting them to take the initiative in using the available equipment for other science activities that went beyond those we modeled during the summer institute and/or invite us to their classrooms to assist with new ideas. Therefore, we capitalized on the students’ interest and encourage them to act on their own agency. That is, whenever students came to us to ask when we would be visiting their classrooms and when would they get to use the learning technologies offered by the project, we would encourage them to share these requests with their teachers, saying something in the order of, “We want to come to your classrooms
too and work with you during science. Why don’t you let your teacher know that you want to use the computers on the cart during science time?”

This action component helped put more pressure on the teachers to use learning technologies in their classrooms. For example, Jack was a very enthusiastic supporter of the project, but one of the teachers who used the available technology the least during year one. When we asked him how his students were responding to the use of learning technologies, he stated,

They’re excited. They’ve seen the cart come through the room and you know they’re always asking when we can use it and what the class next door is doing. So they pick up on it. I mean my classroom is kind of a focal point where everybody comes through there, so they get to see a lot of that. And they’re always curious as to what’s going on next door. (Jack, Interview 2, Year I, p. 2).

When we asked him what his goals were for the next year in terms of using the available technology and our support, Jack explained:

I see the cart going around and I know that I’m not at the same spot as like Ricardo and Becky in terms of what they’ve done. And that bothers me because initially I was one of the ones that were always out there and trying to implement new stuff so I mean I set some goals for myself to utilize not only you guys but what we have here. And I’m bragging about [the project] all the time to my cohort, but I can’t honestly say I’ve utilized it to the extent that I need to, so . . . (Jack, Interview 2, Year I, p. 4).

Jack’s responses are examples of how we used the dialogic conversation and reflexivity (two of the elements of the sociotransformative constructivist [sTc] framework mentioned earlier) to facilitate honest and introspective discussions with the participating teachers. In this way, we also encouraged them to reflect about the differences between their espoused beliefs (their stated professional development goals) and their beliefs in action (what they were actually doing—or not—to transform their practice). Based on this type of responses from the teachers, we believe that the students, who were acting on their sense of agency, played an important role in the teachers’ reflections and plans for changing their practice.

2. Tech Wizards

By the end of year one, the three grade four teachers stated during interviews and classroom visits that they got frustrated when the laptops hung, the wireless printer was not working or was too slow, or when students had questions they could not answer regarding science content and/or learning technologies. Even though we visited the classrooms often, we could not be in all of their classrooms all of the time. Since this was an intervention study with an emphasis of being on-site, ongoing and responsive to the teachers’ concerns, we decided to carry out special workshops sessions with small groups of students (4–6) from each grade level. The goal was to train these students, who were identified by the teachers as
computer “wizards,” so they could become experts in the use of various learning technologies, such as using the scientific probes with the laptops, and/or using i-Photo, i-Movie, Inspiration and so on. In this way, when these students returned to their classrooms they could help their teachers set up equipments, trouble shoot, and assist with connecting the science content with the chosen learning technologies. Since all classes were large (28–32 students), and since we only had nine laptops available in the mobile cart, it was important to maximize the teachers’ instructional time and reduce their set up time. We also wanted them to experience more success in using the equipment so they could focus more on making their lessons inquiry-based and culturally relevant.

This action component was well received by all of the teachers, and we knew it was having a positive impact in the classroom during our weekly visits because we saw students actively trouble shooting minor issues as they came up, providing us and the teacher with more time to assist students in completing the tasks at hand. Another indicator of the success of this action component is the fact that the teachers requested that we do the workshop with their students in the following term. Since we were following a cohort of students from grades 4 through 6, we had the opportunity to provide students with even more advanced instruction in the use of learning technologies during the following years.

By the end of Year 2, we saw a lot of improvement and we rarely heard complaints about minor issues with the equipment. The grade four teachers, however, were still experiencing some difficulties that we believe had to do more with learning to manage the students than with the technology. For example, Maria explains during an interview:

I’m using my wizards a little more now, so that’s helped, but it’s still just challenging. . . just dealing with the technology cause things get slow. Things freeze. We lose things, so that’s still a challenge and I’m still trying to figure out how to make it smooth. I still dread going into the computer lab when it’s a project that they’re working on that’s ongoing cause some of them don’t save it or they save it in the wrong place. They’re just not trained yet, so if I could do something at the beginning to train them a little bit better. I mean we try. We go over it and we repeat and just not sure how to make it flow. (Maria, Interview 2, Year II, p. 13)

While these situations related more with getting grade 4 students accustomed to a working routine (e.g. saving their work), by the time they entered grade 5 and grade 6, these management issues were minimal. In fact, the grade 5 and grade 6 teachers often stated that they were pleased to have students in their classrooms that already had considerable knowledge about how to use the available technology. This is related to the next action component, Tech Coaches.

3. Tech Coaches

An extension to the Tech Wizard action component to support teachers was to involve the same students and other students in the classroom as peer coaches. For
example, the research team and the Tech Wizards would work with groups of students within the classroom and teach them the technology task at hand. If students in a group completed the task (e.g. power point slides or i-Photo animation), that group was broken up and the students were assigned to be peer coaches for another group.

