Pioneers in Engineering

2012 Report

http://pioneers.berkeley.edu

EXECUTIVE SUMMARY

Pioneers in Engineering (PiE) is a STEM outreach organization run by UC Berkeley students. PiE aims to promote higher education in STEM fields, especially among socioeconomically and ethnically underrepresented communities. Our chief operation to achieve this goal is a robotics competition for high school students around the Bay Area, which offers a unique, realistic engineering experience to participants for only $100 per team of about a dozen students. In addition, PiE participates in various other outreach events targeting younger audiences.

Our goals for PiE in its fourth year featured a significant expansion of the robotics competition across the board. A look at the numbers says it all: this effort succeeded.

	Year 3: 2010-2011	**Year 4: 2011-2012**
Schools Participating	9	**20**
Mentors Involved	35	**90**
Funds Raised	$12,600	**$32,800**

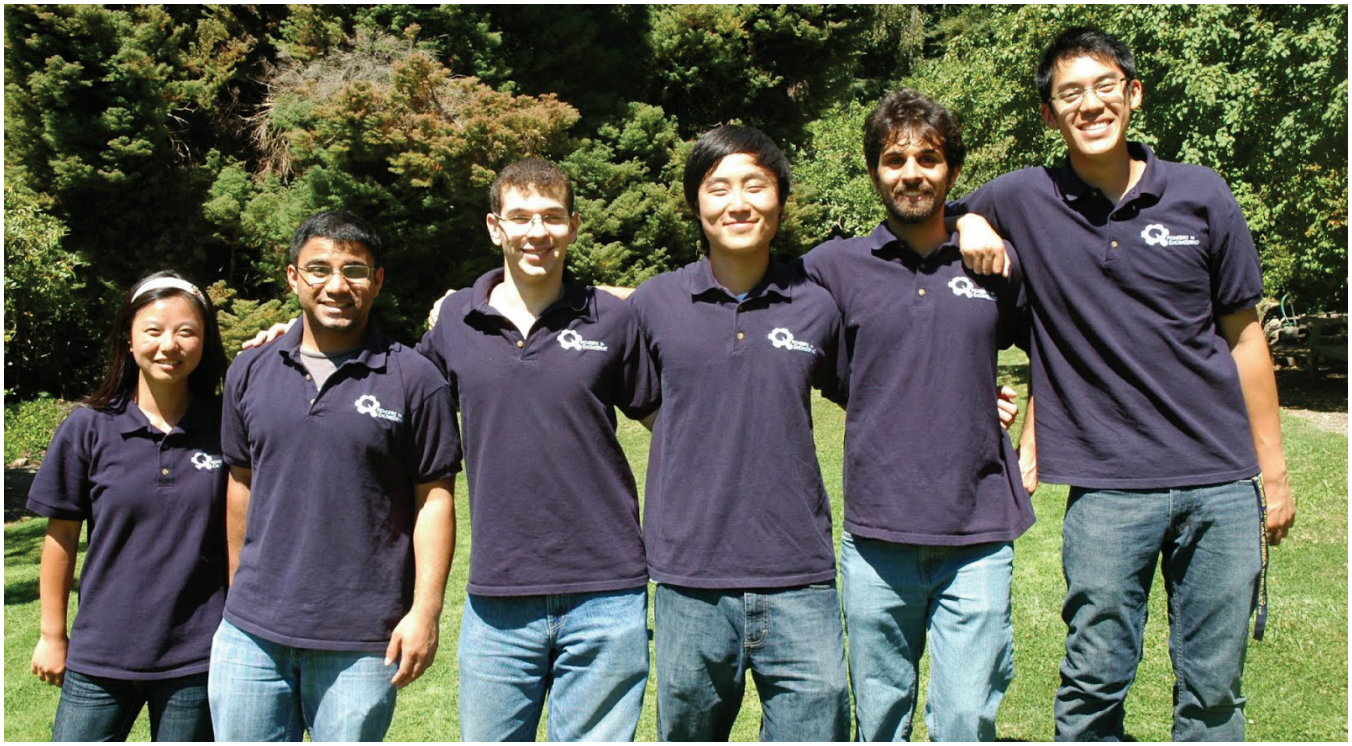
The coordinators made staff recruitment a first priority, with great success. The larger, more versatile staff was able to focus on improving upon our central mission, while looking beyond to new ventures. We updated the kit, including features such as an extensive manual, a robust mechanical base, more accessible code, and our first staff-designed and produced motor controller. We improved the curriculum and methods of our university course, integrating the experience with interactive demonstrations while managing enormous class sizes. We brought in money, gifts-in-kind, new partners, and media attention. Even with the incredible growth, the season was fairly smooth and very successful thanks to the increased staff size and general focus on stability. After the Final Competition held at the nearby Lawrence Hall of Science (LHS), we heard virtually unanimous acclaim from participants.

In addition to the robotics competition, PiE expanded the scope of its outreach, contributing to events such as the Bay Area Science Festival and educational events at LHS. We gained valuable connections and experience, and aimed to inspire an even younger generation.

Next year, we intend to focus on ensuring organizational sustainability and enriching our outreach beyond the robotics competition. With continued efforts to improve above and beyond the respectable achievements of 2012, PiE will deliver progressively more incredible experiences in the years to come.

PREFACE

The Pioneers in Engineering (PiE) 2012 report is a detailed overview of the goals, efforts, and outcomes of the organization spanning from May 2011 to May 2012. With this report, we aim to present information to our supporters and record our successes and shortcomings for posterity.



The 2011-2012 coordinators pose in their PiE polos. From left to right: Director Amy Fu, KitDev Coordinator Aditya Yellapragada, External Coordinator Or Weizman, Deputy Director Robert Luan, fall TBP-PiE Liaison William Wheeler, and Mentorship Coordinator Dennis Wai.

This report was prepared by the PiE 2011-2012 coordinators:

- Amy Fu - *Director*
- Robert Luan - *Deputy Director*
- Dennis Wai - *Mentorship Coordinator*
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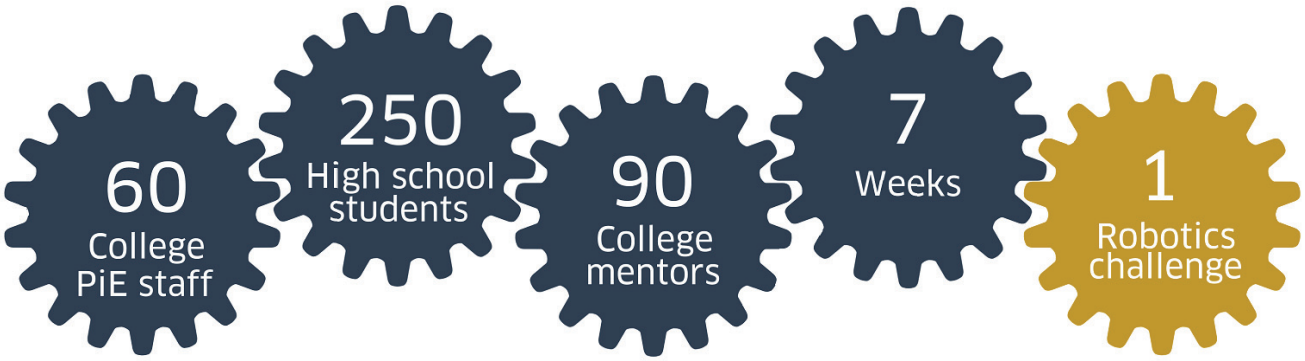


Pioneers in Engineering (PiE) is a student-run organization based in UC Berkeley. It was founded in 2008 by the Berkeley (CA-A) chapter of Tau Beta Pi, the Engineering Honor Society, with the mission of promoting higher education in science, technology, engineering, and math (STEM), especially among socioeconomically and ethnically underrepresented minorities. PiE allows UC Berkeley students give back to the community through engineering.

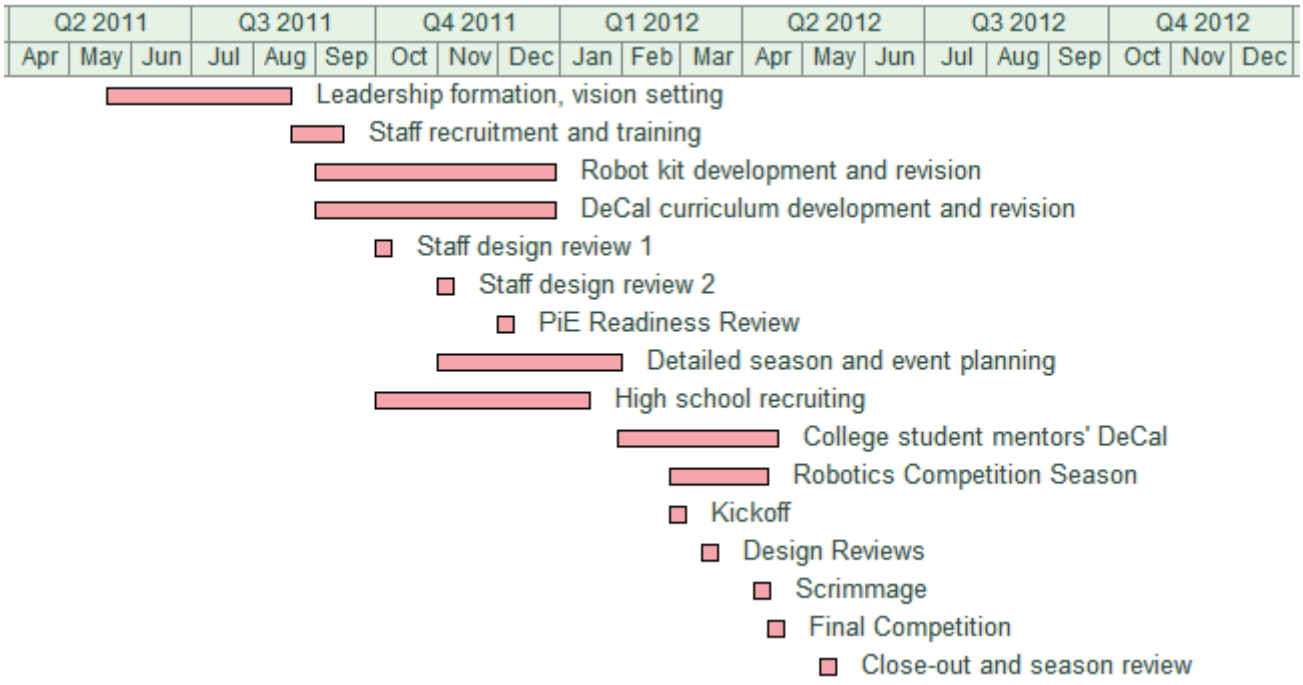
PiE's primary project is an annual low-cost robotics competition for high school students around the San Francisco Bay Area. UC Berkeley students mentor local high school students as they design, construct, and program a mobile robot. By providing a creative, low-cost, and hands-on after-school activity, PiE is able to bring a science and engineering experience to socioeconomically diverse and disadvantaged East Bay high school students. A key feature of the competition is the $100 per team entrance fee, which ensures that finances are not a barrier to entry. Another central goal of PiE is to give UC Berkeley engineering students the opportunity to serve the local community while simultaneously gaining practical experience in hardware and software design as well as leadership and teaching. Promoting the future of engineering at the grade school level and encouraging professional development in college embodies the spirit of our parent organization, Tau Beta Pi.

In addition to the competition, PiE also participates in outreach events that bring engineering and robotics to younger audiences.

GOALS

1. Manage a low-cost engineering education program to serve the socioeconomically diverse communities around the University of California, Berkeley.
2. Draw engineering students to community service that utilizes their unique skill sets.
3. Stimulate student interest in math, science, and engineering and the pursuit of degrees in those subjects at the University of California, Berkeley and other institutions.
4. Enhance the recognition of engineering and the University of California, Berkeley, in the community.

TIMELINE



PIE ROBOTICS COMPETITION

BENEFITS

HIGH SCHOOL STUDENTS

- Design and build a robot for competition in a fun, exciting, and hands-on process.
- Face challenges and develop skills that are applicable in the real world.
- Develop a product, creating a sense of connection, ownership, and self-respect.
- Work with college students as mentors and peers.

TEACHERS

- Are free from the task of finding thousands of dollars to register for a program.
- Gain an outlet for hands-on application of the information students learn in the classroom. Knowledge becomes a useful tool and drives students to learn more.

COLLEGE STUDENTS

- Apply and hone expertise from their own classes and education.
- Serve the local community in a hands-on, interactive project.
- Mentor high school students, playing a part in nurturing future engineers and receiving the opportunity to share their enthusiasm with a receptive audience.
- Practice professional skills while contacting and working with schools, teachers, the College of Engineering, and industry sponsors.
- Teach on technical topics and improve or reinforce their own understanding.
- Encounter many opportunities for leadership and related experience.

TAU BETA PI

- Gains positive publicity and recognition for members and the University of California, Berkeley.
- Fosters inter-chapter connections and assist other chapters' growth.
- Increases opportunities to attract members by demonstrating what it does, both at the college level and to future engineers in high school.
- Encourage less active members and alumni to return and contribute.

TEAMS

The Lionel Wilson College Preparatory Academy's Team Golden Eagle Robot Squad, winner of second place and the Mechanical Design Award.

High school teams are the primary focus of the Pioneers in Engineering robotics competition. Comprising an average of 13 students each, teams develop a robot that they build for competition. Over 250 high school students were involved through the course of the competition. Most students meet with their team and mentors after school a few times per week, and more frequently as the competition approaches.

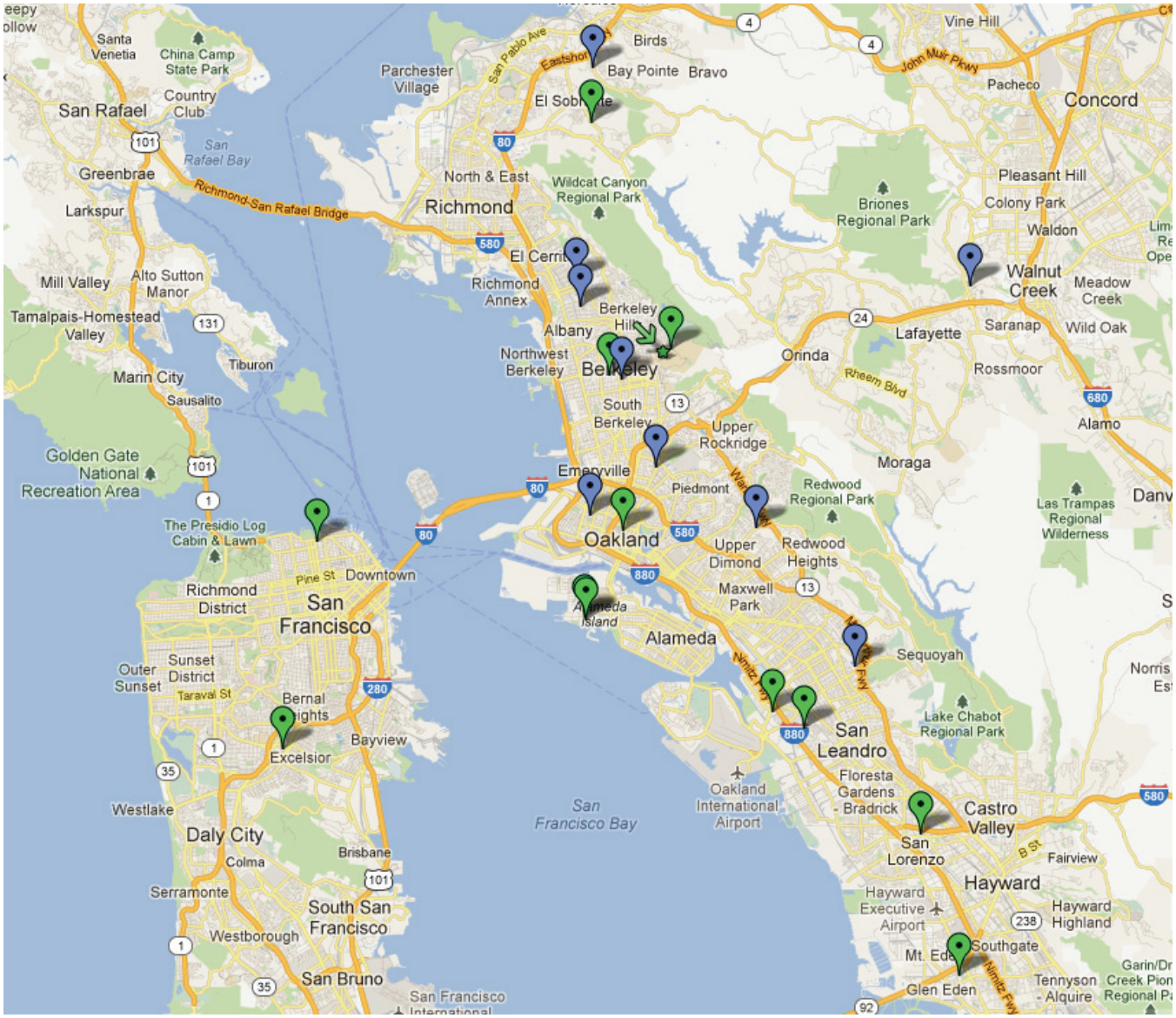
This year saw a total of 21 school groups participating in 21 teams, making the 2012 competition the biggest one yet. Our geographic reach expanded, including two schools from San Francisco and one from Hayward. We welcomed back all 9 schools from last year and introduced 11 new schools and an after-school program. Staff efforts to recruit teams were helped by the growing impact of PiE in the local community. Limited resources forced us to ask each school to submit only one team in the interest of reaching out to more students.

Including schools in San Francisco was a big step for the program. We had been unable to serve SF schools in previous years due to transportation difficulties; this year, we recruited mentors from San Francisco State University's CA-AΓ chapter of TBP to work with the teams at Galileo and Balboa.

Unfortunately, one of the new schools recruited this year was unable to complete the season. Shortly after Design Reviews, the teacher at Oakland School for the Arts became concerned that her students could not commit enough time to working on PiE. Despite our efforts to provide the team with extra support, they decided that an incomplete effort would not meet our expectations. We hope to work with the school to foster a successful team in the years to come.

TEAM MAP

A total of 21 teams were recruited from 20 schools and an after-school program in 5 districts. Blue markers are schools that participated in 2011, and green markers represent new schools. The green star in the center of the map marks the UC Berkeley campus, where PiE resides.

