Date: March 9, 2015

To: Mary Pedersen and Linda Dalton

From: Debra Larson

Subject: College of Engineering Tier 3 Narratives

CC: Kathleen Enz Finken, Engineering Leadership Team

Thank you for providing the campus with the opportunity to pause in our daily work to look up and think together about 2030, and specifically about the Cal Poly of 2030. This exercise is allowing our Cal Poly community to anticipate and reflect upon the disruptive impacts of emerging global, state, regional, and campus trends. Eight of the College of Engineering’s nine departments/programs have responded to your request for narratives to the tier 3 questions and these narratives are attached to this cover memo.

Although each narrative is unique and reflective of disciplinary interests, I also observed many common themes. The narratives provided interesting elaborations and reflect our uniquely engineering perspectives. I’ve attempted to summarize the comments into some common themes for the college. The answers between the two top-level categories are similar enough that I’ve focused my comments into three areas.

**Effective Approaches to Teaching and Learning:** My colleagues present a picture of a college that is readily embracing many different approaches to teaching and learning (studio, vertically integrated project-based, flipped and hybrid), and also giving serious consideration to additional techniques (distance, international experiences, revenue generating webinars). Mention is given to the emerging learning environment-content trends including multidisciplinary, nanotechnology, sustainability, and entrepreneurial attributes.

**Needs and Opportunities into Learn by Doing:** The impact of digitization and computerization is deeply felt by all of the engineering disciplines. The technology - including what used to be hand-operated fabrication and processes - has rapidly evolved. Today our mills and lathes are computer controlled, 3-D printing is the norm, robots manufacture, models and simulations replace hands-on experiments, and rapid prototyping. Our graduates need to have both foundational experiences with older techniques while also being prepared to work with the state-of-the art technologies. We are struggling to stay abreast of these changes in terms of equipment, staffing, computer infrastructure, and space. Our proposed new project building will help in meeting these changes, but it will be insufficient. These technologies and labs span our entire college. We are pushing - and will continue to push - our computational infrastructure.

In a similar way, videos and on-line learning are being effectively integrated and remote testing is providing students with the opportunity to “experience” state-of-the art techniques.

Finally, the rapid gain in knowledge and the emergent of “new” disciplines require conversations and planning. Our departments are realizing these emergent trends through their articulation of
recently developed strategic directions that build upon their current faculty strengths and interest, yet reflect the important future-forward trends. These directions span a wide range of interests that reflect the diversity of our programs. These include, but not limited to: systems on a chip, internet of things, construction engineering, mobile computing, security of embedded systems, regenerative medicine, and robotics.

Others have suggested that we need to adopt ways to turn our students’ extra-curricular learn-by-doing activities into credit bearing experiences. Similarly, we need to make more effective use (through integration and adoption as degree-applicable units) of internships and study abroad activities.

**Teacher-Scholar Model:** This model could fit well with the notion of vertically integrated large projects whereby students from all levels - first year to masters students and club students. We already have a few examples of this type of teacher-scholar method such as: cubesats, algae for energy (WESTT), and tissue engineering. On the other hand, we rely on our teaching spaces to conduct research, which is presenting challenges, conflicts, and even safety issues.

It probably should go without saying that our teaching work load needs to be moderated if we are to truly achieve a teacher-scholar model. A reassignment of ten percent of the instructional load to scholarship creates a demand for at least 14 new faculty members. Many think the teacher-scholar model is a hollow slogan. Similarly, our hiring slow-down (except for the SSF-funded hires) seriously impacts our ability to shift into the important emerging trends of the disciplines.

The GENE program suggests the novel idea of using an appointment to GENE as an internal sabbatical opportunity to explore research and innovation in multidisciplinary fields including engineering education.

Engineers create the technologies that propel societal changes, while also serving to advance solutions to the world’s challenges. The advances of mankind are founded upon the talents of engineers. We have traditionally integrated the fundamentals of broad liberal education (math, science and general education) with the techniques and tools of engineering to create products, processes, and systems in often well-defined disciplinary areas. Tomorrow’s engineers will be working outside the comforts of their “disciplines,” and will need to adapt to solve the unknown and the unexpected. The problems of today and tomorrow are big, interdisciplinary and complex. They will be solved through networked digital solutions, automation, nanotechnologies, modeling, simulation, multi-disciplinary collaborations, scaling, and systems approaches.
Tier 3 Program Narrative for the Biomedical Engineering Program

The following document is the tier 3 program narrative for the BME program. This document reflects the opinions of the Biomedical Engineering (BME) Chair in consultation with the faculty.

Teaching, Learning, Scholarship

For the academic programs you expect to offer and the students you expect to serve:

1. What effective approaches to teaching and learning are emerging in your field and related to interdisciplinary areas?

Biomedical engineering inherently is an interdisciplinary field of study and so it draws from teaching pedagogies utilized in all STEM fields. Recently the flipped classroom as become very popular as method of enhancing student engagement in primarily lecture based courses. Laboratories continue to be widely utilized as the backbone of our learn by doing philosophy. In BME we are investing in the development of project-based learning methods which give students a practical frame of reference behind the application of the fundamental principles and concepts being presented to students.

2. How should Learn by Doing incorporate new learning needs, opportunities and technologies?

Many of the technologies we cover in BME require expensive equipment that are not available at our campus. For example, we characterize bio-materials at the nano scale which requires instruments that cost over $1M. So we have partnered with UCSB who hosts an NSF supported National Materials Research Center and have developed a virtual lab experience; students at Cal Poly are linked via video to the technician running their samples at UCSB and the data is streamed back to our students for analysis.

Prototyping design concepts has moved into the 3D printing world where students create ideas using CAD and then send them to a printer that fabricates the parts in a matter of hours. Currently Cal Poly has some 3D Printers that use plastic materials like ABS (Legos are made of this material) but we do not have any systems that fabricate metallic parts.

Another new technology involves the many computer learning labs that are utilized in the CENG. BME along with Aerospace Engineering are piloting a new Virtual Desktop Infrastructure for supporting complex computational software like FEA, CAD, MatLab and other simulation applications. The department has invested in a high power server
that does all of the computational work; the student can use a kindle or iPad to interface
and see the results. This can eliminate the need to continually invest in upgrading and
replacing computers in our labs. This can lead to a significant cost savings to the
department and college.

3. How does the teacher-scholar model fit?

Scholarship is a key part of faculty professional development and enables students to
experience the application of their knowledge toward solving national and global
initiatives. The blending of teaching and scholarship is critically important to our ability to
advance learn-by-doing into the 21st century. However, currently faculty workload is set
at 45 WTUs/AY with 36 for teaching and 9 for service; no value is placed on scholarship
in this model. As long as this continues, teacher-scholar will remain a hollow slogan.

Learning Environments

What learning environments should Cal Poly develop or modify to
accommodate (1) new modes of teaching and learning, (2) Learn by Doing,
and (3) the teacher-scholar model in the future? Please respond in terms of
the qualitative characteristics of the facilities and other spaces (including
technology) critical to your programs and students:

1. Formal, scheduled or organized instruction

Formal scheduled instruction will likely continue to be the primary mode of education in
the BME program. The face-to-face classroom or laboratory format will continue to be
our primary environment for learning. Smart rooms will be required for all classrooms.
Specialized laboratories such as cleanrooms, bio-hazard rooms and vibration isolation
rooms will need to be expanded. Currently the facilities provided in teaching labs are
very basic and do not provide the infrastructure for more advance testing and analysis.
More advanced learning labs will also require skilled dedicated technicians to operate
and maintain them and their associated equipment. Currently our lab space is
inadequate to safely handle any additional enrollment growth.

2. Informal student learning outside the classroom or laboratory

Outside of the classroom learning will be enhanced by the VDI computational capability
discussed in a.2. This will free-up computer labs to be available for active learning
environments. While videos and on-line lectures may replace the traditional textbook;
mastery of a subject and retention of knowledge are clearly linked to hands-on
experience which require face-to-face interactions. Innovation can only be nurtured in
a student’s mind to a certain degree, real expression of innovation requires
experiencing the physical realities of an idea.
3. The teacher-scholar model.

If we expand the use of co-op experiences to support thesis research work, this could also reduce the financial burden of providing dedicated research labs (in addition to teaching labs) to our faculty. Currently, there are very few spaces available for dedicated research which severely restricts our graduate programs growth.

Considerations

Academic Mix (including state-support/self-support funding)
- Program mix/college shares (program headcount; FTES including GE and support)
The BME program is limited by the number of faculty available to teach, despite intense demand for BME graduates (1890 applicants F14 & 89 FTF). Currently, the BME program has about 450 FTES. This number could grow to 550 over the next decade but an additional 10 FTT faculty must be added to accommodate this growth.

- Undergraduate/post-baccalaureate/graduate mix (by college)
The BME program has 60 graduate students and the demand for students with the masters as the terminal degree is growing. Our IAB has asked that we graduate the same number of bachelor’s and master’s degree students each year, approximately 60.

- CA resident/domestic non-resident/international student mix (by college, by level)
The BME program has a wide appeal to student both within CA and outside of CA. The competition for out of state students is very high as many other states have highly acknowledged programs in BME. Cal Poly does not currently have the community infrastructure to support international students.

Teaching and Learning (by program and student level)
- Learn by Doing; Teacher-Scholar
As previously stated, a work load model that supports T-S must be established. Currently only non-tenured junior faculty are motivated by RPT to do much scholarship. These faculty are at risk of burn-out by the time they reach tenure and are unable to sustain a health balance between professional development-teaching-family.

- Pedagogy/learning modes (e.g., delivery, engaged learning, undergraduate research, community service, internships/field placements, study away, study abroad, technology, session structure)
The blended (4+1) program gives BME students an excellent opportunity to integrate their undergraduate senior project work with a master’s thesis. The Vertically Integrated Project model being piloted by Purdue and Georgia Tech should be considered by Cal Poly. Co-op experiences should be developed that are designed to achieve learning outcomes worthy of academic credit need to be developed. Study abroad provides a rich personal growth experience but often results in increased time-to-graduation; this needs to be reviewed and optimized.
- Space, infrastructure and information systems implications
Space for research needs to be addressed in the next master plan. A more robust ITS infrastructure supporting VDI should be implemented by Cal Poly if they want to stay on the leading edge of technical education.

Co-curricular Learning (in general and by program, level)
- Discipline-based activities; student life more generally
Student clubs are in need of space for holding meetings as well as working on projects. This should be considered in the next master plan.

- Residential community
The idea of expanding the residential capacity of Cal Poly is good. Graduate students should be included in this mix.

Student Success (in general and by program, level)
- Retention, graduation rates; preparation at entry, achievement gaps; student diversity (gender, ethnic origin, financial means)
Retention rates in engineering could be improved by providing “educationally at-risk” students coming from poor performing high schools to receive a free summer STEM boot-camp. Graduation rates are a complex subject but for many BME students the availability of support science/math courses and GE course gates their progress. BME is focused on global health issues and has a broad appeal to all ethnic groups as well as genders. I would recommend that Cal Poly also assess job placement success as this is key performance indicator to assess a program’s value proposition.
Tier 3 Program Narrative for Civil and Environmental Engineering

The following document is the tier 3 program narrative for the Civil Engineering and the Environmental Engineering programs.

Teaching, Learning, Scholarship

For the academic programs you expect to offer and the students you expect to serve:

1. What effective approaches to teaching and learning are emerging in your field and related to interdisciplinary areas?

   We are already seeing collaborative project based learning spreading within the civil and environmental engineering curriculum. This is not being done as new stand-alone courses, but being incorporated into existing courses. Collaborative learning, whereby students learn from one another while working on projects, is being seen as an effective teaching tool and faculty are developing methods for student assessment (although more can be done on this front). Collaborative project based learning is particularly effective when each member brings a strength to the team.