Abigail provides an example of how she used Tech Coaches in her classroom,

> When we had centers, what I did was I made sure that the groups were, like not ability groups, but there was at least one person who I knew was strong with the technology. So if they had to do Brain Pop, they knew that, you know, that person could lead them. “No. Make sure you go to this website” and made sure they followed along, so putting like a strong person that could guide the other kids, that definitely, you know, you just mix their abilities so that each get to share their strengths. (Abigail, Interview 2, Year II, p. 5)

Ricardo also explains how he felt that the Tech Coaches action component helped increased communication and collaboration in his class. In this example, he is talking about how his students were helping each other edit digital video as part of an Earth Science lesson:

> They each add their own little twist to the video, you know, I think maybe we should do it this way, why don’t we try this, and each of them just by communicating with one another, puts in their own little bit. I’ve noticed that the amount of communication between the students is fantastic. I mean it forces them to have to communicate and work together…. (Ricardo, Interview 2, Year 1, 8).

4. Sharing Students’ Artifacts

The students also acted as agents of change within and across classrooms because the participating teachers were encouraged to share the students’ completed work at monthly meetings and by posting them on their school Internet server. This made it possible for teachers (and their students) who were just beginning to use a potentially challenging new technology (e.g. iPhoto for creating animated shorts) to see examples of completed projects before they began developing their own. For example, Becky described a lesson where the students used digital cameras, animation software and materials of their choosing to demonstrate through an animated short video, the three kinds of plate boundary movements:

> Well we’ve used the technology to demonstrate concepts from the science book. And it’s helped tremendously, especially with the different boundaries—divergent, convergent, and transform boundaries—to be able to understand those concepts. And when you use the technology along with the hands on experiments, it does help students learn. So, they can take that knowledge and maybe take it one step further because now they actually understand what’s going on with that particular concept. They get bored
reading the book because half the time they read it but don’t understand it because they can’t visualize it. And I noticed it in class once they started working on these projects. It definitely makes such a big difference. . . . And they love using the cameras and it’s fun for them, but yet they’re still learning. So it’s not just fun and games and not learning the standards but actually taking the time to make learning more meaningful. (Becky, Interview 2, Year 1, 13)

Becky’s students shared their animation products on the three plate boundaries with the neighboring classroom to help support them as they began the same project. Her students provided an important resource for Ricardo’s students, and as a result his students completed the project a few lessons earlier than Becky’s.

Jack also commented that teachers from the lower grades had asked for samples of his students’ work to use as models, “I think is kind of cool that the other grade levels are gonna be able to use our students’ finished products as an introduction to their units” (Jack, Interview II, Year II, p. 1).

In our view, the above examples are also excellent indicators of how two other elements of sTc-metacognition and authentic activity—impacted the participating teachers and their students. Since the teachers were exposed to a variety of authentic inquiry-based and culturally relevant activities using learning technologies, they were able to replicate or modify these activities to their teaching contexts as illustrated above. By being conscious of how they engaged with these activities as learners during the institute, and by being aware of how their students engaged with similar activities during the school year, they were better able to comment on the effectiveness of the pedagogy and technology to impact students’ learning and motivation to learn. As Becky mentioned above, “So it’s not just fun and games and not learning the standards but actually taking the time to make learning more meaningful” (Interview 2, Year 1, 13).

We also hoped that by having teachers talk about and showcase their students’ work at monthly meetings, these strategies would motivate other teachers to implement more inquiry-based and culturally relevant pedagogy in their classrooms. For example, one approach Becky and Ricardo used for making their units more culturally relevant was by having their students visit the Society for Advancement of Chicanos and Native Americans in Science’s web site (www.sacnas.org). At this site, students were to select and read a short biography about a female or traditionally underrepresented scientist in a field relevant to the science unit being covered. Students were then required to either answer questions about these scientists or create a multicultural digital quilt. That is, summarize the biographical information using Word or Inspiration software, then use clip art or other tools for decorating their contribution. All of the “patches” or students contributions were then printed and posted on the wall to create a digital quilt.6

By having teachers and their students more purposely pursue ways to raise cultural awareness and celebrate the contribution of traditionally underrepresented scientists (whose cultural backgrounds mirror those of the students’ in the classroom), we were encouraging them to become more reflexive. That is, to become more aware of who are recognized as scientists, who are the individuals
highlighted as scientists in their prescribed textbooks and other resources, and to engage in dialogic conversations about why there are so few scientists from diverse cultural backgrounds, and so on.

5. Sharing Preliminary Analysis (Using Pre- and Post Concept Maps as an Assessment Tool)

This action component is closely associated with the one described above, but this one is primarily drawn from the analysis of the accumulated research data (teacher and student interviews, field notes, teachers and students’ artifacts, etc).

It is important to mention at the onset that that t-test analyses of the students’ pre- and post unit concept maps showed significant knowledge growth across grade levels for all the units we tested (i.e., Plate Tectonics, Grade 6; Cell Structure and Function, Grade 5; and Living Things, Grade 4). However, the levels of implementation of social constructivist and culturally relevant pedagogical strategies using learning technologies for these units varied a great deal depending on the teachers and their grade levels. Needless to say, these findings are too complex to also include in this manuscript; therefore, they will be described in a separate article along with how we also used the concept maps as tools for collaborative planning with the participating teachers. In that manuscript, we will also discuss in more detail the third major intervention strategy we implemented in this project; that is, Modeling and Demonstrating (see Figure 2.1).