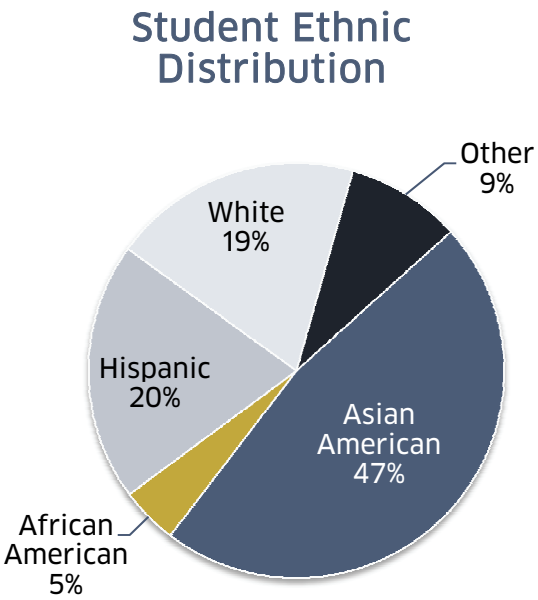


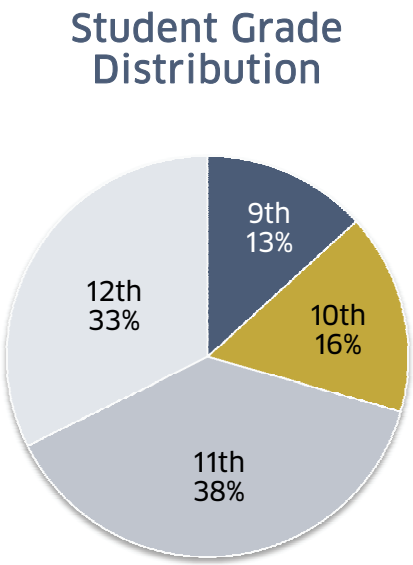
School/Team	City	District
Acalanes High School	Acalanes	Acalanes Union High School District
Alameda County Learning Center	Alameda	Alameda Unified School District
Albany High School	Albany	Albany Unified School District
Aspire California College Preparatory Academy	Berkeley	Alameda Unified School District
Balboa High School	San Francisco	San Francisco Unified School District
Berkeley High School	Berkeley	Berkeley Unified School District
Bishop O'Dowd High School	Oakland	Independent
De Anza Senior High School	Richmond	West Contra Costa Unified School District
El Cerrito High School	El Cerrito	West Contra Costa Unified School District
Encinal High School	Alameda	Alameda Unified School District
Galileo Academy of Science and Technology	San Francisco	San Francisco Unified School District
Head-Royce High School	Oakland	Independent
Impact Academy of Arts and Technology	Hayward	Hayward Unified School District
Lawrence Hall of Science TEAMS	Berkeley	An after school program located at Lawrence Hall of Science
Lighthouse Community Charter High School	Oakland	Oakland Unified School District
Aspire Lionel Wilson College Preparatory Academy	Oakland	Oakland Unified School District
Oakland School for the Arts*	Oakland	Oakland Unified School District
Oakland Technical High School	Oakland	Oakland Unified School District
Pinole Valley High School	Pinole Valley	West Contra Costa Unified School District
Ralph J. Bunche High School	Oakland	Oakland Unified School District
San Lorenzo High School	San Lorenzo	San Lorenzo Unified School District

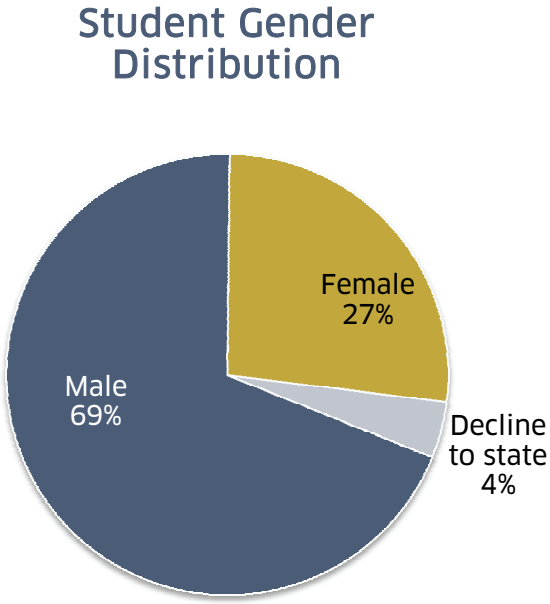
* Departed the competition mid-season.

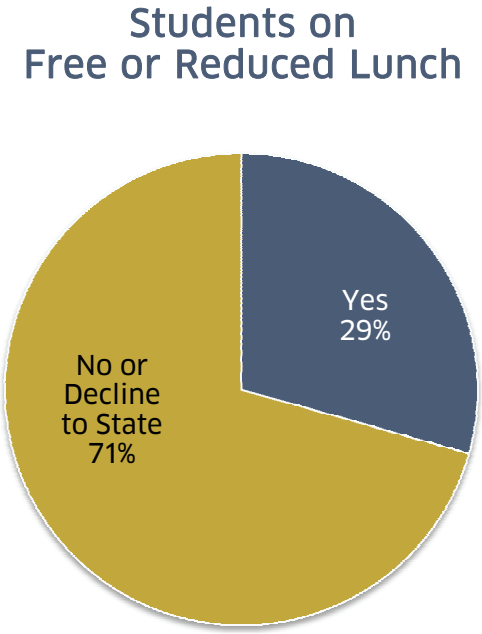
STUDENT DEMOGRAPHICS

At Kickoff, we had 265 students from diverse backgrounds. The pie charts below show the distribution of student ethnicity, gender, grade, and students on a free or reduced lunch program.

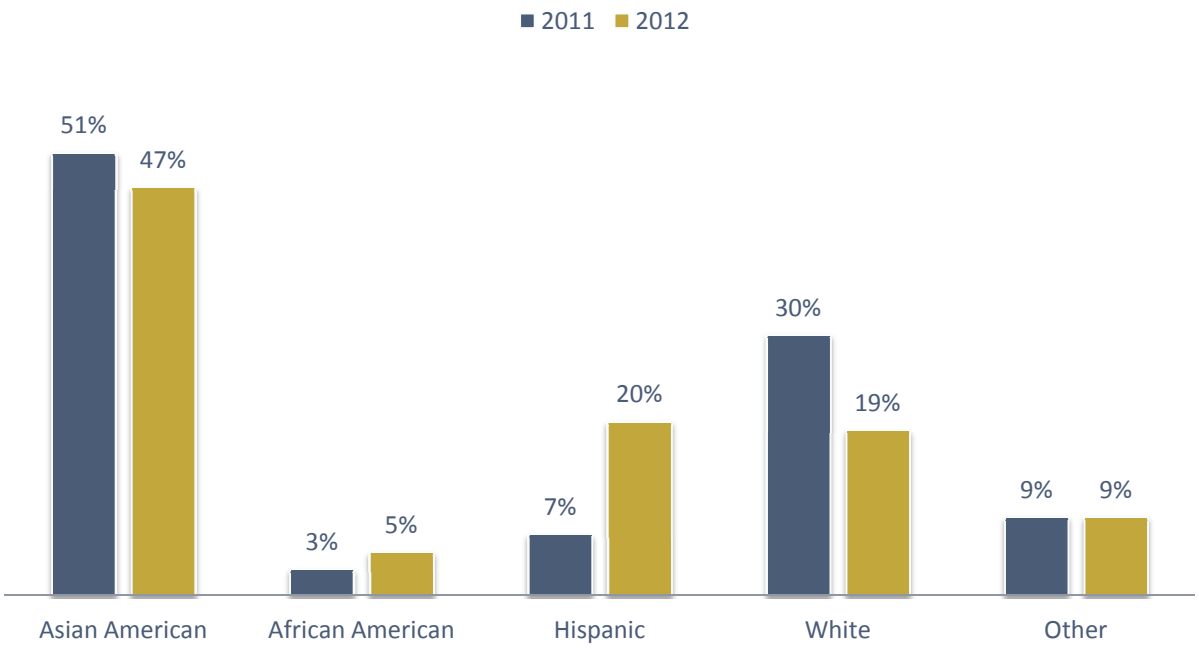




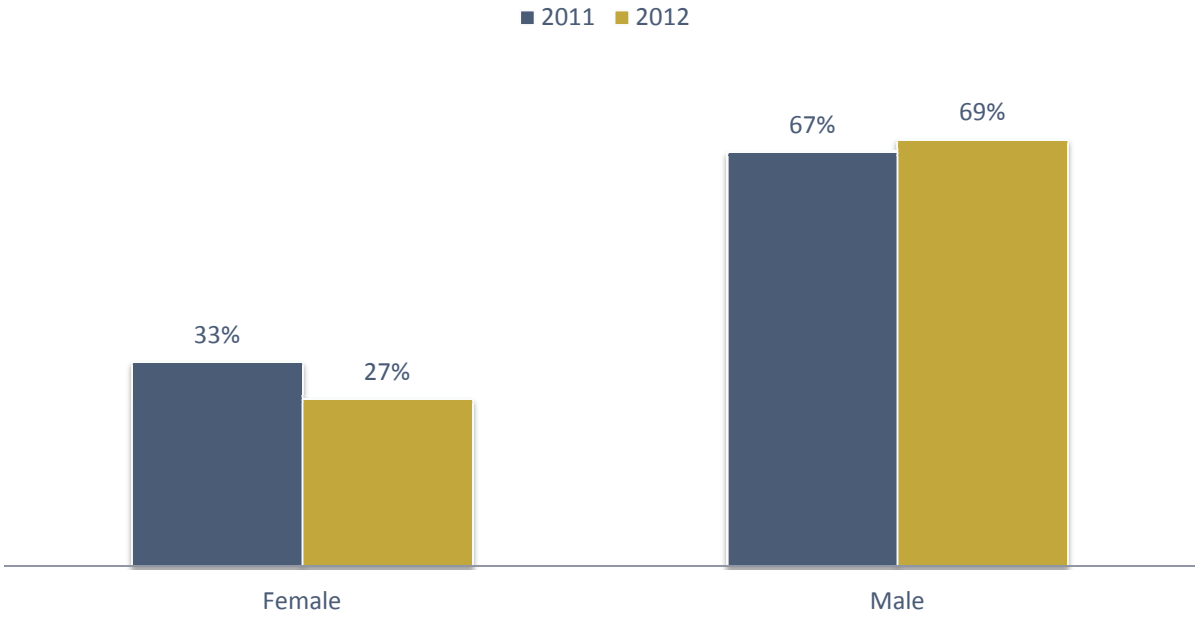


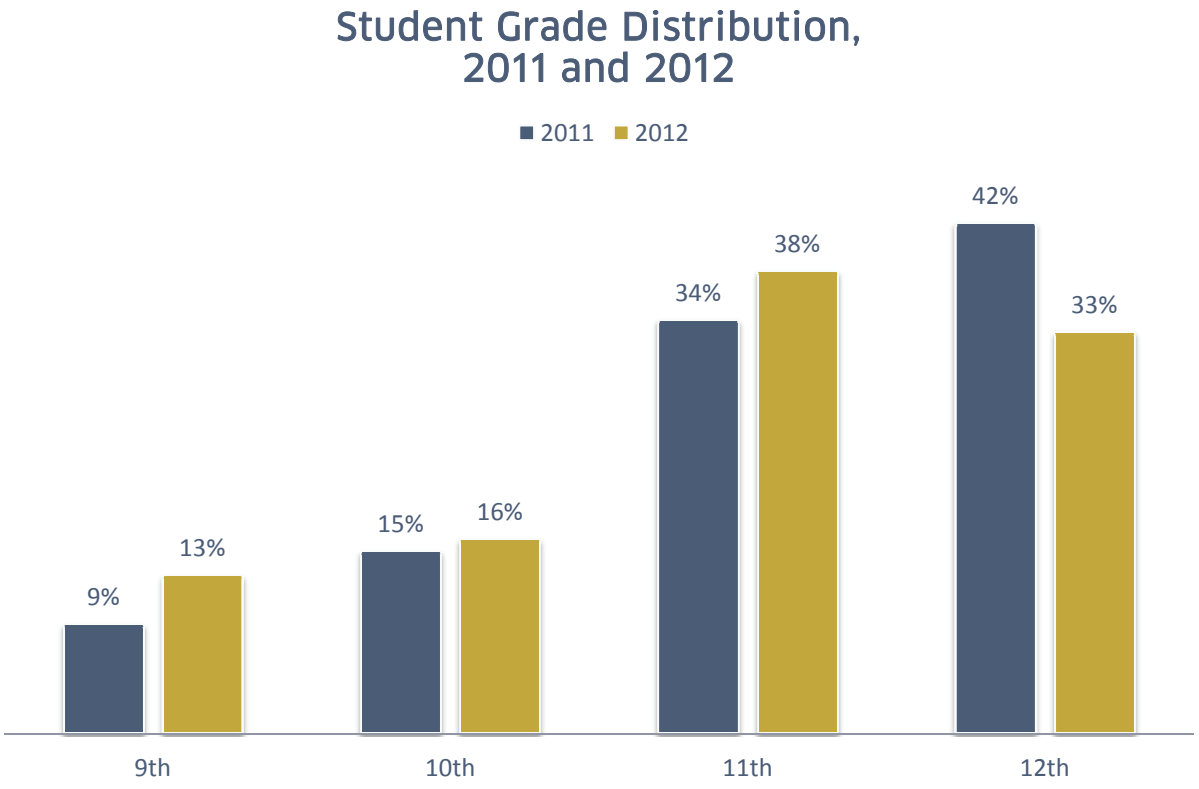


Student Ethnic Distribution, 2011 and 2012



Student Gender Distribution, 2011 and 2012

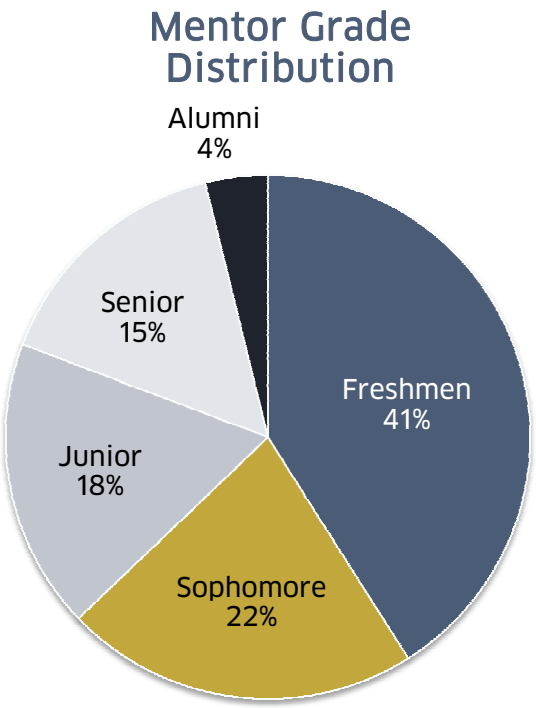


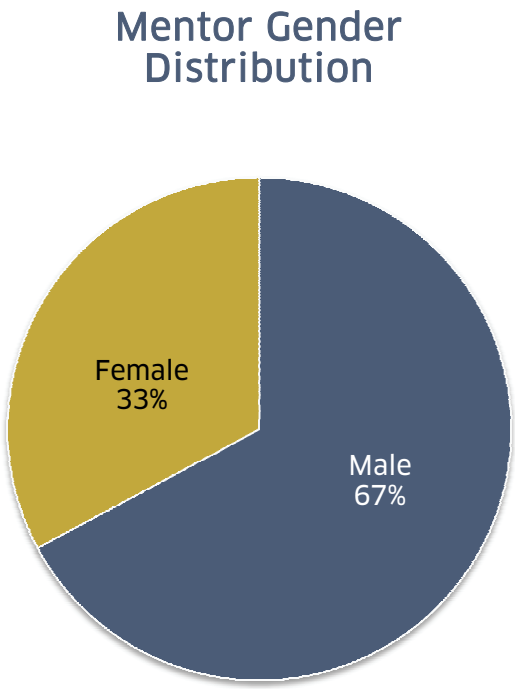

Student Grade Distribution,
2011 and 2012
2011
2012
9%
13%
15%
16%
34%
38%
42%
33%
9th
10th
11th
12th

MENTORS

Mentors are university students who commit to volunteering for PiE during the build period. They act as role models, technical advisors, discussion leaders, and friends to their team of high school students. Although many mentors were UC Berkeley undergraduates from the College of Engineering (CoE), approximately 10% of all the mentors were either UC Berkeley alumni or SFSU TBP CA-AΓ officers and members. Five mentors were TBP CA-A officers or candidates. Most mentors sign up for the PiE DeCal, our undergraduate-taught course. There are no prerequisites to being a mentor, with the assumption that those who are interested are willing to put in the time and effort to learn.

Mentors Ray Pang (far left) and Ayzaan Wahid (second from left) keep a watchful eye as their high school mentees from Impact Academy put the finishing touches on their robot manipulator.





In total, we had 90 mentors for 21 teams in this year's competition. We completely exceeded our expectations of two mentors per team, and reached a steady state of at least four mentors per team. These mentors were recruited through the DeCal, lower-division undergraduate courses, the TBP candidate class, and word of mouth. The inclusion of mentors from SFSU's TBP chapter marked the first time TBP CA-A worked with TBP CA-AΓ on a large-scale service project. Given the success of this year's partnership with SFSU TBP, we are excited about the possibility of further inter-university collaborations next year.

MENTOR RECRUITMENT

Mentors were primarily recruited from UC Berkeley students through a student-facilitated course offering, or DeCal. The syllabus was developed by PiE staff during the fall semester and officially approved by the university as a course for Spring 2012. The course was designed as a crash course in robotics with hands-on labs that educated mentors in assembling, wiring, and programming a kit robot, as well as providing exposure into advanced topics such as mechanical design and autonomous programming.

TBP member and PiE mentor Aaron Wong assembles the base kit in a DeCal lesson.

This year's mentor recruitment successfully recruited a significant number of non-TBP candidates. Recruitment efforts included blackboard advertisements, emails on departmental mailing lists, and classroom announcements in undergraduate courses. Although PiE continues to be a major service project of TBP, it was an important step in the growth of PiE to involve the student body at large. By offering the DeCal, we were able to recruit more mentors from the CoE's undergraduate pool while simultaneously expand awareness and recognition of PiE and TBP on campus.

SAN FRANCISCO STATE UNIVERSITY AND TBP CA-AΓ INVOLVEMENT

To prepare themselves as mentors, TBP CA-AΓ members participated in weekly lesson rehearsals held by PiE. These lesson rehearsals covered the robotics topics PiE teaches to all of its mentors, who in turn will teach their students. Through these weekly meetings and the competition season, TBP CA-A and TBP CA-AΓ fostered a strong connection. It is evident that in future years both TBP chapters will continue to work with one another to provide PiE on both sides of the San Francisco Bay.