   We see distance learning for specialized topics developing more in the future. The benefits are greatest with courses or topics which are quite specialized and may not have broad enough appeal to attract sufficient student population to justify offering of the course, particularly in programs with lower student populations. Our undergraduate degree programs are large enough and don’t have so much depth that distance learning will be necessary, but our graduate program, where students concentrate in narrowly focused areas (structural, geotechnical, water resources, transportation, environmental), would certainly benefit from having our students take distance learning courses. Similarly, some of our courses which wouldn’t have enough student demand to justify their being offered, could be simultaneously be offered to students at other institutions.

   Webinars are a potential opportunity which we have only begun to discuss. Our graduates must engage in life-long learning in order to keep up with changes in the Civil and Environmental Engineering disciplines. Companies regularly pay for webinars on emerging topics, changes to building codes or regulations, or for professional growth for their employees. We need to be looking at webinars not just as an opportunity to offer them but how our students and faculty may benefit from them.
2. How should Learn by Doing incorporate new learning needs, opportunities and technologies

Let's be honest, Cal Poly's engineering is ahead of most other institutions in learn-by-doing (or hands-on learning) and they're trying to catch up because they see the benefits of engaging students in this mode of learning and how it attracts students who are more visual learners. So as we look to our future, we need maintain our reputation as leaders in learn-by-doing and focus on incorporating opportunities and technologies.

We need to develop better ways for students to turn many of their 'learn-by-doing' extracurricular projects into academic experiences. It's one thing for students to work as a team on a project to develop a project, but to make it into an academic experience worth of credit, they need to reflect on the process and assess their outcome. We already do this wonderfully with so many projects (senior design in some programs, for example), but we're missing opportunities with so many of the extracurricular activities in which our students engage. One example is Engineers Without Borders (EWB) projects; while some students in other departments use it as their senior design, it rarely is for the many civil and environmental engineering students participating in EWB. These are great experiences with meaningful projects but also ones where students could get more from the projects. Additionally, if credit is received for it, more students would be able to participate in meaningful ways without interfering with their progress to graduation.

With greater globalization of the civil and environmental engineering disciplines, learn-by-doing opportunities which have an international component, such as EWB, will be of even greater value.

3. How does the teacher-scholar model fit?

The teacher-scholar model fits our academic programs and students by engaging students in meaningful ways in faculty's scholarship. We are already doing this in our department quite well, although there is room for improvement and, more importantly, by more faculty. We have a thriving and growing graduate program; many of these students work on meaningful theses which are part of faculty's scholarship. More recently we have seen more undergraduates engaging in scholarship; most notably, Prof. Tryg Lundquist's WESTT (Water, Energy, and Sustainability Training Team) program which now involves more than 50 undergraduates each quarter from more than 10 different departments in meaningful research. While not every faculty member can sustain a program like WESTT, there just aren't enough students, but it is a model which should be shared and mimicked where feasible.

The growth of scholarship in Civil and Environmental Engineering is limited by space and faculty time. We need space to conduct scholarship, especially the more 'hands on learning' types of work which has greater appeal to our student body. Secondly, the amount of scholarship in which faculty can engage is limited by time; we need a university-wide accepted model for providing release time for faculty engaged in significant amounts of scholarship.
Learning Environments

What learning environments should Cal Poly develop or modify to accommodate (1) new modes of teaching and learning, (2) Learn by Doing, and (3) the teacher-scholar model in the future? Please respond in terms of the qualitative characteristics of the facilities and other spaces (including technology) critical to your programs and students:

1. **Formal, scheduled or organized instruction**
   We need to examine how our service courses are delivered. To maintain the value of courses, we need to ensure consistency between sections and instructors. The CEENVE department has been hiring far too many part-time lecturers to cover these courses, and the students’ experiences vary too much. We need to explore larger classes for lecturing and use of graduate student teaching assistants for activities.

   As mentioned earlier, the CE and ENVE disciplines are increasingly international, so growth of study abroad programs and other opportunities to travel or work in other countries will become more relevant than just having a unique experience.

   Our programs already do a good job of incorporating learn-by-doing in formal, scheduled instruction; in fact, this has been a strength upon which our learn-by-doing reputation has developed. They do need to be supported by staff (lab technicians or instructionally related technicians); often faculty don’t have the skillset to assemble meaningful experiences.

   We could grow programs such as WESTT; this program has recently formalized the involvement of students by an organized course.

   Study abroad opportunities for our students should be increased. I understand the international office has been improving, but this should receive more attention and support.

2. **Informal student learning outside the classroom or laboratory**
   While our students are generally successful in obtaining summer internships, we believe we can and should always do better for them. Employers value that most of our students have had meaningful work experience prior to graduation. In the classroom, summer internships help students place what they are learning in context of how it will be used in their profession.

   International programs and experiences should be grown. This includes better assistance to international student activities (such as EWB) and start opening the doors for opportunities to travel for internships.

3. **The teacher-scholar model.**
   This point was already addressed in the discussion of the teacher-scholar model with "formal, scheduled or organized instruction," but to facilitate the teacher-scholar model, we need additional laboratory space in the future. Space that is dedicated to scholarship would be particularly useful.
Considerations

**Academic Mix (including state-support/self-support funding)**

- **Program mix/college shares (program headcount; FTES including GE and support)**
  The department size in comparison to other departments in the College is fairly well balanced; it has about 16% of the students in the college of engineering and is up there with the larger departments in engineering. The two programs in the CEENVE Department have a pretty good balance between the programs both in number of students and faculty. The ENVE program is currently attracting a stronger applicant pool; however, it doesn’t have the faculty to support larger cohorts nor is there the industry demand. The Department as a whole supports two service courses to the college and a minimal amount of GE support to the university, but it is a pretty fair balance.

- **Undergraduate/post-baccalaureate/graduate mix (by college)**
  The CEENVE Department has approximately 830 undergraduates (630 in Civil and 200 in Environmental) and 55 in the CEEN graduate program. We would like to see growth in the graduate student population in order to reach the critical mass whereby we can provide a solid offering of courses in all areas of Civil and Environmental Engineering (environmental, geotechnical, structures, transportation, and water resources).

- **CA resident/domestic non-resident/international student mix (by college, by level)**
  The CEENVE department has recently noticed tremendous growth in out-of-state students. Our IAB is just now beginning to discuss getting members from out-of-state, and for our career fair we’re starting to try to attract companies from out-of-state. The table below shows the number of California residents and non-resident first time freshmen who started our programs in the Fall of 2014. One item that is missing is good, consistent data; the data below was extracted manually, and we do not have historical data for comparison.

<table>
<thead>
<tr>
<th>Residency Status</th>
<th>Civil</th>
<th>Environmental</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>California Resident</td>
<td>106</td>
<td>28</td>
<td>134</td>
<td>66%</td>
</tr>
<tr>
<td>Non-Resident</td>
<td>44</td>
<td>19</td>
<td>63</td>
<td>31%</td>
</tr>
<tr>
<td>Unknown</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>2%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>155</td>
<td>47</td>
<td>202</td>
<td>100%</td>
</tr>
</tbody>
</table>
Teaching and Learning (by program and student level)

- **Learn by Doing; Teacher-Scholar**
  Our department is quite strong in both learn-by-doing and in support of the teacher-scholar model. The outcomes from the teacher-scholar model is recognized, and rewarded, more at the university level than learn-by-doing, although one can say learn-by-doing is more important to Cal Poly’s reputation and image. One example: faculty are required to have demonstrated results in line with the teacher-scholar model for tenure and promotion, but no such requirement exists for incorporating learn-by-doing. The greater recognition of scholarship on campus may put some of our learn-by-doing in jeopardy as faculty shift their efforts and as we look at scholarship potential when hiring new faculty.

- **Pedagogy/learning modes (e.g., delivery, engaged learning, undergraduate research, community service, internships/field placements, study away, study abroad, technology, session structure)**
  We feel study abroad opportunities are not as available to engineering students as they are to liberal arts students. Furthermore, engineering students’ study abroad needs better support than they currently receive from engineering advising and the department (our department is not knowledgeable enough about the various international programs and/or course offerings).

- **Space, infrastructure and information systems implications**
  Our laboratory space is sufficient for instructional purposes and minimally so for research and scholarly endeavors. Most of our research space has the primary purpose of instruction lab which makes conducting significant research more difficult. Growth in clubs, learn-by-doing projects, and scholarship are being hampered by our existing facilities and will become more so in the future.

Co-curricular Learning (in general and by program, level)

- **Discipline-based activities; student life more generally**
  The CEENVE Department has particularly strong student clubs which support students from freshmen to seniors. The clubs provide significant discipline specific activities, but are also an excellent source for socializing. Our graduate students could use a club with activities more suited to their educational experience.

- **Residential community**
  The residential community meets the needs of our students as far as we have seen.

Student Success (in general and by program, level)

- **Retention, graduation rates; preparation at entry, achievement gaps; student diversity (gender, ethnic origin, financial means)**
  Retention for both Civil and Environmental Engineering are acceptable, although we do lose more than we gain. Environmental Engineering has suffered more retention problems in the
past, largely due to a misconception of what environmental engineering is by first time freshmen, but they have improved in recent years by better defining their discipline and good early advising.

Our 4 and 5 year graduation rates have been improving in recent years, and we anticipate seeing record high 4 year graduation rates in each of the following 3 years. Most of the graduation rate improvements are coming due to cultural shifts. In the past, our programs were referred to as ‘5 year programs’ and everyone joked about it taking them 5 or 6 years to graduate, more recently, we have consciously presenting incoming freshmen with examples of students graduating in 4 years, making them (and their parents) realize it can be done. The 4 year graduation rate took a dramatic leap from 15% in 2011 to over 25% in 2012 (entered Fall of 2008). With incoming freshmen and their parents starting in the Fall of 2012 hearing more than 25% of students graduate in 4 years made it very realistic and an achievable goal. While we anticipate seeing continued improvements in graduation rates, there will likely be a jump with the class which started in the fall of 2012 and will likely break 50% with the graduating class of 2017 (starting fall of 2013).

The 4 year graduation rate has improved not only because of a change in attitude, but our students are coming in better prepared each year. The percentage of students who begin with AP credits and skip one or more calculus classes is rising.

Student diversity is also improving in both the Civil and Environmental Engineering programs (see table below). In the Fall of 2014, we found over 1/3 of the entering first-time civil engineering students were female and almost 2/3 of the entering first-time environmental engineering students. While the Civil Engineering program isn’t quite where we would like it to be (50% is our target), it has a critical mass which makes potential incoming female more likely to feel comfortable with accepting to Cal Poly.

### First Time Freshmen Enrolled

<table>
<thead>
<tr>
<th>Entering Class</th>
<th>% Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Civil</td>
</tr>
<tr>
<td>Fall 2007</td>
<td>17%</td>
</tr>
<tr>
<td>Fall 2008</td>
<td>17%</td>
</tr>
<tr>
<td>Fall 2009</td>
<td>23%</td>
</tr>
<tr>
<td>Fall 2010</td>
<td>30%</td>
</tr>
<tr>
<td>Fall 2011</td>
<td>22%</td>
</tr>
<tr>
<td>Fall 2012</td>
<td>31%</td>
</tr>
<tr>
<td><strong>Fall 2013</strong>*</td>
<td>28%</td>
</tr>
<tr>
<td><strong>Fall 2014</strong>*</td>
<td>34%</td>
</tr>
</tbody>
</table>

* Not Official Results

We aren’t currently tracking minority students or first generation college students, but we’re quite sure the numbers would not be as high as we would like. It would be helpful if we had tools (in dashboards, for example) to track the number of minority and first generation college students (identifying the number of female students would also be helpful).
Tier 3 Program Narrative for the Computer Engineering Program

The following document is the tier 3 program narrative for the CPE program. Due to the short timeline of the academic planning discussions, this document reflects only the opinions of the Computer Engineering (CPE) director and a few industry advisory board (IAB) members from the CPE program. We have had zero faculty meetings allocated to this subject.