In this section then we wish to only draw attention to the potential impact the sharing of preliminary qualitative analyses may have on teacher professional growth. For example, at our monthly meetings, we shared actual quotes from the students’ interviews across grade levels that illustrated how students were responding to their teachers’ efforts to integrate learning technologies in more inquiry-based and culturally relevant ways. We also discussed representative quotes from students about what activities helped them learn the most in science, and what they wanted their teachers to change about the way they taught science. Pseudonyms were of course used to protect students’ identities whenever such data was shared. These are several examples of how we used the students’ voices as a form of agency:

Like with boundaries, how we used i-Photo and i-Movie. I think instead of reading out of books, it’s easier because we make like movies out of it. You could actually see what convergent boundaries are. And like in movies, they move so you can see how they work (Anthony, Interview 2, Year 1, 13).

Without the grant, it would be boring, all books and lectures. We do enough reading during Language Arts. Science should be more hands-on (Monica, Interview 2, Year II, 15).

Instead of reading out of the book, we should do more projects. We should be able to do something with what we read (Elsa, Interview 2, Year 1, 9).
To make it a little fun. . .So, like, more projects and, like, you could do activities with it. So it won’t be so boring. . .Like use the digital cameras to take pictures outside and use the computers more. (Maria, Interview 2, Year 2, 7).

Figure 2.1 Strategies and their respective action components used to address the challenges encountered.
While we stressed that many students felt that nothing should change in the way their teachers taught science, we wanted to expose the participating teachers to some of their students’ thinking about how some of them felt about how they learned best. Though the privacy of the students was protected, the teachers began to discuss which comments might have referred to their classrooms.

We hoped that by allowing teachers to listen to the students’ own voices this would be another way of encouraging teachers to reflect and to make better connections between their espoused beliefs and their beliefs in actions. However, while our interviews and informal conversations with the teachers revealed that this strategy did cause them to reflect, it appeared to have only a temporary effect on most of the teachers’ actions. We elaborate on this finding in the conclusion section.

6. Students’ Leading Parents’ Night

One more action component we implemented within the strategy of students as change agents was supporting students to lead a parents’ night. During the second semester of year 2, we encouraged teachers to select a group of students from each classroom to take the lead in presenting what they had learned during the year to their parents. For this action component to work effectively, students needed to be completely in charge of presenting (i.e., a small group of no more than four students selected a class project or activity of their choice to share with their parents, and they were to do the presentation on their own). Since many parents spoke Spanish as their first language, one of the students in each team was in charge of also translating the team’s presentation into Spanish.

Our role (and that of the teachers) was only to provide support and suggestions, which left the students in charge of demonstrating how the available technology (e.g. power point, iMovie, iPhoto, iBook, Inspiration, animation, and data probes) had helped them complete a relevant science project in their classrooms. The teachers commented that it was hard to select a group to present their work because everyone wanted to participate, so the teachers used good behavior and commitment to prepare the presentations as a way of selecting the group to represent the whole class during Parents’ Night.

It was interesting that one of the students with the most behavior problems in one of the grade 5 classrooms was selected to participate. The teacher used this event as a way to encourage him to improve his behavior in class. He demonstrated a strong commitment to be involved in the project even though his parents could not attend the event. He also managed to secure a ride with the parents of one of his peers so that he could stay after school the night before to rehearse the presentations and troubleshoot (another one of the requirements to be allowed to participate in this event). He and all the students did a fantastic job presenting their projects in front of about 100 parents. Our web site includes many pictures and short video clips of the various activities conducted during the first two years of the project (see edweb.sdsu/edu/i2techscie for more information).
Again, while this event was very well attended and very successful at multiple levels, one of the reasons we used this action component was to encourage some of the teachers to move more decisively forward with their stated professional goals. We thought that by having parents informed of what their children have been accomplishing in science using learning technologies, and by having teachers and students see what others have been doing as a result of being involved in this project, the end result would be increased participation by some of the less involved teachers in the project.

CONCLUSION

Our results indicate that overall, teachers increased their science content knowledge and skills in the use of learning technologies to make their classes more inquiry-based and culturally relevant. In addition, our analysis of two years of ethnographic interviews and other data sources indicated that the participating teachers valued their involvement in the project and that they felt they were making good progress toward their stated professional development goals. Whereas we acknowledge this growth and the teachers’ efforts, we still felt that the majority of them (6 out of 8) were working at a pace for integrating learning technologies and culturally relevant science that was incongruent with what they had stated they wanted to do as teachers in this culturally diverse school. In other words, most of the participating teachers tended to use the available technologies, lesson plans, and activities we helped them design during the summer institute or during the school year only when we were in their classrooms or only for those lesson plans and activities. As mentioned earlier, our original agreement was to model and provide support during the summer institute and first fall term, but then the teachers were to gradually take more initiative in the development of activities and the integration of technologies. Our numerous in class observations and focus group interviews with the students clearly indicated that this goal was being met in only two of the teachers’ classrooms.