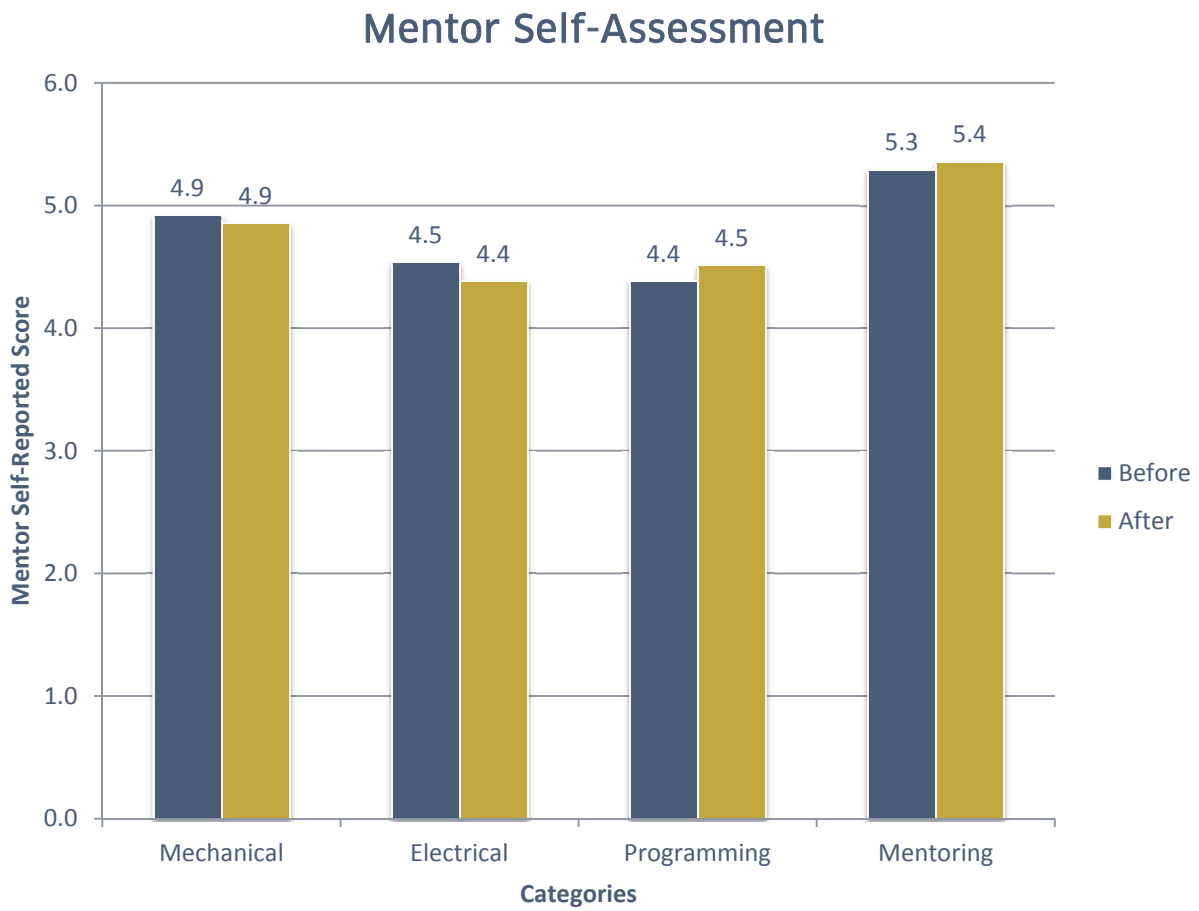
SFSU TBP CA-AΓ mentors Aleksandr Valeyev (center left) and Edmund Hom (center right) discuss the results of a Galileo High practice match with their students at PiE Scrimmage.

PIE DECAL

All mentors for PiE 2012 have to participate in the DeCal in order to gain sufficient knowledge to mentor high school students. Now in its second year, the DeCal is a 12-week-long course that occurs in tandem with the competition season and includes lessons that cover both fundamental and advanced topics in robotics. The DeCal does not only provide mentors with knowledge to pass onto high school students, it also provides opportunities to practice engineering concepts learned in other courses.

New mentors Lauren Farrell, Patrick Xiao, and Maliena Guy (left to right) enjoy assembling the mechanical components of the base kit in the second lesson of the DeCal.

To reinforce concepts taught after hour-long lectures, we created new one-hour lab activities and lessons that focused on base kit assembly, both emphasizing small-group learning. Additionally, through a partnership with the Electronics Support Group (ESG) in the UC Berkeley EECS department, we were able to record webcasts of our lessons for mentors to use as refreshers for themselves or their students. These webcasts, along with other course material, are provided on PiE's wiki page at https://pioneers.berkeley.edu/wiki/Resources. As a result of this DeCal restructuring, mentors demonstrated better mastery in both new and familiar topics.



In the above graph, mentors' self-assessed mastery in several categories in the entrance and exit survey results are averaged and displayed. From the graph, it is unclear whether mentors, after taking the PiE DeCal, made significant improvements in their mastery of the four major spheres of knowledge: Mechanical, Electrical, Programming, and Mentoring. The lackluster improvement in these four categories can be attributed to mentors' recontextualization of their self-worth and abilities after a PiE season, where mentors were faced with real challenges that they might not have been able to solve.

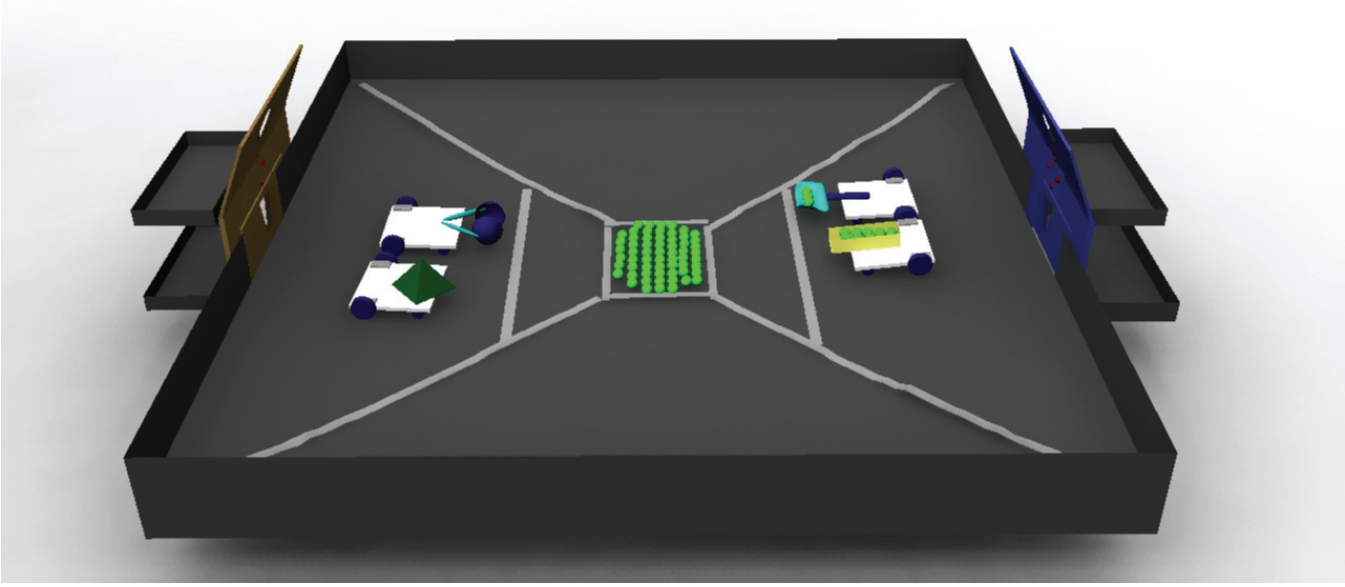
SEASON

A glimpse of the excitement seen at Final Competition.

The seven-week competition season is the focus of the PiE robotics program. The season includes a number of mandatory events; additionally, after-school work sessions were held on the UC Berkeley campus. All these events keep teams on track and enrich their experience. Each year, PiE staff design a new game to challenge the teams and their robots. This game is introduced at Kickoff and defines teams' efforts for the rest of the season.

THE GAME - BALLISTIC BLITZ

Ballistic Blitz is played on a sloped field by two opposing alliances comprising two teams each. The teams in each alliance score points and are assessed penalties as an alliance, not as individual teams. The object of the game is to attain a higher score than the opposing alliance by scoring tennis balls into your alliance's goal.



A 3D CAD model of the Ballistic Blitz field.

The edges of the 12 foot by 12 foot field are 6 inches higher than the 2' x 2' Blitz Zone in the center of the field, making a 10% grade on each side. The goals reside at two opposing ends of the field, each including a trapezoidal low goal and tilted circular high goal. Four infrared LEDs are arranged in a diamond surrounding the high goal to assist with targeting throughout the match. Prior to each match, 61 balls are placed in the center of the field and each team has the option of loading up to 10 balls onto their robot.

Each match consists of a 15-second autonomous period followed by a 2-minute tele-operated period. Once the autonomous period begins, the IR LEDs light up to indicate either the high or low goal for each alliance. Balls scored into the indicated goal at this time are worth 5 points each.

After the autonomous period, the tele-operated period begins. All IR LEDs turn on and drivers step forward to take control of their robots. During this period, balls scored into the high goal are worth 3 points each and balls scored into the low goal are worth 1 point each. At the end of the two-minute period, all robots stop moving. Any robot that is inside the Blitz Zone in the middle of the field earns its alliance 20 points.

KICKOFF

To begin the season, Kickoff gives teams a running start. At the day-long event, teams receive their kits, learn about the game, meet their mentors, and start working on their robot.

Held on the UC Berkeley campus, 2012 Kickoff had an attendance of over 250 high school students and 90 mentors. The day began with an opening presentation featuring mechanical engineering PhD student Ryan Shelby and Director Amy, who welcomed teams and revealed the year's competition game. Teams were introduced to their mentors and received their kit and manual. Following a lunch prepared by PiE and TBP volunteers, students attended safety training and four workshops: mechanical design, electrical, programming, and team management. These workshops familiarized teams with kit components, engineering concepts, and the process of running a team.

Incoming PiE students attend the Kickoff presentation.

A few significant changes were made to Kickoff this year. Due to space needs, the event was dispersed across a wider area of campus. A lot more attention was paid to staff roles, and staffing instructions were written for each post. The schedule of the day was extended so that each teams could attend all four workshops. The software workshops were split into a high-level lesson taught in C#, and a low-level lesson in BYOB, a graphical programming language for teaching computer science. Overall, the event was much more thoroughly planned, and served a far larger audience.

Soon after meeting his team from Ralph Bunche High School, mentor Paul Ruan (left) works with his students on the mechanical design workshop challenge.

Kickoff was a success, with improvements to be made in the future. The check-in process was again disorganized due to the large amount of paperwork involved, so more thought should be put into streamlining. The workshops were very popular across the board, despite technical difficulties in the electrical workshop due to last-minute software development. The low-level software workshop could have benefited from a language more closely related to C#. Sibley Auditorium, despite being one of the largest presentation halls in the College of Engineering, proved small for our audience, whose size was over twice as large as last year's. Serving lunch was another logistical challenge, but was an eventual success. Students seemed to find their way around campus fairly well despite our concerns, and left happy at the end of the long day.

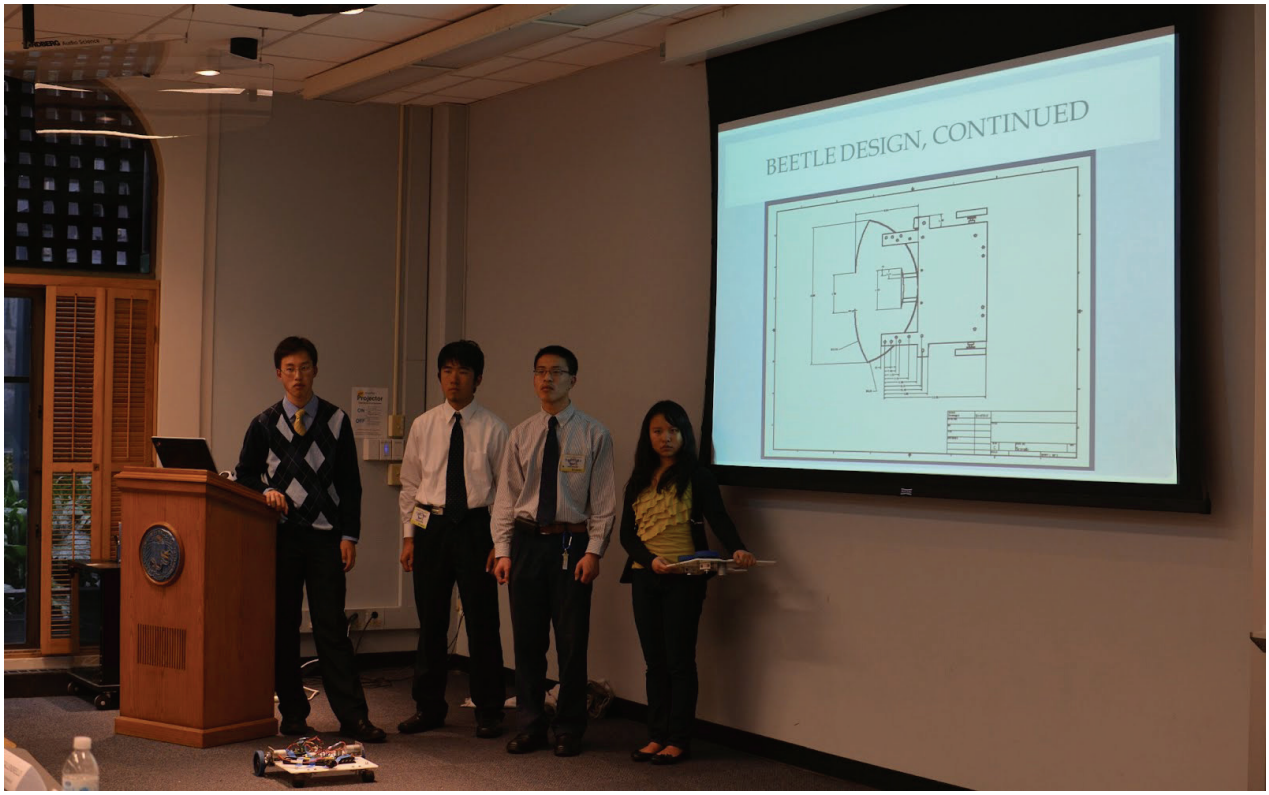
WORK SESSIONS

During the 2012 build season, mentors were required to meet with their teams once a week for two hours, though most mentors met more frequently. To facilitate these meetings, staffed work session hours were held in O'Brien Hall on campus. Containing cabinets with tools, spare parts and equipment and the knowledgeable PiE staff, work sessions at O'Brien proved to be some of the most helpful and productive events of the season.

Due to the increased number of teams, infrastructure was created to more effectively administer the work sessions. Teams were asked to sign up for time slots prior to the date, and student and mentor badges included barcodes that were used to track attendance as well as tool and part checkouts. With these systems in place, our relatively small space in O'Brien did not usually overflow, and our tools were rarely lost. However, this came with a generally lower rate of attendance. Whether this was due to the nature of the teams we recruited or the new sign-up system is unclear.

Mentor Patrick Moore assisting team CMC from the Alameda Community Learning Center as they assemble the basic kit.

DESIGN REVIEWS



The Albany team presents one of their potential designs, using a prototype and their assembled basic kit as visual aids.

Design Reviews provide teams a chance to present to and receive feedback from a panel of engineering judges about their robot designs. Held early in the season, they serve as a checkpoint in teams' development processes while fostering presentation skills and encouraging professionalism.

The 2012 Design Reviews again occurred in the third week of the season. Teams made formal presentations in front of a panel consisting of UC Berkeley professors, professional engineers, TBP alumni, and PiE staff, and received feedback. Each team had fifteen minutes to present their intended design, game strategy, and build prototypes.

Teams came to Design Reviews with different levels of preparation, some with prototypes and detailed drawings and others with notions and questions. We recruited a record number of judges from industry, including representatives from Qualcomm, Lab126, Moog, and Western Digital; we also welcomed back our supporters from UC Berkeley faculty. Judges gave feedback and guidance without giving commands, leaving room for teams to grow and work with their mentors. Teams that came better prepared left with a clearer direction, while others realized the importance of planning and prototyping.

From left to right: Lecturer George Anwar of UC Berkeley's Mechanical Engineering Department, engineer Casey Callendrello of Akamai, engineer Aaron Alpert of Western Digital, and Elton Wong of PiE discuss a team's Design Review presentation.

This year's Design Reviews extended the schedule used in 2011 to moderate success, with five 30-minute time slots each afternoon of the week. Other formats were discussed but never implemented; this should be again explored in future years. Teams arrived on time across the board, thanks to increased communication and greater expectations of team professionalism. Due to the odd number of teams, one time slot saw two reviews with separate panels in separate rooms. Mentors commented that expectations should be made more clear as soon as possible. Despite these setbacks, Design Reviews were extremely successful in guiding every team toward the finish line, and also showed which teams needed more help and assistance.

SCRIMMAGE

Scrimmage is held a week before Final Competition as a practice competition for students, mentors, and staff. Teams have an opportunity to test their robots and learn the match queuing process, while the staff have an opportunity to test the field control system.

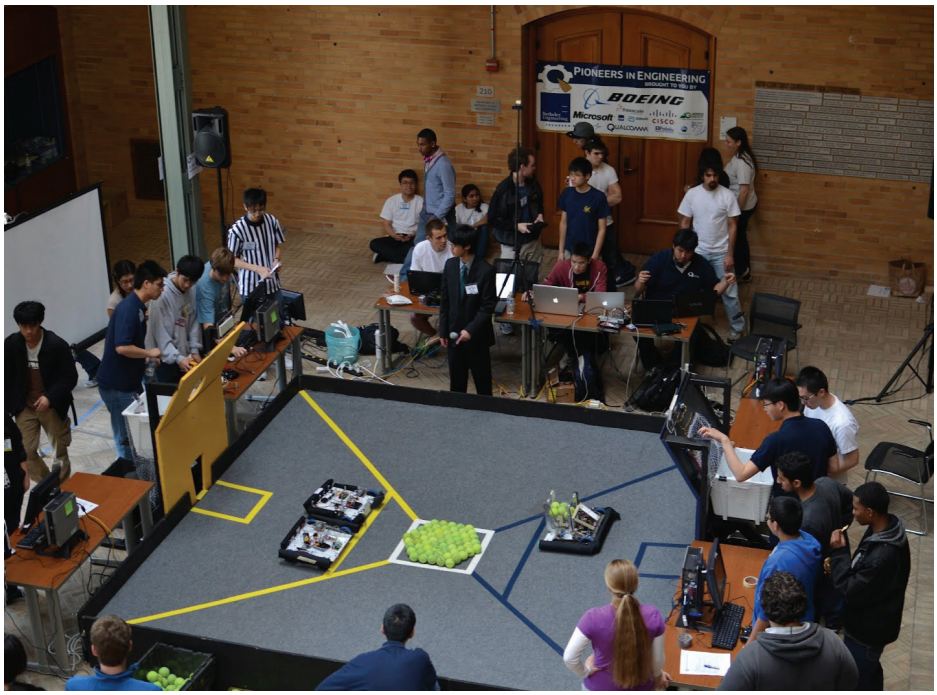
This year, Scrimmage was held the Saturday before Competition in the beautiful Hearst Memorial Mining Building. On Friday night, staff arranged team pits (workstations) throughout the upper floors of the atrium, a tool use and checkout room, and two full field setups. On Saturday morning, teams immediately got to work using the tools and workspaces provided. Most were still finishing their robot builds, and very few robots eventually made it to the field at all, culminating in several low-level practice matches in the late afternoon. Despite the early stage of completion most teams were at, Scrimmage was still extremely useful to everyone. Many robots drove for the first time, and every team was able to see the field and make progress.

