Creating a replicable transformation path for change
A pilot study on overcoming the barriers to individualized teaching and learning

**Project Summary**

We propose a pilot study that demonstrates the potential of a structured learning community in participatory action research to facilitate continuous improvement in STEM teaching and learning praxis. Open educational resources and participatory media tools serve as themes in the proposed inquiry, which revolves around three central research questions: **Q1:** How does a community of practice of participatory action research enable faculty to effectively individualize and assess alternative teaching and learning innovations? **Q2:** In what ways do web-based educational resources and participatory media foster deeper learning? What are the critical situational conditions for their effective use? **Q3:** What role does meaningfulness of the learning situation play in sustaining the engagement of both faculty and students?

There are three existing and separately-funded activity centers that form the context for the proposed study: A five-year educational initiative at Cal Poly and STEM courses at Allan Hancock College and Bakersfield College, both of which are community colleges recognized as Hispanic Serving Institutions. We are requesting funding in this proposal to take advantage of these existing activity settings for exploring the questions outlined above. We estimate this study to involve 900-1000 students during the three-year pilot study. **Our theory is that the cause of limited effectiveness** in bringing about wide scale higher quality STEM learning across all disciplines is two-fold: **1. We lack structured processes** for faculty to systematically and effectively individualize and validate their own teaching innovations and **2. We are failing to integrate emergent ways of learning** that more meaningfully resonate with the nature of today’s students. The core feature of this pilot study is its focus on illuminating the process of change through the practice of change in a supportive setting of a situationally-diverse learning community. The process we propose involves workshops to gain facility with enacting change, assessing its efficacy, and constructively working with the conflict that occurs in communities of practice. It also involves creating and populating an on-going, web-based dissemination interface to function as a feedback loop of information to the learning community and the larger education community external to the proposed work. The proposed processes have been field-tested at Cal Poly and reveal preliminary effectiveness with change.

**Intellectual Merit**

The intellectual merit of the proposed research is that it addresses a key historical barrier to wide scale lasting change in education: traditional reform approaches are incongruent with achieving lasting change in the dynamic, human system of an educational setting. The proposed work utilizes an integration of current social science research aimed at change and objective experimental methods for validation of change. The intellectual merit of the transparent, real-time, web dissemination interface is that “makes the system aware of itself.” Systems dynamicists consider information flows like this to be a fairly high-leverage intervention that is often neglected in change processes. This approach serves to create a new model of integrating first-, second- and third-person educational research in a way that fosters lasting change at institutions outside of the research center. The theme of integrating digital media also addresses important questions about educational approaches that enable effective, individualized, self-regulated learning. Examining the role of meaning in learning serves to increase our understanding of how it factors into sustained personal and organizational development.

**Broader Impacts**

The integration of research and education is the central theme of the proposed work. Through this practice-based discovery within the pilot learning community that is created, we hope to demonstrate a new path for on-going and lasting systemic change in higher education that appeals to researchers and practitioners alike. In this way, the proposed research has the potential to serve as a new type of research infrastructure for the STEM education community. Through our participatory action research with our community college partners, we expect to initiate lasting change at Cal Poly that better serves California’s growing Hispanic community.
Creating a replicable transformation path for change
A pilot study on overcoming the barriers to individualized teaching and learning

The Problem
Since 1950, the National Science Foundation’s Directorate for Education and Human Resources has invested over $22 billion in improving science, technology, engineering and math (STEM) education (Darcy & Henderson, 2008). However, evidence on scientific literacy suggests that the U.S. is “falling behind” in STEM performance compared to other developed nations. In 2006, fewer than 9% of the 15-year olds in the U.S. were high performers in science as measured by the Programme for International Student Assessment (OECD, 2009), ranking our nation 14th out of the 24 developed nations of the Organisation for Co-Operation on Economic Development. At a time when research has provided substantive evidence of the advantage of alternatives, the dominant teaching modality in introductory STEM courses continues to consist of lectures and cookbook-style laboratories (NRC, 2003; Sheppard et al., 2009). Indeed, the existence of the Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics program indicates that historical investments have not produced the intended wide-scale improvements in STEM higher education. Why?

A 2008 commissioned study by the National Academies asserts that the cause is not insufficient scientific understanding of how people best learn STEM, but the existence of two barriers to reform (Darcy & Henderson, 2008). The first barrier is that the vast majority of the change strategies are based on a “development and dissemination” approach. In this strategy, the mechanism of change is considered to be the curricular materials, classroom tools or teaching techniques that are developed by a particular change agent. The assumption is that, as in the technological world, materials and processes can be independently developed, then disseminated to other locations where they will produce the same result if the standard operating procedures are followed. The “development and dissemination” approach focuses on the quality of the learning tools and processes, but often does not consider the role of the faculty or the situational factors of the unique learning setting in which the innovation is developed. The second barrier is that there is insufficient research attention on the study and improvement of STEM educational change strategies or models. In a preliminary review of the literature on college-level STEM reform, Henderson et al. found that 56% of articles involving authors from STEM disciplines utilized the “development and dissemination” model of change without questioning its effectiveness (Henderson, Beach, Finkelstein & Larson, 2008). Thirty seven percent of the articles with a STEM author focused on individual faculty development. Fewer than 5% of the articles involving STEM authors considered other situational factors, such as institutional environments and structures, in their conception of change.

