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Increasing Success and Retention in Engineering and other STEM Fields

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Introduction

The two prominent and related needs for solutions to climate change and more STEM and engineering majors, brought about the Science, Technology & Energy: Expanding Potential (STEEP) project, which was funded by an NSF STEP grant from 2008 to 2014. Research showing the need for greater numbers as well as improved retention and success of students in these fields is plentiful, especially for women and students from underrepresented groups in the STEM professions. The goals of STEEP were to increase the number of students obtaining degrees or transferring in STEM fields. To attain those goals, a multi-pronged approach was taken and programs developed specifically for each approach.

A. To interest new students in STEM majors; the Summer Energy Academy,

B. To prepare existing STEM majors to be successful in their foundational math coursework; the Precalculus Readiness and Excellence Program (PREP), and

C. To retain STEM majors and bolster their efforts to transfer and complete four year degrees; In-house Internships and comprehensive longitudinal support

Our recruitment was focused on underrepresented minority (URM), first-generation and female students for all of our programs. Recruitment outreach at local high schools meant our population contained both incoming new high school graduates and current students. All participants in the Energy Academy, PREP and In-house Internships received stipends, allowing them to forgo outside employment and so participate fully in the programs.

This paper will include details of the implementation of these three approaches as well as some of the curriculum developed, the outcomes and the institutionalization strategies that were eventually employed. We will also discuss this project's contribution to a greater STEM presence and culture on campus which has resulted in our Latino/Hispanic students approaching full representation in STEM and engineering majors on our campus. (Figure 1)

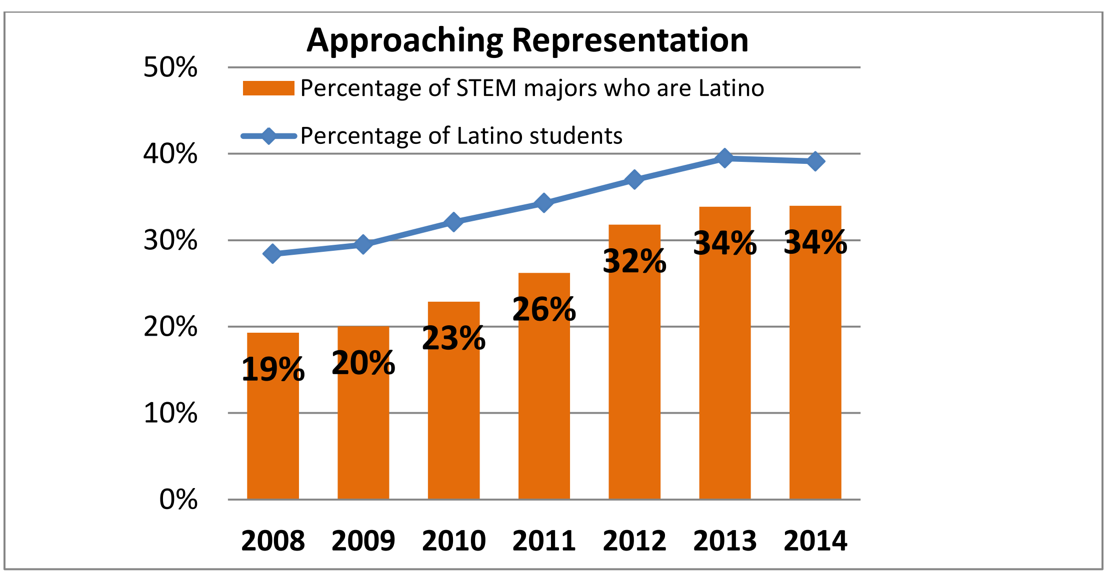

Figure 1 Increase in Latino STEM Majors at Cabrillo College[23]

Those seeking to increase the number of STEM and engineering majors, including URM students, and help ensure their graduations will find replicable activities and pedagogies discussed that may also hold promise at their institutions.

STEEP Outcomes Overview

Data collected over the six year period of the STEEP project reveals several large-scale changes at the college:

- Although the overall college population was in decline during period from 2008-2014, there was almost a doubling in the number of students pursuing STEM majors during that time, (Figure 2)
- During this time period, the number of all Latino STEM majors made the most dramatic increase of 233%, more than doubling; (Figure 3)
- There was also an increased proportion of STEM associate degrees earned by URM students--up from 11.5% before the grant to 33.9% after,
- The number of students completing credits towards a transfer STEM degree increased by more than 50%, going from roughly 7% of the Cabrillo population before the grant to 17% after,
- URM STEM majors in the pipeline have increased from 19% to 34% of all STEM majors over the course of the grant, nearly reflecting their overall proportion of the college population, which is 40%, (Figure 1)

Outcomes that were related to individual activities showed some positive trends, as well:

- Students who participated in the Energy Academy enrolled in math earlier than students in the comparison groups and showed improved performance in math and physics,
- Recruiting efforts resulted in over 45% of participants with undeclared majors changing to STEM majors after the interventions.[1]
- The success rate for PREP students completing precalculus during the semester of the intervention was 10.8% higher than the success rate for a matched comparison group.
- Those who did not pass the precalculus course during the PREP semester, however, had a 61% completion rate in subsequent attempts, compared to a 41% rate that was exhibited by the general college population over the 2002-2010 period. 2,3