Although Scrimmage generally went well, it suffered from a few problems. Among the issues experienced were a lack of effective staffing, during both setup and at the event itself. Tool checkout and use were bottlenecked and only occurred due to the efforts of a large number of staff. The process of queueing teams for matches was done on the fly and suffered due to teams' lack of readiness.

Scrimmage at UC Berkeley's Hearst Memorial Mining Building.

Teacher James Robertson of Lionel Wilson talks with two of his students.

However, all of these shortcomings only served to inform our preparation for Competition, and the successes were many. We received strong positive feedback on the venue, which was loud and exciting. The Cal Band played at lunch to great enthusiasm. Just as in previous years, Scrimmage had the busy atmosphere of a large work session, and was fruitful for everyone.



Teams face off in a practice match at Scrimmage,
a first test of their robots in a competition environment.

FINAL COMPETITION

Colin Fong (left) and Dean Shearer (right) of Balboa celebrate as their robot scores another goal.

The entire PiE season builds up to the Final Competition. After matches to seed teams, an elimination tournament narrows down the field to semifinalists and finally, a Competition Champion. To finish the season, an awards ceremony honors excellent design, engineering spirit, and professionalism.

The 2012 Final Competition was held at the Lawrence Hall of Science, the local children's science and technology museum. The museum hosted PiE as a special event, and devoted an entire floor of the museum to our activities. Team pits were placed in classrooms, the practice field in an amphitheater, and the main competition field in the Hall auditorium. Setup occurred on Friday afternoon and early Saturday morning using cars, trucks, tools, and manpower.

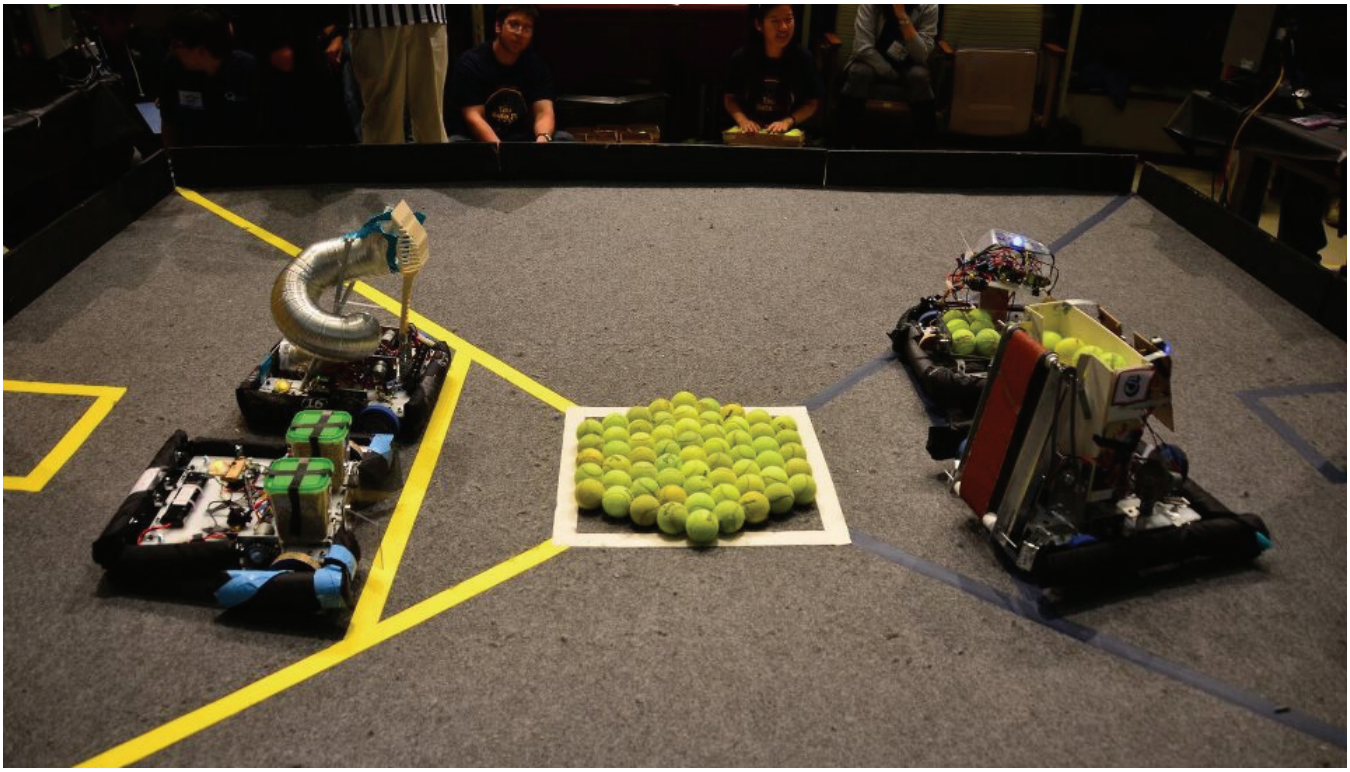
For teams, the Competition event began at 8am. Students arrived and immediately set to work on their robots. We all enjoyed an inspiring presentation by a guest speaker from Boeing, Dr. Andy Bicos. By the time the doors opened to the public at 10am, the qualification rounds were underway. These ran through the morning and early afternoon, followed by alliance selection, elimination matches, and the awards ceremony. Throughout the day, the entire floor was a flurry of activity, and an enormous crowd of students, families, and guests gathered for the final matches.

Dr. Andy Bicos starts off Final Competition with an inspiring presentation on Boeing engineering innovation.

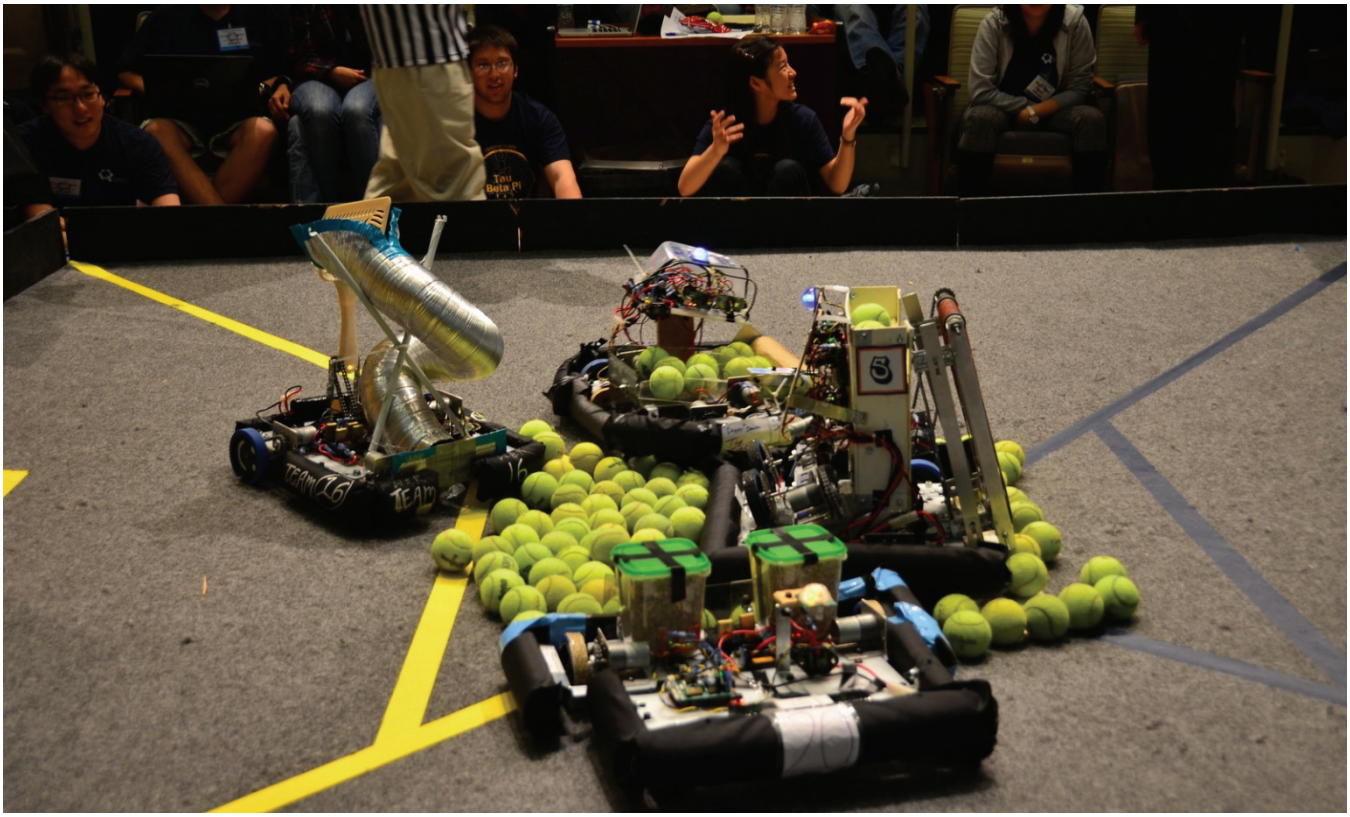
During the competition, dignitaries including professors and industry professionals served as judges. Throughout the afternoon, the judges discussed the awards for engineering professionalism, mechanical design and software excellence, and a special Judges' Award. The closing ceremony featured these winners, as well as awards for the competition champions, second place, and best mentors.

Several challenges arose over the course of the day. Many participants were upset with the luck of the draw as their alliance partners struggled to complete their builds. The lack of preparation also proved challenging for the inspectors, whose job was to approve every robot before it took the field. These factors and more created difficulties for the referees, who did their best to keep the match schedule running smoothly. As expected, the schedule fell behind, forcing us to cut off the seeding rounds early and overseeing a sloppy switch to a single-elimination bracket. Consequently, the ranking system was flawed due to the low number of matches each team played. When alliance selection occurred, teams were unprepared for the process in spite of the information we released. During the elimination matches, some teams - students, teachers, and mentors included - were upset with calls made by the referees, and one rematch occurred as a result. These numerous setbacks are all related to team and tournament preparation, suggesting that we put more thought into determining workarounds, or set higher expectations for teams.

The Alameda Community Learning Center team with teachers and mentors.



The final match between the top two alliances. Ralph Bunche (lower left) and Lionel Wilson (upper left) face off against Balboa (lower right) and Galileo (upper right). Ready, set, go!



William Luong of El Cerrito High School accepts a participation award for his team.

Despite the challenges, the Final Competition was undoubtedly a rousing success. The competition audience was loud and energetic throughout the day. Judges were given clear directives, formally convened to discuss award winners, and had ample opportunity to interact with students, mentors, and staff. Not only judges, but from LHS staff to students to mentors themselves, our supporters and participants had an amazing time and made sure we knew about it. During the finals, we definitely saw some of the most exciting matches ever played in the history of PiE. And at the end of the day, twenty teams went home tired from the excitement, proud of their accomplishments, and carrying a working robot they built themselves.

Students from Cal Prep pose in front of the PiE banner with their robot.

TESTIMONIALS

"It's just so much fun. A very rewarding process seeing the team start out at the beginning, and then in six short weeks, working together and having a lot of fun. Then on the final day, whether we win or not, it's just so much fun, so rewarding. It's also good to see some of the students really take an interest in engineering." - *Ray Pedersen, Albany High School teacher*

"PiE mentors are really great about showing up and helping [students] plan their schedule, and especially helping them do the work that they need to have done." - *Rikki Shackelford, Lawrence Hall of Science TEAMS facilitator*

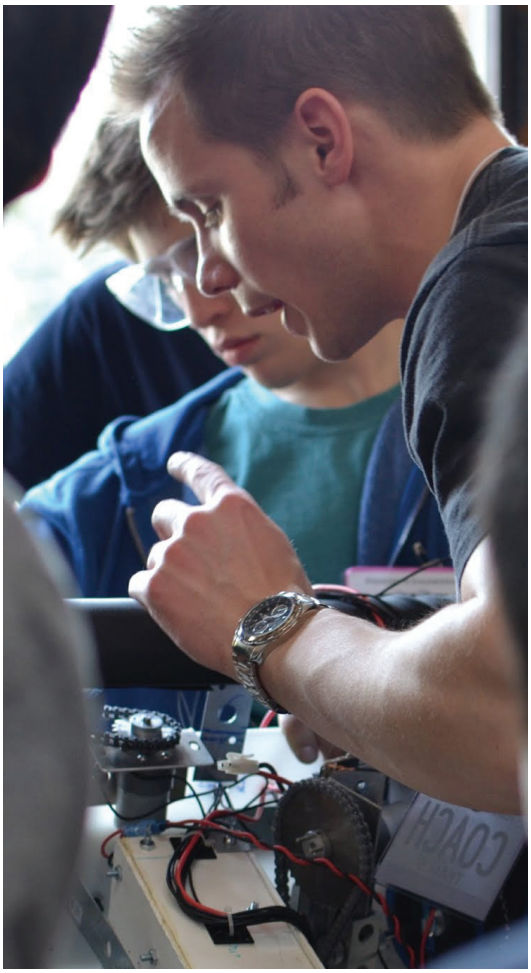
Walter Stokes (center) and teammates Tasajanae Madkins (left) and Shawn Stoddard-Nunez (right) from Ralph Bunche High School drive their robot at a Scrimmage practice match.

"If I can do it, then that just makes me believe in myself. Makes me more confident. Makes me think that I'm better, that I can really actually do something when I put my mind to it. I've never done any kind of work like this before. Just to be able to come in and try something and get it done... that is real good." - *Walter Stokes, 11th grader at Ralph J. Bunche High School*

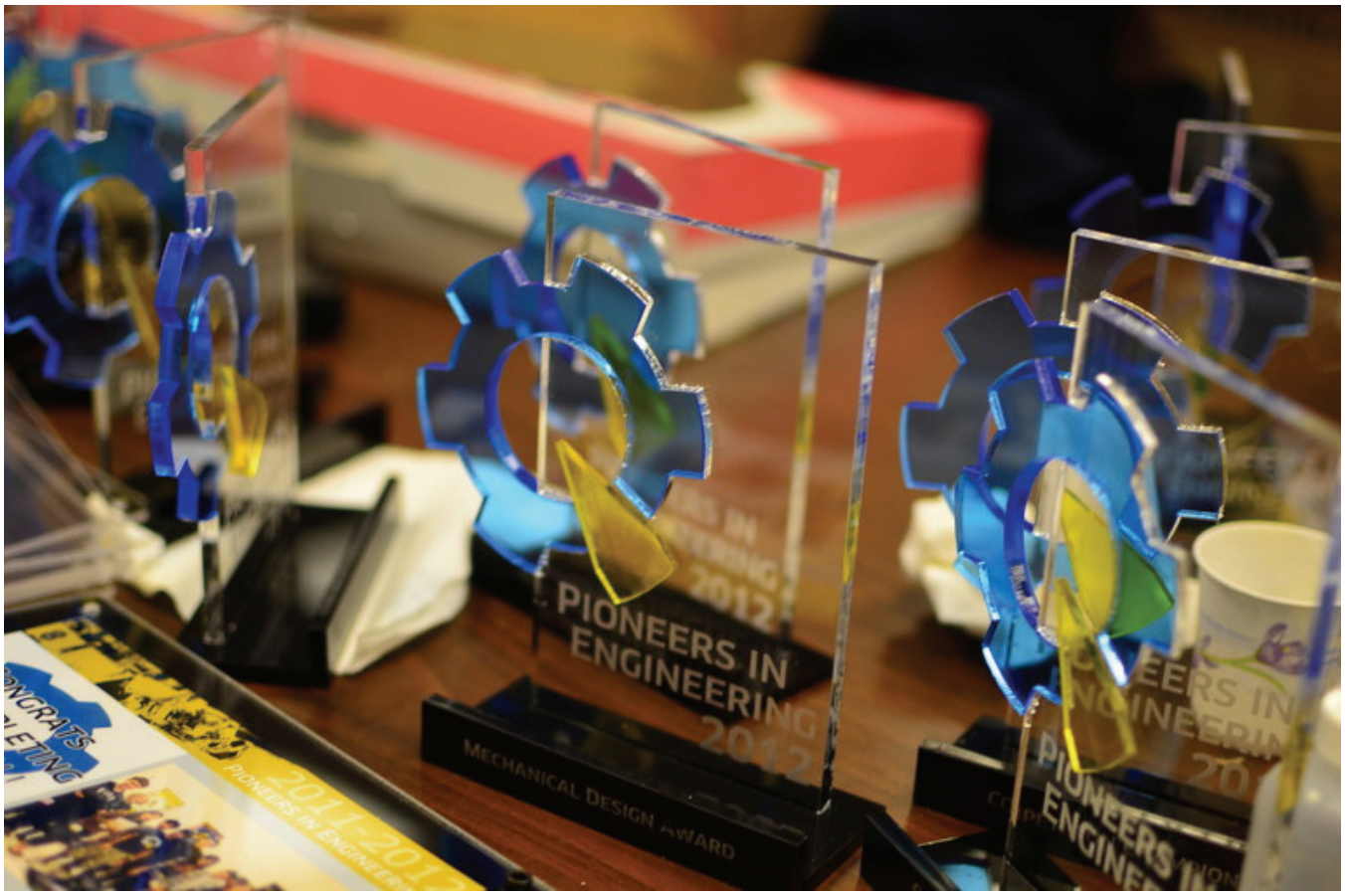
"I have learned so many things from mentors - but not just about robotics. They taught us, inadvertently, about college, applying for jobs, and [other] random stuff."
- *Shruthi Sukir, 9th grader from Lawrence Hall of Science TEAMS*

"PiE was a truly immersive engineering experience that went far beyond what I'm able to provide in the classroom given today's K-12's focus on core subjects (and thus shrinking budgets for technology classes). My students had to think and act like engineers, which also included the technical emails, time management, and hierarchical department structure. Kids that I've known for four years, who have already deeply impressed me, found ways of impressing me even more with their performance."
-*Michael Ferraro, Balboa High School teacher*

"My favorite moment has been getting along with new people I've never talked to, and talking about robotics."
- *Alexander Galvez, 11th grader at De Anza High School*