In essence, Darcy and Henderson contend that reform in STEM education is limited in its impact because most efforts do not account for the fact that education occurs in complex, dynamic human systems and therefore must consider change processes and interventions appropriate to that social system. They recommend the following, which we quote here (Darcy & Henderson, 2008):

- Faculty must have a meaningful role in the change process (p. 6);
- Change strategies must address the strong situational conditions that favor traditional instruction (p. 9);
- STEM change agents should seek to document the success (or failure) of their change strategies (p. 12);
- STEM change agents must explicitly link their change strategies to other change strategies or models and to learn about and incorporate change strategies and models from other disciplines (p. 14).

These recommendations are consistent with others who point out that, if repeated interventions in a system do not change the outcome, the interventions are occurring in the wrong part of the system (Senge 1990). As indicated above, many interventions are aimed at changes in content and teaching mechanics. Systems
dynamics theory suggests, however, that for a high-leverage impact, our attention should be on the human part of the system. They call upon institutions of higher education to develop personal and collective capacities for a participatory, action-oriented educational research praxis (Torbert, 1981; Senge et al., 2000; Boyce, 2003; Dowd & Tong, 2007). This type of social science research, which we discuss in detail below, considers the researcher (“teacher”) as part of the system under study, rather than an objective observer outside of the system under study. And while it holds the promise for overcoming the barriers to reform, we assert that capacity with the process of change is only half the problem.

We believe that the cause of limited effectiveness in creating higher quality STEM learning across all disciplines is two-fold: 1. We lack structured processes for faculty to systematically and effectively individualize and validate their own teaching innovations and 2. We are failing to integrate emergent ways of learning that more meaningfully resonate with the nature of today’s students.

Our aspiration is to catalyze the widespread evolution of higher quality, research-supported STEM learning across all disciplines. While there are likely to be many paths to do so, in this pilot study, we aim to address limit 1 (above) by demonstrating the potential of a learning community of participatory action research (PAR) as an effective process that facilitates continuous improvement and lasting change in teaching and learning praxis. True to PAR, the proposed pilot study would explore these issues in unique learning settings: An existing and separately funded educational innovation at the California Polytechnic State University that begins in the 2010-2011 academic year; two existing and separately-funded community colleges settings at Hispanic Service Institutes. A schematic of the pilot study is depicted in Figure 1; terms are defined in the METHODS section. The differences in these learning contexts serve as points of research inquiry for the PAR community, rather than variations to be minimized so that the results can be generalized to the entire college population. To address limit 2 (above), we use the integration of web-based educational resources and social media as a thematic focus. We are seeking funding in this proposal to both establish and assess a pilot-scale, cross-institutional community of practice of participatory action research, initially focused on the integration of Web 2.0 affordances as a way of aligning with the characteristics of today’s learner.

Our research questions are:

Q1: How does a community of practice of participatory action research enable faculty to effectively individualize and assess alternative teaching and learning innovations?

Q2: In what ways do web-based educational resources and participatory media foster deeper learning? What are the critical situational conditions for their effective use?

Q3: What role does meaningfulness of the learning situation play in sustaining the engagement of both faculty and students?

Figure 1. Schematic depiction of the pilot study activities.
At first glance, our proposed pilot study can occur as duplicating the “development and dissemination” mental model. What differentiates what we propose is our attention to the relational conditions in Darcy and Henderson’s recommendations described above. That is, our primary intent is establishing a learning community of practice and the information feedback structures required to foster sustained teaching and learning innovation. As depicted in Figure 1, activity centers serve as places of practice situated inside a larger community of practice symbolized by the large grey oval. The grey oval represents the social “container” formed by the learning community’s relationships. Within this container, learners (faculty and students) participate in on-going experiments in learning or “action research.” The feedback structures that support their participation in the action research will include on-going capacity building for change and social media as a transparent dissemination path for the change process. In the following sections, we discuss the theoretical foundations, our logic model for the pilot study, our proposed methods, analysis and outcomes.

**Theoretical Foundations:** Why meaning? Why educational media? Why action research?

Research has shown that the process of learning requires the learner to construct their understanding. This process occurs in social settings where the interaction with their peers plays an important role (Harvey, Rothman, & Frecker, 2006; Bruffee, 1993) in creating what is called “epistemic conflict” (Doise & Mugny, 1984). This is the situation one encounters in the face of differing mental models of reality. In resolving epistemic conflict, the learner must self-construct a new understanding. Learning STEM concepts is particularly dependent upon this process, for in the absence of actively regulating epistemic conflict, learners retain their historical misconceptions of physical phenomena, despite exposure to more accurate models.

However, the choice to engage in this process requires an active role, autonomously chosen by the learner (Assor, Kaplan & Roth, 2002). We know that intrinsic value, relevance and autonomy are the best motivators for engagement if given sufficient support in reaching learning goals (Garcia & Pintrich, 1996). Our interest in meaningfulness stems from its potential to enable optimal performance in learning settings (Ford & Smith, 2007). Meaning is considered the predominant means of advancing well-being and a sense of fulfillment (Lent, 2004), both of which fall in the domain of intrinsic motivation. External motivators like grades serve to produce a temporary effort when the reward system is in place, but lead to a focus on superficial learning strategies and can even destroy one’s intrinsic desire to learn (Deci, Koestner & Ryan, 2001). The complexity of teaching learners of various psychometric states is further compounded by variations in learners’ styles and strategies (Kolb & Kolb, 2005).

