EAB

MARKET VIABILITY STUDY

Feasibility of an Undergraduate Engineering Program

At California State University-San Marcos

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Section I: Executive Summary and Preface

1) Executive Summary

Project Challenge

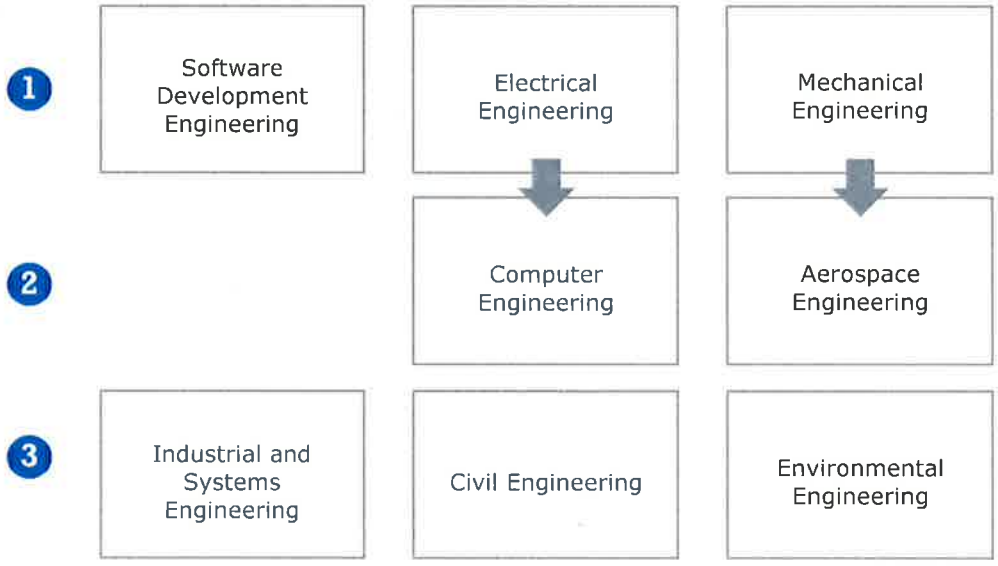
Recommend Development Strategy for Undergraduate Engineering Program

California State University-San Marcos' College of Science and Mathematics has received approval to offer a suite of undergraduate engineering programs for the first time since the University's inception in 1989. The College sought a feasibility study to help design, launch, and maintain a suite of programs that appeal to and promote success among the University's uniquely diverse student populations, including recent high school graduates, the community college transfers that compose half the student body, and thousands of local residents with ties to the area's military community. Given the presence of established engineering programs throughout Southern California and the cost of creating engineering curricula, the study highlights concentrations and specialties that offer CSU-San Marcos an advantageous position among local competitors, draw liberally from existing curricula and faculty expertise, and appeal to the hiring needs and philanthropic goals of local engineering employers.

Program Development Sequence

Prioritize Development of Software Development, Electrical, and Mechanical Engineering Degrees

Recommended Program Development Sequence



Immediate program opportunities:

- Exhibit the lowest risk with:
  - Relevant associate's degree programs at local community colleges, which will help University administrators recruit initial applicants
  - High number of existing courses at California State University-San Marcos, which will require the least amount of faculty time spent on new course development
  - Little competition among local university programs

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- Offer the greatest reward through:
  - Ample employer demand for graduates
  - Interest and preparedness among California State University-San Marcos' major student audiences
  - Projected job growth, which suggests potential for future program success

First stage program expansion opportunities offer potential to expand immediate program opportunities with marginal additions of faculty and resources. Computer engineering relies heavily on resources available from electrical engineering programs (and can also leverage resources from the proposed software development engineering and existing computer science programs). Aerospace engineering serves a niche audience within mechanical engineering, including local defense contractors.

Second stage program expansion opportunities display high rates of projected employment growth and low or moderate market saturation, but lack relevant local associate's degree programs and/or do not align with California State University-San Marcos' current course offerings. After successful development of immediate program opportunities and first stage program expansion opportunities, these fields offer opportunities for expansion.

Research Confirms Local Suitability for Engineering Program Development

Student audiences demonstrate interest and readiness:

- **High school students** exhibit sufficient reported interest and standardized test performance, as well as encounter opportunities to prepare for program enrollment in high school.
- **Community college students** can complete support courses at local community colleges before transfer.
- **Military veterans** offer a large and concentrated population seeking rewarding post-service careers available to engineering graduates.