Therefore, the biggest challenges we encountered in implementing this study were having the teachers follow through their stated professional development goals and changing their teaching practices, and managing our own sense of urgency to effect change. We have explained that since this was an intervention project, our responses evolved according to the issues we encountered in the field. Thus, we implemented a variety of strategies along with their corresponding action components (see Figure 2.1) that tended to have a positive, yet temporary, impact on most of the teachers’ practices. Again, our in classrooms observations, analyses of student focus group interviews, and quantitative analyses of the unit concept maps strongly support this claim. The students were indeed more engaged with the content knowledge and making more socially relevant connections between the content and their everyday lives. However, the majority clearly expressed that they could do more and that they wanted the available technologies to be used more often as well as being provided with more opportunities to do projects.
We agreed with the students, and we were also concerned that the strength of the teachers’ commitment (espoused beliefs) needed to match the pace of their involvement in the project (their actions in the classroom). Therefore, we revisited the goals of the project again with them at end of year one, and we provided them three options meant to further clarify their levels of participation in the project for year two. We offered the option that if they wished to continue to have full access to the mobile computer lab and the equipment and full access to us to support planning, gathering resources, teaching, and so on, they needed to help improve the communication (sometimes we had agreed to come to assist in the classroom only to find out that some of the teachers were not there that day); collaboratively plan a unit with us and give us a copy of the lesson plans for that unit (we were still struggling to get teachers to finish all of the lessons in a unit that was started during the summer institute); teach the complete unit (in the first year some units were not taught as planned or included few of the inclusive strategies we all agreed to use); and assist us in administering a pre and post concept map in order to evaluate the students’ cognitive growth for that unit. The other option for participation in the project was to allow us to teach a unit in their classroom—with the teacher playing a more supportive role. The third option was to simply quit the project without any negative consequences. All the participating teachers chose the first option, and all of them restated that they were committed to the professional development goals of the project.

During Year 2 of the project, we implemented the various strategies described above in addition to Prompted Praxis (Rodriguez, Zozakiewicz, & Yerrick, 2005) and Modeling and Demonstrating (manuscript in progress). While we observed significant progress in the teachers’ involvement, we continued to be concerned with the differing levels of participation demonstrated by most of the teachers (6 out 8), and we continued to be beset by the same challenges—our sense of urgency to effect change and the slow progress in implementing more inquiry-based, multicultural, bilingual, and gender inclusive strategies.

By the end of Year 2, we decided to expand the project to two other schools and continue working with the current teachers only if they met with us in advance to collaboratively plan units in which they would be taking the lead and that were congruent with the goals of the project. We only heard back from the same two teachers who have continuously showed interest in matching their espoused beliefs with their beliefs in action. As we have started working with a new group of grade 4 through 6 teachers from two other schools, we are eager to explore the similarities and differences in teacher cultures we have encountered thus far. It will be interesting to investigate whether the difficulties we have encountered are due to the overall teacher culture in this particular school district and/or other factors.

IMPLICATIONS: WHAT DOES IT TAKE TO EFFECT LONG-LASTING CHANGE IN TODAY’S SCHOOLS?

Overall, more than 240 fourth- through sixth-grade students per year for two years so far have benefited from participating in this project. They were exposed to
innovative learning technologies and culturally relevant science content that they would have not experienced if it had not been for the participation of their teachers in this project. Whereas the study was very productive at various levels and increased the students and teachers’ science content knowledge, and proficiency in the use of learning technologies, as well as the teachers’ pedagogical knowledge, the design of the project revealed other important aspects. That is, the ethnographic and longitudinal design of this intervention project enabled us to gain new insights and formulate new questions regarding the complexity of effecting long-lasting change in today’s schools:

1. What would it take to assist teachers in making a better connection between their espoused beliefs and their beliefs in action?

Unlike other professional development projects we have conducted, we encountered no overt resistance to teaching for diversity or for understanding amongst the participating teachers. In fact, this group reiterated their commitment to the project goals and their professional development goals at each interview. Yet, the pace and the depth at which they were connecting their espoused beliefs with their beliefs in action were incongruent. Only two of the eight teachers were demonstrating the kind of initiative and effort required to effect the changes in practice necessary to make such changes last long after our three-year project was completed. Therefore, we felt that what might be lacking to motivate the remaining teachers to take more decisive action was a policy or mandate from administrators. In other words, whereas we have the strong support of the school principal for the project, it seems that the kind of bottom up change we were seeking also needed the support of a top down mandate that made clear that the integration of learning technologies with culturally relevant science was required within a given time frame. We know that this approach can yield fruitful results, as it was the case in the systematic reform initiatives in Puerto Rico and Miami (Rodriguez, 2004).

Another group of stakeholders we did not include more actively in this project was the students’ parents. We believe that parents could have played an important role if we had solicited their support in terms of asking teachers to infuse more technology and culturally relevant science content in their children’s education more often. Perhaps, having the Parents’ Night twice every semester instead of at the end of each semester would have been a way to increase accountability.

2. What would the results of this study look like if it did not have an ongoing, onsite and responsive design?

It is important to note that if we had chosen to conduct a study that relied only on findings from teachers’ interviews and on sporadic visits to their classrooms, the results of this study could have been reported as another cheerful narrative on teacher professional development. However, the onsite, ongoing and responsive ethnographic features of the study enabled us to...
investigate more deeply the complexity of effecting long-lasting change in culturally diverse and urban schools. In addition, since the study was guided by a sociotransformative constructivist orientation, it inherently expected the teachers (and the researchers) to demonstrate changes in practice (beliefs in action) that were congruent with the stated professional development goals (espoused beliefs). As the teachers were often asked to reflect on whether their beliefs in action were matching their espoused beliefs, the analysis of their responses provided us with more insights into how difficult (and gradual) changing teachers’ practice could be.