There are recent examples of non-traditional teaching modes that take advantage of what is already known about these important factors for student learning. They include active learning approaches such as problem-based learning and project-based learning. Some approaches leverage the meaningfulness of learning that serves a larger social purpose (Sobral, 1995), such as service learning. Practice-based learning pedagogies, such as service learning and project-based learning, have shown promise as a means to enhancing students’ intrinsic motivation for learning and moral reasoning (Coyle et al. 2006; Slivovsky et al. 2003; Harding et al. 2007).

From a teaching perspective, a significant challenge to these non-traditional modalities is that they demand a kind of emergent learning, where what one needs to learn is discovered in the process of doing the project. This places an entirely different demand on the faculty and student (Cress, 2008). Unlike the traditional approach where faculty establish learning objectives *a priori* and “cover them” in the course, learning in an authentic (i.e., “real world”) context requires a customized path of learning dependent upon the project evolution. It calls for self-regulated learning, where the learners “set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment” (Pintrich, 2000, p. 453). Autonomy and self-regulated learning are increasingly important core competencies for citizens in our rapidly changing world. However, traditional learning where faculty control of all dimensions of the course can function to undermine students’ timely development and mastery of these important twenty-first century skills (Black & Deci, 2000).
Additionally, the nature of today’s student is very different than the college students of the twentieth century. They are probably not different in their human cognitive function, but growing up in the digital age has enabled them to learn in ways previously unexplored. Sweeney’s research on these *millenial learners*, summarized in Table 1, supports the notion that today’s students seek experiential, social modes of learning that facilitate a personalized learning process. Sweeney’s findings are echoed in the recommendations of several studies on digital media and learning (James, 2009; Davidson & Goldberg, 2010; Gee, 2010). Youth of today frequently use media for self-expression and experimentation, social networking, educating, knowledge-building, and dialogue and civic engagement (James, 2009; Bellanca & Brandt, 2010). Jenkins *et al.* call this phenomenon a “participatory culture.” (Jenkins *et al.*, 2009). The use of participatory media has also been shown to promote the development of twenty-first century skills, such as systems thinking and design thinking (Salen & Zimmerman, 2003). Within participatory cultures, a great deal of informal learning takes place.

Private and public foundations are heavily invested in leveraging these social trends for the social good of education. One can see these investments through initiatives that provide free access to educational media, such as the Open Learning Initiative at Carnegie Mellon University, the National Repository of Online Courses hosted by the Monterey Institute for Technology in Education and the Open Educational Resources Commons. These resources, often designed by cross-disciplinary teams of content experts and learning scientists, are collectively referred to as open educational resources (OER). In a consideration of learning in a digital age, Web 2.0 affordances, such as social networking tools and open educational resources, are seen as enabling the *customized, participatory and collaborative learning that more strongly resonates with the nature of today’s students.* (Davidson & Goldberg, 2010). Their nature not only encompasses cognitive styles of learning, it includes their high desire for peer-to-peer learning, social relevance of what is being learned, autonomy, customized learning, and creative expression.

Additionally, studies on Carnegie Mellon’s Open Learning Initiative materials have shown that coached use of the OER tools resulted in students learning the same material in half the time as in a traditional lecture-based course. These students performed as well or better than students in the traditional courses (Lovett, Meyer & Thille, 2008). Therefore, we believe that OER and participatory media leverage millenial learners’ skills and orientations while possessing the potential to accommodate the needs of non-traditional pedagogies that require a more flexible learning trajectory.

Participatory action research (or equivalently, *participatory action learning*) is congruent with dynamic teaching and learning needs. PAR sharply contrasts with controlled experiments, as shown in Figure 2. In

<table>
<thead>
<tr>
<th>Characteristics, Millenial Learners</th>
<th>Sweeney Suggested Implications for Universities</th>
</tr>
</thead>
<tbody>
<tr>
<td>expect more choices and selectivity, flexibility and convenience</td>
<td>provide increased learning options and more educational services</td>
</tr>
<tr>
<td>are experiential and exploratory learners</td>
<td>provide active-learning formats for greater student engagement</td>
</tr>
<tr>
<td>expect to personalize and customize products and services to their own liking and interests</td>
<td>provide systems that allow the students to personalize and monitor their learning</td>
</tr>
<tr>
<td>are practical and results oriented</td>
<td>must address “ineffective” teaching or risk losing Millennials as “customers”</td>
</tr>
<tr>
<td>are digital natives and enjoy gaming and interactive multimedia environments</td>
<td>every aspect of college learning must be seamlessly woven to digital services</td>
</tr>
<tr>
<td>have more friends and communicate more frequently</td>
<td>must provide communication channels preferred by Millennials</td>
</tr>
<tr>
<td>know how and when to work with others more effectively</td>
<td>must provide collaborative technology to enhance learning</td>
</tr>
<tr>
<td>are determined to lead balanced lives</td>
<td>must offer a wider range of learning alternatives as well as extra-curricular activities</td>
</tr>
<tr>
<td>value their own and others’ intelligence</td>
<td>consider student perspective while addressing current learning problems</td>
</tr>
<tr>
<td>are impatient and expect immediate feedback</td>
<td>create automated systems of expert feedback;</td>
</tr>
</tbody>
</table>
traditional laboratory research, one aims to capture mechanistic understanding that can then be generalized and beneficially applied to larger populations. This type of research seeks to describe phenomena without disturbing it. The researcher places themselves outside the phenomenon being studied. Dowd (Dowd 2010) characterizes this approach as “third-person research” for the type of narrative used by the researcher in describing the subjects (i.e., “They, them, theirs...”). Third-person research utilizes both quantitative and qualitative observations.

