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The Human Dimension of Systemic Department-Level Change: A Change Agent's Retrospective on a Case of Reform

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ABSTRACT

This paper represents a narrative of the process of department-level reform through the eyes of the initiating agent of change. Over the course of reform, our program has grown by 40%, primarily through retaining students. We exhibit a 10% net important rate of engineering students in the first two years of the curriculum relative to the college's 5% mean export rate. Student freshmen SAT scores also indicate that we are attracting students with more balanced learning interests. The design of our Department Level Reform grant was to advance the knowledge of how to design engineering learning experiences that accomplish two social imperatives: retaining women and other underrepresented groups in the engineering degree programs; and equipping engineers to solve the technical challenges in the context of our complex global society. There is evidence that we are fulfilling our aims, but time will tell. This paper is focused on the impact that our reforms have had on the faculty. In the process of reform, I have emerged with these convictions: 1. Decisions are not made by data but by examining consequences against our values; 2. Humans should not be viewed or treated like mechanistic objects; 3. Structural changes that do not proceed from changes in mental models will not survive; 4. The anxiety around change must be mindfully managed at multiple stakeholder levels; and 5. Sustained change requires interactions with external agents. In this paper, I chronicle the process of change, the agents of change, their actions, and some of the results by the numbers. I also reflect on the meaning and provide recommendations.

Keywords: Change agents; diversity; global and societal issues, organizational change

INTRODUCTION

The growing consensus recognizes that in the course of learning, one is "actively selecting, and cumulatively constructing their own knowledge through both individual and social activity." (p. 348, Biggs, 1996) In the same way, we researchers actively select from the available spectrum of data and assign meaning to our chosen subset of data. Before beginning our story then, I must identify the lenses through which the events were viewed. The first one is that of my own. I acknowledge that my observations are filtered through my humanity, despite my intent to present an objective viewpoint. I provide facts, but in the course of implementing our department-level reform (DLR), I learned that the facts one focuses on and the meaning they then assign to them are unconsciously limited by their own beliefs. In other words, as is the case in reproducing a narrative (Bower and Morrow, 1990), people unconsciously replace the facts themselves with the mental model they have constructed. I found that one's awareness of this process and their willingness to be transparent and inquisitive about their assumptions would ultimately be the key to learning, as suggested by Argyris (Argyris, 1997); thus, I am the first lens.

I served as the author and principal investigator of the grant. As the department chair of the program in question (2002–2006), I had a unique, albeit limited view of the grant's impact. The period of funding was from September 1, 2005 to September 1, 2009. In 2006, I stepped down from the position of chair because I felt that I should lead the most difficult part of the proposed work: the complete integration of all junior-year materials science courses (50% of the junior-level curriculum) into a year-long, project-based learning sequence. In reality, I was often a coordinator of our time and ensured that we were mindful of our proposed DLR goals, but I was no more a leader than every other faculty member in our program.

The second lens is one that sees learning occurring in a social setting where faculty strongly influence what is learned. Our actions as faculty in designing and implementing the classroom activities are important, yet I also acknowledge that our intent, perception, thought and emotions in social arenas are inextricably interconnected in significant and influential ways that we do not yet understand. This new picture of reality is emerging from the recent evidence presented by physicists, engineers (Bohm & Hiley, 1993; Nelson, Radin, Shoup, & Bancel, 2002), and neuroscientists (Siegel, 1999; Taylor, 2008). It supports the notion that students and faculty are not mechanistic, nor can we conduct experiments and expect the results to conform to the same properties that one might expect when working with inanimate objects. My second lens suggests that each person in the learning system (faculty and student alike) influence and are influenced by their surroundings (Bausch, 2001). As reasoned by Dowd et al. (Dowd & Tong, 2007), most outcomes from educational interventions are therefore situational, or in other words, dependent upon the myriad of factors that comprise the context. Social interactions mediate what people learn and how they behave (Tharp & Gallimore, 1988) so valid insights within social systems require experiential self-study (Torbert, 1981). This paper is intended to serve as a kind of self-study through the lens of the agent who initiated the change (i.e., me). I describe the situational facts along with my reasoning to best help the reader discern how these results may have value for them. While I connect our patterns of behavior to the research and theories of others, I make no claims of generalizability to other situations, nor do I insist that our results "prove" the efficacy of our reform in the way that one might expect to prove that a liquid had a pH of 4.7. However, I believe anyone involved in systemic change in an academic setting will find helpful information within this paper. It focuses on the part of our educational system that we often omit from our engineering educational research—the faculty.

Original Context

Our DLR story begins with a materials engineering (MATE) program at a primarily undergraduate, public, state university in California. The California Polytechnic State University in San Luis Obispo ("Cal Poly") has among the largest undergraduate engineering programs in the western United States with approximately 5000 engineering majors, which includes freshmen through senior students. It is well known for its emphasis on "hands-on" learning. However, like many U.S. engineering programs at this time in history, ours emphasized engineering science over practice. Additionally, as one of the six institutions studied by Sheppard et al. in their book, *Educating Engineers* our approach "emphasize[d] primarily the acquisition of technical knowledge, distantly followed by preparation for professional practice…Concerns with ethics and professionalism, which have a new urgency in today's world, have long had difficulty finding meaningful places within this historical model…" (p. xxi, Sheppard et al., 2009).

In 2003, six full-time faculty were responsible for 115 undergraduates who took roughly half their degree requirements from their MATE department. True to the "hands-on" character of Cal Poly, about half of the students' time in MATE courses was spent in a laboratory setting. Graduates of the program enjoyed an 80% placement rate in industries. The six faculty were very internally-focused on the education mission, with each person teaching an average of nine to twelve different cours preparations per academic year. In this acounting system, two sections of the same course constitute one course preparation and preparing for a lecture course with an associated laboratory course would be considered two different course preparations. Faculty also advised roughly three to four students per year on individual senior projects, collectively taught and managed 800-1200 non-MATE students per year in introductory materials engineering lectures and labs. The masters-level graduate program generally consisted of about two to four students, however, the faculty maintained the Cal Poly tradition of teaching all courses. The program, with roughly 55% of its teaching staff's workload dedicated to teaching non-MATE majors, has the fewest faculty available per major student in our college, as shown in Figure 1. To support the faculty and the roughly 40 different sections of laboratories they taught, there were several part-time staff: a 75%-time administrative assistant; a 50%-time technician, a 25%-time computer technician, and three part-time lecturers.

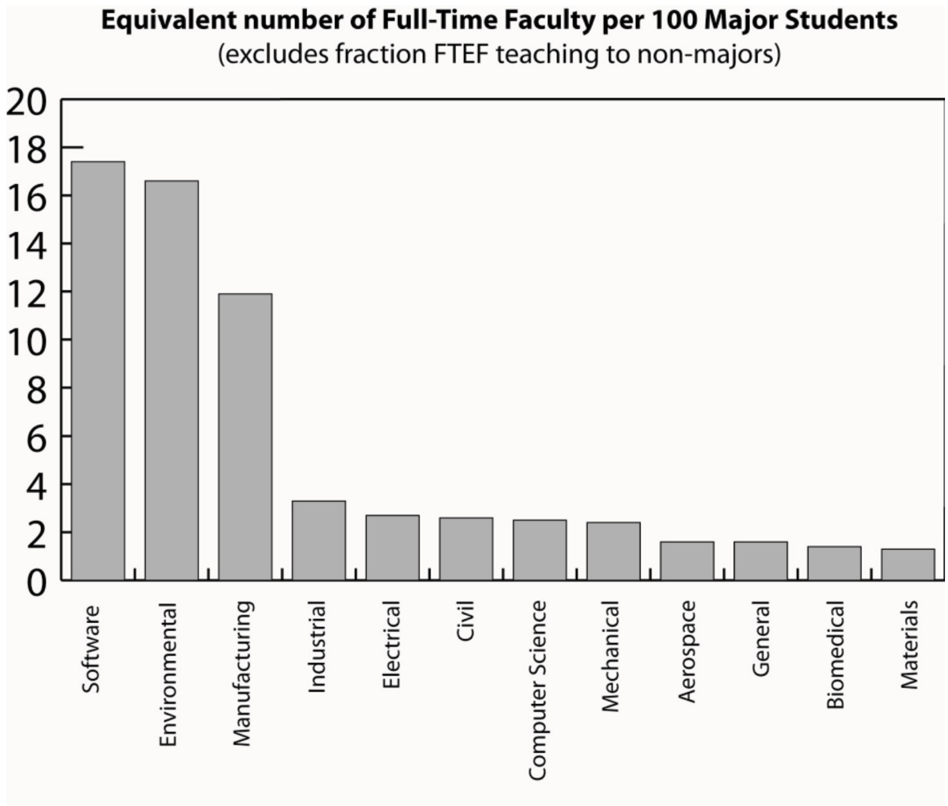

Figure 1. Number of faculty available per 100 students in the major. The MATE program at Cal Poly has among the lowest faculty resources available within its larger college of engineering for the care and feeding of its major students.