3. What would teacher professional development look like without teachers at first?

The design of our intervention study was based on previously successful professional development work and what we know is effective from the work of others. However, since this was an intervention study that evolved in response to the challenges we encountered the strategies and action components described in Figure 2.1 were created and implemented as the project progressed. All of these strategies and action components had a long-lasting and positive impact on the students based on the focus group interviews, and on their academic performance and increased skills in the use of learning technologies. However, the same strategies and action components had a positive—yet temporary—impact on most of the participating teachers. As it was observed that after the various action components were completed most of the teachers reverted back to not taking the initiative to use learning technologies on their own to make their science content more culturally relevant and social constructivist. This finding makes us wonder whether teacher professional development should more centrally include the participation of students as well. For example, we might start with a small group of students who can act as Tech Wizards and Tech Coaches in the classroom, who can later provide support in the classroom after their teachers have received similar training. Another example might find us working with teachers and students side by side in a summer institute together. Another model that is very promising is having project students enter the teacher education process, and visit and lead an activity in a science methods class. We actually used this model in the PI’s science methods class during year three of the project. A group of grade six project students came to the pre-service teachers’ course and lead an insulation activity that had already been completed in their own classrooms. During this activity the sixth graders taught the student teachers how to use the learning technologies, in this case the laptops, temperature probes and Logger pros with software program for data collection, along the way to solve the insulation problem. If there were any misconceptions in the student teachers’ minds about what elementary students could do in science with problem-based learning and learning technologies, those were disrupted on this day. Based on such examples, and many possible others, elementary students can continue to use their role as
Change Agents (see Figure 1.1) to encourage their teachers and teachers to be (and their peers) to do more inquiry-based and culturally relevant science using learning technologies.

We explore these new insights and approaches during Year 3 of the project, as we continue to investigate the complexity of effecting long-lasting change in today’s diverse schools. Our study illustrates that impacting teachers’ practice is a lot more complicated than what some politicians, administrators and teacher educators may believe is possible through their reform policies. The strategies we have described here will hopefully add to the repertoire of innovative strategies that will be needed to effect positive and long-lasting change over time depending on the school context and teacher culture. One of those strategies that appear to be promising is providing students with the tools to become change agents in their own classrooms.

ACKNOWLEDGMENTS

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NOTES

1 By the end of year one, two teachers left the school. One chose early retirement and the other decided to open a business.
2 These results will be reported in a different manuscript, where findings from pre- and post instruction unit concept maps are shared to demonstrate the impact on the students’ cognitive growth.
3 The reader is encouraged to visit our project web site at http://edweb.sdsu.edu/i2techscie to view video and photo galleries, and samples of classroom activities that provide a richer context for the findings section that is constrained by the two-dimensionality of the written word and the economy of page limits.
4 As mentioned in the methodology, we selected students from low to high academic achievement levels, native and non-native English speakers, and conducted same gender focus group interviews for each classroom.
5 Brain Pop is web-based software that provides animated shorts to explain complex scientific concepts. Teachers and students found this software very useful. More information can be found at www.brainpop.com.
6 It is worth pointing out that all teachers ended up using the multicultural digital quilt strategy at the beginning of the school year as a way to introduce the use of digital cameras and i-Photo, and as a way to build community by having students write about themselves and their culture.
REFERENCES


COMMENTARY ON RODRIGUEZ, ZOZAKIEWICZ & YERRICK’S STUDENTS ACTING AS CHANGE AGENTS IN CULTURALLY DIVERSE SCHOOLS

In their chapter, Rodriguez, Zozakiewicz, and Yerrick (herein referred to as “the Authors”) paint a refreshingly non-airbrushed portrait of their work with the Integrating Information Technologies with Science Education (I²TechSciE) Project. Laudable successes are presented alongside unresolved challenges while provocative questions invite the reader to consider intriguing options and alternatives. This “work-in-progress” discussion of their professional development project offers valuable insights for researchers and practitioners. In this commentary I extend those learnings by examining the related concepts of “intervention study” and “students as change agents,” considering both of them in the context of the I²TechSciE Project. My comments are made to support the Authors’ solid work and to further expand the conceptualization and implementation of teacher professional development to the benefit of culturally diverse students and the educators who teach them.

INTERVENTION STUDIES: A DYNAMIC FORM OF TEACHER PROFESSIONAL DEVELOPMENT

As described by the Authors, an intervention study is “a teacher-centered approach to professional development by which the researchers and teachers collaboratively explore areas in need of improvement (e.g., pedagogy, content knowledge, curriculum) and take steps to systematically evaluate and address the identified areas” (p. 48). Akin to the inquiry process, this approach begins with shared understandings and agreements – such as desired outcomes – and proceeds in a manner that is open to continual questioning and revision based on the evidence at hand. Intervention studies are dynamic, ever-changing projects whose actual activities cannot be determined fully in advance. The goal is clear, how to reach it is a constantly evolving process.

The Authors cite the value of intervention studies in addressing shortcomings in teacher professional development in particular and the US educational system as a whole. Regarding the former, there are issues of fragmentation and intellectual superficiality, as well as participant resistance to the desired changes in ideology or pedagogy. With respect to the latter, the Authors highlight the multi-dimensional nature of the poor science performance of culturally diverse students at the elementary level. When focusing on teachers, this problem has aspects that are
intellectual (low levels of science content knowledge), psychological (low levels of perceived self-efficacy) and pedagogical (heavy reliance on textbooks and worksheets/lack of use of reform-oriented techniques, such as inquiry instruction). Perhaps most challenging to address is teachers’ reported lack of preparation to effectively educate culturally diverse students.

Intervention studies, the Authors argue, provide a solution to many of these problems, at least in theory. Their chapter makes real some of the challenges in having intervention studies live up to their full potential. One contributing factor may be the complex nature of the approach itself. As exemplified by the I2TechSciE Project, intervention studies integrate a variety of professional development strategies – such as study groups, coaching, and demonstration lessons – each of which has its own set of caveats and challenges. Effective implementation of any one of these strategies can take the multiple years envisioned in the I2TechSciE Project. While combination of professional development strategies is a common, if not necessary, practice, the issue of “strategy-overload” is one to be considered in such circumstances.