The paradigm of “independent observer” in third-person research requires that we assume the observer (subject) and the observed phenomena (object) are causally disconnected. Using this objective perspective of individual and social learning has greatly aided our understanding of how learning is influenced by many factors, such as the learners’ self-efficacy (Bandura 1977), motivation (Deci & Ryan, 1985), and beliefs about learning (Mueller and Dweck 1998). It has also helped us to better understand how the ecological factors of the learning experience influence the learners’ performance (Assor et al. 2002; Deci and Ryan...
One of the underlying assumptions of third-person research is that measuring the system does not significantly alter the state of the system being measured. This is the fundamental basis for an empirical approach and third-person research and teaching. Whereas this approach is fitting and even necessary for technical procedures, it is not suited to working with the dynamics of a human system nor is its purpose to change the system (Reason & Torbert, 2001). Indeed third-person research is designed to be descriptive. Consequently third-person education research does not change education--this in part accounts for the inability of this type of research to bring about widespread change within the education system (Torbert, 1981). To use a metaphor, “Weighing the pig does not make it grow.”

Proponents of third-person research approaches may counter argue that the insights provide a kind of direction for change. In other words, understanding the underlying mechanisms enables one to intervene toward predictable outcomes. This ability to manipulate/control the system is the value of mechanistic understandings that are generalizable and scalable to larger populations. However, humans and human systems do not function mechanistically, nor are the myriad variables in a real human system controllable as they are in a laboratory setting. As others have asserted (Torbert 1981; Greenwood & Levin 2005), third-person research is necessary to reveal a kind of situational evidence for change within both student and faculty learner, yet it is insufficient as an agent of change within a dynamic human system like higher education.

The basic principles of dynamic human systems (Senge 1990) are:

1. System structure creates behavior;
2. We are not separate from the system;
3. The problematized phenomena of the system (“symptoms”) are created by the system functioning through our own actions;
4. The apparent components of the system dynamically interact.

Because humans are so integral to the behavior of the system (principles 2. and 3. above), a systemic process of change requires personal and group change. Therefore, changing a human system comes through awareness of one’s own role in the system by way of an on-going critical self-reflection and experimentation situated in the authentic context of their own lives (Kemmis & McTaggart 2000; Reason and Torbert 2001; Boyce 2003; Dowd & Tong 2007), i.e., by way of personal change. Dowd refers to this as first-person research (Dowd 2010) for the researcher’s narrative involving the self (i.e., “I, me, my”). The first-person research specifically relates to understanding and being responsible for the bias produced by the enactment of our own assumptions, frameworks, and mental models (Bower & Morrow, 1990).

The process of group learning or organizational learning, is considered second-person research (Dowd 2010), for the second-person narrative involved in the inquiry (i.e., “We, us, ours”). Organizational change comes about when members within the system reflectively dialogue around the conflicts that occur within dynamics of the social setting, i.e., through what constructivists (Baxter-Magolda 1999; Wertsch 1985) call learning. In a community of PAR practice, dialogue serves to uncover these often hidden and unquestioned assumptions of the researcher. Second-person research is dialectical, which naturally gives rise to conflict. These conflicts are welcomed, emphasized and understood as the means for learning and growth. The second person research process is therefore directly concerned with building the capacity to be aware of and productively work with such conflicts where they are present.

First-person and second-person research are part the methods of participatory action research and...
are designed for the purpose of changing the system from within; this research approach aligns with the recommendations by Darcy and Henderson to overcome the barriers to educational reform (Darcy & Henderson, 2008). Figure 2 contrasts other dimensions of PAR and traditional objective experimental research. The view of learning from each of the perspectives are mapped in Figure 3 along with examples of research tools for each.

We are quick to point out that first-person and second-person research are also insufficient as methods for systemic transformation in education. We propose that the holistic integration of first-, second- and third-person research practiced in a lived setting of teaching and learning is what is needed to produce change within the education system. Conceptually, we depict this process as spiraling through a reflexive and dialectic process that integrates these objective and subjective perspectives of practice as well as the individual and social foci, as shown in Figure 4. Moreover, we suggest that the learning environments under study must be situated in a larger community setting of practice and action, rather than the abstracted and artificial settings of university classrooms alone.

Creating these ecological conditions for change strongly aligns with the recommendations of Darcy and Henderson to significantly enroll the agent of change (the “teacher”) in the system to be changed, enable them to critically examine the situational factors, and transparently share their experience of the change process. In the following section we describe how we will address their fourth recommendation on change models and strategies.

**Our logic model and research methods**

Using the theoretical foundation expressed above, we have developed the logic model that is displayed in Figure 5. As shown, we propose to test two theories: one on what is needed for sustained change, the other on the efficacy of participatory learning media. Testing the efficacy of the Web 2.0 affordances serves as a theme for the participatory action research community. The model shows the connection between the theoretical foundations, our planned work, and our intended outcomes.