Teaching, Learning, Scholarship

For the academic programs you expect to offer and the students you expect to serve:

1. What effective approaches to teaching and learning are emerging in your field and related to interdisciplinary areas?

Best practice pedagogy is fairly uniform across disciplines. Use of inverted or flipped classrooms, active learning, hybrid online, project-based learning and service learning are all currently happening in the CPE program. Perhaps one unique aspect would be to use pre-graduation major-specific work experiences as a vehicle for teaching.

The computer engineering program is by definition an interdisciplinary program. Areas of interdisciplinary growth include the areas of big data or data analytics, robotics/mechatronics and sustainability.

2. How should Learn by Doing incorporate new learning needs, opportunities and technologies

Beyond classroom technologies, the CPE program needs better ways to take advantage of the following technologies and opportunities:

a) Rapid prototyping, including 3d printing of circuit boards, reflow ovens and 3d printing of enclosures
b) Infrastructure to support efforts in cyber security of critical infrastructure.
c) Lab space for testing of autonomous robots and UAVs
d) Lab space for development of embedded electronics for healthcare projects and wearables.
We need 1) faculty release time to develop new course work, 2) lab space for these new courses, 3) equipment for these new courses in emerging markets.

Many of these projects have overlap with the Electrical Engineering and Computer Science Departments.

3. **How does the teacher-scholar model fit?**
The model that is currently used is to have faculty use classroom space for research projects. For small projects, this model has worked well.

**Learning Environments**

What learning environments should Cal Poly develop or modify to accommodate (1) new modes of teaching and learning, (2) Learn by Doing, and (3) the teacher-scholar model in the future? Please respond in terms of the qualitative characteristics of the facilities and other spaces (including technology) critical to your programs and students:

1. **Formal, scheduled or organized instruction**
   Formal, scheduled and organized instruction will likely be the primary mode of education in the CPE program.

   In CPE, we have many more CPE/CSC/EE courses in the latter-half of our curriculum. The demand for these required major courses have increased due to our successes in retaining (and graduating) more students and increasing transfer (change-of-major) rates, particular to the computing side of CPE. This puts additional stress in particular on the lab space required by the program and the home departments. In particular, it is believed that three additional general purpose computing labs could be used on the CSC side of CPE, an additional electronics lab on the EE side and an additional CPE Capstone lab would help us meet current demand due to increased retention rates. Additional enrollment growth would further increase our need for labs and lab space.

2. **Informal student learning outside the classroom or laboratory**
   Expansion of co-op, independent study and senior project to include industry-related activities will likely grow over the next several years. In particular, we are looking to enhance the co-op program to increase the number of graduates who have some industry experience and to use this program as a method for growing diversity in the CPE program. Using club projects for curricular enhancement was more promising in the past, but forced reduction in program units have left flexibility in the CPE program relatively minimal.

3. **The teacher-scholar model.**
Research projects will likely be mostly allocated to MS thesis students in the EE and CSC departments. Growth of MS thesis students is highly correlated to the number of young faculty in the EE and CSC departments. The number of research experiences for students should only increase with increased number of faculty.
Considerations

Academic Mix (including state-support/self-support funding)

– Program mix/college shares (program headcount; FTES including GE and support)
The CPE program is limited by the number of faculty in the home departments, despite intense
demand for CPE graduates. Currently, the CPE program has about 550 FTES, all majors. The
CPE program would advocate growing the number of CPE students due to the demand of
skilled workers in computing, but only if the number of T/T faculty increased.

– Undergraduate/post-baccalaureate/graduate mix (by college)
The CPE program has only undergraduate students.

– CA resident/domestic non-resident/international student mix (by college, by level)
The CPE program has concerns about the growth in out-of-state students, as it appears that
some programs have more than a reasonable share of out-of-state students. Increasing the
number of international students would benefit the CPE program.

Teaching and Learning (by program and student level)

– Learn by Doing; Teacher-Scholar
The CPE program does a good job with the teacher-scholar model, despite the absence of
resources to do scholarship. Scholarship should be allocated WTU release if scholarship is
valued. However, this would likely reduce the number of students that could be supported in the
CPE program unless new funding and faculty are provided.

– Pedagogy/learning modes (e.g., delivery, engaged learning, undergraduate research,
community service, internships/field placements, study away, study abroad, technology,
session structure)
The CPE program is on the forefront of adopting new pedagogy, with clear examples of inverted
or flipped classrooms, active learning, hybrid online, project-based learning and service learning
are currently happening in the CPE program.

– Space, infrastructure and information systems implications
The CPE program has one lab solely allocated to the CPE program. CPE benefits from the lab
spaces of the home departments. In particular, the CSC program could use additional lab
space.

Co-curricular Learning (in general and by program, level)

– Discipline-based activities; student life more generally
The CPE program does not have an opinion on discipline-based activities. The main IRA
activities (ACM, IEEE, CPES, WISH) do an adequate job providing discipline-based activities for
students.

– Residential community
If expanding residential students improves success rates, the CPE program is in support.

Student Success (in general and by program, level)

– Retention, graduation rates; preparation at entry, achievement gaps; student diversity (gender, ethnic origin, financial means)

Recruitment and retention of minorities and females in CPE has been elusive. The CSC department has done a good job increasing the number of women interested in computer science and their efforts in this regard have benefitted the CPE program. Programs like “Cal Poly Scholars” have also impacted the CPE program. The CPE program has worked with OCOB’s marketing concentration on developing new media for the CPE program as well as Facebook marketing moving our marketing material from “technology centric” to “people centric”.

Success rates have been traditionally very poor in the CPE program with four year graduation rates around/under 20% and six year graduation rates topping out at 62%.

<table>
<thead>
<tr>
<th>Fall 2002</th>
<th>Fall 2003</th>
<th>Fall 2004</th>
<th>Fall 2005</th>
<th>Fall 2006</th>
<th>Fall 2007</th>
<th>Fall 2008</th>
<th>Fall 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted Cohort (Original-Exports+Imports-Exclusions)</td>
<td>78</td>
<td>51</td>
<td>118</td>
<td>140</td>
<td>79</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>Graduated Within Four Years</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.7%</td>
<td>11.8%</td>
<td>4.2%</td>
<td>7.1%</td>
<td>19.0%</td>
<td>20.7%</td>
<td></td>
</tr>
<tr>
<td>Adjusted Cohort (Original-Exports+Imports-Exclusions)</td>
<td>76</td>
<td>76</td>
<td>51</td>
<td>119</td>
<td>136</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Graduated Within Five Years</td>
<td>41</td>
<td>31</td>
<td>22</td>
<td>37</td>
<td>45</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>53.9%</td>
<td>40.8%</td>
<td>43.1%</td>
<td>31.1%</td>
<td>33.1%</td>
<td>53.8%</td>
<td></td>
</tr>
<tr>
<td>Adjusted Cohort (Original-Exports+Imports-Exclusions)</td>
<td>87</td>
<td>76</td>
<td>79</td>
<td>51</td>
<td>118</td>
<td>138</td>
<td></td>
</tr>
<tr>
<td>Graduated Within Six Years</td>
<td>54</td>
<td>47</td>
<td>48</td>
<td>28</td>
<td>40</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>62.1%</td>
<td>61.8%</td>
<td>60.8%</td>
<td>54.9%</td>
<td>33.9%</td>
<td>42.0%</td>
<td></td>
</tr>
</tbody>
</table>

These graduation rates are in-line with national averages for Computer Engineering. However, as of 2012 we introduced a course called CPE 123 with the intention of improving retention rates. Early indication is that 39 out of 50 students graduating Spring 2015 started in Fall 2011 – 78% of these graduates finished in 4 years!

It should be noted that these increased retention rates have further exacerbated faculty staffing issues.
Narrative for the Department of Computer Science

Computer Science and Software Engineering Programs

Tier 3 Narrative

Ignatios Vakalis, Chair

The following document is the tier 3 program narrative for the department of Computer Science. The narrative covers both the Computer Science Program as well as the Software Engineering Program.

Note: In this narrative, we will abbreviate Computer Science using CSC, and Software Engineering using SE

Teaching, Learning, Scholarship

For the academic programs you expect to offer and the students you expect to serve:

1. What effective approaches to teaching and learning are emerging in your field and related to interdisciplinary areas?

The CSC and SE programs already have incorporated: i) inverted or flipped classrooms, ii) active learning, iii) hybrid online, iv) project-based learning.

Both CSC and SE programs are currently being augmented with unique interdisciplinary emphasis and minor programs. Those include: Cybersecurity, big data / data science, Computational Interactive Arts/Game Design, Mobile computing.
2. How should Learn by Doing incorporate new learning needs, opportunities and technologies
Beyond classroom technologies, both CSC and SE programs need better ways to take advantage of new technologies and opportunities. Additional lab space is of critical need:

a) A Lab space for "Security of Embedded Systems"
b) A "Mobile Computing Lab" (Dedicated to the teaching and research in the area of security and design for mobile and wireless technology). Such lab can be augmented with a lab facility for research on: "Internet of Thing – iOT" (and wearable)
c) A Lab for Game evaluation and Motion capture
d) A Lab space for autonomous robotics

The above labs will serve all majors in: CSC, SE, CPE.

3. How does the teacher-scholar model fit?
The model that is currently used is to have faculty use classroom space for research projects. A lot of consideration must be given in regards to the balance of the components of the "teacher –scholar" model. Faculty colleagues must not feel (high) pressure of producing publications (externally validated work). Our student body (and industry partners and employers), care a lot about the quality of teaching, and the skills the graduates develop/acquire from classes and labs. Thus, faculty should be given time to dedicate in these endeavors.

Learning Environments

What learning environments should Cal Poly develop or modify to accommodate (1) new modes of teaching and learning, (2) Learn by Doing, and (3) the teacher-scholar model in the future? Please respond in terms of the qualitative characteristics of the facilities and other spaces (including technology) critical to your programs and students:

1. Formal, scheduled or organized instruction
Formal, scheduled and organized instruction will likely be the primary mode of education in the both the CSC and SE programs.

The demand for the required major courses (in both CSC and SE programs) has increased dramatically due to: our successes in retaining more students; the increasing number of students who pursue a CSC minor; and the ascending trend of transfer (change-of-major) students. This increase of the above student populations puts additional stress on lab
utilization, since all courses in CSC, SE and CPE do have a lab component (attach to each course).

The department requests that three additional general purpose computing labs should be built very soon not only to alleviate the pressure, but also to allow us the expansion of the CSC, SE, CPE programs. The demand for our majors is unprecedented. Of course, the department will definitely need at least one more “technical support/Sys-Admin” staff member.

2. Informal student learning outside the classroom or laboratory
Expansion of co-op, independent study and senior project to include industry-related activities will likely grow over the next several years. We are looking to enhance the co-op program to increase the number of graduates who have additional industry experiences, and to use this program as a method for growing diversity in both the CSC and SE programs.

3. The teacher-scholar model.
(Substantive) Research projects will likely be mostly allocated to MS thesis students in the CSC department. We are currently at the "limit" of doing a good job in advising MS Theses. The number of research experiences for students should only increase with increased number of faculty.