As gleaned from the Authors’ chapter, intervention studies have five key criteria. They are: (a) teacher-centered – teachers are the central participants and what happens is geared to their needs; (b) collaborative – researchers work in partnership with teachers to determine site-specific needs; (c) improvement-focused – the underlying aim is to improve both teachers’ classroom practice as well as educational outcomes for learners; (d) action-oriented – concrete steps are taken to address identified needs; and (e) data-driven – information on the implementation of agreed upon interventions is systematically gathered, evaluated and used to guide further activity. How a given project fares in each of these areas can provide insight as to its relative effectiveness. Such alignment is explored in the next two sections using the I2TechSciE Project as a case in point.

I2TECHSCIE AS INTERVENTION STUDY

Fundamentally, the I2TechSciE project fits the above-described intervention study criteria. In this section I review the I2TechSciE Project’s alignment with three of the five intervention study criteria: teacher-centered, collaborative and improvement-focused. Insufficient information is provided to constructively discuss the data-driven nature of the project (indeed, the Authors’ mention that this aspect is the topic of another publication) and the action-oriented criterion is taken up in the following section. Throughout this section I make connections to two of the Authors’ self-identified key challenges: teacher follow-through with professional development goals and researcher urgency-for-change.

Teacher-centered

I2TechSciE is clearly teacher-centered. Participating teachers’ voices are sought after in multiple venues and their ideas and concerns are respected and acted upon. Central to these activities are the teachers’ professional development goals set
during the summer institutes. While the Authors do not present teachers’ specific statements, there are questions to consider with respect to these goals. How are they framed? What perspectives do they consider? For example, are the goals written in terms of student learning outcomes such as scores on standardized achievement tests? Are outcomes other than student achievement considered?

If there were goals related to student attitudes toward or skills with using the Project’s learning technologies, then the Authors’ chapter offers evidence that positive outcomes occurred in these areas. As Jack says of his students, “They’re excited. They’ve seen the cart come through the room and you know they’re always asking when we can use it and what the class next door is doing” (p. 59). Anthony, a 13-year old comments, “Like with boundaries, how we used iPhoto and iMovie. I think instead of reading out of books, it’s easier because we make like movies out of it” (p. 63). These comments signal attitudinal changes that may be important precursors to achieving the teachers’ declared professional development goals.

Collaborative

I²TechSciE was designed and implemented very much as a “we” not an “us versus them” project. As the Authors explain, I²TechSciE goals, activities and outcomes were co-determined by themselves and the participating teachers at the first summer institute that took place at the very start of the project. This initial collaborative spirit continued into school-year activities such as monthly meetings as well as the future summer institutes.

Learning technologies, the material centerpiece to the project, present a prime focal point for collaboration. Indeed, the limited supply of computers required shared use among the teachers. What is not clear from the chapter is the degree of collaboration with respect to the selection of the learning technologies themselves. How much input did the teachers have in identifying the targeted technologies? Was there any financial commitment on the part of the teachers, school or district with respect to purchasing or servicing the technologies? In my own work, I have found that teacher buy-in and implementation can be improved with high degrees of involvement along these lines.

A related issue is the nature of the collaboration around the determination of the teachers’ goals with respect to use of the learning technologies. The eighteen learning technologies presented in Table 1 are a formidable gathering of digital wizardry. Gaining adequate proficiency, yet alone mastery, with any one of those items can be a daunting prospect to those new to or uncomfortable with the technologies listed. To what extent did technology-savvy researchers work with the teachers to develop implementation goals that took into account teachers’ prior knowledge of and experience with the specified learning technologies? Was guidance provided with respect to sequencing use from less demanding to more complicated technologies? Exploration of these aspects can inform both the follow-through and urgency-for-change challenges.
IMPROVEMENT-FOCUSED

By definition, intervention studies aspire to yield improvement in two areas: teacher practice and student outcomes. I²TechSciE Project goals for teachers are for them to implement classroom instruction that features “culturally relevant science and the integration of learning technologies” (p. 55). By extension, students are expected to experience “better participation and higher achievement” (p. 49).

Important gains were made in both areas. All of the Project teachers used the multicultural digital quilt strategy. Analyses of pre- and post-unit concept map data showed “significant” knowledge gains for students. The degree of positive classroom interaction afforded by the former most likely influenced the latter. As Ricardo stated, “I’ve noticed that the amount of communication between the students is fantastic” (p. 61).

Nevertheless, as the Authors point out, the level of implementation of the desired pedagogical approach was uneven across participating teachers. This in spite of the considerable support (e.g., summer institutes, monthly meetings, site visits) provided by the researchers in the service of helping teachers meet their stated goals. Partial explanation for the lack of follow-through may lie in the nature of the goals themselves. What specifically constitutes “better” student participation and “higher” student achievement? How exactly are the desired teacher behaviors linked to intended student outcomes? The degree to which these concepts share a common understanding among Project participants, i.e., teachers and researchers, may have profound influences on actual implementation.

STUDENTS AS CHANGE AGENTS

The I²TechSciE Project’s enactment of the action-oriented criterion for intervention studies is perhaps most eloquently displayed in the enlisting of students as supporters and catalysts of the desired improvements. The Authors describe various ways in which student actions influenced project outcomes. Students requested that their teachers increase the use of the learning technologies and students facilitated that use by providing technical support to teachers and other students. These are exciting and powerful mechanisms for engaging students in the professional development process.