Local employers confirm program need:

- Local employer demand for engineering graduates increased 40 percent from the second half of 2013 to the first half of 2015.
- Engineering degrees offer students positive employment outlooks, with expected continued growth in engineering employment through 2022.

Share a Minimum of Seven Support Courses among Engineering Degrees

While some programs require more support courses to encourage well-rounded graduates, a minimum of seven courses should ensure students can succeed in advanced coursework. Support courses at competitor institutions[1] include:

- ENGR 101: Intro to the Engineering Profession
- ENGR 102: Academic Success Skills
- MATH 122: Calculus I
- MATH 123: Calculus II
- MATH 224: Calculus III
- PHYS 151: Mechanics & Heat
- PHYS 152: Electricity and Magnetism

Include communication skill development within these support courses to improve students' career readiness.

Require Senior Capstone Projects and Offer Internships and Hands-On Extracurricular Activities

Employers heavily value hands-on experience across engineering disciplines. Incorporate capstone projects within program curricula to ensure students conduct at least one large-scale engineering project during their education. Support internship participation and host extracurricular teams (e.g., formula racing teams, programming teams) to offer additional experiential learning opportunities.

Because of the hands-on experience essential to engineering success, contacts overwhelmingly prefer face-to-face delivery. Introductory and theoretical courses offer the best opportunity for online delivery, because they include fewer practical assignments and no laboratory requirements.

1) This particular course list is from California State University-Long Beach.

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2) Research Approach

The Education Advisory Board's market research function provides insights that guide strategic programmatic decisions at member institutions. The Forum combines qualitative and quantitative data to help administrators identify opportunities for new program development, assess job market trends, and align curriculum with employer and student demand.

EAB reports analyze labor market data from the Burning Glass Labor/Insight™ tool (description below). Reports use data from the United States Census Bureau and United States Bureau of Labor Statistics data to explore occupation and job trends. Market research reports also incorporate Integrated Postsecondary Education Data System (IPEDS) data to assess student enrollment, demographics, and completion rates across competitor programs. Additionally, researchers conduct interviews with regional thought leaders (e.g., local employers, community colleges) and directors of comparable programs to understand the industry and educational landscape.

Profiled Institutions

The Forum profiled competitor and peer institutions as identified by administrators at **California State University-San Marcos**. The Forum supplemented competitor and peer institutions with other institutions in the California State University System as well as institutions of similar size or geographic location as California State University-San Marcos. Due to the small number of software engineering bachelor's degree programs in California and nationwide, the Forum profiled institutions outside California State University-San Marcos' peer and competitor groups. The Forum researched undergraduate engineering programs at the following institutions:

A Guide to Institutions Profiled in this Brief[2]

Institution	Location	Approximate Institutional Enrollments (Undergraduate/Total)	Classification
Boston University*	Northeast	18,000 / 32,100	Research Universities (very high research activity)
California Polytechnic State University-San Luis Obispo	West	19,200 / 20,200	Master's Colleges and Universities (larger programs)
California State Polytechnic University-Pomona	West	22,400 / 24,000	Master's Colleges and Universities (larger programs)
California State University-Chico	West	16,100 / 17,300	Master's Colleges and Universities (larger programs)
California State University-Fresno	West	20,500 / 23,200	Master's Colleges and Universities (larger programs)

2) National Center for Education Statistics.