**Tier 3 Considerations**

**Academic Mix (including state-support/self-support funding)**

Program mix/college shares (program headcount; FTES including GE and support)
Both the CSC and SE programs have very limited (small) number of faculty relative to the size of the programs. Currently there are appx. 620 CSC majors, 250 SE majors, and 550 CPE majors. All those majors do take required course in the computer science department. In addition the department must provide "computing" courses for students in various majors within CENG, and as courses that are part of the GE curriculum.

The CSC and SE programs would advocate growing the number of CSC and/or SE students due to the demand of skilled workers in computing, but only if the number of T/TT faculty increases.

It must be noted, that during the last two ABET visits (appx. period of 12 years), it has been stated (as a concern) in the respective reports, that the CSC and SE programs do not have adequate number of faculty for the size the respective majors (and growth rate and potential).
- Undergraduate/post-baccalaureate/graduate mix (by college)
The SE program has only undergraduate students.

The CSC program has an MS/BMS program. The size of the program is fine.

The department will consider increasing the "graduate program", if (first), commitment of new faculty, resources, facilities is provided.

- CA resident/domestic non-resident/international student mix (by college, by level)
No concerns.

Teaching and Learning (by program and student level)

- Learn by Doing; Teacher-Scholar
The CSC and SE programs do a good job with the teacher-scholar model, despite the absence of resources to do scholarship. Scholarship should be allocated WTU release if scholarship is valued. However, this would reduce the number of students that could be supported in the CSC and SE programs unless new funding and faculty are provided.

- Pedagogy/learning modes (e.g., delivery, engaged learning, undergraduate research, community service, internships/field placements, study away, study abroad, technology, session structure)
Both the CSC and SE programs are using new pedagogies, with clear examples of inverted or flipped classrooms, active learning, hybrid online, and project-based learning.

- Space, infrastructure and information systems implications
The CSC and SE program has a very limited number of labs. As stated above, in order to alleviate the pressure on the existing lab facilities, and also allow growth in both CSC, SE (as high demand areas) the department will need:

  - Three additional general purpose computing labs;
  - A Lab space for "Security of Embedded Systems";
  - A "Mobile Computing Lab" (Dedicated to the teaching and research in the area of security and design for mobile and wireless technology). Such lab can be augmented with a lab facility for research on: "Internet of Thing – iOT" (and wearables);
  - A Lab for game evaluation and motion capture;
  - A Lab space for autonomous robotics
Co-curricular Learning (in general and by program, level)

- Discipline-based activities; student life more generally
The CSC/SE programs do not have an opinion on discipline-based activities. The main IRA activities (ACM, IEEE, WISH, WHITE HAT, GAME DEVELOPMENT clubs) do an adequate job providing discipline-based activities for students.

- Residential community
If expanding residential students improves success rates, the CSC/SE programs are in support.

Student Success (in general and by program, level)

- Retention, graduation rates; preparation at entry, achievement gaps; student diversity (gender, ethnic origin, financial means)
The CSC and SE programs have done a good job increasing the number of women interested in computer science/software engineering. Specifically, in Fall 2010 we had 9-10% of incoming female students. In Fall 2014 we had 24-26% incoming female students.

  Recruiting, retaining, educating, mentoring, and empowering young women in CSC and SE, is a top strategic priority of the department.

  Programs like “Cal Poly Scholars” have also impacted the CSC and SE programs in a positive way.

  The retention rate (or first year students) have increased, due to the design and implementation of our “signature” and unique “CSC/CPE 123” menu of courses.
Tier 3 Program Narrative for the Electrical Engineering Department

The following document is the Tier 3 program narrative for the Electrical Engineering department. The starting point for this discussion is to highlight the vision for the electrical engineering department. This vision was approved by the EE department in Winter 2015. These vision elements in the next paragraphs will guide the department's future plans.

EE VISION ELEMENTS WINTER 2015

**Mission** To *educate* students to achieve excellence in the discipline of electrical engineering and to teach them to how apply their knowledge to practical problems in a socially responsible ways. To *prepare* students for careers of service, leadership, and distinction in a wide range of engineering and related fields, using a participatory, learn-by-doing, and "hands-on" laboratory, project, and design centered approach. To *foster* appreciation of lifelong learning as an essential skill in the presence of the ever-increasing pace of technological change.

**Vision** As the leader in practical, hands on electrical engineering education, we develop industry-ready talent that advances our connected world by innovating from fundamentals to advanced technologies.
Enhanced Opportunities
For Learning Through:

State-of-the-Art Integrative Learning Environments
- Holistic Learning: Technical+Ethics+Sustainability+...
- Project-based labs: learn-by-doing & earn-by-doing
- Upgrading to state-of-art lab equipment
- New Advanced Power & Communications Laboratories

A Focus on Sustainability
- Life cycle product analysis in core curriculum
- Practices that reduce our carbon footprint
- Collaboration with on-campus SEI
- Student projects with a focus on sustainability

Global Engineering Communities
- Flexible curriculum allowing co-op & study-abroad
- International collaborations & faculty exchanges

Entrepreneurial Experience
- Entrepreneurial threads into the curriculum
- Building lasting relationships with the CIE

Strategic Investment in our Areas of Excellence and Desired Growth

Power & Energy from milli-Watts to MEGA-Watts
- Power Electronics
- Smart Grids, Micro Grids & Grid Storage
- Photovoltaics, Wind and Wave Energy

All things Mobile: Computing & Communication Systems
- Bluetooth, WiFi, Zigbee
- 4G Cellular (LTE) and OFDM signaling
- Antenna Arrays and Coding for MIMO
- Secure communications, Cube-Sat

Electronic Systems on a Chip
- Low-power and energy-efficient Integrated Circuit design
- Design for testability
- Post Moore’s Law circuit and system design

Embedded Computing
- Internet of things, Intelligent Systems, Cybersecurity & Robotics
Teaching, Learning, Scholarship

For the academic programs you expect to offer and the students you expect to serve:

1. What effective approaches to teaching and learning are emerging in your field and related to interdisciplinary areas?

a. Global Engineering Communities  
Flexible curriculum allowing co-op & study-abroad  
International collaborations & faculty exchanges

The Electrical Engineering department wants our students to have international experiences. This is important because today’s engineering companies have team members around the globe. These international experiences might be with an engineering exchange program. The experience could be a senior or masters project with an external partner. It could also encompass a research project with multiple partners and multiple locations. In order to facilitate our students’ global experience, we will need to change how the department offers curriculum somewhat. Today our curriculum is highly structured where one course depends on another. Students are hampered from studying abroad because their time to graduation will be slowed down if they don’t find an international program with equivalent classes in their curriculum. The EE department has started to offer some courses remotely to date (EE112 and CPE133). The department will need to identify key courses that are roadblocks to international education and allow students to take them when they are abroad in order to make international education seamless to the student. We will need to have a closer relation with the international programs office. Our freshman orientation classes must clearly outline various paths toward international education so they can start putting together their educational plan in the first year on campus. We will also need to have close discussions with our international program partners so that they offer critical EE classes in English. EE will also need to show flexibility in our course substitution policies for those students studying abroad. One cannot always have a perfect course substitution and “close enough” substitutions should be allowed.

We also want to encourage international projects between Cal Poly and other universities here in the US and abroad. We will need to improve our audio/video/learning conferencing facilities so that most of our laboratories and classrooms make this very easy to do. At this point we have a good starting facility in room 20-145 that could be used as an international collaboration room but we need to upgrade room capabilities to achieve this vision.

b. Entrepreneurial Experience  
Entrepreneurial threads into the curriculum  
Building lasting relationships with the Center for Innovation and Entrepreneurship (CIE)

The EE department has a vision to incorporate entrepreneurial activities throughout the curriculum. A recent example is to have all freshman and senior students participate in the CIE
elevator pitch contest. We also support the emerging “Draper Institute” study abroad in Silicon Valley quarter at Cal Poly. We are making entrepreneurial classes available both as technical electives and engineering support electives in our curriculum. At the senior project level, we should encourage students to choose projects that could lead to intellectual property creation and potential new businesses. The “Internet of Things” initiative is creating a huge opportunity for students to be entrepreneurial in our field. In recent years EE has had had several senior projects that have evolved into companies. The department should make sure our curriculum with entrepreneurial elements from freshman orientation to graduation. EE should also make a special effort to provide financial support and enabling connections for entrepreneurial students. Special recognition for entrepreneurial effort should be made. Entrepreneurial activities typically involve interdisciplinary contributions. Key partnerships are with computer engineering, computer science, mechanical engineering, and business-focused entities.

c. State-of-the-Art Integrative Learning Environments

Holistic Learning: Technical+Ethics+Sustainability+...
Project-based labs: learn-by-doing & earn-by-doing
Upgrading to state-of-art lab equipment
New Advanced Power & Communications Laboratories

The Electrical Engineering department has a vision of creating state-of-the-art integrative learning environments. Here are some elements of this vision.

i. Continue and expand use of the “studio method” instruction. In EE’s studio teaching environment, instructors can seamlessly go between lecture and laboratory exercises. This allows a lecture topic to be immediately reinforced by a corresponding lab activity. The obstacle to increasing our use of this method is classroom/laboratory layout in larger rooms. We presently only have 3 rooms large enough to handle both a lecture and laboratory in the same room. We will need to do room remolds in building 20 to expand this practice.

ii. Our power and energy program is very popular and we have a vision to create an advanced power lab that brings together multiple disciplines. We need to create a new power lab learning environment where we pull together the fields of power engineering, computer engineering, and computer science. This lab would have a mini-grid to support the power engineers, a smart grid component where everything is communicating to a central control computer and a security aspect so that we can learn how to protect our critical infrastructure. The target rooms are 20-104 and 20-150 for this vision element.

iii. We want to integrate Technical Content, Ethics and Sustainability into our classroom and laboratory curriculum. This would involve educating our EE faculty on these topics along with bringing in expertise from other departments/groups.

iv. In our present laboratory strategy, sophomore students are offered highly structured laboratory experiments. Senior level students are more often offered a project objectives type of laboratory experience with less formal structure. The Electrical Engineering
department would like to slightly modify this structure where project-based activities happen earlier in the curriculum.

d. A Focus on Sustainability
Life cycle product analysis in core curriculum
Practices that reduce our carbon footprint
Collaboration with on-campus SEI
Student projects with a focus on sustainability

The Electrical Engineering department would like to incorporate sustainability elements more closely in the curriculum. We will first need to educate our faculty members on key concepts we want to have our students understand in this area. We will then need to change our extended course outlines to indicate key sustainability learning objectives. We also want to encourage our senior project students to incorporate sustainability elements into their project content and analysis of their senior project.

2. How should Learn by Doing incorporate new learning needs, opportunities and technologies.

The EE program needs better ways to take advantage of the following technologies and opportunities:

a) Rapid prototyping, including 3d printing of circuit boards, reflow ovens and 3d printing of enclosures
b) Infrastructure to support efforts in cyber security of critical infrastructure.
c) Lab space for testing of autonomous robots and UAVs
d) Lab space for development of embedded electronics for healthcare projects and wearables.
e) Laboratories that make it easy to function with off-site collaboration partners. This would include easy-to-use audio/video conferencing.
f) Laboratories that take advantage of our mobile computing initiatives.
g) Laboratories that have access to high-performance computing for CAD programs related to our discipline. This would include Keysight ADS (RF/Microwave and Communication Systems design), ANSYS (Electromagnetic Simulation), Cadence (Integrated Circuit Design), Mentor Graphics (Integrated Circuit Design), MKS (Power System Simulation), Xilinx (computer system simulation), and COMSOL (Materials interaction with electromagnetics) as examples.
h) Incorporation of mobile computing in the classroom activities.
a. How does the teacher-scholar model fit?