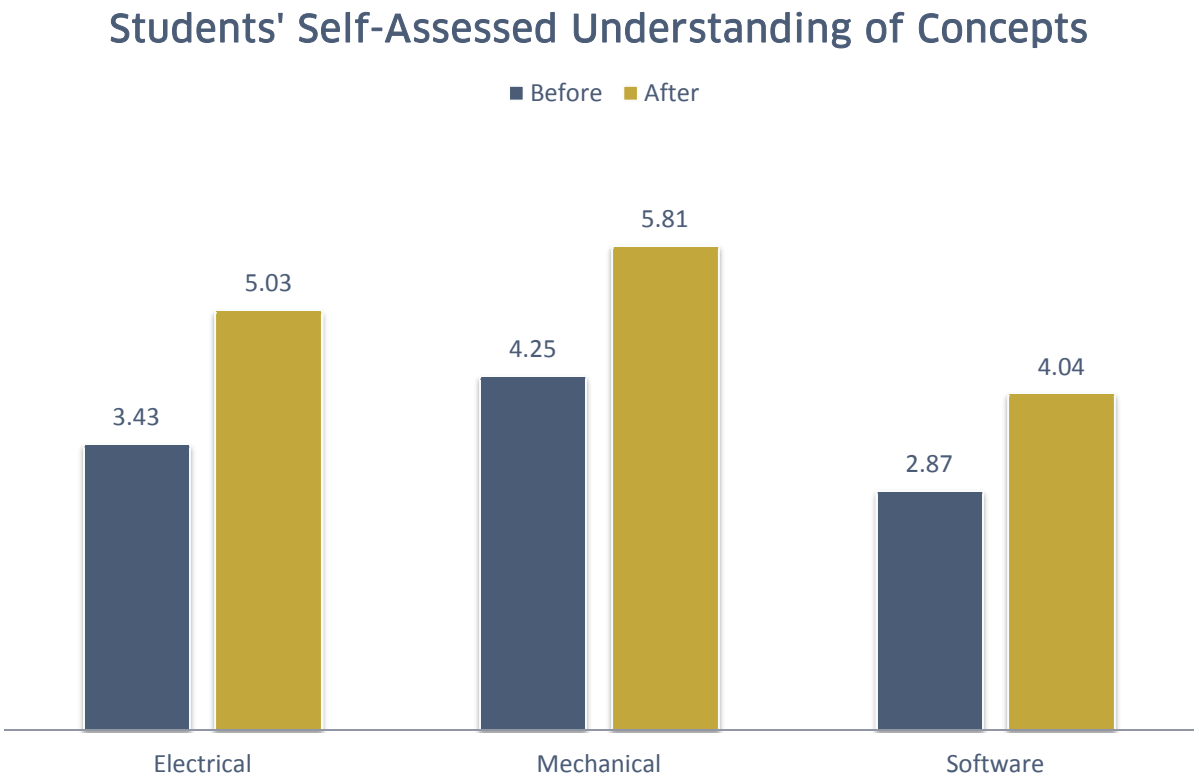
Teacher Michael Ferraro from Balboa High School works with his students to debug their robot's electronics.



The PiE 2012 awards.

"I have learned so much from this experience. When I volunteered for PIE, I didn't expect to take this much away from it myself. But as time went on, I found myself learning things that I will definitely take with me to grad school and any future job. Your team work, your team spirit, each individual's contribution to and attitude towards the team, and most importantly, the dynamic of your relationship, showed me something I haven't even seen in any of the projects I have done at college. As most of you go away to college next year, I hope you look back at this experience and remember all the small things that made this team a great team. I know this will sound like a cliché, but if you look back and see how well the hard work you put in for the past eight weeks paid off, it should remind you that the same will happen in the future. Most importantly, this experience shows that you guys can do ANYTHING in life. So follow whatever path you want to follow, because you have what it takes to succeed." - *Nami Gheidar, SFSU TBP student and mentor for Balboa High School, speaking to his students*

SEASON OUTCOMES



PiE staff were happy with the outcomes of the 2012 season, which went above and beyond expectations from previous years. At Kickoff, teams not only met their mentors but also participated in four workshops and safety training. Design Reviews saw an incredible amount of industry participation, and judge feedback proved constructive to many teams. Scrimmage proved a useful testing ground for many teams. And finally, the Final Competition at the Lawrence Hall of Science was an amazing event featuring Ballistic Blitz played on a grand stage in an atmosphere of genuine, unbridled excitement and enthusiasm.

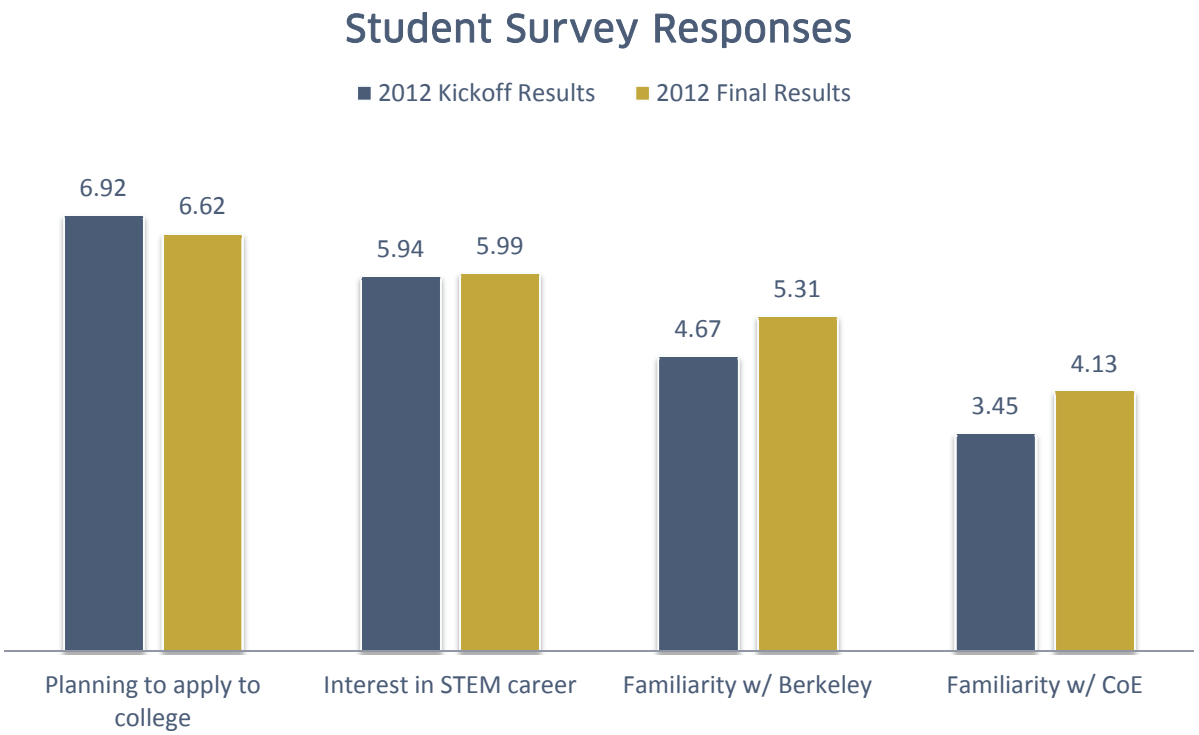
This season saw many new developments beyond the increase in size: a step up in event venues, mature Kickoff workshops, greater industry involvement, improved student and tool tracking, and a more sophisticated level of kit use and competition. All this was due to the groundwork laid by the previous year's program and the determination of this year's staff in improving the program.

The main program goals we set at the beginning of the year were handily met and exceeded. Not only did we sustain the robotics competition, but expanded it to reach over 250 students, of which almost 35% were ethnic minorities, 27% female, and 29% on free or reduced lunch. We were able to sustain and foster the growth of STEM programs in our returning schools (all of which returned from last year) and the 11 new schools we recruited. We brought 90 mentors and 60 staff members from two

universities to community service and outreach. Our success came in both expanding the reach of the program and augmenting its quality and expectations.

SURVEY RESULTS

Survey data showed that our students have a desire to continue their education in STEM, and are becoming more familiar with UC Berkeley.

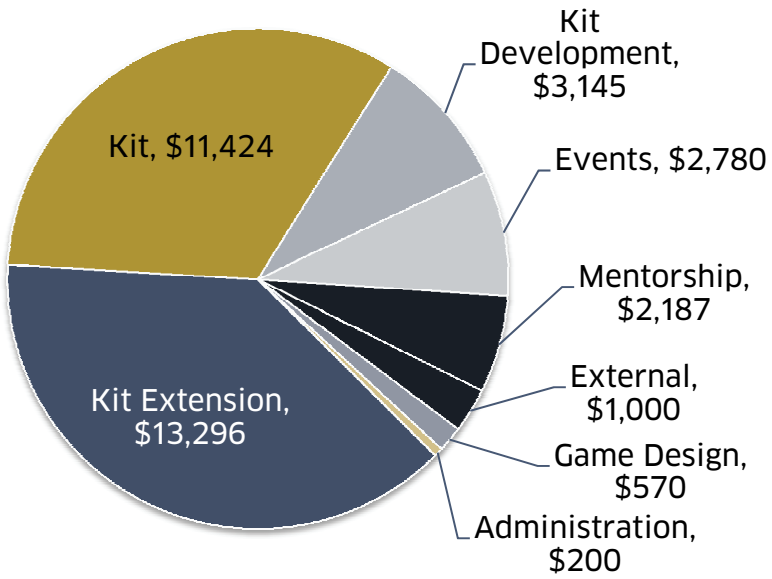


The chart above shows the comparison of the average score for four survey questions (out of 7 points) comparing the results from the surveys collected at Kickoff and Final Competition. While students' desires to apply to college and interests in a STEM career remained high, their familiarity with the University of California, Berkeley and the College of Engineering and engineering at UC Berkeley increased measurably. A change in the surveyed population (the groups polled at Kickoff and at Competition were not identical) is responsible for some error in the results. Most students who left during the season came from our more affluent schools whose teams were overenrolled, suggesting that the results as a whole may be skewed negatively.

FINANCES AND SPONSORSHIP

PROPOSED BUDGET ($34,622)

The PiE 2012 budget was made to support 24 teams in the competition season.



- The **Kit** is what each team receives at Kickoff. It consists of all the necessary components and instructions to build a driving robot base.
- The **Kit Extension** includes additional sensors, microcontrollers, wheels, stock materials, and other parts made available for each team to conceptualize and construct their robot.
- The **Kit Development** budget covers developing said kit and kit extension. During the fall, UC Berkeley students test dozens of off-the-shelf robotic components to find the optimal kit parts in terms of price and performance, and fabricate custom solutions when no existing ones can be found.
- The **Events** budget covers room, printing, refreshments, awards, and other fees associated with Kickoff, Design Reviews, Scrimmage, and Competition.
- The **Mentorship** budget includes developing and running lessons and workshops for training college student mentors to mentor high school teams. It also provides support for mentors' transportation throughout the season.
- The **External** budget covers publicity and both school and mentor recruiting costs.
- The **Game Design** budget covers prototyping and building the robot game field.
- The **Administration** budget covers miscellaneous operational costs.

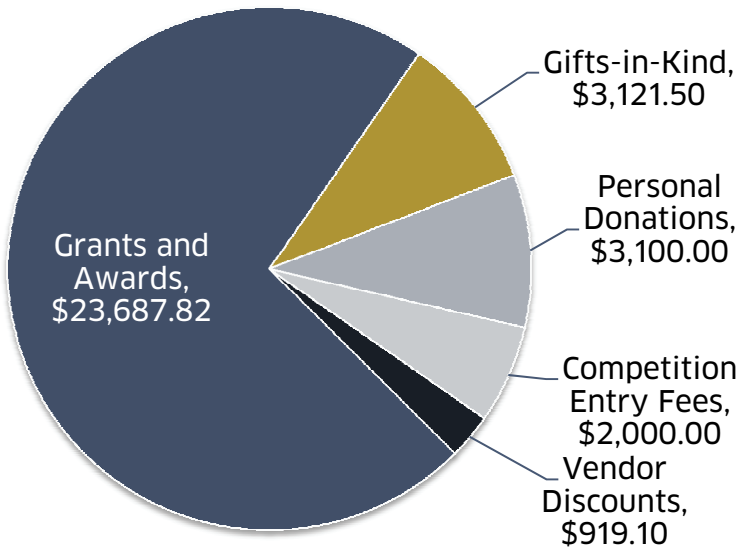
FUNDRAISING

The 2012 income can be divided into five general categories: grants and awards, gifts-in-kind, vendor discounts, personal donations, and competition entry fees. Grants and awards include monetary donations from both UC Berkeley and from corporate sponsors. Gifts-in-kind refer to the equivalent monetary value of parts, materials, and products donated by a sponsor. Vendor discounts refer to those specially offered to PiE by our sponsors. Personal donations are made by individuals, and competition entry fees comprise the $100 required for each team to participate in the competition.

We obtain our corporate grants and awards and gifts-in-kind through our connections and by networking. Our large donations generally come from relationships with recruiters, sales representatives, or executives. Vendor discounts are obtained by speaking directly to sales representatives of our suppliers. Personal donations are typically made by PiE alumni or acquaintances of PiE staff.

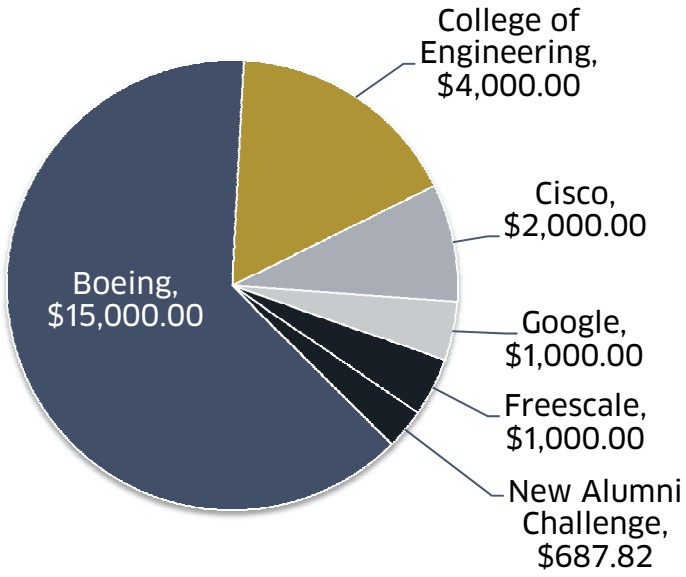
All donations are made through the UC Berkeley Foundation (http://givetocal.berkeley.edu/), where we have established a fund (#FN3231). Through this fund, donors give to a 501(c)(3) tax-deductible organization, and the money is channeled to PiE's sub-account in Tau Beta Pi's bank account. The UC Berkeley Foundation collects a gift fee of 2.5% of the amount of the donation, and any credit card transaction fees also apply.

INCOME ($32,828.42)



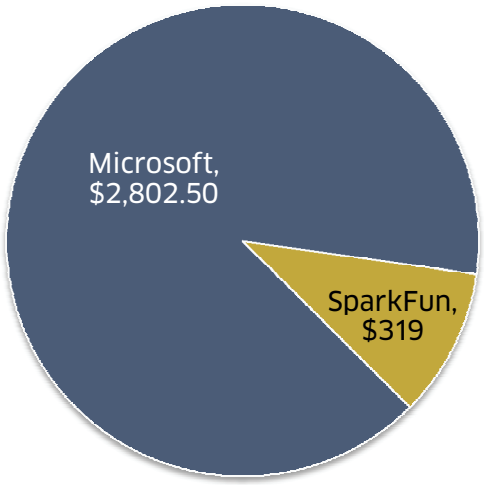
Because we did not hit our fundraising goal of $35,000, we scaled back the number of teams that we could support from 24 to 21. As a result of one team dropping out of the competition, the final number of teams was 20.

Grants and Awards ($23,687.82)

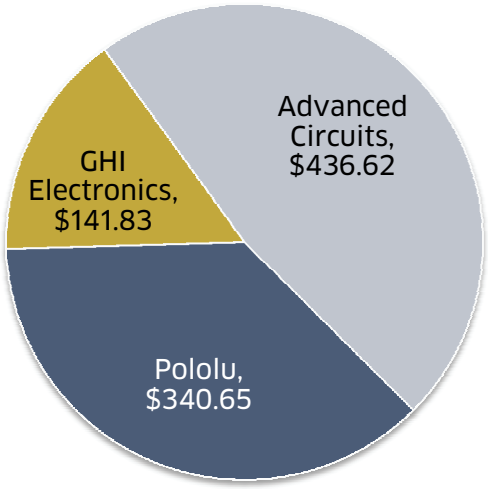


It should be noted that the Google and New Alumni Challenge sums come from matching funds that resulted from contributions from individual donors.

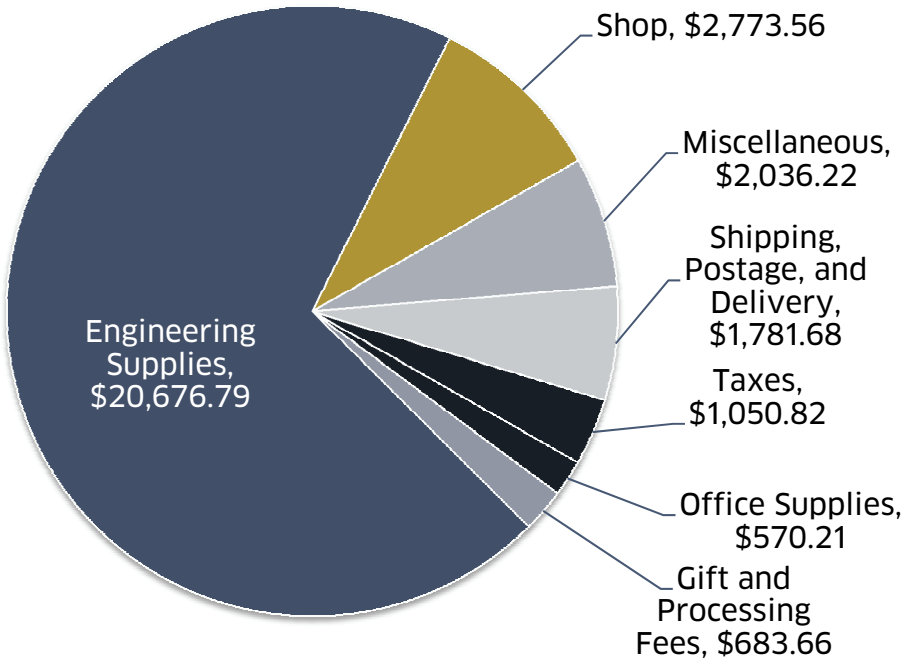
Gifts-In-Kind ($3,121.50)



Vendor Discounts ($919.10)



EXPENDITURES ($29,572.94)



The Engineering Supplies category encompasses the bulk of our expenses, including all kit and kit development costs, field construction costs, and materials needed for mentorship. The Shop category includes tools, organization, and maintenance equipment. Office Supplies include printing and reproduction of all materials, including flyers, press packets, brochures, and banners. Miscellaneous expenditures include equipment rentals, room rentals, and apparel. Taxes refer to sales tax. Gift fees are the 2.5% of every donation collected by the UC Berkeley Foundation, and processing fees refer to the percentage of credit card donations collected by credit card companies.