The MATE program's graduating classes were about 30% female, similar to the national average for materials science and engineering reported by the National Center for Education Statistics (NCES, 2005). However, the MATE freshmen applicant pool consistently held the least competitive scores against entrance criteria for Cal Poly's College of Engineering. This was a commonly-reported situation by faculty colleagues at other U.S. institutions in materials science and engineering programs and other less-renowned engineering programs like manufacturing engineering. Our annual applicant pool was also often the smallest, with fewer than 20 applicants whose score exceeded our college entrance criteria score. Cal Poly's MATE program was one among four ABET-accredited, stand-alone MATE departments at undergraduate institutions in the U.S.

THE PLAN, SYSTEM AND AGENTS OF CHANGE

The agents

Daniel Seigel, in his recent review of the latest neuroscience, points out the social nature of the brain; the way in which we are in the world—and in particular, our intent—can have a profound influence on those around us (Siegel, 1999). With this in mind, I must describe the key individuals and their identities. Table 1 summarizes who these people were and what they stand for. Most identities listed in Table 1 are self-professed and represent that individual's consistent focus in the workplace. Each of these people continue to shape our program, despite some of them (Professor E, Staff C) having moved on.

Each faculty was well accomplished and highly decorated with local or regional awards. Since 2003, individual faculty had been experimenting in their own classes with different content and methods. Each was also a practitioner of developing and using learning objectives and grading rubrics in their course design. The program faculty acknowledged that content that is taught in the courses is not equivalent to what is learned by the students. In fact, they collectively committed to the proposed reform work in 2004 and began the necessary changes a year before receiving the DLR funding. In terms of organizational models, the MATE program group could be described as a loose collection of associates who were polite to and respectful of one another. Some had developed stronger bonds of friendship with one another over the years and one was new to the program, but accomplished and tenured elsewhere (Professor D). In 2006–2007, Professor E was participating

Agent	What they stand for	Title
Professor A	Mastery of technical materials science knowledge and skills	professor (co-PI)
Professor B	Engineering professionalism and practice	associate professor (co-PI)
Professor C	Exploring scientific frontiers and inspiring young people through science	associate professor (co-PI/chair 2006-2009)
Vanasupa, Linda	Sustainability*, social equity, serving humanity	professor (PI/chair 2002-2006)
Professor D	Service, personal integrity and ethics	associate professor
Professor E	Service to a greater good, commitment	assistant professor (2006-2008)
Professor F	Unconditional positive regard and personal growth	visiting professor (2006)
Staff A	Flexibility and levity	administrative assistant
Staff B	Service and encouragement	instructional assistant
Staff C	Compassion and hope	Technician

*balance of social equity, environment health and economic needs

Table 1. The agents of change and their leadership.

as a post-doctoral fellow under the sponsorship of the Center for the Advancement of Scholarship in Engineering Education. He was largely responsible for the freshmen year experience. Professor F was a visiting scholar from September 2006 to December 2006 and was an important catalyst in the change process.

The plan

The plan was to reform our program by transforming the learning experience into one that was strongly aligned with the needs of student and societal stakeholders. To us, this meant learning environments and experiences based on principles of "best practice" and the integration of the knowledge, attitudes, competencies and tools needed to create a more just and sustainable world. The most dramatic embodiments of the changes within the curriculum were the freshmen year experience and the junior year sequence, which constituted approximately six percent and fifty percent of their scheduled courses, respectively. The specific aims of our grant were to:

- Empower and retain underrepresented individuals by enabling them to experience early mastery of appropriate challenges and develop strong connections with peers;
- Birth a new breed of engineers who are holistically-oriented systems thinkers who embrace the engineering professions' ethic of applying their knowledge to benefit humanity;
- Motivate engineering students to study by providing a larger purpose and role in society;
- Enhance the initial learning of engineering students' supporting subjects (math, science, communication) by engaging them in experiences that have clear connections to the supporting subjects;
- Improve engineering students' ability to transfer their knowledge to subject domains beyond the one in which the knowledge was acquired (e.g., apply statistics principles to engineering solutions);
- Inspire engineering students to make a positive contribution to society;
- Cultivate in students the responsibility for and ability to monitor their own learning process;
- Encourage faculty at other institutions to implement sustainability design principles within engineering curricula;
- Facilitate the adoption of effectual learning experiences by other engineering programs.

Our strategy was to apply the rich body of results and best practices from education research to the re-design of a curriculum that emphasizes the necessity to consider the broader issues of social needs and environmental impact in the design process. This plan, developed in 2003, is strongly aligned with the recommendations of Sheppard et al. in their recent book, *Educating Engineers: Designing for the Future of the Field* (Sheppard, Macatangay, Colby, & Sullivan, 2009).

Our intent for the freshmen year engineering experience was that it would be much closer to that of a practicing engineer. This effort was lead by Professors D and E. Biased by research in fields comprising learning sciences, it was very important to us that this experience also initiated the cognitive, affective and behavioral development needed for the envisioned engineer. We attempted to design an experience for the students that had personal relevance or meaning and involved an authentic practice of solving real problems for a client. The actual product or process that each team produced varied with the needs of the client. The year-long course experience comprised 3 of 48 quarter units of the freshmen-year. Later we coupled this course sequence with English and Speech so that it represented 15 of 48 quarter units of the freshman year. The first third of the year-long course involved designing, building and testing a solar water heater to build a sense of engineering mastery and provide a natural context to explore the connections among self, engineering, society and technology. It also involved reflection exercises around the intersection of these issues.

For the junior year, the plan was more ambitious, as it required us to integrate previous traditional incarnations of eleven, junior-level engineering materials science courses into three, quarter-long learning experiences of approximately the same total hours in class (i.e., twelve hours per week). We intended design projects to be the context in which students learned the material, however, this required us to create artificial aspects of the projects to meet the learning objectives.

The system

Like other institutions, the MATE program was part of a university that was also changing. For example, during the duration of our grant, the college dean of seventeen years retired, we received a new dean, had three different provosts, two of the six faculty left and were replaced by two new faculty (2006), and we lost one of those faculty members to the harsh realities of the California cost of living (2008). I also took a position to direct a wider College of Engineering initiative (2006-2008) to broaden the impact of the grant work beyond our department. This resulted in another MATE faculty (Professor C) serving in the department chair capacity (2006-2009). I point this out only to illustrate the dynamic nature of our situation.

THE PROCESS

The reform involved new courses and content, but the most challenging dimension of the transformation would prove to be changing from a model where individual faculty "delivered" their courses to one that involved collaborative decision-making and teaching. More specifically, we would discover that we were ill equipped to constructively work through conflict around deeply held values and beliefs.

I hired a consultant in 2005 to prepare the group for a deeper level of dialogue and resolution in anticipation of working through anticipated differences. The consultant was an organizational communication specialist. Her focus was on leadership and communication styles. She worked with our group for roughly four days over a three-month period, including an all-day retreat designed to understand one another's leadership style better. The faculty judged this service to yield too low a return on the investment. However, we made critical planning and timing decisions during this period. This included a 4-year roadmap with critical assessment points and a plan to embed sustainability throughout the curriculum.