The model that is currently used is to have faculty use classroom/lab space for teaching needs and research project needs. For small projects, this model has worked well. For our future vision elements, this will be inadequate.

Learning Environments

What learning environments should Cal Poly develop or modify to accommodate (1) new modes of teaching and learning, (2) Learn by Doing, and (3) the teacher-scholar model in the future? Please respond in terms of the qualitative characteristics of the facilities and other spaces (including technology) critical to your programs and students:

1. Formal, scheduled or organized instruction

The Electrical Engineering Department Vision Documents Outlines the Following Areas for which it wants to enhance its learn-by-doing capabilities:

a. Power & Energy from milli-Watts to MEGA-Watts
   Power Electronics
   Smart Grids, Micro Grids & Grid Storage
   Photovoltaics, Wind and Wave Energy

The field of power and energy engineering is a critical area for the Electrical Engineering Department. Approximately 25% of our students pursue careers in this area. The power and energy field is of long term importance as the world transitions away from hydrocarbons as its primary energy source. The state of California has economic forces in play with its recent renewable energy mandates in 2020 and 2025. A key Learn-by-doing activity will be to create an advanced power laboratory in the EE department. The advanced power lab would incorporate next generation power laboratory equipment (very expensive such as the RTDS power simulation equipment rack costing $200k each). The power system equipment would include all aspects of a power grid including generation, storage, transmission and distribution. The equipment will be “smart grid” enabled. The laboratory will also be fully communication-enabled including elements of critical infrastructure computer security. The department plans on using existing facilities in 20-103 and 20-150. The department would also like to incorporate the future Engineering Projects Center (under proposal) as part of an advanced power systems laboratory.

The power field also incorporates power electronics. As an example, the i-phone has a single voltage battery that is distributed for 12 different voltage requirements around the phone through
a power management integrated circuit. Photovoltaic systems have a huge need for efficient DC to AC voltage converters. The EE department needs to continue to update its learn-by-doing facilities in power electronics. The test and measurement equipment in the present power electronics laboratory is not set up for automated measurements.

The Electrical Engineering Department would also like to create learn-by-doing facilities to track the advancing use of Electrical and Electronic systems in transportation. An example activity is adding Learn-by-Doing infrastructure around electric vehicles around campus. Another example is collaborating with other departments around the design of intelligent vehicles. The Electrical Engineering department will need to form a joint vision with other groups to put together this Learn-by-Doing direction for the college along with its associated facilities.

All things Mobile: Computing & Communication Systems
*Bluetooth, WiFi, Zigbee*
*4G Cellular (LTE) and OFDM signaling*
*Antenna Arrays and Coding for MIMO*
*Secure communications, Cube-Sat*

The mobile communications and mobile computing industry employ a large fraction of our graduates. Companies such as Apple computer for instances have stock market valuations approaching one Trillion dollars. A large fraction of the population now carries a mobile computer with them. One only needs to look around to your neighbors on campus, on a bus or at an airport to see how ubiquitous these computing tools have become. The communications industry is in the middle of the 4G LTE communication systems upgrade for enhanced data services. The 5G standards bodies are in action to roll out even higher speed services over the next 10 years. The Obama administration has instituted a major initiative to restructure Federal Communications Commission electromagnetic spectrum allocations. Up to 1 GHz of spectral bandwidth will be re-allocated for high speed data services. A tremendous amount of investment in new technologies and replacement equipment will be needed in order to accomplish this spectral re-allocation. The electrical engineering department needs to accelerate investment in learn-by-doing tools that enable our students to be competitive with their skills in this area upon graduation. Additional Learn-by-doing laboratory equipment will be needed to put together an advanced communication laboratory and its associated curricular changes. Rooms 20-116, 20-113 and 20-126 will be a starting point for this investment. Key collaboration partners will be Keysight Technologies and Anritsu (They both sell test and measurement equipment into the mobile communication/mobile computing market segment). The Electrical Engineering department would also like to have a roof-top laboratory on top of the proposed new Engineering Projects Center. The department would install advanced pre-commercial 5G equipment as part of our learn-by-doing strategy in the mobile communication/mobile computing area in the roof-top laboratory.

The cube sat program is also an area of desired learn-by-doing investment for the electrical engineering department. The communication portion of most of the launched cube sats to date has suffered from less than optimum transmitter and receiver performance of the design. Even
the most recent launch in Winter 2015 has suffered from insufficient path signal-to-noise ratio. Data rates to cube sats need to improve and the electrical engineering department would like to help the cube sat program be more successful in this area.

The cyber security program at Cal Poly to date has been focused on the highest levels of the communication stack protocols in its effort. The electrical engineering program would like to invest in learn-by-doing activities for communication security at the lower levels of the communications stack protocols at the physical layer and link-layer levels. The worldwide sales of mobile communications computing integrated circuits and equipment has now surpassed that of traditional desk and lap top computing solutions. The electrical engineering department would like to focus on learn-by-doing activities associated with security of this mobile environment.

The mobile computing/mobile communications initiative will also need to be closely coupled with our entrepreneurial vision for the department and college of engineering. There is a large amount of venture capital being spent in this sector. We want to enable our students to be part of this entrepreneurial investment wave. Our students should not be afraid of writing applications on their mobile phones as an essential skill upon graduation.

**Electronic Systems on a Chip**

*Low-power and energy-efficient Integrated Circuit design*

*Design for testability*

*Post Moore’s Law circuit and system design*

The International Technology Roadmap for Semiconductors (ITRS) guides the international global development structure for advancing semiconductor integrated circuits. The field of integrated circuit design is very important for the employment of our Electrical Engineering students. Learn-by-Doing investments include advanced computing facilities for simulation of complicated integrated circuits. Our Learn-by-Doing strategy for Electronic Integrate Circuits Design also includes partnership with the MOSIS multi-user fabrication service that is available to universities. We will need to develop a funding source that allows our department to design in some of the more complicated semiconductor foundry services at MOSIS. The Electrical Engineering department will also need to invest in Learn-by-Doing service for functional verification of the MOSIS-fabricated integrated circuits that come back from the foundry. New mixed-signal design verification laboratory equipment with a high level of automation will need to be purchased and incorporated into our building 20 laboratory facilities. Our IC design program will also need to invest in an advanced computer server cluster for simulating some of the more advanced integrated circuit designs. Our curriculum will also need to create new course that go beyond our present introductory course on Very Large Scale Integration (VLSI) topics.

**Embedded Computing**

*Internet of things, Intelligent Systems, Cybersecurity & Robotics*

Some of the largest advances in engineering systems over the last 40 years involve taking basic functionality and adding computational intelligence. Example solutions are robotic systems that
are used in advanced manufacturing environments. Embedded computing solutions are a major part of the employer base for Electrical Engineers. The department needs to invest in enhanced Learn-by-Doing opportunities for our students. This area of engineering has many opportunities for collaborations with many different departments and organizations. The computer engineering program has additional vision elements in this area.

2. **Informal student learning outside the classroom or laboratory**

Expansion of co-op, independent study and senior project to include industry-related activities will likely grow over the next several years. In particular, we are looking to enhance the co-op program to increase the number of graduates who have some industry experience and to use this program as a method for growing diversity in the EE program. Using club projects for curricular enhancement was more promising in the past, but forced reduction in program units have left flexibility in the EE program relatively minimal.

3. **The teacher-scholar model.**

Growth of research and scholarly activities with students is highly correlated to the number of younger faculty in the EE department. Investment in new faculty members will be critical to our success in advancing the teacher-scholar model at Cal Poly.
Considerations

Academic Mix (including state-support/self-support funding)

– Program mix/college shares (program headcount; FTES including GE and support)

The Electrical Engineering department currently has a total undergraduate student population of 650 Electrical Engineering students at the BS and MS level combined. In addition, the Electrical Engineering and Computer Science Departments jointly manage the Computer Engineering program with 500 students. In 2014-2015, we are able to support student demand but have had to go back to Cal Poly upper management several times to ask for additional funding for sufficient class and lab offerings. The fraction of full time tenure track faculty as a percentage of total faculty has been continually declining as retiring full time faculty members are not being replaced with entry-level full time faculty. Department finances are such that there is little money left over for laboratory support.

– Undergraduate/post-baccalaureate/graduate mix (by college)

The EE master’s program has historically been focused on the Master’s Thesis option. The EE program is presently limited in size by the number of faculty who are available to help with MS Thesis advising. The Electrical Engineering department continues to place a high value on graduate education. Any expansion of the MS thesis option student numbers would need to be tied to faculty expansion or the reduction in teaching work load for the faculty.

We do not currently have any self-support programs other than the self-support summer quarter. In the self-support summer session, we do not have enough demand for our major students to offer much of our curriculum. The main courses we offer are electrical engineering support courses for the entire college. We have had some success in offering on-line major courses where the students do not need to be on campus.

– CA resident/domestic non-resident/international student mix (by college, by level)

The EE department values having a mix of students from in-state, out-of-state, and international sources. Cal Poly as in institution will need to consider the balance of these three student sources in terms of diversity, our obligation to the tax payers of California.
Teaching and Learning (by program and student level)

– Learn by Doing; Teacher-Scholar

The EE program does an adequate job with the teacher-scholar model, despite the absence of resources to do scholarship. Scholarship should be allocated WTU release if scholarship is valued. The department takes primary financial support (non-state resources) for faculty travel to professional conferences. In 2013-2014, the EE department spent $35,000 in support of faculty and student travel expenses. A decade ago, primary travel support came from state funding sources for professional development travel. More state support of faculty travel would allow the department to devote more non-state resources to laboratory development.

– Pedagogy/learning modes (e.g., delivery, engaged learning, undergraduate research, community service, internships/field placements, study away, study abroad, technology, session structure)

The EE continues to try new teaching modes. Our department vision has international education as one of its key departmental initiatives. The department would like to develop a closer relationship with the International programs office. Our EE web site has been updated to include testimonials from folks who have traveled on engineering exchanges.

To date, a flipped classroom approach has been taken in EE112 and EE133. The flipped classroom approach to date has been initiated by proactive faculty and one of our lecturers. We hope to learn from these department pioneers and have a broader implementation. Several faculty members have written America Society of Engineering Education (ASEE) publications on the topic. EE201 is the next target class.

To date most of the internship/field placements have been managed outside of the department’s influence. On exception is the long standing MS EE student internship program with Lawrence Livermore National Labs. The EE department would like to join a CENG wide initiative where the college more actively promotes internships with its industrial partners.

In the EE department’s entrepreneurship vision element, we would like to be more involved in the technology study away program at the Draper Institute in Silicon Valley.
- Space, infrastructure and information systems implications

In Conjunction with the EE Vision, the department has identified the following items which have space, infrastructure and information systems implications.

Senior Project Learn-by-Doing facility for EE students:

A general need for space is to accommodate our senior project students. We currently have a design space utilized by the computer engineering program in 20-145. The EE department could benefit from a similar space. A desired outcome would be to have the English department vacate the space in room 20-133 and the space be allocated to the Electrical Engineering senior project program. With the large addition of office space on campus, there is not the need to put English graduate student cubicles in such an important potential laboratory space in building 20.