Ultimately, our intent is to serve into existence higher-quality STEM education across disciplines, indicated by the aspirational long-term impacts listed in Figure 3. Our intended means to this envisioned end is the (pilot) demonstration of viable and effective structures and processes of continuous learning for faculty and students shown as outcomes in Figure 3. The short-term and on-going formative assessment products that serve the outcomes are listed as outputs in Figure 3. These include assessments of test and quasi-control cohorts which are described in detail under the section titled Methods of assessing cohort differences. These outputs are direct products of the proposed activities (Figure 3). The inputs to the proposed work are existing and separately funded initiatives. We are not requesting funds within this proposal for these inputs. The requested funds will support the proposed activities which include data gathering and analysis, and establishing and empowering the pilot-scale learning community on participatory action research.

**Building the learning community of practice (1st and 2nd person perspectives)**

As indicated in the timeline below, we have been building a community of practice for the Cal Poly educational innovation (Figure 1, activity center 1) since September 2009. We have invested roughly 500 man-hours of individual and collective planning time in this effort. This process included engaging faculty, staff, students and community partners in a weekly 2-hour workshop on managing change and action research. At the time of this writing, we have completed 70% of the workshop. The focus of the workshop, facilitated by Roger Burton (senior personnel), is the validation of theory through practice situated in our own lives.
Figure 5. Logic model of the proposed pilot study.
Mr. Burton spent the previous 20 years as a high-level consultant to Fortune-20 multinational corporations. His area of expertise is transformational change in large human systems through building individual and collective capacity for learning. He has been working with the PIs as a partner in this initiative since late 2008. Mr. Burton currently serves as an executive board member of the Society for Organizational Learning-China and has relocated to the San Luis Obispo area for the purpose of engaging in the five-year transformational education experiment which Cal Poly is launching in Academic Year 2010-2011.

The workshop curriculum that Mr. Burton is creating comprises practice with change models and productive dialogue. These models, listed in Table 2, serve as frameworks for personal and collective inquiry, i.e., first- and second-person research. The methodologies, practices and disciplines for the first- and second-person action research are well known (Argyris, 1996; Kemmis & McTaggart 2000; Reason & Bradbury 2008). They are utilized in organizational change applied to educational institutions (Boyce 2003; Senge et al. 2000; Senge et al. 1999). Very briefly, for first-person research, one develops a practice of reflection and experimentation with personal change. These practices grow a personal sense of agency, or capacity for change. As one enters dialogue within a group (second-person research), the capacity for productive dialogue requires an awareness of one’s own mental models (Argyris, 1997) and the ability to recognize the mental model of another. As indicated in Table 2, we have explored both change models and models that support what David Bohm calls “generative dialogue.” (Bohm, 1996). This is a type of group dialogue that requires people to suspend the internal, associative narrative that normally occurs in a group dialogue. In essence, the listener is focusing attention on understanding what the speaker is actually saying rather than their thoughts in response to what is being said.

In PAR, however, the evidence of the theories’ effectiveness is whether actions they imply result in more effective personal practice of change. We sought to determine whether workshop participants were becom-

Table 2. Change models, theories and practices explored in the change workshop.

<table>
<thead>
<tr>
<th>Change Models</th>
<th>Productive Dialogue Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kantor’s meta-model of change (Kantor, 1977)</td>
<td>Bohm’s dialogue (Bohm, 1996)</td>
</tr>
<tr>
<td>Torbert’s interpenetrating attention (Torbert, 1987)</td>
<td>Chomsky’s transformational grammar (Chomsky, 1987)</td>
</tr>
<tr>
<td>Meadows systems interventions (Meadows, 2008)</td>
<td>Kuhn’s structure of scientific revolutions (Kuhn, 1970)</td>
</tr>
<tr>
<td>Fritz’s creative tension</td>
<td>Argyris’s Ladder of inference (Argyris, 1982)</td>
</tr>
<tr>
<td>Teleologic change</td>
<td>The four-player model of healthy teams (Ancona &amp; Isaacs, 2007).</td>
</tr>
<tr>
<td>Aristotelian’s causality</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Summary of themes in workshop participant responses to the question, “What benefits are you personally gaining through your involvement in this workshop?”

<table>
<thead>
<tr>
<th>Broad category</th>
<th>Example comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater facility with change models and personal change (19 comments)</td>
<td>I am gaining new “lenses” for seeing how personal theories of change influence interpersonal, social and professional activities. Overall the workshop gives me the ability to better understand my world and then take action if I so desire. I am able to look at consequences and trace the paths that influence them into existence. Being able to see the paths allows me to think about altering, or changing, the paths.</td>
</tr>
<tr>
<td>Personal and professional growth (14 comments)</td>
<td>The workshop has bolstered the manner in which I frame many things from the personal to the professional. This has helped not only professionally, but in my personal relationships as well. I am gaining different ways of thinking about things.</td>
</tr>
<tr>
<td>Enhanced relationships (10 comments)</td>
<td>As a group I have really enjoyed the overall atmosphere. It gives me time to think about the change and how I can work with many people to provide a positive change for the campus. The workshop is helping to spur genuine conversations.</td>
</tr>
<tr>
<td>Intellectual Engagement (6 comments)</td>
<td>I have benefited from the readings, thinking, and discussions that have been presented. The readings challenge my assumptions I’m also enjoying the intellectual engagement.</td>
</tr>
</tbody>
</table>
ing more effective in their own change practice through an open-ended, anonymous survey. The 24 participants were asked, “What benefits are you personally gaining through your involvement in this workshop?” Fifteen participants responded, each with several comments. Table 3 summarizes participant’s reactions and includes example comments.