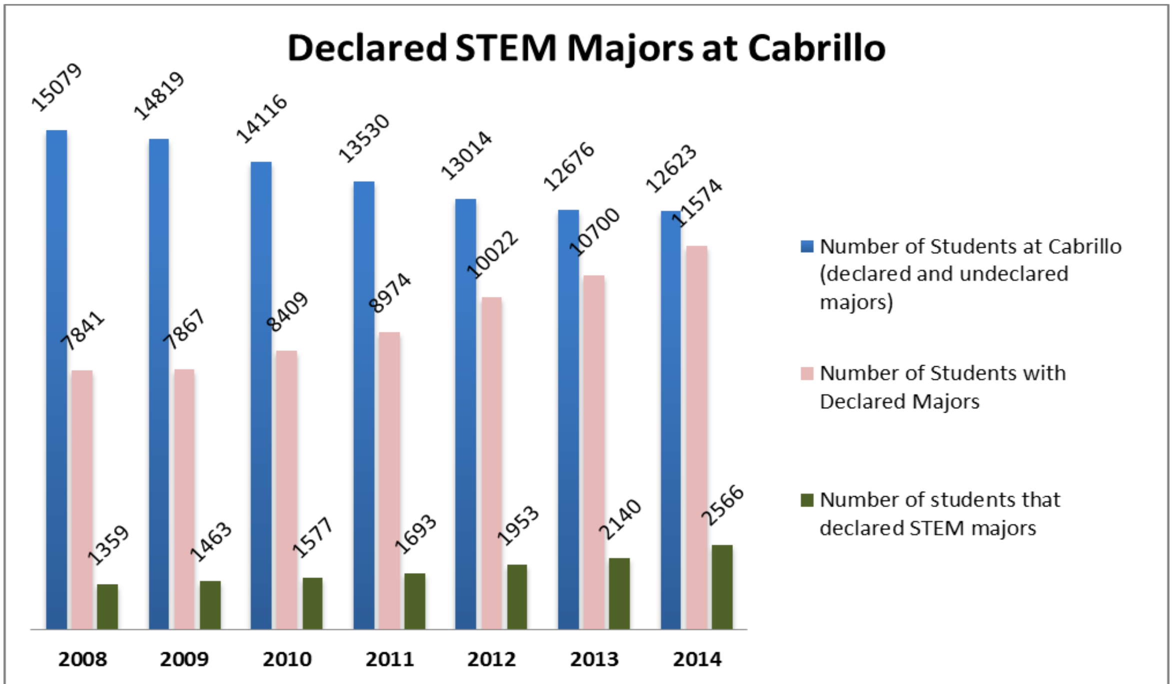

Figure 2 Cabrillo Population vs Declared STEM Major[23]

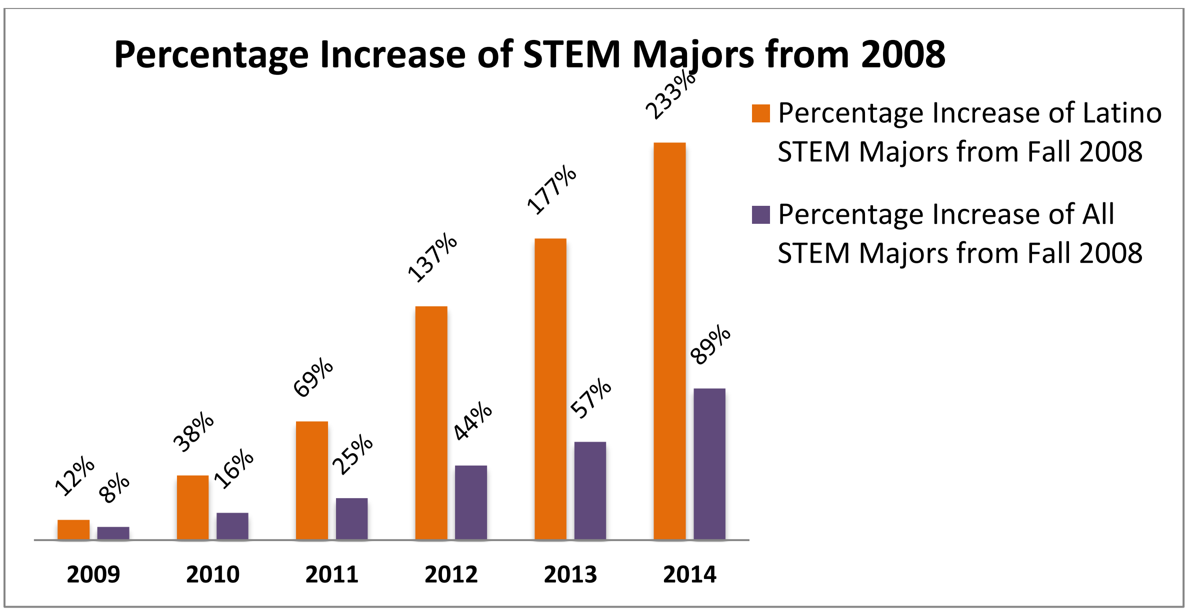

Figure 3 Percentage Increase in Latino and All STEM Majors from base year 2008[23]

Energy Academy Overview

As educators disturbed about the worsening state of climate change, creating the Energy Academy was a way to engage students and ourselves in moving toward positive change. It was evident that the promise of sustainable energy sparked interest among the participating students in the possibilities of studying science and engineering as a means to creating a more sustainable future.

The Energy Academy was a month-long summer program consisting of a team-based learning experience centered on renewable energy and culminating in service-based learning projects. This program ran for five summers and each time included around 24 student participants with an interest in renewable energy or sustainability but, typically, little previous coursework in math or science. Each cohort had 8 student peer leaders or TAs, who were committed STEM majors and served as mentors and teaching assistants. The emphasis was on hands-on activities within small teams in a daily four hour lab setting. An important component was built-in time for tinkering and creativity around contextualized assignments. Unlike most college experiences, the desired outcome was to provoke interest rather than to impart a specific body of knowledge. Participation, exploration and fun were valued over the rigidity often found in STEM instruction. A wide range of approaches were used including; demonstrations, games, hands-on activities, research, guest speakers, team-building, computer applications, field trips, design projects, and presentations. Teams completed demonstration projects which were presented in a day-long public service event, the Energy Fair, to educate the community about renewable energy. Each day of the program there were two to four regular and visiting faculty who represented various STEM disciplines.

The Energy Academy participants were recruited from students incoming from high school as well as students already at Cabrillo who had not yet decided on a major, or who had a non-STEM major. At the beginning of STEEP, 48% of students at our college did not have declared majors so there was a broad pool of possible applicants.[1] (Figure 2) We focused on selecting under-represented minorities and aimed at having half of the participants be female. (Figures 5, 6) These criteria were also applied to the selection of TAs. After submitting an application, each was interviewed and selections were made based on attitude and interest for the participants, and experience and coursework for the TAs. The precariousness of the lives of students in our target demographic often required adjustments and alternate participants, though new students were not added after the first 3 days.