California State University-Fullerton	West	32,700 / 38,200	Master's Colleges and Universities (larger programs)
California State University-Long Beach	West	31,600 / 36,800	Master's Colleges and Universities (larger programs)
California State University-Los Angeles	West	20,700 / 24,500	Master's Colleges and Universities (larger programs)
California State University-Northridge	West	35,600 / 40,100	Master's Colleges and Universities (larger programs)
California State University-Sacramento	West	26,700 / 29,300	Master's Colleges and Universities (larger programs)
City University of New York (CUNY)-Brooklyn College	Mid-Atlantic	14,100 / 17,400	Master's Colleges and Universities (larger programs)
MiraCosta College	West	14,700 / none	Associate's – Public Suburban – serving Multicampus
Monmouth University*	Mid-Atlantic	4,600 / 6,400	Master's Colleges and Universities (larger programs)
Mt. San Jacinto College	West	14,600 / none	Associate's – Public Suburban – serving Multicampus
Palomar College	West	24,900 / none	Associate's – Public Suburban – serving Multicampus
Point Loma Nazarene University	West	2,600 / 3,400	Master's Colleges and Universities (larger programs)
San Diego State University	West	28,400 / 33,500	Research Universities (high research activity)
University of California-San Diego	West	24,800 / 30,700	Research Universities (very high research activity)
University of Maryland-Baltimore County	Mid-Atlantic	11,400 / 14,000	Research Universities (high research activity)
University of San Diego	West	5,700 / 8,300	Doctoral/Research Universities
University of Tennessee-Martin	South	6,700 / 7,000	Master's Colleges and Universities (medium programs)
University of Texas-Tyler	South	5,900 / 8,000	Master's Colleges and Universities (larger programs)
University of Wisconsin-Milwaukee	Midwest	22,700 / 27,600	Research Universities (high research activity)

*Institution profiled due to the limited availability of information on software engineering bachelor's degree programs.

Burning Glass Labor/Insight™

The Education Advisory Board's Partner for Real-Time Labor Market Data

This report includes data made available through EAB's partnership with Burning Glass Technologies, a Boston-based leader in human capital data analytics. Burning Glass Technologies specializes in the use of web spidering technology to mine more than 80 million online job postings and analyze real-time employer demand. Under this partnership, EAB may use Burning Glass's proprietary Labor/Insight™ tool to answer member questions about employer demand for educational requirements, job titles, and competencies over time, as well as by geography. The tool considers job postings "unspecified" for a skill, industry, employer, geography, certification, or educational requirement when the job posting did not advertise for one of these particular job characteristics. Unspecified postings represent null values and should be excluded from the total number (n value) of job postings analyzed in the query. A more complete description of the tool is available at http://www.burning-glass.com/products/laborinsight-market-analysis/.

For more information about the Labor/Insight™ tool, please contact Kelly Bailey, Business Development Manager, at kbailey@burning-glass.com or 732-800-2484.

Section II: Competitive Landscape for Engineering Programs

1) Research Methodology

Purpose

Analyze the competitive landscape for undergraduate engineering programs and confirm employer demand. The Forum analyzed the relationship between local employer demand data for engineers and relevant degree completions at California universities. The Forum categorized employer demand data by occupation codes (ONET codes) from the U.S. Department of Labor. The Forum identified a corresponding Classification of Instructional Program code (CIP code) for each ONET code to calculate the number of relevant bachelor's degree completions for each engineering discipline.

Classification of Instructional Program Code and Occupation Code

National Center for Education Statistics, U.S. Department of Labor

CIP Code	ONET Code
Aerospace Engineering	Aerospace engineers
Agricultural Engineering	Agricultural engineers
Biomedical Engineering	Biomedical engineers
Chemical Engineering	Chemical engineers
Civil Engineering	Civil engineers
Computer Engineering	Computer hardware engineers
Electrical Engineering	Electrical engineers
	Electronics engineers
Environmental Engineering	Environmental engineers
Mechanical Engineering	Mechanical engineers
Software Engineering	Computer programmers
	Software developers, applications
	Software developers, systems software
Industrial and Systems Engineering	Health and safety engineers
	Industrial engineers
Mining Engineering	Mining and geological engineers
Nuclear Engineering	Nuclear engineers
Petroleum Engineering	Petroleum engineers
Materials Engineering	Materials engineers
Marine Engineering and Naval Architecture	Marine Engineers and Naval Architects

Sources

- Burning Glass Labor/Insight™
- U.S. Department of Labor occupational data
- Integrated Postsecondary Education Data System

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2) Demand for Engineering Bachelor's Degree Programs