An analysis of the 50 distinct statements (i.e., sentences) indicates that there are four broad overlapping areas of benefit. The first is personal change through clearer understanding of their assumptions, mental models and thinking processes. Many felt that the exercises helped them understand change and facilitate it in their own span of influence. A second broad category of benefit indicates that this workshop has helped to facilitate personal and professional growth. The third area refers to enhanced relationships that are developing through meeting together as a group. The fourth area cited participants’ enjoyment of the intellectual stimulation from the instruction and readings regarding change models and theory of change.

In addition, all the responses were run through a “wordle” analysis (www.wordle.net). This online tool creates a picture that indicates the frequency of words used, excluding common English words. The word “change” was used most often (33 times). A second graphic, shown in Figure 4, was created by excluding the word “change” to yield a more nuanced view of other benefits. In Figure 4, one can see the most often used words were “personal” and “thinking.” These pictures semi-quantitatively reflect the first-person narrative about the ways that people are benefitting from the workshop. As can be seen, the dominant themes are “change,” “personal” and “thinking.” But there are also personal stories involving “positive,” “professional,” “feel,” “effective,” “group,” “learning,” and “new.” These pictures represent the rich experiences of the workshop participants in the process of their own change.

Using on-line tools (1st and 2nd person perspectives)

Our project design includes the use of open educational resources (OER) to test the effectiveness of faculty and students co-creating the process of learning. What we are proposing is not a “distance learning” model of internet use, but an integrative use of OER and participatory media; this is an emergent area of research in education. Students and teachers may learn from a global community of educators and experts if they are also developing the essential skills of finding, evaluating, interpreting and applying the information in situated contexts. Through our partnership with Monterey Institute for Technology and Education (MITE, a non-profit organization funded by the William and Flora Hewlett Foundation’s global OER program, The Bill and Melinda Gates Secondary Education program, and the John D. and Catherine T. MacArthur’s Digital Media and Learning program), we will gain...
access to the National Repository of Online Courses, which contains complete and adaptable online courses in entry-level science and math, as well as a growing library of multimedia collections. MIT will also work with us to develop protocols for gathering usage data, interview and survey questions, and developing participatory assessment models, to understand the impacts of OER in the learner by doing approach. MIT will also make available their expertise in the field of OER to help the project team identify other OER resources to supplement learning, such as Stanford's Woods Institute for the Environment lectures, specific Open Yale courses, iLumina, part of the NSF's NSDL (National Science Digital Library), NEEDS (National Engineering Education Delivery System), and others.

**Methods of assessing cohort differences (1st, 2nd and 3rd person perspectives)**

As a reminder, we propose to address the following three research questions:

- **Q1:** How does a community of practice of participatory action research enable faculty to effectively individualize and assess alternative teaching and learning innovations?

- **Q2:** In what ways do web-based educational resources and participatory media foster deeper learning? What are the critical situational conditions for their effective use?

- **Q3:** What role does meaningfulness of the learning situation play in sustaining the engagement of both faculty and students?

These questions will be addressed through an integration of the first-, second- and third-person research perspectives as illustrated conceptually in Figure 4 and on the logic model of Figure 5. At the partnering community colleges, the test cohorts will be existing courses in STEM courses (e.g., physics, math, chemistry, statistics). The interventions at the community college partners will largely be the instructor participation in PAR, with the use of OER and social media in existing courses. These community college efforts are on-going and funded separately from the proposed work. The assessments used in the Cal Poly initiative will also be used in the community college partnering sites.

At Cal Poly, the assessment will take place around the existing and separately-funded learning innovation. In each year beginning Fall 2010, test and quasi-control cohorts of 100 students each will be recruited to participate in the freshman-year learning experience at Cal Poly (activity center 1). The process we intend to use is an open recruiting process where the design, risks and potential benefits of the learning experience are made transparent. Of those who apply, applicants will be sorted by declared major field of study. Within their categories, they will be stratified by traditional predictors of college success (SAT score). We will then choose 100 students at random for the test cohort and 100 students for the quasi-control according to these criteria for the whole pool:

1. Must represent a range of “academic potential” as traditionally measured to ensure that we can assess whether the teaching/learning approach works for all. Ideally, students’ would be stratified by abilities within the disciplines (e.g., within the college of liberal arts, students, have low/med/high “academic potential” as indicated by the SAT score);

2. Must represent a range of disciplines. Ideally, this would be disciplines from all colleges, but at minimum, there should be those from three different colleges;

3. Must represent a gender balance (50/50) within the colleges.

No interventions are planned for the quasi-control cohort. Students in the quasi-control will be enrolled in traditional curricula. However, we note that Cal Poly schedules incoming freshmen in blocks for the purpose of improving the chances that they will form strong learning communities. Therefore, the quasi-control cohort is likely to be scheduled within blocks. Over the course of the 5-year learning initiative at Cal Poly, a minimum of 500 students are expected to be involved in test cohorts. Within the time frame of the proposed work, we expect to engage a minimum of 300 students in test cohorts and 300 students in quasi-control cohorts. It is anticipated that a minimum of 100 will be engineering majors. We realize that the test cohort is relatively small and therefore have chosen our research instruments in a way that the results can be compared to larger data sets.
Specifically, we will use the *Course Valuing Inventory* (Nehari & Bender, 1978) and the *Situational Intrinsic Motivation Scale* (Guay, Vallerand, and Blanchard, 2000). Both are intended to be completed after a course of study. Those in the test cohort will also be recruited to complete the same surveys after traditional courses for the purpose of collecting longitudinal data about their college experiences. For the faculty and community partners, we are more likely to use an instrument developed for an older population. Melton and Schulenberg review five reliable and externally validated instruments (Melton & Schulenberg, 2008) which we consider candidates.