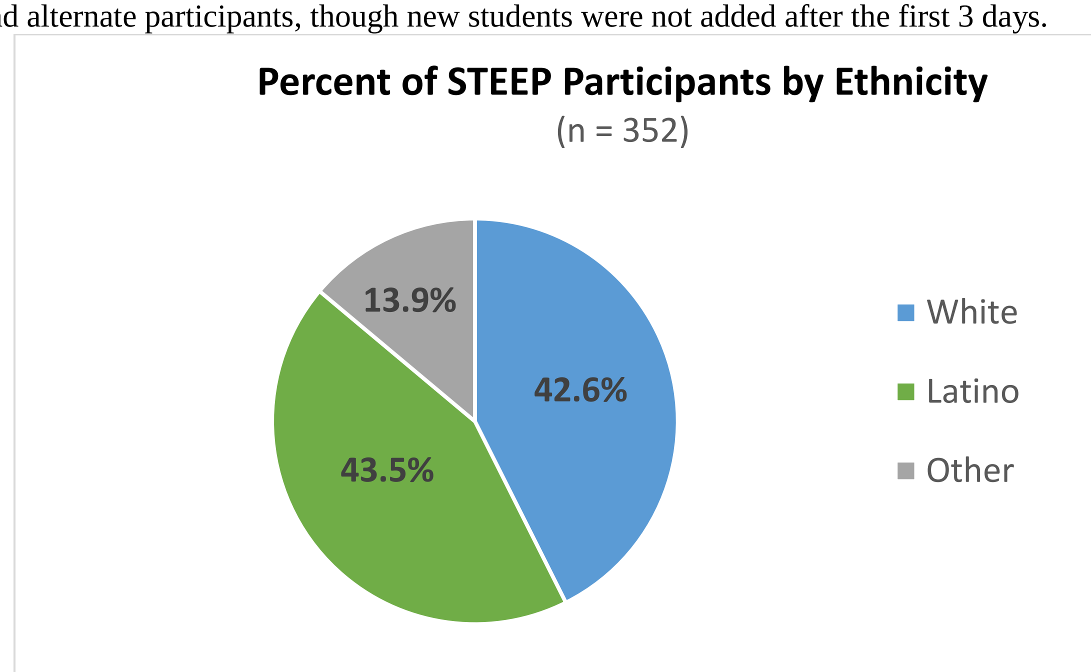

Figure 4 Ethnicity of All Steep Participants 2008-2014[22]

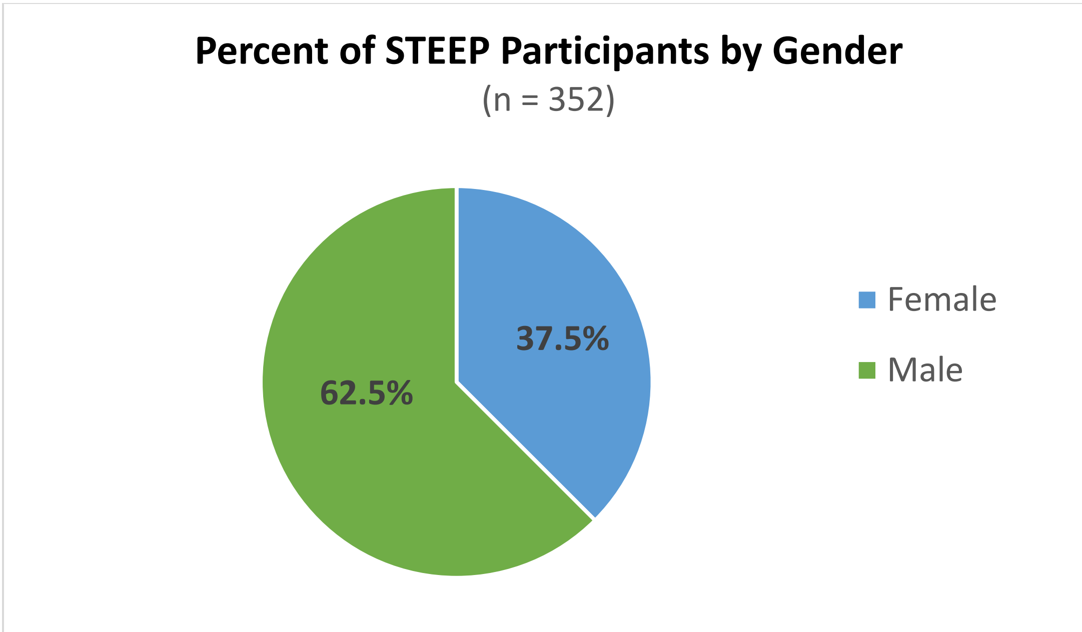

Figure 5 Gender of All Steep Participants 2008-2014[22]

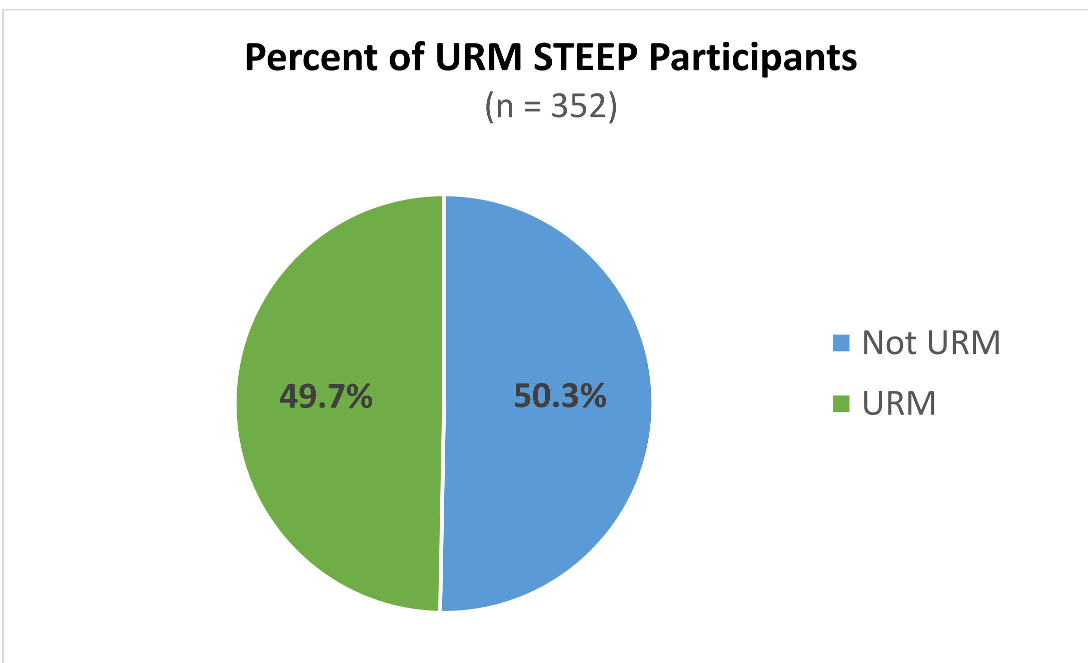

Figure 6 URM Percent of All Steep Participants 2008-2014[22]
Under-represented Minority (URM) excludes White, Asian, and ethnicity unknown

PREP Overview
Students who want to pursue a major in the sciences must be successful in their mathematics. Precalculus is the first college level math class STEM students will take, but it was found that historically, the success rate for that course at Cabrillo had only been 51.5%. Furthermore, of those students who are not successful, only 40% will retake the class, and of those students, just 42% will be successful, which means that only 17% of those unsuccessful the first time will move past this course. [2] This general pattern, in fact, exists across all of California's 112 community colleges.[4] Lack of success at this critical first step in a long pathway ahead of math and science courses often results in students abandoning the goal of a STEM profession thinking they are not capable of mastering the material. More often it is their approach that needs to be overhauled. This intervention was designed to address this leak in the STEM pipeline.