In January 2006, I hired a second psychologist who consulted with the faculty and staff over a six-month period. The purpose was to increase our capacity to usefully resolve conflict. The consultation involved individual interviews with all MATE program staff and faculty. While I felt better informed on the group dynamics, our collective ability to resolve conflict did not notably increase, nor did the faculty value her contributions to our process.

From January to June, I set up several subgroups populated by people external to our program and university. They were campus partners in assessment, advisory boards for a course involving design for sustainability, two test beds at other universities, an external assessment group and a research group for outreach at a local Hispanic-serving high school.

During this first year of our DLR grant, Professors A, B, C and I were implementing new sophomore-level courses addressing the intersection of materials, society, and the environment. In truth, each of us had experimented with educational improvements throughout our careers. However, our comprehensive programmatic reform was initiated by an 80-hour, intensive workshop in the summer of 2006 after we had replaced two faculty with Professors D and E. Our goal was to create a detailed roadmap of each of the three, quarter-long junior-year course series that would be implemented in Fall 2006. These courses were each 8 quarter units for which students had 12 hours per week of scheduled class time, so they were half (or more) of the units that students were taking during their junior year. We entered this workshop with roughly 400 man-hours of dialogue with our external advisory board members about what our students needed to be successful in today's world of complexity. I designed the agenda and set very specific workshop overall and daily goals, depicted in Table 2. At that time, I considered myself responsible for setting the agenda and ensuring that the proposed work was complete. I presumed that the process of change involved working together to resolve our differences. All other faculty reviewed the proposal prior to submission, embraced the direction that I proposed as a vision and served as co-Principal Investigators. As any engineer would, we presumed that we could design the curriculum that we wanted to the performance criteria we established. We also considered the learning experiences as independent of the instructors. This would prove to be a flawed mental model of the reality.

Participants: Professors A, B, C, D, and F, Vanasupa
Overall workshop goals: Solidify good team practices of communication and cooperation Complete our strategy on how we are going to "do" the junior course series Complete a rough course design for the first four weeks of each junior-level (Fall pair, Winter pair, Spring pair) a. Choose candidate projects for each course b. Develop overarching learning objectives for the projects/course c. Choose classroom readings for the first four weeks
Daily goals Day 1: Review successes and areas for improvement; recall design principles; evaluate curricular changes; have fun together. Day 2: Create Master list of things we want to teach throughout the 300-series courses. Day 3: Complete first two weeks of Fall-pair course design Day 4: Complete next two weeks of Fall-pair course design Day 5; Complete first two weeks of Winter-pair course design Day 6: Complete next two weeks of Winter-pair course design (and so on through Day 10).

Table 2. Department Level Reform summer 2006 Workshop goals.

We began the summer workshop by reviewing an assessment report prepared by the external expert in educational assessment. The subject of this report was the freshman-year experience of 2005-2006. The expert did an analysis of student responses to an on-line evaluation that she designed and administered by long distance. This experience was a turning point in our work, since the results of our alleged "experiment" with the freshmen experience were neither clear nor conclusive. Additionally, we had spent half our assessment budget to obtain these results. This result forced us to a crossroads where we had to ask, "Do we entirely rely on others or grow our own ability to understand and explore these issues?" With Professor D's encouragement, we chose to grow our capability in partnership with colleagues on campus.

By the end of Day 1, we had used a brainstorming method with Post-its™ to develop a comprehensive list of topical areas that encompassed the development that MATE students should undergo in their junior year. We categorized these into two major groupings: *materials engineering* and *general*. The general categories included cognition/problem solving, communication, teamwork, psychomotor skills, and business skills (see Figure 2). Strangely, we completely neglected any reference to human values, feeling, interests, or other affective development. Looking back on this, I recall that we were very familiar with Bloom's taxonomy of the cognitive domain (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956), but not his later work on the affective and attitudinal domains. In other words, these other areas of human development were not part of our teaching vocabulary. We also neglected any and all considerations of ourselves in the learning system. We considered ourselves "plug and play" actors for any of the courses that we were developing. At the end of this first day, we collaboratively cooked a gourmet meal with a hired chef as a way of building team cohesion.

Figure 2. General categories of skills and knowledge.

Day 2 began with a review of the material that we needed to integrate. Incidentally, each day included an equal balance of structured time with the team and unstructured, individual time. I was mindful of the fact that all the faculty tended toward individual modes of working. These individual times were distributed throughout the day so that we could alternately work together, work alone and return to build upon what we had created individually. During the second half of this day, Professor F lead the group through the initial steps of user-centered design, using our curriculum as the subject of the design.

By the middle of Day 3 we were thoroughly exhausted. We had managed to get through the agenda by brute force. However, the need to make detailed decisions about exactly what was to take place in the course forced us out of the "polite" zone of conversations and firmly into the zone of "conflict" as shown in Figure 3, which is based on Bohm's model of group dialogue (Bohm, 1996). Value differences began to emerge. While we knew that one another had different approaches in their classrooms, we had never before been in a place where we had to resolve these. This place of conflict was an unfamiliar group dynamic; our reactions to it varied from withdrawal behaviors to confrontational behaviors. At the time, we were not aware of the options available to us in the conversation. With respect to Bohm's model, our individual strategies were to retreat to the "polite" conversation domain, or further the conflict with the plan of convincing the "other" that they were incorrect. There were times when we entered the "inquiring" domain.

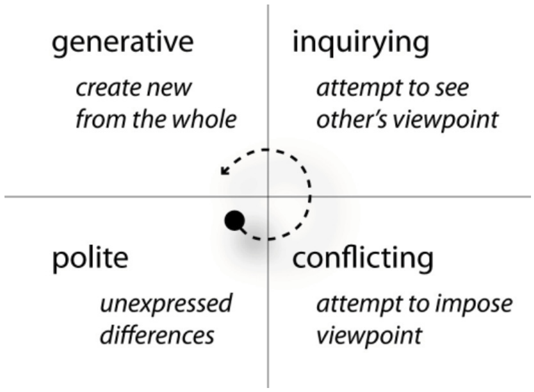

Figure 3. Types of conversation, adapted from Gergen, Gergen and Barrett (Gergen, Gergen, & Barrett, 2004)

The group unconsciously entered into a team dynamic that can be described with the Four-Player model of Kantor and Lehr (Kantor & Lehr, 1975). In this model, used by Ancona and Isaacs to advocate healthy team functioning (Ancona and Isaacs, 2007), individuals in teams take on various functional roles during the conversation: *move, oppose, follow,* and *by-stand* (or *observe)* as shown in Figure 4. These functional roles, which were not conscious to us at the time, are not fixed in healthy teams. Individuals play different roles at different times. Each of the roles has a healthy version and an unhealthy version. In the healthy state, the *Move* player initiates through action or suggesting an action ("We should do X"). The *Oppose* player, in an effort to conserve something valuable, opposes the move ("*If we do X, we will jeopardize what we value, Y").* The *by-stand* player will offer perspective ("*I notice that we are assuming that X and Y can't exist together. Is this an accurate assumption?"*) The *follow* player ensures completion (*"Now that we've come to a consensus I'll take the responsibility of getting X going."*). These players balance one another in a healthy team (Deborah Ancona & Isaacs, 2007). Without all four roles, a team can get stuck, as in the case of a team consisting only of *move* and *oppose* players. Or, it is possible for the team of *move* and *follow* to implement action that results in losing something valuable. Figure 4 also shows the function that each faculty member naturally gravitated to and the one which they were least likely to occupy. (Staff are omitted for clarity, since we did not directly involve them in the conversations on curricular design). The characterization of less natural tendencies is not strictly correct because each faculty could and did function in all roles. As shown, we were fortunate to have a balance of natural tendencies; each faculty could and did function in the *move* and *follow* roles. Professor F's role as a strong *by-stand* was critical to the group, especially since he was from the "outside" and could see