Our expenditures stayed under the amount of money we fundraised for the year, so we are in the green for the PiE 2013 season.

Additional Outreach

Given the success of the robotics competition and the increasing stability of the organization, we placed emphasis on expanding our outreach efforts through small-scale expositions. The goal of these events is to bring PiE and robotics to a wider audience, including hobbyists, elementary school students, and parents.

Maker Faire and Mini Maker Faire

An excited Mini Maker Faire visitor shows Stephanie Ku that he can successfully use a robot to place a pillow.

The 2011 Maker Faire marked the first public outreach event that PiE attended. Maker Faire is an event created by Make magazine to "celebrate arts, crafts, engineering, science projects and the Do-It-Yourself mindset". We were invited to have a booth from May 20-22 in San Mateo. In our space, we set up an information table with a banner, brochures, business cards, and laptops streaming video. Robots built for the 2011 game by Albany and Oakland Tech constituted the interactive portion of our exhibit; visitors were invited to participate in a challenge by driving and scoring a pillow into a goal. While young kids drove the robots, we explained some of the engineering and provided parents information about the PiE program.

Maker Faire proved to be a great place to spread the word about our program and to connect with other groups and companies that specialize in electronics, engineering, and education. Some of our staff were able to meet the CEO of Sparkfun, triggering a relationship with the company.

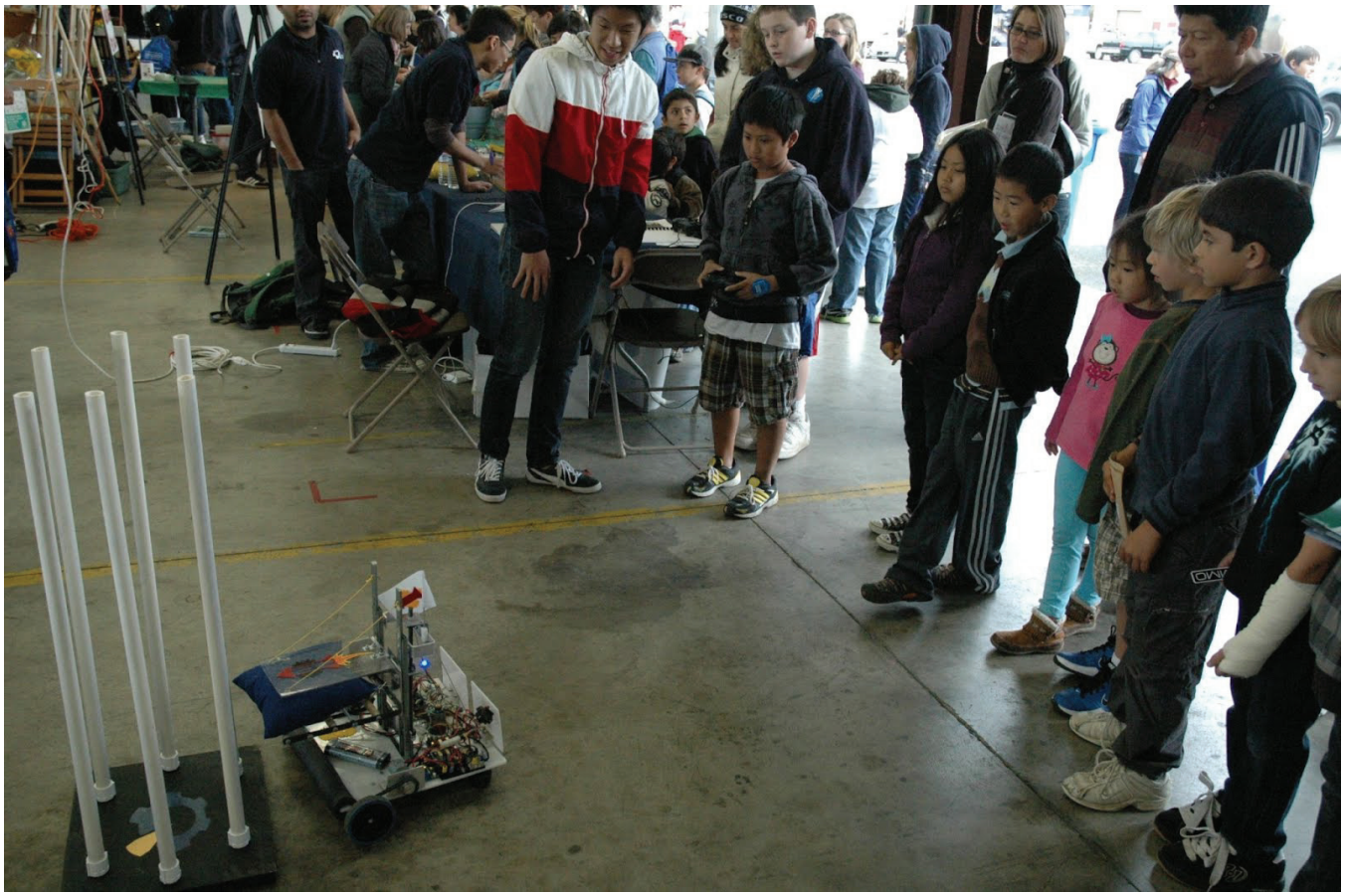
At Maker Faire, Dennis Wai (right) explains the structure of a robot to a father and son.

As a local “maker”, PiE was also invited to attend the East Bay Mini Maker Faire on October 16, a family-friendly event in the spirit of the official Maker Faire. Our setup, quickly becoming standardized, followed directly from the one used at Maker Faire. As it was mid-fall, new staff members had the opportunity to participate and interact with younger students. Despite some issues with understaffing, the event’s success underlined how fun and effective this style of outreach could be.

BAY AREA SCIENCE FAIR

Bay Area Science Fair was part of the NSF-funded Bay Area Science Festival in fall 2011. PiE participated in three different events that were part of the festival: Discovery Days at Cal State East Bay and Infineon Raceway (on October 29 and November 5, respectively), and Robots vs. Dinos (on October 30). With the exception of Robots vs. Dinos, these events were very similar to Mini Maker Faire.

The week-long Bay Area Science Festival culminated in a major PiE effort in creating and providing robotics activities for the Lawrence Hall of Science event Robots vs. Dinos.



At the Infineon Discovery Day, Bryant Luong (left) teaches a young visitor how to drive a robot and score a pillow in the goal.

ROBOS VS. DINOS

Mentorship staff Vanathi Ganesh (left) and Sam Fung (center) watch a visitor enjoy PiE's dynamic Dino Tail.

Robos vs Dinos was a day-long event held at Lawrence Hall of Science as part of the Bay Area Science Festival. Visitors were invited to engage in a day's worth of dinosaur- and robot-related activities, then vote at the end of the day on the group that they liked the best.

Planning for the event began only two months in advance. Sue Guevara, the LHS Visitor Programs Manager, suggested that PiE create and provide many of the robotics activities. PiE staff created eight distinct robotics activities, from shooting lasers to building autonomous cars, that exhibited at Robos vs. Dinos to the delight of several hundred children and their families. One of the best received activities was Dino Tail, a backpack with an active tail attachment that turned in the opposite direction of the wearer, simulating a dinosaur using its tail to stabilize its motions. Candidates and officers from TBP and Eta Kappa Nu, the Electrical Engineering honor society, volunteered as staff for the event.

E4K

Engineering 4 Kids Day (E4K) is an annual day-long event held at UC Berkeley in which the engineering student groups on campus run activities for young participants. On March 17, hundreds of elementary students came to visit campus and try their hand at engineering. The activity we held challenged students to drive a kit robot along a marked figure eight path. Many participants were so excited that they returned to try a second and third time. One young visitor proclaimed, “This is the best challenge ever! I love robots!”

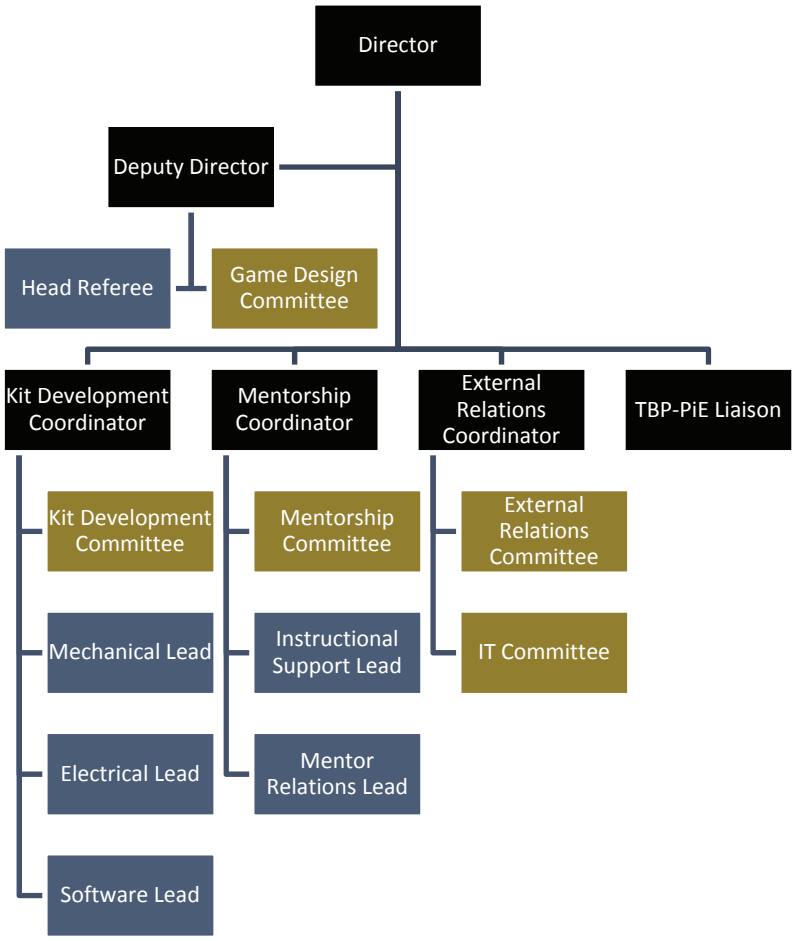
External Coordinator Or Weizman explains robot driving to a visitor as her siblings wait their turn.

JOHN GREEN ELEMENTARY SCHOOL SCIENCE FUN FAIR

PiE was invited to participate in the annual John Green Elementary School Science Fun Fair in Dublin on March 29, 2012, after a parent saw our robotics demonstration at Maker Faire. The science fair is a school-wide event, where every student is required to design and execute an experiment using the scientific method, then put together a display board summarizing the experiment and its findings. PiE was invited to be a guest exhibitor, along with representatives from the Lawrence Livermore National Labs and the Spectrum of Science Foundation. The children had a great time learning about and driving our demonstration robots.

Or Weizman and Amy Fu at the John Green Elementary Science Fun Fair in March 2012.

STAFF AND ADMINISTRATION



Organizational structure for PiE 2012. Coordinator positions are in black, lead positions in blue, and committees in gold.

Pioneers in Engineering is a completely student-run organization. It is led by a group of six coordinators: the Director, Deputy Director, Kit Development Coordinator, Mentorship Coordinator, External Relations Coordinator, and TBP-PiE Liaison. These coordinators usually serve for one year with the exception of the TBP-PiE Liaison, who is re-elected every semester. The Director organizes the other coordinators, sets the agenda for the organization, represents PiE to other organizations, tracks finances, and nominates the next year's coordinators. The Deputy Director is responsible for the internal health of the organization, event planning, and overseeing the Game Design Committee. The Kit Development, Mentorship, and External Relations coordinators lead their respective committees. The TBP-PiE liaison is responsible for facilitating communication and collaboration between PiE and TBP. This organizational structure was first employed successfully during the 2011 competition.

PiE staff pause for a snapshot on the morning of Kickoff.

KIT DEVELOPMENT COMMITTEE

KITDEV OVERVIEW

The Kit Development Committee (KitDev) designs, creates, manufactures, and tests the robotics kits that are ultimately given to the high school teams. KitDev provides two resources to the teams. The first is the Kit, a programmable driving base that expedites the build process and ensures a minimum degree of functionality for all robots. The second is the Kit Extension, a bank of electrical and mechanical components from which teams may pick and choose components to build end effectors like catapults, pulleys, and conveyors.

KIT AND KIT EXTENSION

The purpose of the Kit is to provide an initial level of functionality for all the robots. Because PiE is often the first robotics experience for our high school participants, the goal of the Kit is to give an informative and complete head start. Teams can participate in the competition using only the programmable driving base, yet still learn about the basics of mechanical, software, and electrical integration in an embedded systems project.

The purpose of the Kit Extension is to provide a versatile treasure trove of parts for robot construction, encouraging teams to focus on design and resource management. We place a virtual monetary value on each item in the Kit Extension (except for fasteners, wires, connectors, and raw materials) and set a virtual budget limit of how much teams can spend on Kit Extension ($200 this year). Because the Kit Extension is designed to be capable of providing items for any end effector usable in the game, we aim to compel teams to carefully plan out what they want to build and select only the specific parts they will use. In order to stimulate creativity and encourage some risk-taking, we allow teams return the items they purchase at full price to buy other parts if they are close to their budget.

The KitDev crew poses at one of the review sessions.

This year, the Kit comprised:

- 1 HDPE sheet base
- 2 motor-controlled wheels (fully equipped with gearmotors, motor mounts, sprockets, universal hubs, chain, and motor controllers for each motor)
- 2 casters
- A power distribution system consisting of a fuse panel, fuses, circuit breaker switch, crimped wires, 2 batteries, and a battery charger
- A programmable unit consisting of a microcontroller, a Top Board (a custom physical interface to pins on the microcontroller), and a radio
- Driver components for the computer consisting of a GUI-based control software, a radio with a USB-board, and a game controller
- Programmable software consisting of an IDE, firmware, a custom-made API for all electrical components in the Kit, pre-loaded driving code, and documentation
- A Kit Manual

This year, the Kit Extension comprised:

- Sensors (all types of potentiometers, switches, encoders, buttons, IR and Sonar rangefinders, accelerometers, gyroscopes, force-sensing resistors, et cetera)
- Motor controllers
- Gearmotors of different speeds
- Sprockets
- Axles, chain, and shaft collars, hubs
- Servos
- Servo Controllers
- Rollers
- PVC pipe
- Custom-requested machined parts
- Spare Kit parts
- Raw materials
- Fasteners, wires, and connectors

ORGANIZATION AND GOALS

Even though KitDev provides resources to the teams, the committee is more than just a third-party parts distributor. KitDev also provides a professional, hands-on STEM experience for our college staff. The ultimate goal, from an internal perspective, is for KitDev staff to learn to efficiently mass-produce intuitive, stable kits to not necessarily technical end-users.

KitDev is divided into three subgroups, Mechanical, Electrical, and Software; from prior experience, main projects fall nicely under these categories. Of course, there are inter-group projects that require extensive communication and collaboration - this sort of teamwork is another skill that KitDev aims to teach its staff. Beyond the Coordinator, each group is further organized by a Lead.

After recruiting staff in the beginning of the fall semester, KitDev trains its new members, bringing them up to speed on the wide expanse of projects. Over the course of the semester, staff review problems in the previous year's kit and make decisions on the design features of current projects. They buy small quantities of components to implement and test design features on Kit prototypes. Throughout this process, staff undergo several organization-wide Design Reviews. For KitDev, Design Reviews serve to update the coordinators and other committees on KitDev's progress, as well as offer staff a forum through which they receive technical feedback on the direction of their projects. The last Design Review, known as PiE Readiness Review, represents a final review of which projects are mature enough to include in the Kit or Kit Extension.

In the few months before Kickoff, once designs have been tested, reviewed, and frozen, KitDev staff mass-produce and test Kit components. Production this year included the machining of approximately 1,000 parts and population of almost 200 electrical boards. Before the final Kit check-off, staff test that all the parts that are provided to the high school teams are fully functional. This validation process is coupled with the manufacturing process in order to provide feedback and remain in accordance with professional procedure.

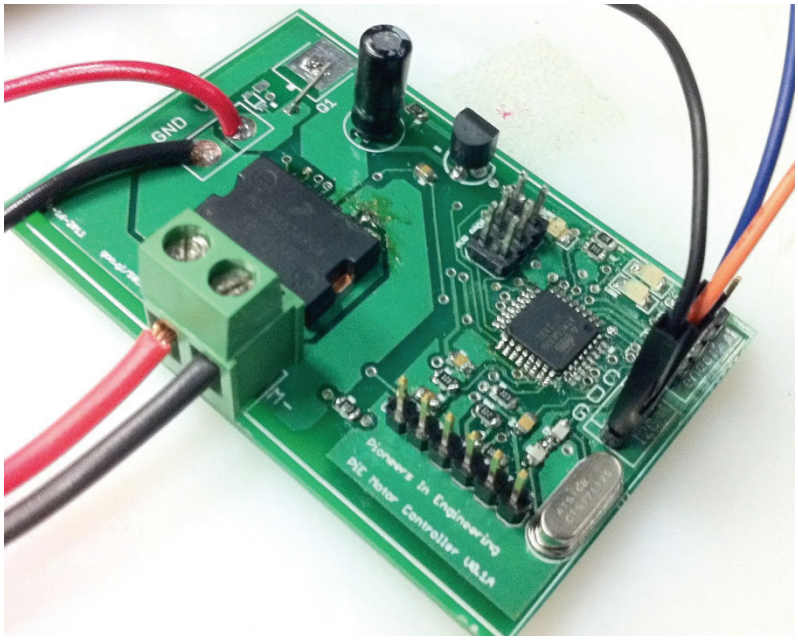
KitDev also functions to help other committees and events through technical development. As an example, KitDev supported TBP's College Bound event, creating a set of circuit boards for use in a teaching module displaying the concept and applications of range-finding. Additionally, KitDev developed the interactive infrared game pieces as well the field control system used for Ballistic Blitz.

Douglas Hutchings of Mechanical creates axle mounts in the student machine shop.

ACCOMPLISHMENTS

In the past year, KitDev increased production but also focused on making the Kit more stable. Each subgroup ventured into new waters in a quest for better reliability.

After identifying issues with the drivetrain in the previous Kit, Mechanical set forward to improve it. The use of thicker plastic and strengthening support bars virtually eliminated a problem with sagging. By redesigning universal hubs and motor mounts, we allowed for increased customizability of the drivetrain and other powered components. For the first time, we introduced mandatory bumpers into the Kit, allowing it to be usable in a game with increased contact between robots. We also attempted to streamline the creation of end effectors by providing elements in the Kit Extension such as an integrated roller system.