PREP consists of a two week intensive before the start of the semester, and weekly workshops throughout the semester for a total of 80-100 hours. This program has been offered 10 times so far and each time includes 18-28 students who will be enrolled in the same section of precalculus and 4-6 student peer leaders or TAs who are STEM majors and serve as mentors and tutors. The emphasis is on small group work and close interaction with the TAs. During the intensive, students review topics from college algebra by preparing mini lessons and teaching in pairs to the rest of the class. TAs also give teaching presentations on some math topics and on study skills relating to mastery of math topics. Time for team-building, daily icebreakers, and a change of activity every hour or so help maintain an atmosphere that is informal, safe and fun. Students experience a deeper level of understanding by having to teach to their peers. This level of mastery can then be a goal for their subsequent studies. Beyond increased levels of success in the course, a cohesive community of learners results that persists for many semesters afterward as these students take their physics, chemistry, calculus and engineering courses together. After transfer, students often report they end up studying with the same classmates at their four year schools. A team of two math faculty facilitate PREP. Their roles are to train and support the student teaching assistants, and oversee the activities. The amount of direct lecture time from the faculty is perhaps just two hours altogether.

Like the Energy Academy, there is an application and interview process and a focused recruitment effort for determining PREP participants as well as TAs. Students are selected who 1.) are already decided on a STEM major and 2.) are considered to be at risk of not being successful in precalculus. Defining a student as at-risk means one of the following: they have already had an unsuccessful attempt at precalculus, they got a C in the prerequisite class which is Intermediate Algebra, they have had a long break since the last math class, or they have a fearful attitude toward the subject. URMs and women are an additional recruitment focus for this group. When possible, TAs are selected from previous PREP participants.

Internships and Longitudinal Support Overview
In-house Energy Internships and Teaching Internships were created to extend the curriculum of the Energy Academy and PREP so students would have the benefit of real world applications for topics they had been studying. According to Alverez et al.

"Internships stimulate academic achievement, leadership qualities, and communication skills, and can influence the career pathways students pursue".[5] Many of these internships were offered in January, when the college was not in regular session so that students could devote more time without compromising their studies. Energy Interns worked in small teams together with the college facilities department to inspect campus buildings and grounds and collect data as part of an energy audit to aid in reducing energy use. Another team of Energy Interns built the Energy Bike--a bicycle generator that was donated to a local high school for kinesthetic learning demonstrations and inspiring new STEM majors. Another team studied the principles of solar photovoltaics and practiced installation of these systems, then went on to take the NABCEP solar installer certification exam with a 63% pass rate. Students in the role of TAs for the Energy Academy and PREP often became interested in exploring teaching, and they could choose to take up a Teaching Internship which placed them in a local middle or high school classroom assisting a science or math teacher there.

Longitudinal support for students in the program and for all those in a STEM major was provided through the MESA Study Center. MESA, for Mathematics, Engineering & Science Achievement, is an equity STEM transfer program at the heart of which is a Study Center open 60+ hours per week where students have access to drop-in tutoring; peer-led team learning workshops; academic and career counseling, and most importantly, a welcoming community of learners working on college level math and science topics. This program has been a part of the college since the early 1990s. The STEEP grant made it possible to significantly increase the scope of services provided and numbers of students served so that over the six year project there was a fivefold increase in the size of the Study Center's community of learners.

Pedagogies and Related Curriculum

From years of teaching experience we incorporated particular principles into STEEP programs that had proven successful with our students. These principles were applied in an interconnected matrix of activities and curricula for all of the STEEP programs. In this section, under headings of known best practices, overlapping examples of how these pedagogies were fused with the curriculum for all STEEP programs are given. Some significant faculty discoveries were made which have had positive effects on regular classroom instruction as well as for the STEEP programs. These are discussed in the Institutionalization section that follows this one about pedagogies.

1. Optimal Learning Environment

For the Energy Academy, pedagogies employed focused on student participation and engagement because the overall goal was to interest students in STEM and engineering majors. Since college credit was not offered, grades and evaluation were not necessary. The resulting learning environment became an atmosphere filled with the sheer joy of learning and community. Fostering a sense of inquiry and wonder seemed to help students overcome preconceived notions of science as dry and boring. According to Jensen in his discussion of *Brain Based Learning*, making space for play and allowing it to hold equal importance with academic content is a way of optimizing a learning environment.[6] While this is not always accepted in college academic settings, it was entirely appropriate for our programs and seemed to make all students more comfortable.

A sense of play permeated the activities of the PREP intensive, as well. Certain games were developed such as Find the Error, Guess My Graph and our own version of Math Jeopardy. Students remarked that they were surprised to learn that math could be fun in the program evaluations. The creation of an atmosphere that was respectful, safe, informal and fun was a necessary precursor to fully engaging the student in her/his mathematics skill-building.

Another aspect of having an optimal learning environment in PREP is addressing the whole student, including any hidden attitudes and beliefs. We have discussions to lead students to what is currently described as a "growth mindset." We discuss that unfortunate cultural myth that "some people just don't have a math brain" and provide interventions to shift their mindsets. We encourage them to embrace the state of struggle that exists on the spectrum of learning new material rather than taking it as a sign that they should give up. We cultivate a more profound sense of responsibility in the students for their own education. For instance, during the last day of the intensive, students complete and sign a formal-looking document titled, "My Personal Contract for Success in Math 4 and Beyond," and supply eight things they will do as part of their study plan for the upcoming semester. Some of the study plans include, "I will ask for help when I need it," "I will not give up," "I will have fun," I will become a PREP TA after next semester."

For both the Energy Academy and the PREP intensive, each four hour day included a break time which also plays an important role in the learning environment. A particular room and adjacent outdoor area was designated for breaks and "hanging out" before and after the program. Peer mentors were in charge of food preparation and each day nutritious snacks were provided. Sharing food is one of the most common forms of human camaraderie as well as a basic need [7] and incorporating this into the program was an important part of cohort building. Many participants would also join in, bringing food from their homes to share with the group. From a more practical standpoint, providing food can enhance learning and well-being for those students who leave home for an early start without breakfast.