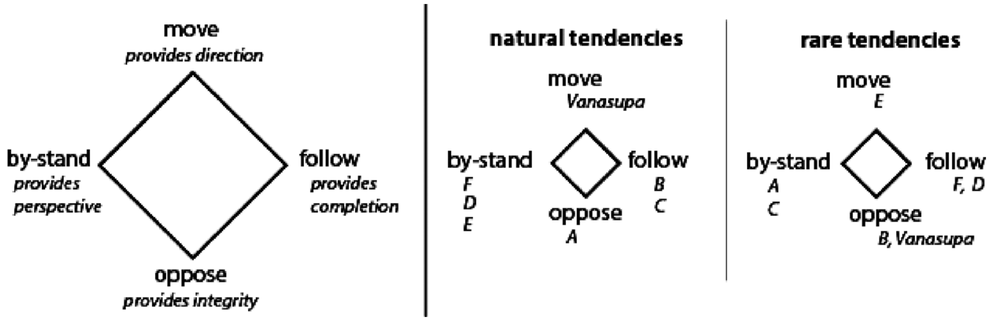

Figure 4. The Four-Player model of Kantor and Lehr (Kantor & Lehr, 1975) on left and an analysis of each faculty's natural and rare tendencies in the four-player functions.

our dynamics without the filter of extensive prior history with us. In terms of Bohm model, Professor F most often moved conflicting conversations to inquiring ones by asking genuine questions. I differentiate genuine questions from rhetorical or manipulative ones that are designed to illustrate the deficiency in other peoples' viewpoints, such as *Don't you think you're reasoning is incorrect?*

By the end of the 10-day workshop we had achieved from Table 2 our overall workshop goals 2, 3a, and 3b. We also believed we had achieved goal 1: *Solidify good team practices of communication and cooperation*. With the benefit of hindsight, I see that we were able to reach a state of dialogue where we moved beyond our differences into a state of inquiry, Figure 3. There were times when we even entered into generative dialogue, but about half the time, we reached consensus before we knew we held hidden mental models beneath our conflicts. In our consensus, probably all compromised for the sake of making a decision. In some cases this took the form of compliance to the larger will of the group, which would prove to undermine lasting change or at least cast doubt on the perceived benefits and validity of the results.

Our disappointment with the initial assessment results caused me to delve into the research literature on fields related to learning. Professor F was the inspiration for this new direction, as he has a regular practice of reading papers that are completely outside his field of expertise. I began reading research on educational psychology, cognitive psychology, sociology, neuroscience, organizational behavior, and education. I discovered that the so-called "best practices" principles that we had been using have underlying psychological, social and learning dynamics. Professor F and I began to develop a systemic model of the interacting relationships found in the learning science research in the hopes of leveraging their combined influences to achieve deeper learning. The model reflects what we believe are the dynamic relationships between the individual, their learning, and the classroom interventions (Vanasupa, Stolk, & Herter, 2009; Vanasupa, Stolk and Harding, in print). The theoretical underpinnings of the model have been published elsewhere (Vanasupa, et al., 2009).

The junior-series began in Fall 2006. It was team-taught by Professor B, Vanasupa and Professor F. There were two topical foci: metallurgical material systems and electronic material systems. We began the work with a fairly detailed plan, week-by-week and daily plan for the 11-week quarter. The first project was a cast metal "trinket," created to meet some materials science educational goals, to address broader societal issues and to develop techniques for design innovation. The second was an engineering design project of an optical spectrometer developed by Professor B and piloted twice before. The faculty initially met daily for 30–60 minutes to jointly organize how to conduct their three hours in class together. Professor F, who had extensive experience teaching project-based courses, provided insights throughout. We collected research data from the test cohort of juniors and a recruited cohort of engineering juniors outside of MATE whom we considered the quasi-control group. The data we collected came from a battery of public-domain assessment instruments and some that we had developed on our own.

The students were extraordinarily generous in their patience with the process, which was experienced as foreign and somewhat disorienting compared to the traditional test and lecture method. The presence of Professor F was a significant benefit, as the students were fond of him. They trusted his experience, which proved to be a very important contribution to the students' sense of safety around the unfamiliar learning mode.

The winter quarter junior series was lead by Professors A and D. The focal points were amorphous material systems and structural material systems. This quarter students continued to work in teams whose project was around the process of design improvement and simulated FDA approval of a biomedical implant. In this scenario, they were required to illustrate through testing results the potential of their design. One inspired team won a national student design award on their design. However, some faculty expressed doubts about the quality and quantity of learning.

The spring quarter was lead by Professor A and I. The focal points were process design and hybrid material systems. This last quarter was intended to release students into a mode dominated by self-directed learning. Self-paced course materials for the projects were developed prior to the course and made available for the students. These materials included learning objectives, learning milestones and self-assessments. Faculty gave students milestones for the self-paced work. Students were given more autonomy to choose their own teams, work at their own pace (within limits) and work wherever they preferred. In parallel, they were to complete an interdisciplinary project with art and design students, history students and architecture students. This involved three additional faculty members from history, art and design and architecture in weekly coordination and "damage control" meetings with the students. At the end of this year, by suggestion of an advisory board member, we had developed a mock resume for them. This resume had two sides: one for a student educated in the previous curriculum and one educated in the project-based setting. This resume helped students to understand how they might represent their new skill set to a potential employer.

In summer of 2007, the six of us came together again. This time, we were joined by Professor E, who had been serving as a post-doctoral fellow in the 2006-2007 academic year. Our time was limited to three days. We had collected a great deal of research data during the year, but we had not yet grown the in-house capability to analyze the data. This short workshop was spent reflecting on the experience and how to improve it. We also created a student guide for the curriculum for the purpose of reducing the anxiety that students felt about the changes. The guide that we developed was very well received by the students and significantly diminished the questions and concerns that they expressed about the curricular changes. It described our developmental aims and what to expect in the curriculum.

The classroom in which all of these experiences took place was designed for collaboration. In the video below, you can see how the students used this space. This particular clip is from a sophomore-level course on nanotechnology, ethics and society. It was conducted in a team-based learning mode (Michaelsen, Knight, & Fink, 2004). In this clip, students are working on the design of simple biomedical device. As shown, the students gathered around tables and engaged in peer-to-peer learning as conflicts in understanding emerged. One of our goals was to more deeply engage the students in learning as shown in these video clips. As can be seen from the clips, students' body language (leaning forward, direct eye contact or focus on the externalization of the ideas) indicate a high level of engagement. The second clip is the same group of students trying to develop a systemic causal loop diagram to explain the link between public policy, and the epidemic of early-onset of Type II diabetes in the U.S. This activity was designed to promote systems thinking. The third clip shows the high level of engagement. The fourth clip shows a typical end of class. Notice that although the class has ended, the students continue their work together. In this particular class, they were tasked with the job of coming up with designing an artificial liver via planar technology. This was a challenging task, but one which they actually could do with the available data taken from primary readings (i.e., peer-reviewed journal articles). We frequently had to ask students to leave the class after it was over to make room for the next class.

Video clips 1-4 at http://advances.asee.org/vol02/issue04/08.cfm#media

One of the aspects that continued to haunt everyone was the question of whether the students were going to be as professional prepared as past graduates. During the 2007-2008 school year, there was growing concern about the efficacy of the program, particularly the course featured in the video above, which arguably had the strongest level of integration of social issues, engineering ethics in design and systems thinking. This course was co-taught by Matthew Ritter, a biologist, and me (Vanasupa, et al., 2006). It culminated in a debate on nanotechnology and society which required students to draw upon their newly-acquired research and critical thinking skills. Despite the students' strong positive statements about what they learned in this course, they openly questioned whether it should be considered an engineering course because of what they viewed as "non-engineering" content of the broader social issues. Freshmen students also continued to express their angst about not having a clear identity of a "materials engineer." The freshmen course, while very effective on many measures (Harding, Vanasupa, Savage, & Stolk, 2007), was necessarily general in its approach, rather than constrained to "materials engineering." In 2008, the course involving systems thinking around societal and ethical concerns of engineering was removed from the curriculum and replaced by a more traditional materials science course that incorporated societal issues.