The Authors lay out various other venues for extending the “students-as-change-agents” strategy. These include providing professional development for students before their teachers (e.g., prepare Tech Wizards first, orient teachers afterwards) and simultaneously with their teachers (e.g., include students in the summer institutes). They also consider the option of adding another Parent Night, an action that would allow opportunities for increased student participation as well as parental involvement.

I respect this line of thinking and feel that this approach empowers the ultimate beneficiaries of the professional development – namely the students – in meaningful ways that support their having more responsibility for their own
learning. Imagine a summer institute at which students, teachers and researchers collaboratively develop goals for classroom implementation during the school year. Imagine monthly meetings at which students, teachers and researchers reflect on progress to date and agree upon appropriate next steps. Imagine the innovative intervention strategies that might emerge from this expanded partnership.

Such imagining invites the notion of expanding the basic precepts of intervention studies themselves. In addition to the five earlier mentioned criteria, fully incorporating students as change agents implies the need for a sixth criterion – that intervention studies be “student-centered” as well. This should include the identification and consideration of student-centered problems and what sorts of interventions might be appropriate for them. Such problems may or may not have a teacher corollary. For example, linguistically diverse students may raise the issue of the lack technology-related terms and concepts in their native language.

As the Authors state, by design their intervention study was intended “to allow students’ voices and cultural backgrounds to become integral parts of the curriculum planning, teaching, and assessment” (p. 50). I concur with their assertion that an effective means of achieving this goal is to directly involve students as prominent partners in teacher professional development. This deeper integration of central players in the teaching/learning process has the potential to positively address previously cited problems such as the fragmented nature of professional development and teachers’ heavy reliance on textbooks and worksheets. The benefits of such collaborations also can include enhanced teacher knowledge about and understanding of their diverse students, which in turn may increase teacher efficacy with respect to effectively educating those students.

Such an approach is not without its dangers. One central concern is the inherent tension between students and teachers due to power and status differences. The field would benefit from depictions and analysis of the facilitation of professional development activities that foster trust and constructive communication among teachers and their diverse students. I encourage the Authors to continue their work along these lines and await their sharing an equally frank and forthright discussion of learnings from this perspective.
RESPONSE TO SHAW’S COMMENTARY

Looking Beyond the Looking Glass

Jerome Shaw’s well articulated commentary on our chapter provides us with an excellent opportunity to expand our arguments and to bring attention to other important aspects of the study. Our chapter challenges the reader to look beyond the traditional looking glass used to judge the appearance of progress in teacher professional development projects. To this end, we strive to move away from the traditional “successful/not successful” binary used too often to describe the complicated and fluid aspects of supporting teacher professional growth in culturally diverse urban school contexts. This is an important research methodological issue that I wish to stress here first because it will help the reader to gain a better understanding of how the dialogic conversation and reflexivity—two of the components of sociotransformative constructivism—demand that a different kind of collaboration be established with the participants (teachers and their students). Furthermore, these components require that the researchers listen to each other and the participants in such a way that the researchers themselves also become subjects of the change process. How we were influenced by the study and by each other’s perspectives would require a separate manuscript. However, in our present chapter we shared one of these stories as represented in one of the main challenges we encountered in the project—managing our own sense of urgency to effect change.

Again choosing to expose this aspect of our study is important to note because—as we asked in the Implications section of the chapter—“What would the results of this study look like if it did not have an ongoing, onsite and responsive design?” If we had chosen to report only the successes we saw and/or those recounted by the teachers and their students, this study would have simply added to the already existing body of cheerful narratives in teacher professional development. We hope then that if the readers look with us beyond the looking glass a more complicated (and interesting) story can be discerned from our chapter.

LOOKING BEYOND THE LOOKING GLASS THROUGH SOMEONE ELSE’S EYES

This metaphor—in my view—captures the essence of what an intervention study is. We defined intervention study as a teacher-centered approach to professional development by which the researchers and teachers collaboratively explore areas in need of improvement (e.g., pedagogy, content knowledge, curriculum) and take steps to systematically evaluate and address the identified areas. So the short answer is “yes” to one of Shaw’s questions in his commentary regarding whether

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we discussed and set professional development goals with the participating teachers. We did this at the beginning of the study during our one-on-one ethnographic baseline interviews with them, and followed their progress through our on-going, on-site schools visits and end of year interviews. However, since this was an intervention study, we went beyond documenting what was working and/or not working well. Through dialogic conversations during follow up one-on-one interviews and during our monthly meetings, we also discussed with the teachers where we saw progress being made toward the project’s goals, and where there were disconnects between the teachers’ espoused beliefs and their beliefs in action. In addition, we shared with them highlights of how students were responding to the teachers’ pedagogical efforts and to the use of learning technologies. As we explained, in our chapter, this kind of honest feedback and interaction (dialogic conversation) gave impetus to generating various intervention strategies (see Figure 2.1) to address the main challenges we encountered (i.e., Teachers’ Follow Through and Managing Our Sense of Urgency to Effect Change). It should be stressed then that the focus in our chapter (and in our study) was to document what happens when steps are implemented to take a professional development project that was working well and having a positive impact on teachers and their students to the next level. In short, we were interested in exploring what kind of intervention strategies can be put in place to help teachers make more productive connections between their espoused beliefs and their beliefs in action.

By sharing our honest perceptions, and those of the students, we were hoping to assist teachers to look beyond the looking glass and further advance the project’s (and their espoused) goals.