2. Themed Contextualized Learning

The quest for finding new sustainable and environmentally friendly ways of generating energy has been an ongoing human endeavor which has accelerated due to climate change. Because it holds the promise of a better future, students are drawn to renewable energy regardless of the level of understanding they have of the physics of energy and power generation. Their enjoyment and attachment to technologies ever requiring power for recharging also provides a context of a sort and increases the relevance of the topics. According to Baker & Karanjeff, Contextualized Learning (CTL) "helps students find and create meaning through experience, drawing from prior knowledge in order to build upon existing knowledge. A primary principle of CTL is that knowledge becomes the students' own when it is learned within the framework of an authentic context." [8]

Renewable energy and sustainability topics provided the context for students to engage in exploring engineering and STEM content.

It was usually easy to recruit students to join the Energy Academy. Other summer bridge programs at our school focused on recruiting Hispanic and female students to STEM and engineering summer programs have not been as successful in finding students willing to participate without a context that students are familiar with. Johnson found a narrow focus on decontextualized science actually negatively impacted women of color.[9] Students with little or no high quality laboratory experience in K-12, lack of experience building things during childhood and adolescence, lack of understanding about how mechanical things work and a lack of experience measuring and hypothesizing have little background that would lead them to know about or to choose a STEM course of study without making a connection to something they care about.

The culture of inquiry and freedom from required content promoted questioning and what would be considered “off topic” discussions sometimes arose. Encouraging these questions can increase student engagement when the facilitators are able to provide appropriate context for the student’s question rather than dismissing it.

3. Community Service and Service Learning

Being part of and serving community is clearly something students care about. The opportunity to give something to others even if it is newly acquired knowledge is very empowering and brings a deeper sense of purpose to work. People-serving professions are especially attractive to women and minority students.[10, 11] Service learning can be considered as a reciprocal type of learning where learning takes place by the students engaged in a project as well as by the viewers or participants experiencing the students’ product. [12, 13]

This was the case for the Energy Academy’s culminating event, the Energy Fair, a public event first held in downtown Santa Cruz then later in the town plaza of Watsonville, California. Watsonville is a farming town where 75% of the residents are Hispanic, 34% are under 18 years of age, and where many of our students lived.[14] The last week of the Energy Academy was spent by student teams creating a project and poster for display at the Energy Fair. Each project was designed and built to demonstrate some application for renewable energy or sustainable practices. Posters and enthusiastic participants explained the principles to visitors, often in Spanish. Some examples of projects were; a human-powered smoothie blender, a solar-powered boom box with live rapping, solar quesadilla & cookie ovens, and a water wheel power generator. Students from the nearby university—UC, Santa Cruz—also came to display their renewable energy projects. Local community organizations and businesses were also invited. Tours of the newest building on our Watsonville campus, a LEED Platinum Green Technology Center, were also offered to the public.

Also within the PREP curriculum, the principle of service to others and belonging to a community are underlying themes. During the intensive, before the semester begins, students review a significant amount of material from the prerequisite course, Intermediate

College Algebra, primarily by preparing presentations in small groups and then teaching in pairs to the rest of the group. There is homework every night based on the presentations as well as quizzes and games based on the same material. The students quickly observe that those students who have presented a particular topic become the local experts and are subsequently consulted by other students on those kinds of problems. In another activity, teams played “Math Jeopardy” in which team members must insure that all others in their team understand and agree upon the solution because one person would be called on at random to present the answer. This provides further practice and incentive for students to learn how to teach each other. The service to others in this case, then, consists of students helping each other to learn. Fostering students teaching each other has some very beneficial side effects such as improving math vocabulary and communication skills and helping students be comfortable in sharing their logical thought processes as well as being questioned about them.

Intentional community building in PREP begins on Day 1 of the intensive when students, TAs and faculty are randomly paired, interview each other and then introduce their partner to the group. The same short bios are later posted to a members-only website that supports the cohort, next to a photo of that person. During the first week other ice-breaker and team-building activities continue to be implemented so that students bond and feel known. Having this sense of ease among the group is important, as the academic tasks they are given can be daunting. Students are divided into four different small groups over the two weeks so that they have worked closely with nearly all the TAs and other students in the cohort. By the time the intensive is over, students understand how to better use their peers as resources and experience a strong sense of community.

4. Problem-based learning

Problem-based learning is seen as a way to engage students in critical thinking and problem-solving applied to real world problems which affect their own lives.[15] Many of the activities introduced in the Energy Academy relied on aspects of this pedagogy to engage students in design, tinkering, and creation of a product reflecting their collected knowledge or resolution of a particular challenge. Various degrees of constraints or scaffolding were provided until the final project, which was entirely selected and executed by the participants with faculty support for supplying information or training as required. Projects were most often carried out by teams or pairs of students. Teams were assigned at the beginning of the course until everyone had had an opportunity to interact at least once with each other participant. For the final project, students self-selected their team mates which turned out for some to be as much of a priority as what the project was actually about. A design process was introduced for activities such as the windmill project and later for the final project proposals, and management tools such as task and time scheduling (Gantt charts), bills of materials and selection matrices were used.

5. Collaborative Learning

Small groups from 3-6 were employed in both the Energy Academy and PREP in order to encourage problem-solving and critical thinking. [16] Advantages in using this model of group learning that were observed in the Energy Academy were 1.) the collective effort produces more involved projects in less time than would be possible by individuals; 2.)

motivation increases and the sense of responsibility to others in the group improves performance; 3.) group members teach, learn and share skills with each other; and 4.) students improve their communication skills.

For PREP, use of small groups means students could have more individual attention from the TA, can learn to be comfortable presenting their work at the whiteboard, and in general, will have to be more active than in a larger group where some students may be quite passive and find a way to not participate out of shyness or fear. For the presentations, which are a key feature of the PREP intensive, the groups each has two sets of presenters. This means that there is a sufficient number to do a good job researching the assigned topic and developing a good presentation with accompanying posters and then to break into pairs or trios and practice in front of the other presenters. This was important, because many students were quite nervous about their first presentations. It turned out that by the time they went through the process three times during the intensive, however, they were fairly comfortable in presenting their topics. After the semester was underway, there were two hour workshops each Friday and group work continued with the TAs during this part of the program as well. Small group assignments were established for the students during both the Energy Academy and PREP activities, and groupings were changed periodically so that a student would have worked with about 8 different groups by the end of the semester.