We will also administer pre- and post-tests on established concept inventories to facilitate meta-analyses with other studies. We are particularly interested in replicating studies using Carnegie Mellon’s Open Learning Initiative tools, which automatically track a number of usage statistics. Candace Thille, director of Carnegie Mellon’s Open Learning Initiative (OLI), is willing to share their research protocols and consent forms in an effort to replicate past studies in the different learning contexts of Cal Poly, Allan Hancock Community College and Bakersfield Community College. She also offered to set up a webinar for our participatory action research community so that they can better utilize the functionality of the OLI resources. They will also provide information on the learning outcomes on which the students are doing fine and on which students are struggling, which is an embedded function in their OER tools. Dr. Thille also offered to collect detailed data on usage statistics and make them available to researchers who have been authorized to analyze the data. OLI is also active in creating their own community college user adaptation network; at least one of their California community college partners is an Hispanic Serving Institute (HSI), so there is the possibility of further collaboration with our HSI community college partners as well.

While we are not requesting funding for the educational innovation at Cal Poly, the proposed research and assessment would not be valuable if the main educational innovation that is being studied is not worth studying. In the following section we provide detail on the activity center of research at Cal Poly.

**Activity setting 1: a potentially transformational experiment**

Since September 2009, a group of about 30 individuals at Cal Poly and in the San Luis Obispo community has been creating a community of practice around participatory action research for the purpose of launching what we believe is a transformational educational innovation in the 2010-2011 academic year. It is transformational in its integration of first-, second- and third-person research with teaching so that the actual educational research transforms the teaching. What is revolutionary about what we are doing is not any of the pedagogical techniques; it is the application of systems thinking for systemic change. This community, initiated by Vanasupa (co-PI), includes faculty from all six colleges within Cal Poly, student representatives, staff, a government representative, individuals from non-profit agencies and local businesses. The PI (Schlemer) has also been a core member of the leadership team to design the learning experience and the associated evaluation plan.

The pedagogy of the learning experiment is grounded firmly in the theories and practices espoused by the education visionaries John Dewey (1938) and Paulo Freire (1968). In short, this means that students and faculty both participate as learners, learning is situated in a real context, learning is integrated, all learners are viewed as sufficient and able to thrive with enough autonomy support. In our modern-day version, OERs play core roles in students’ self-regulated learning. Essentially, we believe the teaching model where a faculty acts as an authorized conduit of information (Figure 8, left) is giving way to the emergent learning model, where students have access to many different sources of information and faculty are co-learners in
the context of authentic projects (Figure 8, right).
The design of the learning innovation has been created through a participatory action learning process, complete with field testing many of the ideas. The design has also drawn from core members’ successes and failures involving over 200 engineering and 30 non-engineering students within the past five years (Schlemer & Mimnaugh, 2010; Schlemer & Mecedo, 2009; Vanasupa et al. 2006 - 2010; Harding et al. 2007; Savage et al. 2007; Zhang et al. 2008; Widmann et al. 2008; ). It also derives from a holistic, research-based pedagogy (Vanasupa et al. 2009a).

The nuts and bolts of the learning experiment: (Figure 1., “activity center 1")
In this learning innovation, we are creating an interactive and dynamic learning environment and community, out of which the stakeholders will be engaged in a portfolio of service-based projects. Students will opt into an immersion-type “track” of learning where they participate in the innovation for three consecutive quarters in lieu of the “regular” curricula. After completing the three quarters, they advance 48 quarter units toward their degree requirements. Students will be coached through learning the course content normally assigned to their traditional curricula by faculty and community coaches. Its faculty and community coaching structure follows the model of highly-effective business teams (Ancona et al. 2002) with two permanent core faculty mentors and one rotating core member and up to 15 different content experts as needed for individual projects. Other members of the mentoring team play different roles according to the needs of the projects.

The primary competency that the students will be cultivating is their own capacity for participatory action learning. Both students and faculty will be engaged in this process. In practice, developing this capacity will occur in repeated experimental cycles of planning, acting, reflection and connecting the empirical to the theory. This is depicted in Figure 9, against Kolb’s cycle of learning (Kolb, 1975). This cycle (or learning loop) is traversed by both individual and group. In the group form, the steps are parallel: joint planning, coordinated action, group reflective dialogue, and creating shared meaning. In terms of the projects, this cycle would begin with creating the shared meaning of sustainability goals and indicators, advance to project planning, project implementation, and project assessment.

One of the functional foci of these projects is applied sustainability. The execution of these projects will therefore require the direct application of scientific, mathematical and engineering rigor, effective team and community process, and the abil-
ity to actively reflect and learn in a self-directed way. We acknowledge that freshmen will be limited in their technical foundation. However, the challenges of complex human systems, collaboration in transdisciplinary settings, design for sustainability, and the rapid pace of change are not primarily concerned with either the reception or dissemination of technical material, but with the application of technical material in a lived, necessarily community, setting. Additionally, the leadership team has several years of experience in service-based freshmen engineering projects (see: Biographical Sketches); their experience is that clients’ needs are often addressed through innovative designs that draw on freshmen-level understanding of technology. Additional campus expertise was sought when project solutions were outside the scope of students’ level of mastery.