THE RESULTS AND THE MEANING

The student response

As shown in the videos above, the change in learning mode completely changed the traditional dynamics of the classroom: students came to their MATE courses with the expectation that they would engage in design and dialogue with one another. The physical space was set up to facilitate this type of learning. We had planned to retain more students and this result was achieved over and above our target. Some freshmen students brought their dormitory roommates to class with them because of their engagement and enthusiasm for the class. The historical net loss of students in the first two years (up to two thirds of the entering freshmen) has been changed to a net influx of students—some of these from fields outside of engineering (e.g., business, landscape architecture). As shown in Figures 5 and 6, the MATE program is now a net importer of students within the overall college of engineering. We only include the first two years, since these have been shown to be the most critical years for engineering. At this point, it is too early to tell if this is a stable trend. However, the data in Figure 7 indicates the impact of the trend in recent years; here you can see that the program has grown 40% during the period of the DLR work. This growth has been primarily through retention. We note that our MATE programmatic growth has occurred in a time period during which the other three materials engineering programs at undergraduate institutions that we mentioned in the introduction have been combined with other programs or dissolved.

We also have an analysis from an outside engineering evaluator with a Ph.D., Environmental Engineering, who evaluated 20 individual senior project reports before and 20 individual senior project reports after curricular changes. She reported that the projects by students in the new curriculum exhibit a much higher level of integrated consideration of design, societal, environmental, political

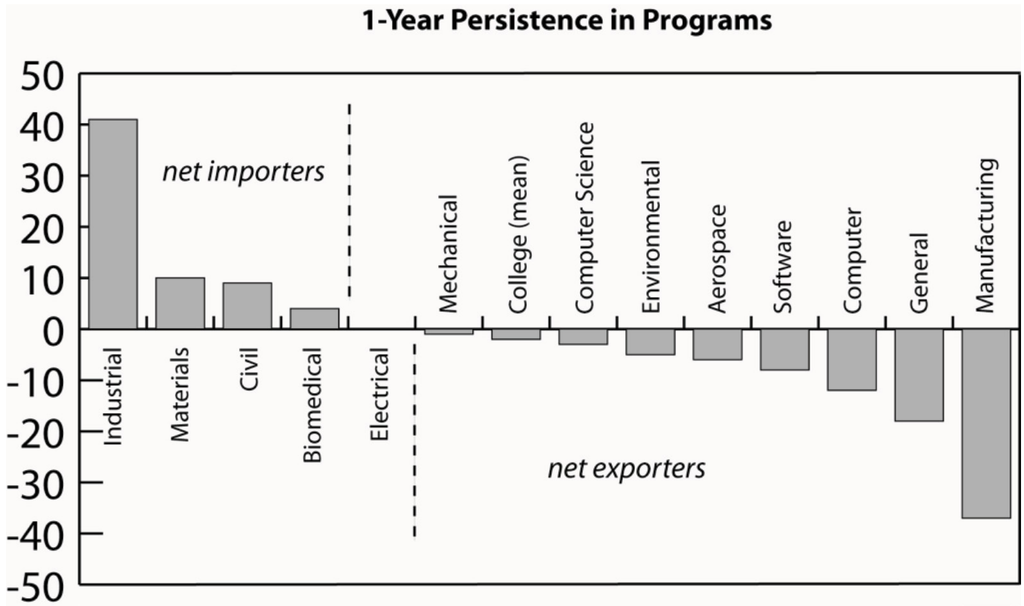

Figure 5. One-year persistence rates across the engineering programs at Cal Poly. MATE is a net-importer of students.

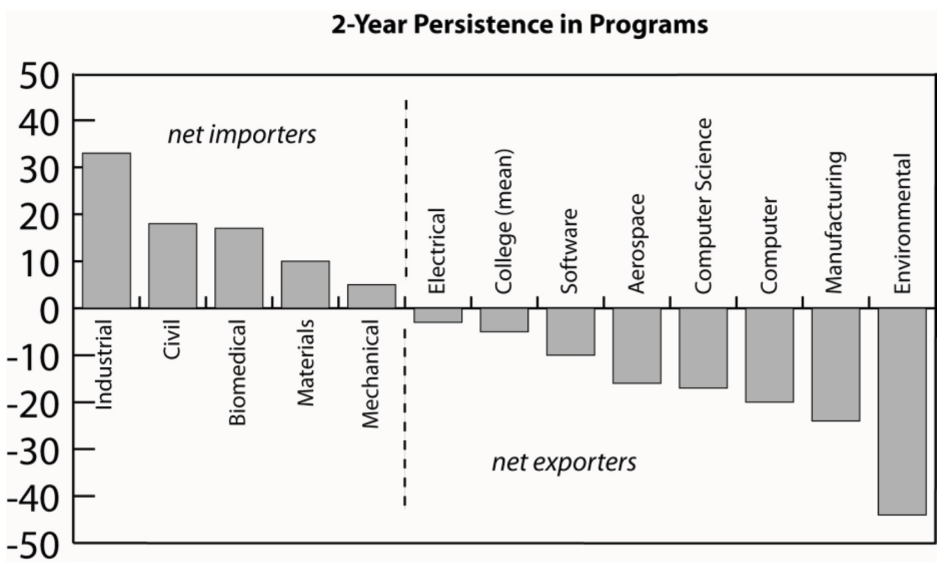

Figure 6. Two-year persistence rates across the engineering programs at Cal Poly. MATE is a net importer of students here as well.

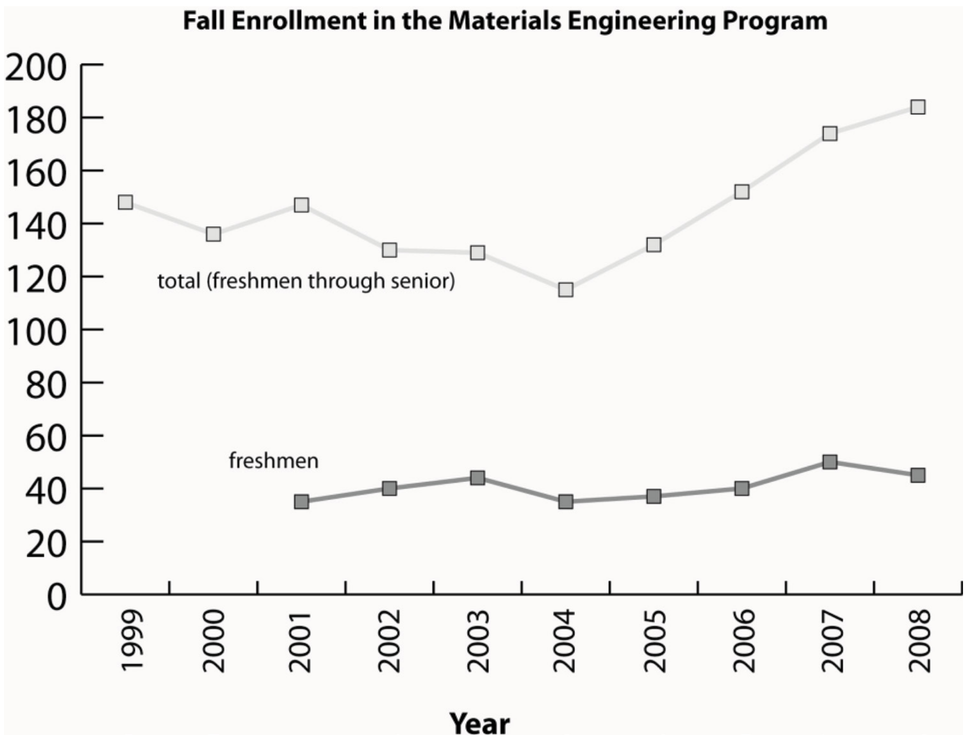

Figure 7. Number of MATE students over time, dating back to 1999.

and sustainability issues. However, we now require that students address these issues in their senior projects, so her report did not serve as solid evidence of the value of the new curriculum since individual faculty did not see students' competency in areas they valued. Prior to starting the reform, these same faculty were initially "sold" (or convinced of) the value of the programmatic changes against their own deeply-held teaching values and convictions.