6. Hands-on activities and exploration (Active Learning)

For active learning Bonwell suggests:

> "They must read, write, discuss, or be engaged in solving problems. Most important, to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation. Within this context, it is proposed that strategies promoting active learning be defined as instructional activities involving students in doing things and thinking about what they are doing".[17]

During the Energy Academy principles of the physics of energy and power were introduced by way of demonstrations and activities rather than lectures. For example, to explore types of energy, participants visited stations set up with various apparatus such as falling weights connected with generators, or performed particular actions such as running up and down stairs. Rather than receiving lectures, students were queried about what they knew, then given basic concepts, and encouraged to play with the devices, observe the effects and answer and discuss amongst their groups question prompts about the types of energy experienced and how energy transitions from one type to another as well as identifying how energy was "lost" by the system. Each participant was given a notebook to record data, questions, and ideas and to reflect on activities in journal entries. Participants were able to learn by asking their own questions which often revealed a lack of basic knowledge that would take time to address from an instructional standpoint. However, since the goal was more to spark interest than to instill a particular body of knowledge, individualized responses to questions could be formulated by student peer leaders. Letting participants know which classes to take to learn more helped those students with little science background begin to formulate possible courses of study. In California Community colleges, there are no science courses that students can take if their math and English is at a Basic Skills level so if a student has not had much science in high school they are less likely to tend in that direction in college. The Energy Academy experiences were designed to connect these students and their interests with STEM careers and courses of study.

The seemingly simple exercise of putting together an extension cord engaged some participants with new experiences of using tools, assembling parts into a functioning whole and learning about the grid and electrical distribution system. Surprisingly some students had never even used a screwdriver. (Figure 7) Multi-meters were used to check continuity and insure safety.

Figure 7 Hands-on Learning

Another activity which engaged all students on a variety of levels was constructing Energy Houses. Teams of students designed and built model houses that incorporated sustainable design and renewable energy. Some students focused on the layouts or aesthetics of the buildings while others built elaborate operating solar photovoltaic systems with circuits for lighting and "appliances". One year a visiting faculty architect helped students to understand how buildings can relate to particular sites.

Within the PREP intensive, most of the activities were in the realm of active learning. In fact, faculty delivering lectures occurs less than 4% of the time. During each of the three rounds of student presentations--one on graphing families of functions, another on word problems and the third on solving various types of equations--students prepare in teams of 4-6 on one particular topic, such as Graphing Exponential Equations, for instance. They consult textbooks, select or make up problems, discuss key ideas with each other and their TA, make supporting posters, practice their 30 minute presentations within their small groups, and then finally make a presentation to the rest of the class, during which they are instructed not to read from notes, but to do "live" computations on the board. The TA's role in this process is primarily to guide, step in if there is general lack of understanding on something, to give good feedback and to model problem-solving techniques and occasionally to give mini-lectures themselves.

Discussions are another active learning activity in the PREP intensive. Short discussions are led on The Challenges of Math, Learning Styles, Math Vocabulary and these study skills topics; In-class Behavior & Taking Notes, Out-of-class Behavior & Doing Homework, Preparing for Tests, Dealing with Math Anxiety & Overcoming a Weak Math Background. The discussions on study skills topics are led by the TAs, who each present on one of those topics during the intensive.

7. Peer Learning

STEEP activities incorporated peer learning in two ways. Boud distinguishes between peer learning occurring with students at equal levels from peer tutoring where more advanced students tutor or teach their peers. [18] Opportunities were created for the first type while the second type was a strategy we relied heavily upon for engagement with course content. Activities were offered to students in groups which included an advanced peer mentor who would encourage interaction and provide a push when the group's momentum decreased. Equal peer learning was evidenced when participant groups were responsible for producing some results on their own and this engaged them in reciprocal peer learning. For instance, one research assignment from the Energy Academy was to prepare a presentation on a currently used source for generating electrical energy. After their collaboratively created and delivered presentations, feedback was given and received by all participants.

Significant peer learning also occurs in PREP, as was described in the previous section on active learning. The idea of students learning to mastery when they study so they can teach others is of primary importance to the intervention. A further level of peer learning occurs when students learn how to help each other study and how to be a good study partner. The study relationships they form in PREP carry through for a long time.

8. Advanced Students as Peer Leaders/Mentors or Teaching Assistants (TAs)

Peer tutoring was a daily occurrence in the Energy Academy as the student assistants provided demonstrations or support to small groups in our stations-style activities where small groups rotated between various hands-on demonstrations and activities. Peer Tutors would arrive each day before the other participants to prepare and test the activities for the day. Each week the groups and the peer tutors assigned to them would change, giving plenty of opportunity for informal mentoring around general campus familiarity and things like instructor choice for particular courses. This allowed new students to learn about navigating college life from their peers. When possible, we chose peer tutors who matched the demographics of the participants. Meetings and trainings with these students were important in coaching them to support a culture of inquiry whereby they could encourage students to figure things out rather than simply provide answers. The culture of questioning is key to science and was continually emphasized. A whiteboard in the lab was dedicated as a place for questions. Contributions were placed by faculty and students alike and periodically answers were researched and reviewed by interested participants or student assistants. When faculty do not answer all questions, learners are empowered to take initiative. Support for a research project on current energy technologies was provided by a trip to the library for instruction on searches by librarians.

In both the Energy Academy and PREP, the peer tutors/TAs themselves received benefits of strengthening their knowledge and finding gaps when they thought that they understood a topic but found they were unable to explain it. PREP TAs were STEM majors who had up to two more years of coursework beyond the program participants. Their role was critical as mentors, tutors and peers in terms of their also being Cabrillo students on a STEM major path. For instance, the TAs were considered much more credible discussion leaders for the study skills topics than faculty would have been by virtue of their being peers.

During the semester, PREP TAs take turns sitting in on the precalculus section and as a team put together a weekly quiz from current material in the course. During the Friday two-hour workshops, PREP students take the quiz and then meet with a TA in a small group, where the students work to determine the correct answers to the quiz and propose additional problems from their homework.

Retention Strategies

In this section, three primary retention strategies are considered: internships, creation of a campus STEM culture and longitudinal support. Within the heading of internships, we also discuss the experience of the students who acted as peer tutors/mentors/TAs because they constitute a large number of students, many of whom had been participants in the Energy Academy and/or PREP. Their academic and professional development and deep engagement in facilitating learning among students they worked with certainly helped to retain them as STEM majors. We considered their development to be another layer of the program.