Table 4 summarizes the institutional contexts for activity centers 1, 2 and 3. While Cal Poly is among the top 10 institutions in the country for number of Hispanic engineers annually graduating, our population of Hispanic students on the whole is only about 20% of the roughly 19,500 students. However, both Allan Hancock College and Bakersfield College are Hispanic Serving Institutes. Our partners at these institutions are Donald Philbin, Chemistry Instructor, Allan Hancock College; Liz Rozell, Engineering and Technology Instructor, Bakersfield College. These partners are the pilot-members of a larger, longer-term initiative to create robust transfer paths to Cal Poly through a holistic examination of policy. The transfer initiative is being lead by Alicia Dowd and Estella Bensimon of University of Southern California’s Center for Urban Education. The foundational work of the transfer partnership is being hosted by Drs. Dowd and Bensimon and begins June 1, 2010. We mention this effort here, although somewhat unrelated, to indicate our participation in this longer-term partnership where our co-investment in PAR can yield changes beyond the scope of the proposed study.

**Timeline**

The proposed research will take place in the larger context of the career work of the PIs and collaborators. We include a picture of the previous work here because we believe the success of any change initiative is dependent upon the historical context in which it is situated. In other words, we believe...
the kind of transformational learning experiment that is proposed requires those involved in the initiative to be an integral part of the existing system of change.

As shown below in Figure 10, the proposed research has its roots in activities dating back to 2003, a period of time when the co-PI, then department chair, sought to better align her materials engineering program toward societally-relevant ends (See Results from Prior NSF Support). The efforts from 2003 to the present served to build the personal and collective capacity for the current research. Another way of stating this is that the co-PI has encountered successes and failures within educational reform (Vanasupa 2009; Vanasupa et al. 2008c; Vanasupa et al. 2008; Vanasupa and Granados 2008) which serve as learning experiences and contribute to the higher probability of success of the current initiative.

As indicated on the timeline, we will host monthly meetings and quarterly reviews via internet tools. Cal Poly has multi-media internet tools that can be used for the proposed work. We also expect to hold face to face formative assessment workshops every other year at a central location.

Results from Prior NSF Support

**Triple Bottom Line Awareness in Design (TriAD): Diversifying the engineering profession of the 21st Century**

Department Level Reform Grant#EEC 0530760: September 1, 2005-August 31, 2009 (funding: $1 M)

Vanasupa (principal investigator), B. London, R. Savage, K. C. Chen

California Polytechnic State University, San Luis Obispo, California

This grant provided funds to transform the content and pedagogy of 80% of the major courses in an undergraduate materials engineering (MatE) program. The department-level reforms were aimed at bringing to the forefront the imperative for engineers to place society’s welfare above all other considerations through integrating considerations of social equity and the environment in the traditional engineering design process. There have been four main results from this work to date have been organizational transformation within the department; evidence accelerated student development; establishment of a new community of scholars across the university and with other institutions; and a spread of institutional transformation beyond the department into the Cal Poly College of Engineering. The five faculty involved in this initiative published over 25 manuscripts since 2006 involving this work, many of which are referenced within the text. Table 5 indicates the evidence surrounding the impact of this work. We note that Cal Poly is a primarily undergraduate institution without Ph.D. students.

Table 5. Summary of prior NSF support for L. Vanasupa.

<table>
<thead>
<tr>
<th>Impact</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>materials engineering department transformation</td>
<td>Increase in undergraduate student population from 128 (2005) to over 200 (2009); Use of learning science to convert traditional materials courses into project-based learning courses; Institutionalization of freshmen level design combined with service learning; Net influx of female students from freshman to sophomore years; Awarded Cal Poly President’s Community Service Award; Disseminated results in twelve publications to date (see biographical sketches for a brief listing).</td>
</tr>
<tr>
<td>accelerated student development</td>
<td>Significantly higher performance of test cohorts compared to quasi-control groups on a number of constructs shown to critically support self-directed learning, and design, such as intrinsic motivation (Vanasupa, et al., 2007), greater use of peers in the learning process, greater use of integrative cognitive learning strategies as well as content-rehearsal learning; boost of moral reasoning of the freshmen to that above an adult with a masters degree and slightly below that of an adult with a professional degree (Vanasupa, Harding, Hughes, &amp; Stolk, 2008).</td>
</tr>
<tr>
<td>new community of scholars</td>
<td>Established new research directions with Cal Poly faculty in psychology, ethnic studies, education, political science, history, and art and design; Established new research initiatives with colleagues at other institutions (UC-Berkeley; Carnegie Mellon; Stanford; Yale; MIT; University of South Florida; Michigan Tech).</td>
</tr>
<tr>
<td>wider institutional transformation</td>
<td>Influenced College of Engineering to adopt new vision and mission aligned with serving society through innovation &amp; engineering education; Established college-wide initiative with small groups of engineering faculty to pursue innovations in engineering education.</td>
</tr>
</tbody>
</table>
References


Melton, A., & S. Schulenberg. (2008). “On the measurement of meaning: Logotherapy’s empirical contri-
butions to humanistic psychology.” *The Humanistic Psychologist*, 36(1), 31-44.