Upon graduation, students who participated in the entire reformed curriculum had very positive things so say. As shown in their responses (see Appendix 1) to *What has been the best contributor to your success?,* the human elements along with the project-focused learning environment was perceived as most strongly contributing to their success. In this survey, students were also asked *What do you feel is the most important skill or concept that you learned in your MATE classes?* We converted their collective response into a Word Cloud with the Javascript tool "Wordle" (www.wordle.net), where the higher frequency words are larger. Larger words are those that appear more frequently.

The staff and faculty response

All of our reforms have been institutionalized in the curriculum, but their exact form continues to change. We are now experimenting with co-teaching assignments that couple faculty with like teaching styles. Those who are uncomfortable with the ambiguity that comes in authentic projects are now co-teaching with one another. They are shifting the form of their junior-level course toward traditional modes (lecture and laboratory exercises that have known and predictable outcomes). Those who believe in the value of the reforms continue to experiment with ways to minimize the perceived problems of project-based learning and learning experiences with clients. One individual recognizes the value of the reforms but also experiences discomfort with the chaos that comes with authentic projects.

At this time, our program is the subject of a case study on organizational change. All of us openly continue to reflect on the effectiveness of all that we do as educators, but we hold very different mental models of the cause of perceived ineffectiveness. The interviews reveal that the faculty are not equally or collectively sure that the students are better prepared compared to our past curriculum. Some would say that we are graduating students who have a tenuous grasp of what feels like a smaller body of technical information. Almost everyone agrees that the quality and depth of the senior projects and team projects on the average is higher with a greater integration of societal issues, yet we would agree that there appears to be a wider standard deviation in skills. We also see that team projects can enable a kind of intellectual hitchhiking by those who are academically less developed or for those who are, for whatever reason, inclined to allow others to do the bulk of the work. This is something that we have struggled with. We have lost what felt like a clear assessment of ability—the exam. We can logically see that the exam does not test the complexity of skills required of an engineer, but it is a familiar, if false, proxy indicator. Some faculty have returned to a predominantly lecture/test mode out of the belief that this is better for the students; they also self-identify a preference for controlled learning environments, where the faculty member determines how students' time is spent in the classroom. All faculty express concerns about individual students' grasp of the concepts, which is much harder to assess in a team project.

The meaning

As stated in the introduction, the changes in the program that we witnessed and measured don't necessarily prove that our reform interventions are the source of the improved programmatic metrics. There were too many interacting changes in the system to isolate the source. We intentionally altered a host of variables of the learning experience because we were focused on improving our practice and believed that the interaction of these variables was needed to maximize the benefit

Figure 8. Word cloud created with www.wordle.net from the student responses to What do you feel is the most important skill or concept that you learned in your MATE classes? The frequency of the word in the response is proportional to the font size used for the word.

to the student. For example, our entering freshmen now consistently embody the highest total SAT math and reading scores as well as the highest ratio of SAT reading to SAT math scores within our college (Figure 9).

Combined with our high first and second year persistence rates (Figures 5 and 6), this is an indication that we are attracting and retaining bright individuals who appear to be more balanced in their reading and math development relative to their engineering peers. We propose that these balanced scores represent individuals with arguably broader interests beyond the math domain. While engineering has always attracted individuals who test well on standardized exams, there is evidence that those with broader interests choose to leave engineering because of its narrow focus (Loshbaugh & Claar, 2007). Another study by Atman illustrates that very few graduating engineers at their institution consider broader societal issues as part of the top five things of importance for engineers (Atman, 2007). It is our hope that we are growing a fundamentally different type of engineer—one who thinks broadly and welcomes diversity in all its forms. However, this data only suggests evidence of this hope; we can't tell at this point. However, it is the first time in our department history that our graduates are seeking employment with non-profit organizations, pursuing K-12 teaching careers and starting their own businesses in appreciable numbers. That is, the initial

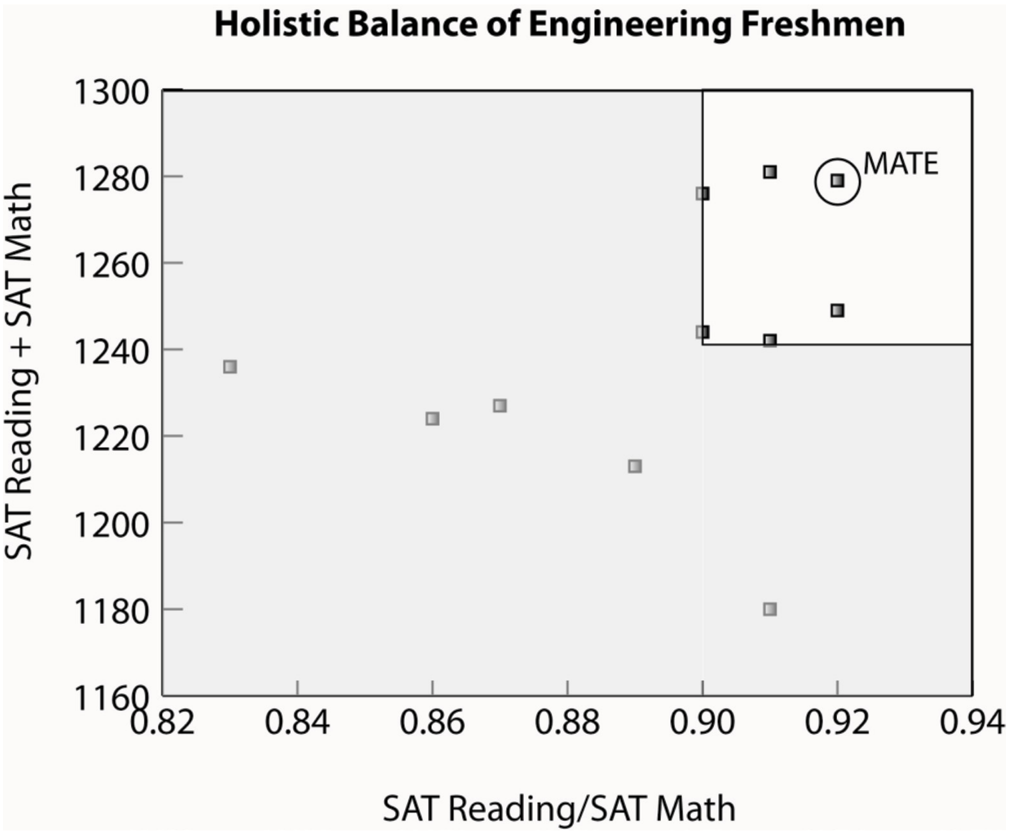

Figure 9. SAT reading/math balance profile of incoming freshmen. The MATE program is represented by the upper-most data point in the right-hand corner. The upper-right corner represents our department's target for the incoming freshmen.

graduates of our reformed program are pursing alternative career paths relative to their engineering colleagues.

However, before I praise our curricular interventions too highly, I must point out the fact that in 2005, we launched a new website (www.mate.calpoly.edu). This website laid out our educational philosophy (http://mate.calpoly.edu/prospective/), and prepared prospective students for an entirely different learning environment (http://mate.calpoly.edu/prospective/rightforyou/). In a sense, the website created our programmatic brand. It is likely that it acted as a filter to self-select students of a fundamentally different orientation in the world compared to the traditional engineering student.

We also considered that our move to a new building was the cause of higher persistence. However, we ruled this out by doing a z-test of significance for proportions between our program and AERO, who also moved into new facilities. Our 1-year and 2-year persistence rates are higher than the AERO programs at a statistically significant level (95% confidence interval, $p < .01$).