LOOKING BEYOND THE LOOKING GLASS WHEN NO ONE ELSE IS LOOKING

The ultimate goal of any teacher professional development project is to continue to observe the changes brought about by the intervention long after the research project has expired. While researchers do not have control over what happens after a project leaves the participating schools, it is nevertheless valuable to know if the project’s impact was sustainable. This was particularly important to us given the social equity focus of the sTe theoretical framework.

In addition to the impact on teachers’ practice and on students’ learning that we were able to gather from the analysis of multiple data sets, there were other important telltale signs of positive growth. For example, one of the teachers in the project tended to be at school at least 2 hours before class started. He preferred to be there early to plan for the day or to catch up with some grading. He was also the teacher who felt the least confidence with his science content knowledge and with using learning technologies at the beginning of the project. However, the mobile computer cart and other equipment tended to be stored in his classroom because he became one of two teachers who used the equipment the most. During several visits to his classroom in the early morning to plan activities together with him, we noticed that more and more of his students were coming into his classroom early. As it was the routine, after a swift “good morning,” the students proceeded
unceremoniously to grab a laptop from the computer cart. We noticed that some of them worked in groups or individually to finish an assignment, and some of them went on the Internet to play games (most of which were educational games as we discovered during our interviews). Most interestingly, we discovered during these onsite visits that the students and the teachers were using the laptops across curriculum areas—especially for social studies projects and language arts. Although our project had a focus on science, we were pleased to see that the students and the teachers were using many of the pedagogical strategies (problem-solving scenarios, concept mapping, graphic organizers, etc) along with the learning technologies available (Inspiration software, BrainPop, etc). In short, all of the teachers and their students were using the project’s laptops and equipment for much more than just typing tools—they were using this powerful equipment to facilitate and enhance learning.

Fortunately for the students at this school, the participating teachers took another important step to ensure that their students would have access to a computer cart after our project expired—they got one of their own. In other words, as it is customary, after a project expires all the equipment bought with a grant belongs to the sponsoring university. The participating teachers knew this, so they took steps—with very little help from us—to apply for a wireless laptop computer cart. In the school where we started the project, the teachers got together and wrote a strong learning technologies plan and were funded for a 15 high-end wireless laptop computer cart. In another school, one of the teachers submitted her own grant proposal for a 15 laptop computer cart to a funding agency—again with only little help from us—and she received the award. She shared this computer cart with the other teachers participating in the project at her school. The third school participating in the project during its final year already had a laptop computer cart with 30 laptops. However, it was in the hands of their technology specialist and always under her control. We helped the teachers participating in our project negotiate access to this cart with their principal so that at any time that they needed to use some laptops they could have at least have access to 10 laptops in their classroom.

We still provided access to some probeware and other equipment as the teachers needed them and while we still had access to them ourselves. However, we felt that it would be ideal if all the equipment bought with federal moneys is left with the teachers who learned to use it but current guidelines prevent this. In any case, while we continued to observe an uneven use of the laptops and other learning technologies across the schools even when the schools had access to their own laptops, it is important to note and appreciate that at least these tools were being used—and being used more effectively across curriculum areas.

So, if we return to Shaw’s commentary, it can be observed that the extended examples described above provide further evidence for how our project fits well with his five criteria for assessing effective intervention studies. That is, our project was teacher centered, collaborative, improvement focused, action-oriented and data-driven (Shaw’s Commentary, p. 2). He feels that we did not address the last criterion—data-driven—enough in our manuscript. I believe that his statement has
to do with not having access to the students’ quantitative achievement data since we have provided extensive qualitative data to describe the positive impact of the project on teachers and their students, as well as the challenges we encountered. The quantitative analysis of the students’ performance on several of the unit concept maps we developed with the teachers can be found in our project’s website (http://edweb.sdsu.edu/i2techscie/) under the Conferences section. This manuscript was recently presented at the Annual Meeting of the American Educational Research Association in Chicago (Rodriguez & Zozakiewicz, 2007). In any case, as we have argued in our chapter and in this response, to better appreciate the impact of our intervention study, we are encouraging readers to look beyond the looking glass and to reflect on the challenges we encountered, and how they were addressed using an evolving intervention approach.

This kind of approach is going to produce some unavoidable tensions amongst participants (e.g. students expecting more hands-on activities with learning technologies from their teachers; teachers expecting students to move faster through the curriculum due to time constraints and standardized testing; researchers expecting more from everyone else, and so on). However, perhaps it is indeed these kinds of tensions that create multiple spaces for growth and meaningful learning, and perhaps the challenges we encountered could never be completely resolved. So, in addition to reporting what works well, researchers should also strive to identify and document the challenges encountered. In this way, we can work collaboratively to address them as long as there is a political will amongst participants to do so. The more we learn about how to manage intervention studies of this nature in the complex and demanding contexts in which teachers are expected to work, the better prepared we will be to generate more meaningful and long-lasting teacher development programs.

NOTES
1 Sociotransformative constructivism is the theoretical framework guiding this study.
2 This was done in general terms and across classes and schools to protect the anonymity of the students.
3 BrainPop is a web-based educational software that covers many key curriculum areas, such as science, mathematics, social studies, and others. This service is also now available in Spanish.
4 This was the first time ever that teachers at this school wrote their own plan.
5 We expanded the project to two other schools in year three of the study.
6 For example, students were never allowed to handle the laptops without the technology specialist’s strict supervision. The teachers and us helped convince the principal that students needed to be more trusted with the equipment.

REFERENCES