Our newly designed Polar Bear Motor Controller, ready to use.

Electrical's primary goal was to reduce instances of component failure by short-circuiting. Our redesigned top board with polarity protection and organized pin headers allowed for easier connection of auxiliary components to the microcontroller. We introduced the new PiE motor controller, a professional-level project, which allowed us to design customized features such as using current sensing to prevent stalled motors from burning out the component. We supported these developments with more intuitive connectors between components. Finally, a last-minute but important shift to a higher battery voltage made the Kit more powerful for the inclined field of Ballistic Blitz.

To encourage students' programming endeavors, Software focused on making PiER (our API) and PiEMOS (our user-control computer program) more responsive and user-friendly. First, we significantly reduced the latency between user controls and robot reactions, and shifted all the code to a new version of the FEZ Panda microcontroller (the Panda II). We also protected our important background code from accidental student changes by packaging it in a dynamic link library (DLL). At the same time, we made sensor output easier to receive and feedback control, and programmed several gamepad layouts for different driving styles. Finally, we laid foundations to allow greater customizability to the PiEMOS interface.

Beyond design changes, KitDev made huge improvements upon its production processes. Machining was a highly organized project; based on staff schedules, jobs were pipelined efficiently to mass-produce hundreds of parts. Similarly, Electrical split up its production among individual stations, grouped by difficulty level and by like through-hole and surface-mount components. For this process, we established detailed quality assurance procedures to confirm the functionality of the electrical components. Our staff's dedication to production and validation made supporting 20 teams a possibility.

KEY CHANGES

There has been a major shift for KitDev to produce parts in-house rather than buy professionally sold parts due to desires for increased customizability and internal learning. One of the most significant new projects this year was the development of our own motor controller. We realized that certain functional limitations of the previous year's motor controllers were problems for our young end-users. Thus, we included features like reverse-polarity protection and current sensing to bypass problems caused by connecting power wires incorrectly and stalling the motors, respectively.

Bryant Luong of Electrical solders together a motor controller.

There has also been a transition toward creating higher-powered, more capable Kits. By increasing the voltage from 7.2V to 12V and creating bumpers as a requirement, we made the Kits playable on a ramped field with pushing other robots as a relatively safe strategy. Among other things, an effort to obtain batteries that supply more power, allowing for larger motors, is already in the works.

FUTURE DIRECTION

Ultimately, as KitDev evolves, it faces several problems that threaten its sustainability. These are among KitDev's highest priorities on its to-do list for the future. In the past years, the size of KitDev has been under 10 people; however, it tripled in the past year with more anticipated on the horizon.

Because this growth engenders organizational difficulties, KitDev is making a constant effort to scale smoothly. A main problem is effectively training new staff and finding projects for them to work on, which increases staff retention and engagement. KitDev attracts many engineers who want to do technical work, but they can be turned away by lack of interactions and connections within the organization. This summer, due to the increased number of trained, conveniently located staff, we aim to develop detailed plans for all the projects and training modules for incoming staff, to be completed and deployed within the first few weeks of the semester. These plans may be tested out by the influx of mentors and other staff who wish to join KitDev during the summer.

KitDev must also focus on improving its internal organization. We need a centralized file systems that are updated consistently and properly, ranging from a standardized code repository for Software to CAD counterparts for Electrical and Mechanical. On top of that, there needs to be better communication between the subgroups. In the past, a lack of proper information flow has resulted in projects being delayed or dropped. Along the same lines, communication is the first step to increased participation and collaboration between staff. During weeks of increased academic stress, a lack of preparation by the Leads and Coordinator, and staff caused a large amount of work to be dumped on a few willing but unfortunate individuals. In addition to overburdening a small core, this also prevented staff at large from being capable of solving teams' technical problems when they arose during the season. To address these issues with communication and engagement, we plan to restructure each group around their projects to contextualize them in a consolidated vision of the whole. KitDev has become skilled at designing and developing modular projects, but still needs to work on their ultimate integration into one central product, a systems engineering challenge worthy of industry.

Main issues with Kit stability directly result from the organizational issues labeled above. We were generally aware of how intuitive and stable the Kit would need to be based on previous competitions, but were unable to follow through during the year. For instance, Electrical has yet to successfully design a system that mostly precludes the creation of useless tangles of fried components. With better communication, we could have faster production and testing; furthermore, better inter-group integration would have allowed for the creation of easy-to-use electronics enclosures, a project that failed during the year. Other problems include designing better Mechanical and Software infrastructures for easier construction of anything teams want to develop, such as better programming modules and mechanical end effectors.

KitDev's increase in skilled, motivated staff forecasts large, positive organizational overhauls for the next year. Considering that two-thirds of the staff were new this past year, the fact that KitDev was able to consistently deliver parts and debug errors for 20 teams indicates the sheer ability of the group's collective talents and willpower.

MENTORSHIP COMMITTEE

MENTORSHIP OVERVIEW

The Mentorship committee was formed to recruit, prepare, and oversee the mentors for each season, as well as offer learning resources to high school students. This year, the committee also gauged each participating high school team's progress during the season. Mentorship's most important duty is managing the PiE DeCal, a 12-week course critical to mentor development. To perform these tasks, the Mentorship coordinator works with the Instructional Support Lead to prepare the DeCal's lessons and material logistics while the Relations Lead works with the coordinator to provide oversight and assistance to mentors.

Mentor Justin Sin (left) and his high school students from Lawrence Hall of Science share an early victory as their robot drives for the first time.

PiE DeCal

In its second year, the PiE DeCal prepares mentors for the PiE season through a series of lessons that mimics the competition season. In the first five weeks of the DeCal, mentors were guided through fundamental lab lessons that gave many mentors their first glimpse into the world of robotics via assembly of a drivable robot from the PiE kit. After these five weeks, the competition season is in full swing and the DeCal focuses on a series of supplemental lessons designed to demonstrate advanced features possible with the base kit to the mentors, who will in turn convey it to the students. Some examples of advanced topics included feedback control, autonomous programming, and end-effector design.

The Mentorship committee built off of last year's lessons and sought to improve on various selected shortcomings, such as the lack of labs for supplemental lesson and lack of emphasis on programming techniques. One of the most important direction Mentorship took this semester was a heavy investment into the hands-on component of the DeCal, the labs. As a result, all DeCal lessons include an extremely hands-on, hour-long lab that provided a small group of mentors a chance to work with Mentorship staff to investigate a problem related to the supplemental lesson.

To combat last year's lack of autonomous programming in high school robots, the Mentorship committee extended the entire line of programming lessons in the DeCal by increasing the total amount of lessons by one for a grand total of three. Mentorship also provided novel lab assignments for each lesson, which provided practical experience for mentors in programming the robot to perform certain game-oriented tasks, such as moving forward and turning. In other cases, some lessons were completely redone. For example, the Mechanical 2 lesson, which emphasized mechanical design for end effectors, was completely revamped to reflect the PiE game, Ballistic Blitz.

The PiE program and DeCal curriculum are not mature to the extent that lessons can be directly repeated for every PiE season. The fluidity of the DeCal curriculum and the modularity of its lessons appropriately reflect the continual change of the annual PiE game as well as the varying needs of the high school students and mentors.

Mentor Recruitment

After the decision to host more schools, Mentorship invested heavily in recruiting new mentors during the first three weeks of the spring semester. In collaboration with TBP's Publicity committee, PiE was able to reach many engineering students via classroom announcements, classroom chalking, and flyers. We also advertised in departmental mailing lists to recruit mentors outside of the College of Engineering. Mentorship's hard work and effort culminated in an attendance of over 100 mentors at the initial interest meeting.

MENTOR EXPERIENCES

By the end of the season, many mentors had developed friendly relationships with their students and inspired in them enthusiasm for robotics and engineering. The increased number of mentors caused two side effects unprecedented in PiE. First, many mentors were able to divide the week amongst themselves and generally visited schools twice a week. Second, many groups of mentors assigned to a school developed friendships with one another. As a result, all of our mentors not only had an increased chance to share their passion for engineering with high school students, but also made new circles of friends within the CoE.

Mentors Nolan Chan (far left) and Darena Tulanont (second from left) watch as their students from Head-Royce brainstorm ways to improve their robot's performance. As a TBP candidate, Darena was able to fulfill her service requirements through PiE.

MENTOR ACCOUNTABILITY

A key project Mentorship undertook this year was increased oversight of high school teams and mentors. We required DeCal mentors to write a weekly report detailing their visits and team progress, with an emphasis on technical difficulties. Through the reports, we were able to obtain a better sense

of teams' progress during the competition season as well as better recognize problematic mentors. On the whole, we were able to identify issues and provide intervention when necessary.

Challenges remained, however; a nontrivial percentage of mentor reports were lacking in detail, and in-person contact was required to determine whether high school teams had reached certain competition milestones. This was mitigated by "office hours" meetings initiated this year through the PiE DeCal. After Design Reviews, each mentor was mandated to make an appointment with the Mentorship coordinator to pick up judges' comments and privately discuss their high school's status and any personal difficulties that had arisen during mentoring.

NEW ROLES

As in previous years, Mentorship was given the responsibility of planning and teaching four novel Kickoff workshops for high schoolers. These ran smoothly and were met with widespread approval. One of the most well-received workshops was the mechanical design workshop, where high school students and mentors brainstormed a way to build the tallest freestanding structure out of office supplies such as manila folders and straws. The workshop provided a medium for students and mentors to channel their creativity as a warm-up for the robot-building that would follow during the season.

Mentor Nighelles David (left) works with a San Lorenzo High student to build the tallest structure at Kickoff's mechanical design workshop.

Mentorship also had the opportunity to develop science activities for the Lawrence Hall of Science (LHS) during the Robots vs. Dinos event, as well as for the Ingenuity Lab, a regular museum exhibit for LHS. For Robots vs. Dinos, Mentorship developed over eight different types of activities for hundreds of visitors to enjoy. One of the exhibits was an LED array activated by a well-aimed laser pointer that lit up to reveal a robot. The event was key in providing new staff with a concrete goal early in the year. For Ingenuity Lab, Mentorship also provided an hour-long activity for young visitors. Participants constructed motorized Lego cars that moved faster or slower based on how quickly they clapped their hands.

FUTURE DIRECTION

The success of Mentorship's efforts this year suggests some avenues for future improvement. Many students suggested that workshops should be spread out throughout the season instead of crammed into Kickoff. For that reason, we intend to look into offering a series of workshops that are spread out and taught at opportune times during the competition season.

Different DeCal structures and staffing schemes should be investigated to ease Mentorship staff's weekly commitment during the competition season. Also, office hours between mentors and Mentorship staff should become more frequent to allow for deeper oversight of high school teams' progress as well as the mentors' well-being.

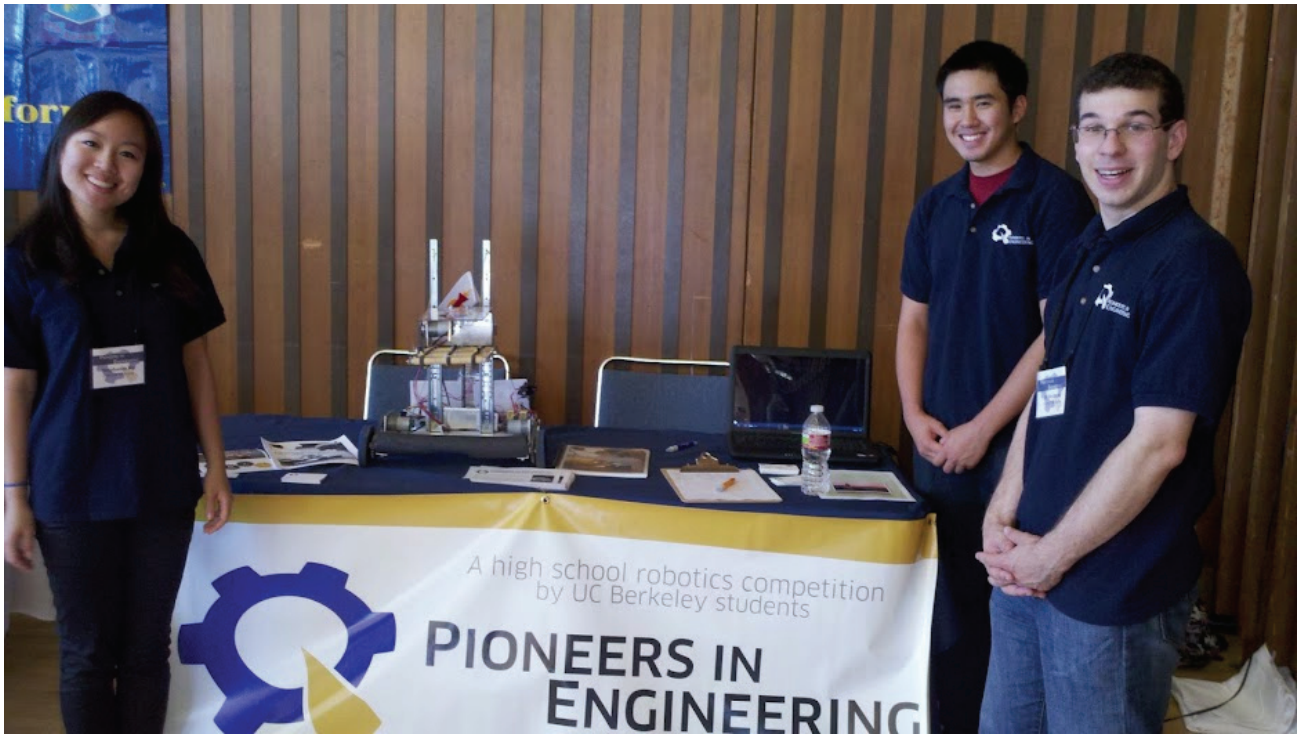
Finally, due to the success of PiE 2012, many mentors expressed an interest in returning as mentors in 2013. Because this year set many precedents for the organization, PiE 2013 should include suitable options for experienced, returning mentors that might not want to retake the same DeCal. Possible countermeasures include a new DeCal focusing primarily on kit assembly and more advanced topics.

EXTERNAL RELATIONS COMMITTEE

EXTERNAL OVERVIEW

Certain elements of PiE never rest, least of all the External Relations Committee. In addition to putting efforts into fundraising, school recruiting, university relations, and publicity, External expanded by spearheading outreach events and establishing a budding IT committee.

External started with a staffing challenge, as last year's team consisted of the coordinator alone. Fall recruitment brought in a small team of staff; until they settled in, various coordinators and staff helped out as needed.

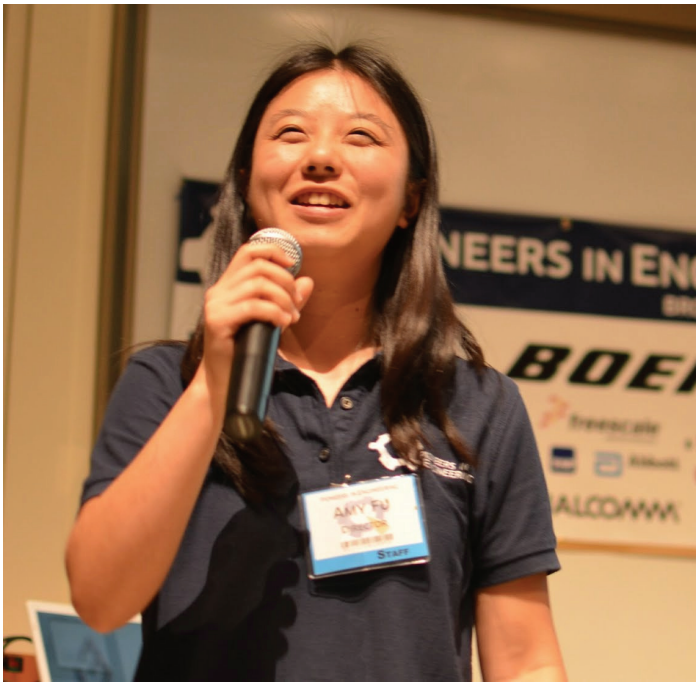


Stephanie Ku, Jeff Khvu, and Or Weizman (left to right) represent PiE at the Turn the Tables Career Fair.

FUNDRAISING AND ALLIANCES

External began working on industrial relations early on. Personal interactions with industry yielded the majority of the funding for this year's program. We raised $18,000 from Boeing, Cisco, and Freescale after the Director and External Coordinator met with various corporate contacts. We received $15,000 from Boeing - our largest gift - thanks to the Director's personal determination in building a relationship. We also received gifts-in-kind from Microsoft and Sparkfun for a total of more than $3,000. Each of these successes is accompanied by a continued personal relationship that bears promise for future collaboration.

Qualcomm CEO Paul Jacobs (right) drives Oakland Tech's 2011 robot at the Global Technology Leaders Conference with coordinators Dennis Wai (center) and Aditya Yellapragada (left).



At Final Competition, Amy Fu congratulates all the competitors on their excellent performances.

During the season, PiE contacted companies to provide judges for the Design Reviews and Final Competition. Judges from Boeing, Qualcomm, Lab126, Akamai, and Western Digital worked together with UC Berkeley professors to judge teams for key awards. Additionally, Dr. Andy Bicos of Boeing attended Final Competition as our first ever keynote speaker from industry.

On campus, PiE has had a strong, beneficial relationship with the College of Engineering (CoE). The College invited us to exhibit at a number of key events such as a Dean's Society dinner and the Global Technology Leaders Conference, where we were able to present PiE to CEOs and other influential CoE supporters. PiE also received advice from the Dean's Office in running large events, obtaining sponsorship, and working with media. The College has helped PiE grow rapidly and gain a strong presence on campus.

Grants are another aspect of PiE's fundraising strategy. This year, we sharply reduced our efforts to only a few specific grants. In the past, PiE has had poor returns on grant applications, so we focused on grants attached to personal connections. One major grant we worked on was for the Big Ideas Competition, a contest open to UC Berkeley students with proposals on certain topics. The contest inspired us to propose the new PiE Prep program; after our application succeeded, Big Ideas awarded us $8,000.

SCHOOL RECRUITMENT

School recruitment is an essential part of each season, and the associated communication between External and teachers creates key first impressions that will define the season to come.

To achieve our goal of doubling the number of students involved in PiE, External began preparing for school recruiting early in the year. We began by exploring and researching schools, taking note of location, accessibility by public transportation, and school performance. During the fall, staff contacted schools and made presentations to students. The registration timeline consisted of a priority registration period for target schools, followed by open registration. Logistical issues with schools and staff forced us to fall behind our original schedule, but ultimately, the process completed on time.

As part of recruitment, staff made visited schools to make presentations on site. Each school presentation consisted of a short slideshow and video and a live robot demonstration. This outreach allowed us to gauge students' and teachers' interest and commitment levels while simultaneously kindling excitement at the schools. Most teachers greatly enjoyed the presentations and could not wait until the competition. To further assist teachers in recruiting students, we passed along our demonstration materials.