One might suppose that it is a small-department phenomenon. To test this idea, we compared our department student numbers to those of a comparable small program that is also directly associated with serving society: environmental engineering. Again, a test of proportions reveals that the MATE program's persistent rates are higher at a statistically significant level (95% confidence interval, $p < .01$).

One of the unintended consequences of our reforms is that we actually have a smaller proportion of female students in our program than we had prior to the grant. We had intended to increase the proportion of women, but what we found was that females applying to our program were now top performers in the the state of California. These females were heavily recruited by institutions with more financial resources. For example, of the incoming class of 2007, 15 of the admitted students were women. For a freshman class of 45 students, this would have constituted one third female, which is our historical average. However, all but two of these 15 female applicants were offered scholarships at other institutions. Cal Poly does not offer scholarships to freshmen as a matter of policy, so 13 of the 15 females from that particular cohort chose to attend other institutions.

However, through word of mouth, we have had a net import rate of female students at the freshmen and sophomore levels. They have come from majors such as landscape architecture, speech and communication, chemistry and general engineering.

At one point, we worried that the project-based nature was actually turning female students away, so we hired an outside researcher to conduct focus groups with all male MATE students and all female MATE students. Using the approach of appreciative inquiry, she unearthed no evidence that the project-based format was in any way a negative dimension of the curriculum for the 12 females in the studies.

THE PITFALLS

Decisions are not made by data, but by examining consequences against our values

As someone trained in a quantitative discipline, I believed that good decisions are based on data. What I didn't notice in my belief was that one needed to first make meaning of the data and that process of assigning meaning is not devoid of our humanity. It requires a rationale process that mixes our individual historical beliefs, emotions, values and mental models—it is a process of rationalization (Argyris, 1996). When one is faced with a data-based change in worldview, Kuhn, in his classic work, *The Structure of Scientific Revolutions,* states that their usual response is to find a way in which to either invalidate the data using the rationale of their existing belief system or to complexify their existing belief system to account for the unusual data (Kuhn, 1970). Kuhn states that in making a decision that shifts one's paradigm, one is required to go outside the logic and rationale of their belief system and evaluate the consequences of their choices against their values. In this model of making decisions, a group contemplating a major change would put priority on examining their deeply held values. A mistake that we all made was in simply seeking evidence to prove the efficacy of the reforms without really considering that we would in fact refuse to believe things that conflicted with our existing beliefs about the value of the reforms we were implementing.

Humans should not be viewed or treated like mechanistic objects

My expectation that we would get definitive answers and direction from our initial assessment of the freshmen experience in 2005 spoke to my naïveté about educational research. We had a belief that we could apply our empirical methodology from the physical sciences to this educational situation. Although we consulted educational researchers at all stages of writing the proposal and implementing the research, the complexity of an issue unfolds only when one attempts to apply the theory through practice. Underneath our initial approaches was a belief that educational research is closely analogous to research involving non-sentient beings, although one has less control over the prior and current conditions of the experiment. I have since adopted the emerging worldview of educational researchers that recognizes that real, significant and unique dynamic social interplay is present in every learning context (Berliner, 2002; Dowd & Tong, 2007) and requires a kind of research that involves considering the human dimensions and the internal dialogue of those in the system (Torbert, 1981; Boyce, 2003). My present thinking is similar to that of Berliner, who replaces the notion of the "hard" (physical) and "soft" (social) sciences with the "hard-to-do" sciences (education and other social) and the "easy-to-do" sciences (physical) (Berliner, 2002).

Also, students in the new curriculum often said they felt like guinea pigs. Oddly, it did not occur to us to include students in the design conversations about the curriculum. We followed Institutional Research Board (IRB) protocol on the use of human subjects but curricular experimentation is actually considered part of the normal educational process and largely exempt from approval. We were somewhat sympathetic to students' complaints, but felt perfectly justified in the name of the beneficial ends of improving education for others. It was not until I was in a situation where I felt that I was under study without my consent, that I understood what the students were trying to say. Being the "object" of a study felt genuinely dehumanizing. In retrospect, I truly question the morality of running experiments with anyone as the "subject," when one is in fact treating them like an "object," as one does in conventional, physical science research. For me the differentiating feature is whether I consider myself under study as much as my students are, or whether I am studying them as one would study something under a microscope—with no regard for the object's feelings, interests, autonomy or values. Adhering to the "letter of the law" within IRB approval now feels below the simple moral standard of treating others as you would have them treat you. I feel faculty need to find a new way of collaborating for the systemic educational change that is needed at this time in history. My current thinking is that action research methodologies hold the promise of conducting research in a way that is morally defensible and geared toward moving the human system toward a more mutually desirable state (Reason and Torbert, 2001).

Structural changes that do not proceed from changes in mental models will not survive

We indeed transformed our program with the aid of the National Science Foundation funding. Most of the changes were significant and structural. They involved what we taught as well as how we taught. However, these changes did not unearth or challenge the hidden mental models of reality that were underneath our decisions. I now share the view promoted by Senge (Senge, 1990): events are symptoms of patterns of behavior which themselves result from systemic structures that we created from our own mental models of reality. We were not aware of our mental models that formed these structures or even able to manage conflict around these if we did see them. For example, we wanted to better equip our students, but we did not talk about our assumptions. *How would we know they were better equipped? What would we measure? What were we assuming in the measures? What were we assuming in the process?* I presumed that a simple analysis of the senior projects before and after the new curriculum would prove the effectiveness. But I didn't realize I was assuming that we could actually wait for four years to know the answer to this question. We presumed that at the end of the quarter, we would measure change in the test cohort relative to their peers. We didn't talk about all the assumptions that are required to support conclusions within this methodological approach.

Most importantly, we did not discuss our mental model of the change process. If we had consulted a substantive reference on organizational change, such as *The Dance of Change* by Senge (Senge, et al., 1999), we would have anticipated the following trends that we indeed experienced:

- Initial enthusiasm followed by a loss in belief caused by a lack of definitive indicators of success;
- Students' fear and anxiety about the impact of the changes on their education;
- Resistance and animosity by certain parts of the larger organization (i.e., the university);
- Development of "believers" and "non-believers" within the change initiative;
- Concern over marginalization and loss of traditional identity by those involved in the change initiative.

Furthermore, we faculty did not have a high level of meta-cognitive awareness within ourselves. We were not familiar with the idea that all humans' perceptions, thoughts and conclusions were influenced by their own views of reality (Argyris, 1997). As trained by our discipline, we believed that we could design processes that met our functional requirements for performance, but somehow overlooked the fact that we were working with humans, not inanimate objects. We did not know of any way to resolve conflicts except by force or concession to the force of another. In retrospect, we would have greatly benefited from an understanding of communication techniques for dealing with conflict, such as Non-Violent Communication (Rosenberg, 2003). Like many educated in our present U.S. engineering and science system, our education was largely absent of the reflective habits of mind required for these types of personal development. I have a theory that science and engineering educators in the U.S. believe that by avoiding all deeper questions of human existence in our classrooms, we are focusing on our disciplinary expertise and thereby being morally and ethically neutral about these issues. My belief is that we are not cultivating moral neutrality as intended, but "moral impotence" as described by Filion (Filion, 2004).

The anxiety around change must be mindfully managed at multiple stakeholder levels

Much of the anxiety around change can be managed. For example, in the summer of 2007, the student guide to the curriculum significantly allayed students' fears about the curricular changes. It made known the unknown and put these changes in context of their value system. Another way of reducing the anxiety for students would have been to engage them more deeply in the change process—to co-create some the solutions. To some, respecting students' views is an unusual suggestion, but we are in unusual times. Our incoming freshmen often have more detailed knowledge on topics that they are passionate about. In my view, it is a time where universities are no longer the gatekeepers of knowledge. My observation is that for many faculty (in general), this loss of authoritative power appears to be uncomfortable.