Power & Energy from milli-Watts to MEGA-Watts
Power Electronics
Smart Grids, Micro Grids & Grid Storage
Photovoltaics, Wind and Wave Energy

1. Advanced Power Lab in room 20-104 and 20-150. This lab would include an RTDS system, a microgrid (Generation, Storage, Transmission, Distribution), Smart grid features, and communication infrastructure to simulate critical infrastructure security.
2. Advanced Power Electronics Lab with improved test and measurement capability. The lab also needs to work in collaboration with our departmental integrated circuits initiative that tests integrated circuits fabricated at the MOSIS foundry.
3. Power and Energy Laboratory features should be incorporated in the proposed College of Engineering projects laboratory facility.

All things Mobile: Computing & Communication Systems
Bluetooth, WiFi, Zigbee
4G Cellular (LTE) and OFDM signaling
Antenna Arrays and Coding for MIMO
Secure communications, Cube-Sat

1. The communications laboratories found in Rooms 20-126, 20-116 and 20-113 are in need of significant equipment updates to meet the needs of today’s mobile communication environments. Example equipment includes vector signal generators, and vector signal analyzers so that students can generate and receive digital communication signaling formats. Our equipment presently focusses on analog (obsolete) communication methodologies.
2. The proposed College of Engineering Projects Laboratory should have a roof-top communications laboratory.
3. The Antenna Test Chamber and Electromagnetic Compatibility Chamber presently found in the Aero-Hanger Complex needs to be updated and moved to the proposed Engineering Projects Center when it is built.

4. Significant investment in the signal processing laboratory found in 20-126 is needed. The computing boards are over 10 years old. A Field Programmable Gate Array combined with a DSP processor system should be put in place in this laboratory.

**Electronic Systems on a Chip**

*Low-power and energy-efficient Integrated Circuit design*

*Design for testability*

*Post Moore’s Law circuit and system design*

1. The EE Department needs to invest in laboratory space for integrated circuit chip design verification.
2. The EE Department needs to invest in an upgrade of our CADENCE server so higher complexity chips can be designed and fabricated with MOSIS.

**Embedded Computing**

*Internet of things, Intelligent Systems, Cybersecurity & Robotics*

In conjunction with several College of Engineering departments and programs, we need to make critical laboratory investments in applications of embedded computing. Please refer to the computer engineering statement for more detailed description of laboratory space needs in this area.

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**Co-curricular Learning (in general and by program, level)**

- **Discipline-based activities; student life more generally**

The main IRA activities (ACM, IEEE, CPES, WISH) do an adequate job providing discipline-based activities for students. There is room for improvement especially in the area of industrial financial sponsorship.

- **Residential community**

The Electrical Engineering supports this but the College and University will need to take a leadership role. If expanding residential students improves success rates, the EE program is in support.
The EE department has focused on providing a “Residential Community” within the department walls of building 20 and 20A. We provide a large amount of open-access laboratory space and space in the building 20A lobby so that students that they can have a “home away from home” when they are on campus.

Student Success (in general and by program, level)

- Retention, graduation rates; preparation at entry, achievement gaps; student diversity (gender, ethnic origin, financial means)

The department did a study of EE-specific graduation rates by looking at the Freshman Class of 2010 and by analyzing the graduating class of Spring 2014.

The primary cause for student delay was re-taking classes that were failed. Other major causes included taking less than the required number of units and industry internships. Students were able to get EE department classes. There were more problems in getting support classes from around the college and University. The Fall 2015 EE retention report is available to interested parties.

The Electrical Engineering program has relatively low percentage of female students that hovers in the 10-15% range as freshman and continues to decline before students graduate. The Women in Software and Hardware along with the Society of Women Engineers has helped with support but the department needs to take a more active role.
General Engineering Program
Tier 3 Narrative

Teaching, Learning, Scholarship

For the academic programs you expect to offer and the students you expect to serve:

1. What effective approaches to teaching and learning are emerging in your field and related to interdisciplinary areas?
   As a college-wide program not tied to any one department, General Engineering has the opportunity to serve as the primary mechanism for future interdisciplinary efforts. Examples include the Multidisciplinary Senior Project, team teaching from multiple disciplines, and the highly interdisciplinary Individualized Course of Study. Activities such as these are expected to grow dramatically in the future, both in student and faculty participation. General Engineering also has the opportunity to serve as the home of a centralized, interdisciplinary, lower-division core curriculum (whereby subject areas are “owned” by a committee of interested faculty rather than by a discipline/department). This would be a major curricular shift, but is key to achieving a truly interdisciplinary student learning experience.

2. How should Learn by Doing incorporate new learning needs, opportunities and technologies?
   Tools for rapid ideation and physical prototyping of mechanical and electrical designs are undergoing explosive development (e.g. MakerBot, Arduino). These tools present an opportunity for engineering students at lower division levels to focus on systems development, analysis and evaluation without the time and expertise limitations imposed by the need to create individual hardware components from scratch. Thus, for many students and for interdisciplinary projects, future Learn by Doing will involve more time on interaction with systems, as opposed to detailed component design.

3. How does the teacher-scholar model fit?
   General Engineering will be the home for faculty interested in research and innovation in multidisciplinary fields, including the broad topic of engineering education. Examples identified in Tier 2 include Innovation & Entrepreneurship, Big Data, Product Development/Industrial Design, System Sustainability, Autonomous Systems, etc. General Engineering faculty will grow to nominally 5-7 rotating positions, each with a 3-year, 50% appointment to support interdisciplinary research initiatives and deliver curricula that has a college-wide scope. This model of a fixed duration “internal sabbatical” for scholarship with a broad impact is consistent with the goals of the teacher-scholar model.
Learning Environments

What learning environments should Cal Poly develop or modify to accommodate (1) new modes of teaching and learning, (2) Learn by Doing, and (3) the teacher-scholar model in the future? Please respond in terms of the qualitative characteristics of the facilities and other spaces (including technology) critical to your programs and students:

1. **Formal, scheduled or organized instruction**
   A centralized, interdisciplinary, lower-division core curriculum as described above would require a series of larger classes, taught by engaging faculty who enjoy this setting and supported by appropriate technology for managing and interacting with large classes/remote learning: these large classes would be combined with smaller, discipline-specific recitation sections providing greater depth, discipline context, and opportunities for laboratory activities. The physical and technology infrastructure to support this model would be essentially bi-model: large technology-enhanced classrooms, and small reconfigurable laboratories.

2. **Informal student learning outside the classroom or laboratory**
   Cal Poly engineering students have historically embraced extracurricular activities; in the future, these activities will be more formally recognized, assessed, and considered to be an integral component of a student’s education. College-wide facilities to support interdisciplinary projects, such as the proposed Engineering Projects Workshop, are key to enabling this. With the gap between curricular and extracurricular activities blurring, the importance of informal learning must be reflected in an increase in meeting and working spaces that are not tied to a particular department or curriculum. Early examples include the QL+ Laboratory and the Innovation Sandbox.

3. **The teacher-scholar model.**
   The biggest limitation to a robust teacher-scholar model is the lack of available space for dedicated research or project-based activities.
Tier 3 Narrative for the Industrial & Manufacturing Engineering Department

Curriculum, Pedagogy, Space

a. Teaching, Learning, Scholarship

For the academic programs you expect to offer and the students you expect to serve:

1) What effective approaches to teaching and learning are emerging in your field and related interdisciplinary areas?

IME faculty use some combination of: (a) flipped modes of instruction for lectures, (b) active learning, (c) project based learning, and (d) linking industry projects across sophomore & senior level courses, for several years, and its use is likely to increase. The computer labs are changing to support more teamwork and “collaboration” between students. The manufacturing labs are becoming more technologically advanced. There is an increasing interest for industry partners to bring their experts to offer seminars in their technical area of expertise, of advice student projects, often facilitated by distance learning technology. There is an increased number of multidisciplinary projects, and we are still discovering how to facilitate these type of student experiences. An emerging area of much interest to industrial engineering is “system analytics”, which is related to big data but is oriented to design/engineer information systems to support business decisions.

2) How should Learn by Doing incorporate new learning needs, opportunities and technologies (in your field, etc.)?

The manufacturing labs serve close to $2,500 engineering students per year, and have helped support hands-on “learn by doing” for the past 50 years. The equipment used in these labs is becoming increasingly computerized and automated. For example, manual mills and lathes are now computer controlled mills and lathes, and manual welding is now robotic welding. Our labs are slowly getting updated.

Additive manufacturing or 3D printing is rapidly being adopted by industry and educational institutions. This new technology is creating many opportunities and new needs for the ways we teach product design and manufacturing at Cal Poly. We will need more lab space to support teaching and student project needs related to this new technology.
3) How does the teacher-scholar model fit (again in your field, etc.)?

Faculty use teaching laboratory space for student projects, including graduate students and sponsored projects. We do not have any Departmental space dedicated solely to research. Some faculty use industry partners lab facilities for some of their sponsored research projects.

b. Learning Environments

What learning environments should Cal Poly develop or modify to accommodate (1) new modes of teaching and learning, (2) Learn by Doing, and (3) the teacher-scholar model in the future? Please respond in terms of the qualitative characteristics of the facilities and other spaces (including technology) critical to your programs and students:

1) Formal, scheduled or organized instruction,

We will need more (or update) classrooms/labs that can support: (1) distance learning and teaching from a remote location by either industry partners or faculty from another university. (2) computer labs that encourage teamwork and collaboration. (3) we need to increase the capacity in our freshman manufacturing labs to accommodate the increased enrollment demand of students – right now it is at capacity with some labs already being offered on Saturdays. (4) we need to have a sustainable plan to maintain, operate and update the high-tech equipment that these new technologies require. As we increase the number of machines that are high tech, computer-controlled, such as 3D printers, robotic welding, CNC mills and lathes, and testing/metrology equipment, the needs for technician support, maintenance & repair, and update to new machines, needs to be reflected in the budgets.

2) Informal student learning outside the classroom or laboratory, and

In engineering, the student projects facilities are extremely important to support senior projects, club activities, etc. Engineering has two student project spaces, the Bonderson Bld. and the Aero Hanger, which is in need of replacement. An adequate replacement for the Aero Hanger needs to be available in the timeframe for this Master Plan. It is important to understand that the manufacturing labs in the IME Dept. are primarily used for teaching (mostly freshman), and the manufacturing facilities in Bonderson and the Aero Hanger are used exclusively for student projects. The replacement of the Aero Hanger needs to be designed with the capacity to accommodate the planned increase in student population and the increased emphasis in multidisciplinary projects.
3) The teacher-scholar model.

The IME Dept. currently does not have any space that is used exclusively for research or scholarly activities. Last Fall, we hired a new TT faculty in over 12 years, and hopefully will hire more TT faculty in the next 15 years – when all of our previous faculty are expected to retire. The expectation for new (and future) faculty is to do scholarly activities. We do not have any space to give to this new (and future) faculty to do their research.

Tier 3 Considerations

- Academic Mix (including state-support/self-support funding)
  - Program mix/college shares (program headcount; FTES including GE and support)

Currently the IME Dept. has around 470 students (350 IE undergrads, 70 MfgE undergrads, and 50 graduate students in three grad programs MS-IE, MS-ITM, EMP). In addition, the IME Dept. offers several freshman-level hands-on manufacturing classes/labs for most of the other engineering programs. These freshman manufacturing labs are offered for about 2,500 students per year. These labs are capped at 24 students per lab due to limitations in lab space and equipment capacity, as well as for safety reasons.

The IME Dept. offers a handful of classes/labs during summers as self-supported courses.

- Undergraduate/post-baccalaureate/graduate mix (by college)

The IME Dept. has about 420 undergraduates and 50 graduate students.