Retention through Internships

Internships are a way for students to make real connections between their coursework and chosen careers. Past experience with an internship can be a deciding factor for employers looking at entry level engineers with new four year degrees. Internships also afford the benefits of service and project based learning. The STEEP Internship program was initially conceived as a way to get students involved in practical work in local industry. Due to the timing of the grant beginning in 2008 just when industry experienced a downturn, finding opportunities for students was difficult if not impossible. We also realized that our targeted students often lacked skills and professional development for success in an industry position. So we created in-house internships where we could provide them with coaching, tools and skills as needed. Most often these internships were offered for teams of 4 to 12 students who worked at least 4 hours a day over a two to four week period during our winter break. Following is a description of each of the internship experiences offered:

Energy Interns

The Energy Interns were groups of students who offered their services to the campus Facilities Planning and Plant Operations Department on our campus. They first met with the director who reviewed a list of possible projects he needed help with. The interns chose a project and were led through the process of producing a proposal for the director outlining their scope of work including a schedule and deliverables.

The first group of Energy Interns were a team of six students who chose to survey the electrical plug and lighting loads for 15 buildings on campus. Through this project the students gained skills in organization, management, data collection and analysis. They produced a final report with recommendations and a database of information including all electrical devices and lighting types used in every room. They prepared a presentation of their findings which was given on campus to the Climate Initiative Task Force and other groups. The college gained data to initiate energy efficiency projects as well as document benefits in reduced energy use due to following the recommendations of the team. Visiting every classroom and office was also an effective outreach and opportunity for educating the campus community on sustainable practices and energy efficiency.

The next group of Energy Interns surveyed campus outdoor lighting facilities including parking garages. Fixture locations and specifications were compiled into a spreadsheet. Interns wrote work proposals, created schedules, organized information in spreadsheets and on drawings, and coordinated efforts to produce a final report. Data collected was later used in developing an energy efficient system for remote lighting control which continues to save the college energy and money.

Another group of Energy Interns designed and built a bicycle powered generator for demonstration purposes. Realizing that the kinesthetic experience of pedaling to light LED bulbs and tungsten bulbs is a memorable exercise in energy efficiency, the students built the Energy Bike and donated it with documentation and curriculum to a local high school to inspire future college students to study physics and engineering and to be more energy efficient.

Solar Interns

The Solar Interns learned through hands-on projects how to site and install solar photovoltaic panels. After their month-long program they formed study groups to prepare for the North American Board of Certified Energy Practitioners (NABCEP) industry certification for solar PV installers. Sixty three percent of the interns passed the exam giving them the necessary qualifications for hiring into a well-paid position or engineering internship.

Teaching Interns
Some successful PREP program participants or TAs participated in a Teaching Internship where they had a field placement in middle or high schools to work in science and math classrooms and explore a potential interest in a STEM teaching career.

Student Peer Mentors
All three of the STEEP programs involved committed STEM students as mentors. Orientation and training sessions helped these assistants to learn good practices for tutoring and facilitating learning with small groups. They were required to be present for at least an hour more a day than the program participants and were relied upon for setting up activities and guiding participant's explorations.

During the Energy Academy, each morning before the participants arrived, the activities of the day would be reviewed with the peer mentors who would have the opportunity to run the activities to determine effectiveness and suggest modifications. Briefing them on the physics, math or engineering principles behind the activities empowered them to aid in students understanding on an as-needed basis rather than using a less engaging lecture process. Though safety was reviewed with all participants, these assistants were responsible for insuring safe use of tools and equipment in their assigned groups. Generally, there would be one assistant for each group of 3 students. They also kept faculty aware of the progress of each group so that timing could be adjusted. After the participants left for the day, debrief sessions with the peer mentors helped us to improve the activities, gauge interest and develop threads for future activities.

Similarly, PREP TAs met a half hour before each session with students to review the plan for the day and to anticipate student needs. Then after the day's session ends, another half hour is used to debrief from the day, determine what needs arose and plan accordingly.

Internship Outcomes
There were significant contributions to the teaching skills and experience of those undergraduate students who have worked as TAs for PREP and the Energy Academy, or as tutors and workshop leaders in the MESA Study Center. The program pedagogy for Energy Academy and PREP relied heavily on student peer leaders for delivering content and working one on one with participants. This responsibility was empowering, especially for URM students who may have previously been disempowered in STEM educational settings.

Motivation increased when evidence of actual progress is realized. Students who must work while going to school may take four or more years of work before transfer. When they work with beginning students, they seem to gain a better perspective on their own progress to-date and recognize themselves as successful.

Retention through Enhanced Campus STEM Culture and Longitudinal Support
The STEEP proposal contained a plan for the college to institutionalize the longitudinal support piece by locating new and much expanded quarters for the MESA Study Center and so, as the grant was at the halfway mark, college decision makers who sat on the Internal Advisory Board contracted the services of a grant-writing team and secured a

Department of Education Hispanic-Serving Institution STEM award that could be used for building and remodeling. As a result, the Cabrillo College STEM Center opened in Fall 2013 and has a much greater capacity to serve students. It has enlarged space for the MESA Study Center by a factor of 4, has a capacity of 175 and typically serves 750 students each semester with tutoring, workshops, counseling and information of interest to the student working toward transfer in a STEM major. With the greatly enlarged space, there is still an atmosphere of cooperation and a welcoming community of scholars. In this way, the effect of STEEP grant activities rippled out across many more students than had direct involvement with one of the activities.

The expanded facilities for the MESA Study Center have been instrumental in enhancing the STEM culture on our campus. There are gleaming new STEM facilities, new grant initiatives and a new level of cooperation and collaboration among STEM faculty. This all makes for a certain STEM buzz and awareness among students.

Places where students can complete their coursework, give and receive tutoring and congregate for social interaction create a campus culture and give students a sense of ownership and belonging. Labs and study spaces which do not allow or encourage social interaction, food, game playing and the like may be effective for study but are less likely to further a sense of home, safety and belonging which clearly play an important role in STEM students success [19, 20] and may be overlooked by faculty and administrators focused on academics. Since Maslow's work in 1943, it has long been known that belongingness plays a definite role in a person's pathway to self-esteem and success.[7] Attention to the bottom levels of Maslow's hierarchy of needs which must be met on that person's way to success may fall between the cracks or receive lower priority than academic programming. These of course include food and water as well as a safe comfortable space to set the stage for belonging. The actual home environments for many community college students do not include conditions conducive to studying so providing a home-away-from-home is an important support system for these students' success.