The anxiety for the faculty should have been managed through identifying a suite of indicators that satisfied all stakeholders. We are all prone to seeing what we want to see (Johnson-Laird, Held, Knauff, & Vosgerau, 2006). The measures that we analyzed satisfied "the believers," but not "the skeptics." We should also have identified critical points along the reform path to take the data; We should have agreed on our mental model of the time scale for significant change and the evidence for the changes. Some were convinced of the need to return to previous modes of teaching after six months of personal observations in the classroom. Others were equally convinced of the efficacy of the reforms. Neither camp transparently considered the limits and biases in their own personal observations. What began as an apparently cohesive department in 2006 grew into one split by our unexamined belief systems by 2009. However, it is more likely that effect of the reform activities was to surface our previously hidden differences. We are now re-evaluating our path of change. In the spring of 2009, I began to consider the framework of sustainable development by Donella Meadows (Meadows, 1998) as a way in which we can think about tracking an array of indicators that are meaningful to us. While she addressed the issues of sustainability from the perspective of balancing social, environmental and economic needs, her insights are very valuable for any systemic change initiative involving humans. She advocated that to monitor sustainable development, one must measure the sufficiency of well-being for all, the sustainability of the means of obtaining the well-being, and the efficiency of converting the means to the ends (well-being). In our context, I have asked myself the question, "What is well-being in a higher-education context?" This has something to do with the students and their education, but it also brings the faculty and staff into the system. This also requires us to dialogue about values. I believe that the faculty and staff within the MATE program are ready to have this conversation with one another, but not skilled in doing so. Furthermore, we are not ready to have this conversation with students. We continue to hold onto the "us and them" mindset, rather than a "we" mindset, despite our fondness for our students.

This change process is not only confined to the program in question, but extends to the institutional context. In 2006, our new dean initiated a strategic planning process that resulted in a new vision statement in 2007 that is very similar in principle to the goals of our department reform. It is *To lead engineering education and innovation to serve humanity.* To my knowledge, the college did not previously have a vision statement, but their mission statement included preparing students for service and employment in industry. In the college-level strategic planning process, a couple MATE faculty were present and vocal about the need to redirect our focus toward addressing societal challenges. Although not alone in this view, this was the minority viewpoint. Initial reactions were statements from engineering department chairs like, "We should not be serving society. Aren't we supposed to be serving industry?" "We should not use the phrase 'serving society' in our vision statement because it sounds like we are a social non-profit organization." and "We will lose our funding if we adopt a vision statement about serving society." The majority of engineering faculty felt this way in 2006. However, much to these individuals' credit, after I pointed out that serving society is part of the National Society of Professional Engineers' Ethics Creed, "...I dedicate my professional knowledge and skill to the advancement and betterment of human welfare." ("Engineer's Creed," 1957), they began to shift their thinking. The crafting of the new vision statement a year later was done by a group that excluded the MATE faculty, which speaks to the change in thinking within the college. Other faculty who were working on more society-oriented issues are now more visible and recognized for their work.

However, a new vision is somewhat threatening to those invested in the previous identity. We attempted to bridge these gaps by using our department level funding originally-slated for MATE faculty to purchase time for those within the college but outside our program to have an opportunity for personal development. We set up a weekly meeting of "fellows" who would gather, share journal articles and discuss pedagogy. This lasted a quarter and cost the MATE program about ~$55K, an amount equivalent to the annual laboratory operating budget of the MATE program. We also attempted to assist the dean by hiring and producing a 7-minute video montage that connected the new vision to Cal Poly's original institutional roots.

Sustained change requires a collaborative leadership and interactions with external agents

After one year into the grant work, I saw that the work would require that we ourselves develop in our own scholarship. This may be obvious, but when starting the grant, we were thinking about the improvement of the curriculum and the students' education, not of our own development. A few of us tried various levels of collaboration with those in the College of Liberal Arts and the College of Math and Science, ranging from co-creating the class experiences to coordinated "teaching." (Vanasupa et al. 2008). In the end, I feel that the most successful model of sustaining high performance in organizations is the one developed by Ancona et al. (Ancona, Bresman, & Kaeufer, 2002). This model consists of three concentric tiers of team engagement: the core which holds the vision of the overall work, the operational tier which makes sure the work is completed and the outer network, a group of content experts who engage when needed. The membership of these tiers often shifts throughout the work. We used a similar structure and worked with those outside our program, college and eventually outside our university. This dynamic of interaction has lead to a whole new arena of scholarship for the faculty in the MATE program and lasting working relationships with those outside our program.

My style of leadership was generally consultative or collaborative in what I perceived as important decisions, such as anything around the curriculum. However, looking back on it all, there were many times in which I was unaware of my attachment to a particular outcome, yet presented the issue as a collaborative one. These were times in which I had a tendency to unconsciously manipulate the outcome of the conversation to my predetermined conclusion or participate in the conversation in ways that caused others to eventually concede to my viewpoint. I was truly unconscious of the ways in which my deep commitment to certain ideals (Table 1) created a subtle demand for conforming to my ideology. In the dynamic human system of our department, this caused some to position themselves against my suggestions. There were times in which I enacted a "selling" mode of leadership to secure "buy in." This would prove to be the undoing of many of the more innovative reforms. There were also times in which I was autocratic or delegating when I viewed the decision as unimportant. In essence, I was enacting the "hero model" of leadership; I feel this model is anachronistic for the complexity of our times. Like others (Boyce, 2003; Senge et al., 2007) I believe the emergent model of genuine collaboration and co-creation in organizational leadership is necessary for the kind of changes that we seek in higher education.

SUMMARY

To those who would undertake a dramatic change in your curriculum, I would encourage you to consider the idea that institutional change will fundamentally involve people. Our experience was that the most difficult part of the change was the people. We continue to evolve in our ability to resolve conflicting viewpoints, but being grounded in an understanding of yourself, others, and the dynamics of organizational change may be more important than the teaching methods and subjects of the change. In the process of this reform, I have emerged with these convictions: 1. Decisions are not made by data but by examining consequences against our values; 2. Humans should not be viewed or treated like mechanistic objects; 3. Structural changes that do not proceed from changes in mental models will not survive; 4. The anxiety around change must be mindfully managed at multiple stakeholder levels; and 5. Sustained change requires interactions with external agents. I believe the human race is at a time in our collective history when we must find a way to do things differently if we desire the prosperity of future generations As an educator, I feel society is fundamentally facing a question of how we learn differently. To those who share my conviction, I hope this paper has provided some insight on how to be more successful in academic change endeavors.

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APPENDIX

APPENDIX I: Verbatim responses of the 22 graduating students who were the first cohort in the junior series. Note that the majority of the comments refer to the learning culture.

What has been the best contributor to your success at Cal Poly?

- The supportive, friendly MatE department staff.
- The faculty and the learn by doing structure of classes.
- Mate teachers and students
- caring faculty
- Project based learning
- The great students and faculty who support me
- The small close nit department.
- challenging group projects, especially the MATE Junior Series
- The close interaction with the professors
- The project based learning, hands down
- Dr. Linda Vanasupa
- I think the focus on sustainability is what kept me interested in the major and by exposing me to that topic area provided me with a passion. Learning how to make and give good presentations has also been very valuable. I have to say that the dedicated and passionate staff and their willingness to overhaul the curriculum to give us more pertinent lessons and experiences was beneficial. The group projects are very valuable as well. Also, all the opportunities sent out to all the students via email; I found two summer REU's and a worldwide youth sustainability conference (and got all of them with the help of faculty recommendations) via department emails.
- Close-knit faculty and students. The people I have met through this department are amazing.
- The projects based learning approach to classes.
- The sheer amount of resources that are available to me, and the fact that you can really get involved in your projects and take them as far as you want.
- The faculty's ability to not stress the importance of succeeding but the ability to take your project and develop your understanding of why your project failed and some things you could do to improve next time.
- Good projects and a good faculty (for the most part) that guided my learning and expressed commitment in my education and my future
- Club involvement, active involvement on campus

- the small family-like department of materials engineering
- The hands on learning experience along with the one on one assistance from professors during office hours.
- Helpful students and faculty.