- CA resident/domestic non-resident/international student mix (by college, by level)

The IME Dept. has some domestic non-residents (out-of state students), but we don’t track the numbers or percentages. Anecdotally, they have a higher expectation to get the classes/labs they need/want to enroll in, and sometimes we do not have the resources to provide.

We have a few undergraduate international students (about 1%) that are here for their degree, and many more who come for an exchange program (about 3%).

Every year we have one or two international students in our graduate programs. This year, for the first time, we have a Fulbright graduate student from Germany.
• Teaching and Learning (by program and student level)

  o Learn by Doing; Teacher-Scholar

  There is a lot of variability in the amount and quality of scholarly work done by faculty in the IME Dept. and the College of Engineering. An effective reward and support system will be required to help faculty and recognize scholarly work.

  o Pedagogy/learning modes (e.g., delivery, engaged learning, undergraduate research, community service, internships/field placements, study away, study abroad, technology, session structure)

  It would be wonderful if each Dept. could have the resources to bring every year (on a rotating basis) a faculty on sabbatical from other institutions or an industry expert on leave from their organization. This will require a surplus of office spaces, and some funding.

  o Space, infrastructure and information systems implications

  Office space is currently in a state of disarray. This past Fall, most of the IME Dept. manufacturing lecturers who had offices in Bld. 41 next to the manufacturing labs where they teach, lost their office space, and were relocated to trailers far away from Bld. 41. Their previous offices were assigned to faculty from other departments who do not use the adjacent manufacturing labs.

• Co-curricular Learning (in general and by program, level)

  o Discipline-based activities; student life more generally

  We are increasingly finding it difficult to find resources to fund student travel to student competitions, conferences, plant tours, and other similar activities. IRA activities need better oversight procedures regarding safety practices, professionalism and ethics.

  o Residential community

  This is far too removed from the Dept. functioning, and we do not have sufficient information to comments on its merits.
• Student Success (in general and by program, level)

- Retention, graduation rates; preparation at entry, achievement gaps; student diversity (gender, ethnic origin, financial means)

The IME Dept. retention and graduation rates are average for the college of engineering. Close to 30 students per year transfer into the IE program, mostly from other Cal Poly engineering programs.

It would be great to have data on the reasons why students are disqualified from Cal Poly, and the reasons why the five (and six) year graduation rates are not higher, so that we can develop data-driven processes to improve these metrics. Cal Poly has a very selective admission process, so we admit very good students, who should be successful. It is a shame that six years after admission, about 30% of engineering students do not have a degree from Cal Poly, and most of these 30% will never receive it. These were promising students, otherwise they would not have received admission from Cal Poly.

It will be great to be able to increase student diversity in engineering. That includes female, minorities and first generation attending college.
Materials Engineering (MATE) Program Narrative

Tier 3 – Curriculum, Pedagogy, Space

March 6, 2015

a) Teaching, Learning, Scholarship
For the academic programs you expect to offer and the students you expect to serve:

1) What effective approaches to teaching and learning are emerging in your field and related interdisciplinary areas?

Recent studies have reported that students tend to be successful if they make a meaningful connection with a faculty member and had an extended project in their discipline. When designing future teaching, learning, and scholarship endeavors, we might keep those simple criteria in mind.

Use of online learning with videos, modules, simulations, etc. is being integrated within traditional courses, or utilized for flipped courses. “Real world” projects through service learning, project-based learning, contests, or clubs are effective approaches to learning that provide high motivation and opportunities to develop professional skills.

Materials Engineering is a natural field to usher in the interdisciplinary areas of nanoscale science and engineering, and sustainability. These areas cross disciplinary boundaries even beyond science and engineering, such as communication, public policy, art, and K-12/adult education. New ways of teaching, learning, and scholarship in nano and sustainability are being developed. For instance, these broad topics have been incorporated into the MATE 359 GE Area F course with great response from non-engineering students. Use of in-class demos and videos are instrumental to teaching “nano” since the length scale is too small to be seen by the naked eye. Because nanotechnology and sustainability are emerging areas that impact everyone as consumers and citizens, learning these topics with students in other fields would provide wide perspectives. Thus learning in the future should be more integrative rather than compartmentalized (while still specialized for disciplinary knowledge).

In the field of Materials Science and Engineering, computer simulations and computations from first principles is emerging as a more efficient way to investigate and test new materials. Computation (e.g., Materials Genome Initiative) offers “short cuts” to extensive and costly lab experimentation. Thus, computation that makes sense for a practical, undergraduate degree is being considered for the MATE curriculum.

2) How should Learn by Doing incorporate new learning needs, opportunities and technologies (in your field, etc.)?
Learn By Doing (LBD) will probably include a lot more online learning with videos and use of computers (e.g., simulations, computations). Learning can be enhanced with integration of videos that show safe lab procedures, equipment training, industry practices, and remote locations.

Learn By Doing can also incorporate more partnerships with others, such as community members and organizations (e.g., non-profits), national labs, other universities, and industry. Such partnerships could parallel emerging industry models of working with various entities across different locations and time zones. Video conferencing and sharing of electronic files are ways that allow people to work together but not physically at the same place.

In the materials field, remote testing or characterization opportunities are possible. For example, a sample can be sent to a user facility at another university or national laboratory and can be analyzed in real time remotely. Such opportunities are wonderful since students can be exposed to state-of-the-art equipment and techniques that are prohibitively expensive for Cal Poly.

3) How does the teacher-scholar model fit (again in your field, etc.)?

The teacher-scholar model in MATE most easily applies to the senior and masters projects where students work closely with faculty, usually in areas of their research. Club activities are also an area where the teacher-scholar model can apply since students and faculty might work on projects together or learn together through field trips and speakers.

Unfortunately, the current system of student course units and faculty assigned weighted teaching units (wtus) usually does not count independent research projects or club activities. There is also currently no incentive for faculty to include non-Cal Poly students (e.g., local high school students, community college students, other university students) in their scholarly work.

b) Learning Environments
What learning environments should Cal Poly develop or modify to accommodate (1) new modes of teaching and learning, (2) Learn by Doing, and (3) the teacher-scholar model in the future? Please respond in terms of the qualitative characteristics of the facilities and other spaces (including technology) critical to your programs and students:

A larger question that arises when considering new modes of teaching and learning is – What metric should be used to grant a degree? Would outcomes-based learning be more appropriate than accumulation of unit hours? How would that change the facilities, spaces, and technologies that would be needed?
As an example, threshold or mastery-based learning (i.e., outcomes-based) might take shape in a badging or exam system to earn credits. The concept of a course or classroom or 4-year degree could drastically change.

In addition to considering physical facilities and spaces for the future, the actual work and learning environment of people that includes the psychological and emotional aspects should be considered as well. The learning environments should be inviting and inclusive of different learning styles, as well as different individuals (e.g., gender/ethnicity/socioeconomic status, etc.). Faculty and staff might also be considered more as mentors and coaches or partners in discovery, rather than gatekeepers.

1) Formal, scheduled or organized instruction

The MATE curriculum has been evolving with project-based courses that combine lab and lecture components, and we have already run into challenges where new modes of teaching/learning don't nicely fit into the structure of the current system. Class scheduling and use of classrooms and labs has been tricky, and flexibility is often required.

Project-based courses are often structured such that learning is driven by a significant project (often team-based), and lectures might occur at a regular time or happen “just in time.” Great flexibility is required in terms of time and space (especially the use of different labs and machine shops). The formal, scheduled class is convenient for class announcements, training sessions, meetings with instructors or other teams (e.g., progress updates or reviews), and formal presentations. The schedule class time is also essential for student teams to work together since arranging times outside of class to work on group projects is difficult when students have such different schedules. Furthermore, instructors are available for assistance during scheduled instruction time.

For effective team project-based learning, comfortable meeting spaces are essential for people to be able to be physically together and the spaces should allow reconfigurations to allow lots of flexibility for different needs (e.g., formal presentations, brainstorming sessions, etc.). Access to supplies and equipment are also needed.

2) Informal student learning outside the classroom or laboratory

There is need for more shared computer labs for different classes to use, especially when the computers are not needed every class time or for only a short amount of time. Many department computer labs appear to be underutilized, yet can also be costly for departments to maintain.
Because online learning will most likely become increasingly important, sufficient wifi capability and digital space (e.g., email, PolyLearn sites, shared online files) are essential. In addition, working virtually with others will require fast Internet speeds and viewing areas with projectors and large screens.

Experiential learning outside of the classroom or lab, such as field trips, club activities, or service/community-based learning, could be supported by easier paperwork and means of transportation. Learning opportunities, such as internships, co-ops, and study abroad programs would ideally be experience by more of our students.

3) The teacher-scholar model

In order to foster faculty-student interactions, having comfortable spaces for people to congregate formally and informally is important. The physical space should allow for small group discussions, and the ability to conduct brainstorming sessions and presentations (e.g., white boards). For example, the open spaces in the new Baker building provide productive meeting spaces for a variety of uses.

When students participate in research or other long term projects, they need places to keep their supplies and lab gear (e.g., lab coat, safety glasses), such as lockers or cabinet space.

For many projects, shared facilities, such as machine shops are needed to build and store things. A MakerSpace-like facility that encourages creative design and problem-solving with a multi-disciplinary approach is critical for a polytechnic university to thrive.
Tier 3 Program Narrative for the Mechanical Engineering Program

Teaching, Learning, Scholarship

For the academic programs you expect to offer and the students you expect to serve:

1. What effective approaches to teaching and learning are emerging in your field and related to interdisciplinary areas?

Effective approaches to teaching and learning in the ME discipline are not inherently different than emerging practices in other fields. A growing amount of scholarship is being devoted to the question of how best to teach students. At this time in our department there are instructors who use a host of teaching methods that include: lecturing, inverted classrooms, project based learning, team based learning, learn-by-doing, online or hybrid courses, active learning, and service learning. It is not clear whether one approach or a combination of approaches is most effective. Cal Poly has committed to the learn-by-doing approach to the point of it becoming our brand.

Mechanical engineering has always been an interdisciplinary program. Students in ME take CENG courses in EE, MATE, CSC, CE, and IME. Mechanical design, especially in our era of microprocessors, incorporates programming, sensing, actuation and modeling. Our concentrations such as HVAC, Mechatronics, and Manufacturing are actually blends of disciplines. The main stems of ME; thermodynamics, fluids, heat transfer, and mechanics are fundamental to many applications. The newest area of interdisciplinary growth within ME involves manufacturing. Advances in manufacturing methods and practices have led manufacturing companies to request this blending.

2. How should Learn by Doing incorporate new learning needs, opportunities and technologies

Learn by doing in the ME program is supported by our shops and laboratories. These facilities also support our teacher scholar model since much of our research is done in a corner of a laboratory during unscheduled teaching hours. Emerging needs in advanced manufacturing
methods, sustainable design, design for an aging population, incorporation of new materials and processes, modern simulation tools, and efficient and clean energy production are challenges to be addressed by our graduates. Today's lab must give them the skills to tackle these problems. Learn by doing to an engineer means putting your hands on hardware.

3. How does the teacher-scholar model fit?

The teacher–scholar model is not just a good idea; it is a necessary component of a University that expects to attract the best students, faculty, and industry partners. Faculty must be engaged in their profession throughout their career in order to prepare students for their own academic and professional careers. Unfortunately we are moving backward in this regard. When a lecturer is evaluated it is common to write NA, for not applicable, in the evaluation form for professional development. Lecturers are not explicitly expected to participate in professional development activities since they teach a full time load of 15 wtu per quarter. Faculty are expected to teach 12 wtu with 3 wtu of service for a full time load of 15 wtu per quarter. Where is the time allocated for teacher-scholar activities? Faculty can write grants and use other internal mechanisms for release time to do scholarly activities but this is coming into jeopardy. For the upcoming quarter several faculty gave up release time for scholarly activities in order to meet the demand for undergraduate classes. This is a direct consequence of under staffing and insufficient resources allocated for scholarly activities. Until a programmatic model is built into our system to support scholarly activities, they will continue to be secondary and intermittent activities that do not utilize the full potential of our faculty to advance the reputation of our school or our profession.