The services comprising longitudinal support include academic counseling, peer tutoring, placement into internships, peer-assisted team learning and integration into a lively learning community. These components guide and assist students from the point of becoming interested in pursuing STEM major through to a successful completion of courses necessary to transfer to a baccalaureate-granting institution and/or earn an associate's degree in a STEM field.

Institutionalization Options

Curriculum has been created for a science course and lab called "Energy and a Sustainable Future" which is based on the Energy Academy experience. The course ties in with a new course framework--Energy 101-- created by the US Department of Energy to identify and amplify best practices in teaching energy at the college and university levels. Becoming part of this national community of practice surrounding energy education will allow future opportunities to better implement the new class, which is classified as a General Education Laboratory course, and as such is likely to be a popular choice for non-STEM students in completing the science requirements of the general education pattern.

PREP has been institutionalized as a mathematics laboratory course that is tied as a corequisite to a particular section of precalculus. The class is team taught by two faculty and supported by four student teaching assistants. It has been offered for three consecutive semesters now and continues to be successful. All four TAs in the current cohort were once PREP participants themselves.

Curricular modules from the Energy Academy, such as a windmill designing project, a Peak Oil game, use of an "Energy Bike" that transforms pedal power into electricity, have been incorporated within many programs at Cabrillo and in the community.

Examples are given below of ways that faculty may adopt other pieces of the curriculum as it fits their courses.

Strategies transferable to regular coursework

Design or invention of the day. Show a video of a new invention or research that has potential to shift the way we do things or improve life. Due to the rapid pace of technological innovation many students will end up working in fields and on projects that may not even be conceived of or possible at this time. Encouraging students to explore and think beyond the current options expands their sense of possibilities.

Create team projects with well-defined specifications but with the topics left open for students to choose. Students empowered by choice select the topics most in line with their personal goals and remain engaged.[21]

Provide a Question Board to encourage inquiry. This can be physical as a white board in the classroom or a wiki on a website. Anyone can post a question and anyone can present an answer.

Provide desk sized white boards for each group working on a problem or generating ideas. A single white board with enough pens for all team members encourages participation and collaboration more than individuals with their own papers. Communicate the expectation that everyone will contribute.

Include team-building activities for participants to get to know each other. The comfort level of individuals can affect participation and engagement. Creating an environment where fun is allowed has positive effects on attendance and attitude during class.

Initiate discussions of science and technology in social, economic and political contexts. Helping students connect course matter with current affairs creates context and helps them see how their current work connects to future careers and global citizenship.

Create opportunities for students to help each other. Students are often more familiar with the kinds of mistakes possible and common errors involved in learning a particular skill or technique. Once a student has demonstrated correct application of a concept, having them explain it to someone else furthers their understanding, empowering both the helper and helped. On the final course evaluations for an Engineering Graphics and Design course when asked what most aided their learning of the material, students routinely mark "working with other students" equally or more often than "instructor demonstrations".

Some Lessons Learned

We learned through the course of this project that the topic of Energy and Sustainability was a compelling and relevant hook to use for getting students not just interested in a STEM field, but passionate about their STEM career goals and what they might achieve with their degrees. This seemed to motivate them enough to carry them through much coursework, and allowed them to be ultimately successful. In both the Energy Academy and PREP, it was the attitude changes that were the most important predictors of future success.

Another important lesson learned was that a student's decision to go to college and their major choice is often not made as an individual for solely their own benefit. Hispanic/Latino students often mention helping their families as a motivation for completing STEM and engineering majors. First generation college students who do intend to embark on a STEM or engineering education often need the support of their families who also need information on what it means to choose such a major. During a recent family night event sponsored by the new Hispanic Serving Institution (HIS) Title III grant participants and their families heard Latino STEM professionals talk about their educational and career paths. At the end of the program one mother of a female Energy Academy student who had chosen a major in Electrical Engineering indicated that she had been thinking that this was not the best choice for her daughter to go into a male-dominated field, but that speaking with the practicing Latina engineers changed her mind about that. Understanding students' situations and cultures enables creation of effective support and retention strategies.

The most surprising lesson may have been how the tone and atmosphere for teaching and learning shifted when grades and the need to cover specific content are removed from the classroom. The opportunity to experience a college learning environment free from fear of failure and the stress of grades was a gift for both students and faculty and a highlight of the STEEP programs.

Overall, the most notable outcome is the production and support of waves of cohorts of students in whom interest has been sparked and attitudes changed being easily assimilated to an expanding community of learners. For some participants, the activities provided a bridging experience from high school to college or from the workplace back to college. All were exposed to a curriculum that featured group learning that connected students to each other and to the college.

Measuring the success of our programs by looking at the number of majors and watching their progress at Cabrillo has turned out to be the most effective metric. Obtaining actual transfer and degree data has been difficult and inaccurate as the larger statewide data collection systems are not able to track the majors of students who transfer. Also, since many of these students take longer to complete the requisite course work due to their original levels of preparation and their need to work while in school, having completed our program in 2011 they may have not yet reached transfer level by 2015. We have also observed how students will often disappear entirely only to return two or more years later to continue their studies.

From Energy Academy students:
"The Academy gave a wide variety of knowledge that I'm pretty sure I would never have learned in other places. It's also something that made things like math and physics worth studying in the future."
"Learned so much in such a short period of time."

From PREP students:
"Reviewing (Math) 152 was extremely helpful. I have learned more about myself as a student, and I really admired working with other students. Their dedication to their education, has helped me feel more accepting to the fact that I have a long road ahead of me, and I am not alone in it."
"I have gotten greater confidence in asking questions about mathematics and greater confidence in teaching/doing math in front of others as well as relaying information that is integral to certain concepts needed in mathematics."
"I am extremely happy that I decided to do the PREP intensive. Not only have I gotten more comfortable with math, I now have a community of deeply enthusiastic people who I can study with. It was also really cool to see how much fun math can actually be, that is something that I was not expecting out of this experience."

Summary

In this paper, we reported on the activities, outcomes and institutionalization of programs developed as part of STEEP, a recently concluded six-year NSF STEP project. Some details of the curriculum developed and pedagogies employed were presented. Project outcomes suggest that the activities and programs developed show promise for improving STEM education for students at the community college level by increasing the number of STEM degrees and transfers through a three-pronged approach; early interest through an Energy Academy; academic support with a strategic math intervention at a key point in students' course-taking; and longitudinal support consisting of in-house internships, services and opportunities. Finally, a method for institutionalization of some activities was described for adoption at interested institutions. This report is presented in the hope that some of the programmatic elements that were used here might be implemented at other colleges and universities with similar positive results.

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