Aditya Yellapragada (front) demonstrates a basic kit robot at a school presentation for Albany High.

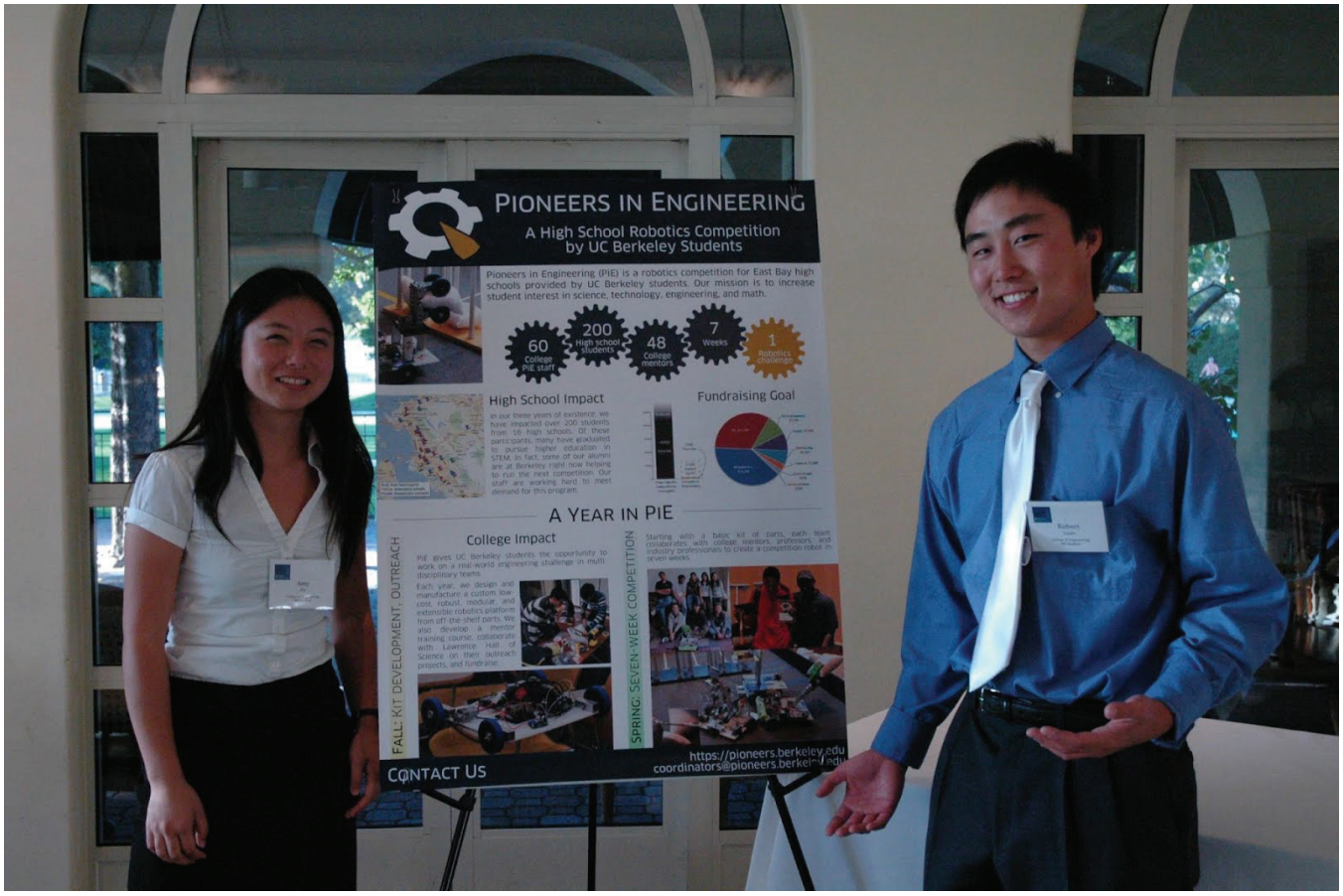
Team applications arrived between January 9 and February 1, with 27 team applications submitted from 23 schools. From this pool, we selected 21 teams from 21 schools. For the first time, we had to reject schools because of the limited resources available and the large number of schools that applied.

Future programs may want to consider visiting schools and helping them establish teams earlier in the year. Students from previous years might even be able to play a part in recruitment.

PUBLICITY

External worked on creating publicity materials to introduce PiE to the public, including the press packet, Corporate Sponsorship Packet, business cards, and banner. Over the summer, we created the press packet, an informational pamphlet that included a summary of PiE for the newcomer. The packet proved incredibly flexible and useful due to its large scope and professional presentation. External also wrote a Corporate Sponsorship Packet that compiled important information for potential sponsors. We created business cards to help spread contact information easily. Finally, we ordered a banner including our sponsor logos.

As a new project, we created the first ever PiE Newsletter for our friends and supporters. The PiE Winter 2011 Newsletter contained a summary of the first half of the year and a message from the Director inviting readers to the Competition. The newsletter was delayed but still released about a month before Competition.



Amy Fu (left) and Robert Luan (right) man the display at the Dean's Society event.

INFORMATION TECHNOLOGY

One intended addition to External's oversight was the PiE Information Technology (IT) committee. Unfortunately, efforts to consolidate a committee fell short of creating a lasting work group. The IT committee began its work in mid-fall but faced challenges early on. A lack of strong leadership, compounded by the challenges of educating new members and developing on the shared TBP server, made progress difficult; when the IT lead resigned after fall, the committee ground to a halt. Throughout the season, we depended on the efforts of TBP's IT committee and a few key staff members, who delivered important results when they were crucial.

Critical developments implemented this year included a barcode tracking system, a worksession sign-up tool, match scheduler, and a video livestream of Competition. The barcode system was used to track attendance, tool checkout, and Kit Extension purchases. Initiated as a personal project, it was integrated with participant badges and set up in time for Kickoff.

Developments in IT this year were fully dependent on the hard work of a few essential individuals. Following the 2012 competition, the IT committee was revived with a push for staff training, and will hopefully become a permanent, essential fixture in PiE.

FUTURE DIRECTION

External was able to accomplish many goals this year, but room remains for improvement. To start, staffing remains a challenge, considering that the non-technical responsibilities of the committee are unpopular to most PiE staff. It may be prudent to increase efforts to engage undergraduates studying business or other humanities majors.

Many corporate relationships have been forged by the coordinators; future External staff must be ready to maintain these relations and develop new ones. We should take a more comprehensive strategy towards our alliances, including recruiting supporters, making concerted efforts to engage companies and suppliers, and staying in touch with our contacts across the board. Our ultimate goal is financial security - with an organized effort, we may have a chance of establishing long-term financial support in the form of an endowment or recurring donation. Of course, this would be dependent on the strength of our ties with supporters and ability to coordinate such a movement.

We must grow and sustain our community involvement through outreach events, possibly expanding to include different formats and even new programs.

Finally, the IT committee is a critical team that deserves focus. With the support of the TBP IT committee, we are optimistic that a reliable working group will come to fruition.

Game Design Committee

The Game Design Committee (GDC) is tasked with creating a fun, challenging robotics game and managing it over the course of the season. The committee is kept on task by the Deputy Director and led by the Head Referee. During the season, the committee and Head Ref officiate the games, run the match schedule at major events, and serve as a key resource for students.

Afternoon emcee Sebastian Ruf (left) and Head Referee Arnab Mukherji control the floor at Competition.

In previous years, game development was bootstrapped just in time for critical deadlines. This year, the committee's activities expanded and were given a structure and schedule. Several staff were assigned to the committee, allowing them to focus on GDC tasks. Initial brainstorming began in the fall, with candidate games selected for potential student and audience appeal. These candidates were then further formulated to ensure that robots of all levels would be able to play a competitive role. The final 2012 game was selected prior to the PiE Readiness Review in early December, allowing time for field construction and rules revisions. This extra time proved crucial, allowing us to barely complete our plan to build two full fields: the first just in time for Kickoff, and the second for Scrimmage.

This year's game was far more ambitious than in previous years due to a large, complex field structure, an increased level of field automation, and stringent kit integration requirements. The technical difficulties of constructing the wooden ramps to cover a 12' by 12' field was compounded by the GDC's small size and relative independence from other committees, making it difficult to muster manpower. Development of the Wiimote IR camera by a GDC member began early, but secrecy surrounding the project hindered progress by preventing collaboration with Kit Development staff until after the game was released. Furthermore, as this same member was tasked with developing the corresponding IR indicator lights on the field, indicator development was delayed until days before Scrimmage, and correspondingly, the first full field test. Despite these challenges, the field setup was effective and robust. No critical field issues arose, and we celebrated a milestone when our field control systems worked as expected throughout the entire day of Competition.

Aditya Yellapragada (left) and Ryan Julian (right) measure and mark wood to be cut for field construction.

Ballistic Blitz was well received, but also took its typical share of criticism. Particular points of contention included robot collision damage and the allegedly high value of the skirmish bonus. In line with the aforementioned complaints about the Competition tournament, the heaviest grievances were related indirectly to the level of play and teamwork. This was demonstrated by unhappiness with the

skirmish bonus, which teams generally overlooked in favor of developing ball manipulators. It may be prudent to explore elastic scoring mechanisms that result in more balanced gameplay. However, lending this complaint too much credence runs the risk of compromising our critical aim of challenging students technically and strategically. Many teams did indeed aim high, and many fell short due to time or complexity, settling for a simple design that worked. Regardless of whether the gameplay was as sophisticated as we hoped, the game itself compelled each and every team to hold themselves up against our expectations. This is a fundamental role that game design plays in the educational mission of PiE, and it was well executed this year.

Ultimately, Ballistic Blitz was irrefutably, exceptionally fun to watch and to play. The deafening roars of the audience, packed wall to wall during the final rounds of the competition, were more than enough to make us proud.

Next year's leadership intends to start the game design process as early as possible to allow for further rules refinement and playtesting. Increasing integration with the kit development process will also ensure that game requirements are realistic and also allow greater collaboration between GDC and Kit Development members. The degree to which the game utilizes and challenges the kit should be carefully designed.

FUTURE DIRECTIONS

The exceptional success of the 2012 season sets high expectations for the future. PiE has become a well-known and respected student group on campus. Firm ties with the College of Engineering and the Lawrence Hall of Science, as well as strengthened relationships with industry professionals, have opened up a veritable sea of opportunity for future development. Since PiE started engaging in public outreach, word continues to spread throughout the Bay Area, bringing in routine communication from interested students, parents, and teachers. We have only scraped the surface of the possible. However, challenges remain.

At 20 teams, the PiE competition reached a size that strained the limits of our venue capacity and staff work limits. Therefore, further expansions to the PiE program must be made sustainably. Because the number of teams UC Berkeley can support is limited, more thought should be put into a policy detailing which teams should be prioritized for acceptance into the program. Expanding the PiE robotics competition to more high schools can occur through reaching out to additional university campuses through their Tau Beta Pi chapters. While we may not have the capacity to support more teams in the competition, there are other areas of expansion such as targeting younger audiences and extending our high school outreach to the fall semester.

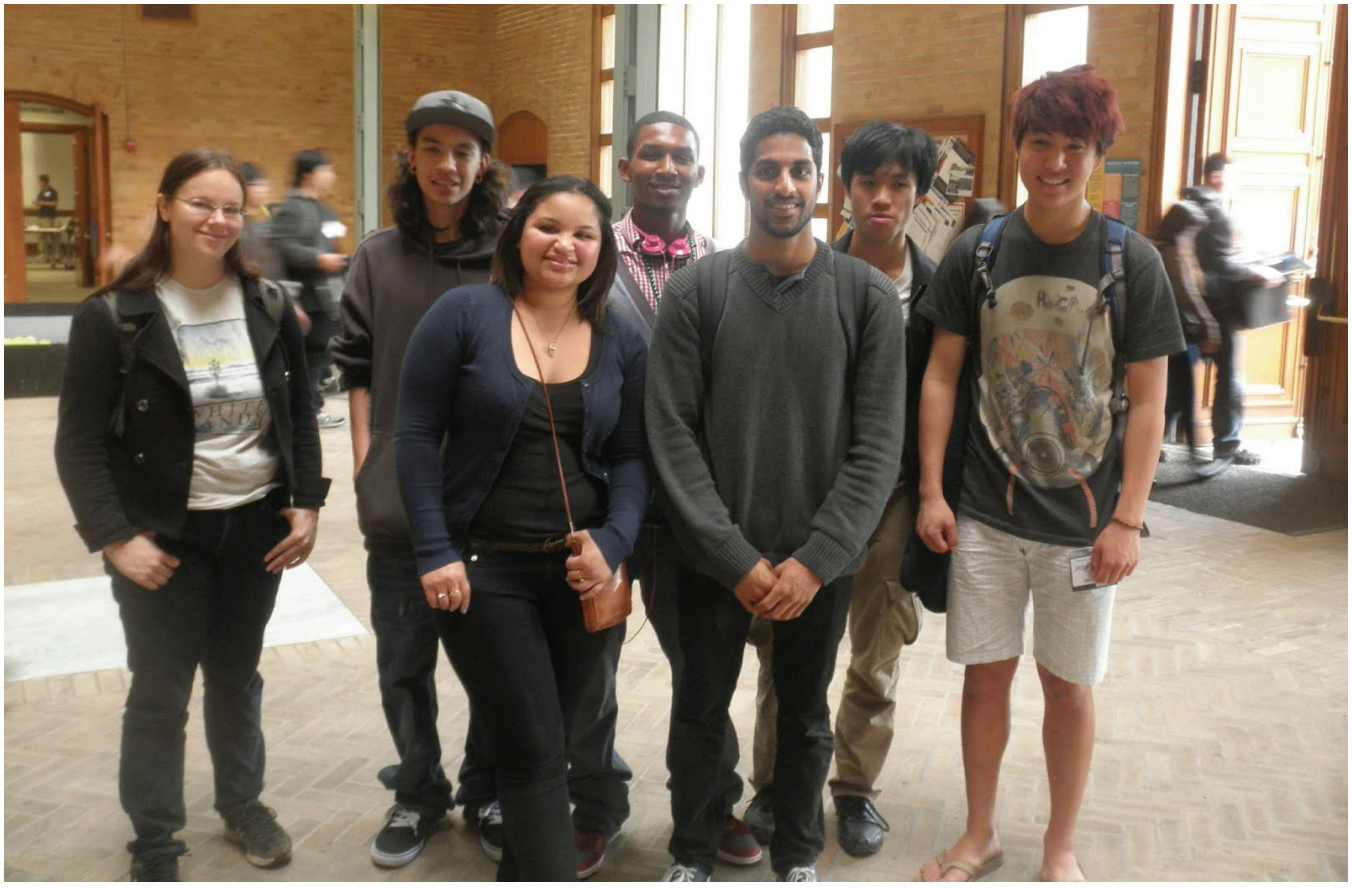
To sustain our further growth, it is necessary to continue to expand the size and reliability of our staff and infrastructure. Currently, a committed staff member spends around 10 hours per week on PiE, and the average coordinator spends upwards of 30 hours per week. Given that we are a student-run organization, the workload necessary for a coordinators to do their job is unsustainable for the average college student. More thought should be placed on spreading out the work over more people, and improving communication between staff to allow effective collaboration to continue.

PIE PREP

PiE is creating PiE Prep, a year-round mentorship program with weekly meetings involving hands-on activities and college preparation leading up to the spring robotics competition. UC Berkeley students will connect personally with Bay Area high school students, inspiring them to pursue STEM in higher education.

Beginning this fall, we will pilot this program at Ralph J. Bunche High School in Oakland. Berkeley student mentors will interact one-on-one with high school students at this targeted underprivileged school. At weekly meetings, the high school students will participate in hands-on STEM activities. Some weeks will feature college preparation modules on topics including SAT prep, college application essay

composition, and financial aid. As suggested by the focus on college, the program as a whole will be directed mainly at high school juniors and seniors, though younger students may also benefit from participating.



The 2012 Ralph Bunche team with some of their mentors. From left to right, Eliza McDonald (mentor), Shawn Stoddard-Nunez, Tasajanae Madkins, Walter Stokes, Vivek Nedyavila (mentor), Paul Ruan (mentor), and Joshua Kim (mentor).

At the moment, the program remains to be implemented, from mentor recruitment to lesson design and scheduling. Development will begin over the summer with the full support of the PiE committees. We have also reached out for support from Berkeley Engineers and Mentors (BEAM), another rising student group with a focus on STEM educational outreach. PiE-BEAM collaboration bodes well for the prep program and raises exciting possibilities for future work.

Potential challenges include mentor recruitment and retention, overburdening PiE committees, and managing commitment and engagement from both mentors and students. Any new program comes with its own unique set of difficulties that must be gradually worked out. One certainty this year is financial stability through a grant from the Big Ideas competition. Future sources of funding remain to be discovered.

CONCLUSION

The goal of PiE to create an affordable science and technology experience was handily realized by the 2012 PiE program, the largest to date and a huge success. As outlined above, the successful participation and completion of the robotics competition by 20 high school teams spread interest in engineering-related topics across the San Francisco Bay Area. This year's kit, game, mentors, and staff were more mature than ever before, and all positively contributed to students' experience. Although the goal of wildly increasing the size of the competition initially seemed like a pipe dream, PiE eventually more than doubled many critical elements of the robotics program.

	Year 1: 2008-2009	Year 2: 2009-2010	Year 3: 2010-2011	**Year 4: 2011-2012**
Schools	6	8	9	**20**
Teams	8	9	12	**20**
Students	44	60	102	**265**
Mentors	18	27	35	**90**
Active staff	4	10	20	**61**
Fundraising	$8,5000	$14,900	$12,600	**$32,800**

The growth PiE experienced was accompanied by its transformation into a fully fledged student organization with staff recruitment, retention, training, and culture. The influx of new staff was a great blessing, allowing us time to pursue ventures beyond the robotics season, such as small outreach events throughout the year and the conception of PiE Prep, which represents a first effort to expand PiE to a year-round program for high schools. However, challenges in communication and efficiency obviated a need for greater focus on management and infrastructure.

Our main goals for next year are to ensure organizational sustainability and expand the scope of our outreach. We must continue to recruit and retain talented UC Berkeley engineers as PiE staff, improve our internal infrastructure, and further strengthen our corporate ties. With continued effort and innovation, Pioneers in Engineering will thrive as an organization and deliver progressively amazing experiences in 2013 and beyond.

ACKNOWLEDGEMENTS

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- Vanessa Rivera - *Executive Director, Engineering Student Services, UC Berkeley*
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- Ferenc Kovac - *Manager, Electronics Support Group, Department of Electrical Engineering and Computer Sciences, UC Berkeley*
- Sue Guevara - *Visitor Programs Manager, Lawrence Hall of Science*
- Emma Duran-Forbes - *Special Events Coordinators, Lawrence Hall of Science*

Judge Branko Sarh of Boeing presents Nicole Kleunker with Impact Academy's Boeing Spirit Award.