Learning Environments

What learning environments should Cal Poly develop or modify to accommodate (1) new modes of teaching and learning, (2) Learn by Doing, and (3) the teacher-scholar model in the future? Please respond in terms of the qualitative characteristics of the facilities and other spaces (including technology) critical to your programs and students:

1. Formal, scheduled or organized instruction
New modes of teaching that allow for a greater through-put of students must be examined/developed in the future. Our curriculum is impacted to the point where classes have filled up on the first days of registration. Students taking priorities are not getting classes for which they took priority registration. Simply increasing the class size is not a solution because it may not be the best way to deliver the course, and it is not easy to get lots of large capacity rooms.
Increasing our graduate program may offer a way to help through-put by utilizing graduate students to support teaching with office hours and recitation periods. By no means should graduate students teach classes at Cal Poly. But the use of graduate student could help cement learning objectives to avoid re-taking of classes.

We must embrace the coming of the electronic textbook. These are not PDF versions of the book. Instead, they are well researched software packages that address both conceptual and traditional homework problems in the delivery of a course. Retention models lurk in the background providing the students with recharge questions based on exponential knowledge decay. After a certain time period, mastered learning objectives will be probed again. What needs to be done? The bookstore will likely sell only technical and spirit goods. Warehousing bound books will no longer be needed. Drop-in computer labs will be in demand where students will interact with a “book”. Wired common areas will allow for student interaction with a course while in between classes or activities.

Laboratories must be refurbished and recharged for learn by doing. Old fashion labs allow for learn by doing.

2. Informal student learning outside the classroom or laboratory
Learning outside the classroom will help impaction and budget struggles. An open mind regarding learning experiences needs to be kept to take advantage of off campus learning.

Coop experiences are an area of growth that can take some of the on campus learning load off our shoulders while providing exceptional experiences for students and companies. We should explore the possibilities of companies providing the equivalence of a senior project in two or three quarter coop rotations. A report done for the company would be the senior project. Companies would like having this close relationship with our students. The value to the companies may be such that a “pay-to-play” model could be put in place.

The trendy fourth quarter may be obtainable in the form of a summer international program. Programs need to put together five courses, say three technical and two GE, that span a summer outside the country. For instance, get a GE and technical elective in Greece from June 30th to July 15th. Then head to Munich for four weeks where students can get credits for another GE and two more technical electives. One of the most expensive parts of a student’s summer in Europe is the plane ticket. So we should design the programs such that credit for a full fourth quarter can be realized. This valuable experience is a plus for students and relieves some of the classroom seat pressures we face during the regular school year.

Finally, our buildings on campus must provide a much greater component of student “hang-out” space. Common areas and green spaces that have wireless connectivity. Student groups can meet, homework can be done, or just relaxation. The new Baker Building has this feature. Building 13 has a courtyard that could become such an area. But money and effort must be made to provide the students a comfortable home where ever they are on campus. Going forward, every building should have an area for students that looks like the UU.

3. The teacher-scholar model.
The teacher-scholar model must be implemented at Cal Poly cause all our students are student-scholars.

We have many companies clamoring over our students for prospective employees. An effective way for companies to build a lasting bridge to the Cal Poly graduates is to build lasting relationships with faculty. We need company sponsored research to give companies the visibility they want on campus. Companies need champions, in the form of faculty, on campus to bring student attention to whatever the companies are doing. At the college level, companies donate money because they want a presence at Cal Poly to attract students. Wouldn't using that money to have a faculty member work in an area of interest to the company be the best way to do this. Better than pizza parties. Provide faculty with summer internships. Then labs could be developed. Cal Poly would provide applied research to companies, but more importantly, a pipeline of students ready to contribute as soon as they show up for their full time job.
Considerations

Academic Mix (including state-support/self-support funding)

- Program mix/college shares (program headcount; FTES including GE and support)
The ME program has nearly 1200 FTES. The program also teaches about 30% of the service
courses to other department in the college.

- Undergraduate/post-baccalaureate/graduate mix (by college)
The ME program has approximately 1100 undergraduate students and 60 graduate students.
The program headcount has grown 20% over the last four years with a concomitant reduction in
faculty.

- CA resident/domestic non-resident/international student mix (by college, by level)
The ME program has approximately 40% of FTF coming from out of state. Most of the
international students in the program are exchange students who are here for a short time. The
ME department has several programs with international exchange partners that include summer
programs, and student and faculty exchanges

Teaching and Learning (by program and student level)

- Learn by Doing; Teacher-Scholar
The ME program supports the teacher-scholar mode using two endowments; the Bently
endowment supports release time for faculty and the Chrones endowment funds equipment.
Several smaller endowments support lab development.

- Pedagogy/learning modes (e.g., delivery, engaged learning, undergraduate research,
community service, internships/field placements, study away, study abroad, technology,
session structure)

Faculty within the ME program have adopted new pedagogical methods for teaching; examples
include inverted or flipped classrooms, active learning, hybrid online, project-based learning and
service learning. Undergraduate research occurs but not on a regular basis. Internships are
student initiated and not a required component of the degree, although about a third of our
students have an internship.

- Space, infrastructure and information systems implications
The ME program has about a dozen different laboratories that accompany required courses in
the curriculum. The department also has several student 24-7 open access computer labs. The
program maintains approximately 250 computers. We are at the crossroads of 32 bit versus 64
bit machines. Newer software requires 64 bit machines. At $1300 per computer replacement
cost, the total would be $325,000. We are looking into a VMI solution as we obtain 64 bit
machines from other programs that are replacing machines.

Co-curricular Learning (in general and by program, level)
– Discipline-based activities; student life more generally
The ME program has a host of student project clubs and professional societies. Student project clubs: Human Powered Vehicle, Mini-Baja Car, Formula Racer, Electric Vehicle, Chainless Challenge Club, and Frame Builders Professional Societies: ASME, Tau Beta Pi, Pi Tau Sigma, SPE.

– Residential community
The department does not track residential community activities per se.

Student Success (in general and by program, level)
– Retention, graduation rates; preparation at entry, achievement gaps; student diversity (gender, ethnic origin, financial means)

<table>
<thead>
<tr>
<th>ETHNIC GROUPING</th>
<th>Fall 2008</th>
<th>Fall 2009</th>
<th>Fall 2010</th>
<th>Fall 2011</th>
<th>Fall 2012</th>
<th>Fall 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under Represented Minorities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Applications</td>
<td>361</td>
<td>425</td>
<td>478</td>
<td>519</td>
<td>647</td>
<td>837</td>
</tr>
<tr>
<td>Total Selected</td>
<td>97</td>
<td>95</td>
<td>54</td>
<td>65</td>
<td>79</td>
<td>99</td>
</tr>
<tr>
<td>Selection Rate</td>
<td>26.9%</td>
<td>22.4%</td>
<td>11.3%</td>
<td>12.5%</td>
<td>12.2%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Total Enrolled</td>
<td>34</td>
<td>31</td>
<td>17</td>
<td>19</td>
<td>25</td>
<td>36</td>
</tr>
<tr>
<td>Yield</td>
<td>35.1%</td>
<td>32.6%</td>
<td>31.5%</td>
<td>29.2%</td>
<td>31.6%</td>
<td>36.4%</td>
</tr>
<tr>
<td>Non-Under Represented Minorities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Applications</td>
<td>1,289</td>
<td>1,274</td>
<td>1,426</td>
<td>1,447</td>
<td>1,711</td>
<td>1,966</td>
</tr>
<tr>
<td>Total Selected</td>
<td>461</td>
<td>401</td>
<td>385</td>
<td>467</td>
<td>443</td>
<td>478</td>
</tr>
<tr>
<td>Selection Rate</td>
<td>35.8%</td>
<td>31.5%</td>
<td>27.0%</td>
<td>32.3%</td>
<td>25.9%</td>
<td>24.3%</td>
</tr>
<tr>
<td>Total Enrolled</td>
<td>156</td>
<td>134</td>
<td>132</td>
<td>190</td>
<td>159</td>
<td>204</td>
</tr>
<tr>
<td>Yield</td>
<td>33.8%</td>
<td>33.4%</td>
<td>34.3%</td>
<td>40.7%</td>
<td>35.9%</td>
<td>42.7%</td>
</tr>
</tbody>
</table>

The percentage of total applicants for URM FTF has increased from 22% to 30% over the last 6 years. In terms of raw numbers they have more than doubled. Unfortunately, the selection rate URM FTF has decreased at the same time as application rates have increased. Yield rates for URM and non-URM students indicate that our program is approximately equally attractive to both demographics.
<table>
<thead>
<tr>
<th>GENDER:</th>
<th>Fall 2008</th>
<th>Fall 2009</th>
<th>Fall 2010</th>
<th>Fall 2011</th>
<th>Fall 2012</th>
<th>Fall 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Applications</td>
<td>1,511</td>
<td>1,522</td>
<td>1,687</td>
<td>1,740</td>
<td>2,105</td>
<td>2,473</td>
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<tr>
<td>Total Selected</td>
<td>489</td>
<td>418</td>
<td>355</td>
<td>449</td>
<td>443</td>
<td>475</td>
</tr>
<tr>
<td>Selection Rate</td>
<td>32.4%</td>
<td>27.5%</td>
<td>21.0%</td>
<td>25.8%</td>
<td>21.0%</td>
<td>19.2%</td>
</tr>
<tr>
<td>Total Enrolled</td>
<td>165</td>
<td>147</td>
<td>129</td>
<td>180</td>
<td>157</td>
<td>202</td>
</tr>
<tr>
<td>Yield</td>
<td>33.7%</td>
<td>35.2%</td>
<td>36.3%</td>
<td>40.1%</td>
<td>35.4%</td>
<td>42.5%</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Applications</td>
<td>139</td>
<td>177</td>
<td>217</td>
<td>226</td>
<td>253</td>
<td>330</td>
</tr>
<tr>
<td>Total Selected</td>
<td>69</td>
<td>78</td>
<td>84</td>
<td>83</td>
<td>79</td>
<td>102</td>
</tr>
<tr>
<td>Selection Rate</td>
<td>49.6%</td>
<td>44.1%</td>
<td>58.7%</td>
<td>36.7%</td>
<td>31.2%</td>
<td>50.9%</td>
</tr>
<tr>
<td>Total Enrolled</td>
<td>25</td>
<td>18</td>
<td>20</td>
<td>29</td>
<td>27</td>
<td>38</td>
</tr>
<tr>
<td>Yield</td>
<td>36.2%</td>
<td>23.1%</td>
<td>23.8%</td>
<td>34.9%</td>
<td>34.2%</td>
<td>37.3%</td>
</tr>
</tbody>
</table>

One continuing concern with the ME program is the lack of gender diversity in the program. The table above shows several examples of how gender balance in the ME program is skewed. The ratio of men-to-women who apply to the ME program has fallen from 10.9:1 to 8.3:1. The selection rate of women is approximately 10 to 15 percent better than male applicants. The yield rate for women has stayed approximately the same over the past six years.
The graduation rate for the ME program has increased in recent years. The four year graduation rate is unclear because of the large number of students in the blended 4+1 program. Available data does not separate out those students working on a master’s degree in this way nor does it consider internships which are a popular and valuable experience for our students.