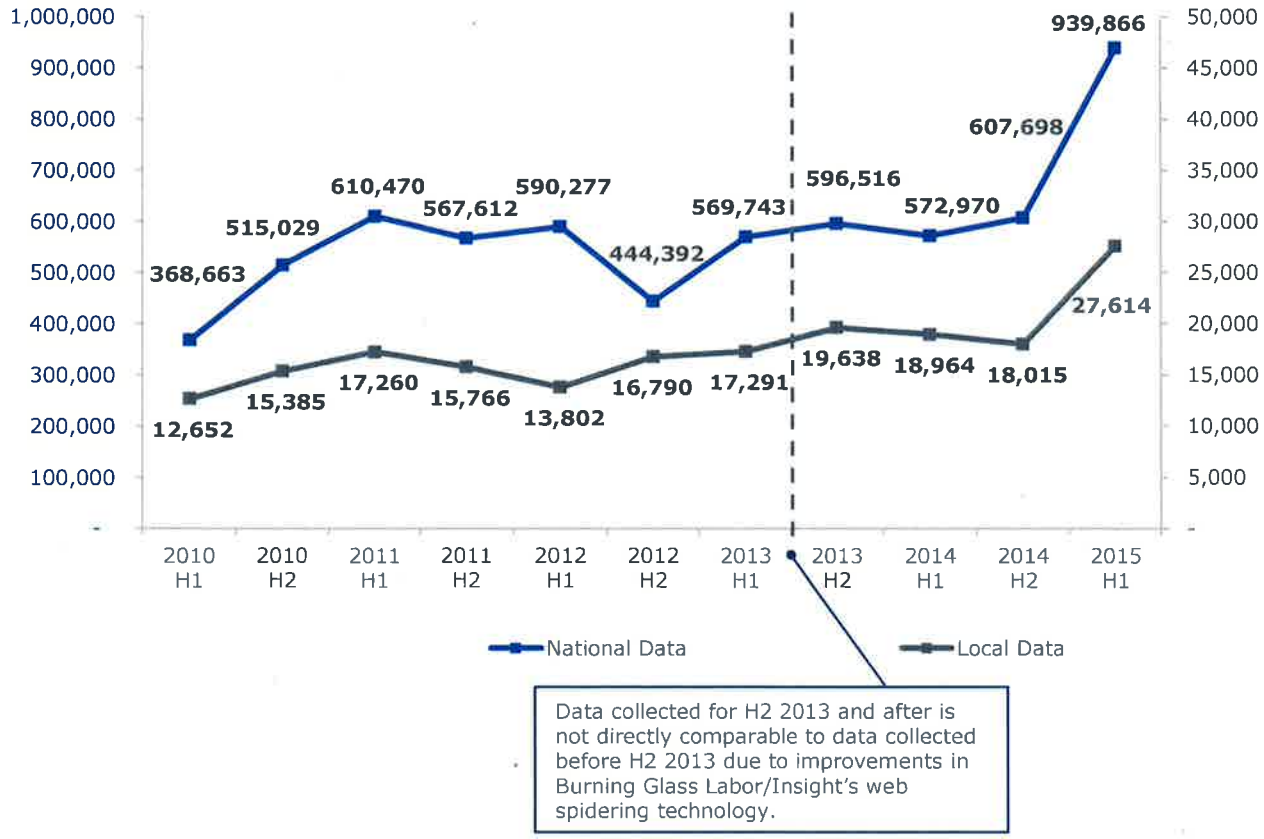
Employer Demand Trends

Bachelor's Degrees in Engineering Offer Students Positive Employment Outlooks

Employers increasingly sought graduates of bachelor's-level engineering programs from 2010 through 2015. Local employer demand increased 40 percent from the second half of 2013 to the first half of 2015. National employer demand increased even more dramatically, at 58 percent.

Engineering-Related Job Postings

January 2010 to June 2015, Bachelor's Degree Required, National and Local Data[3]



The Bureau of Labor Statistics (BLS) projects architecture and engineering occupations will experience a 7.3 percent growth in employment between 2012 and 2022. The value of a bachelor's degree will increase, as more than 90 percent of new architectural and engineering occupations during this period will require a bachelor's degree. Architectural and engineering occupations, however, will experience a slower growth than employment overall (with 10.8 percent growth projected).[4]

3) Burning-Glass Labor/Insight™.

4) http://www.bls.gov/opub/mlr/2013/article/occupational-employment-projections-to-2022.htm

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3) Selection of Immediate Program Offerings

Immediate Program Opportunities

Programs in Software Engineering, Electrical Engineering, and Mechanical Engineering Indicate the Best Immediate Opportunities for California State University-San Marcos

The best engineering program opportunities for **California State University-San Marcos** exhibit the lowest risks to implement. Immediate program opportunities:

- Draw upon a large number of existing courses and require the least amount of faculty course development,
- Experience ample employer demand (i.e., large numbers of job postings and higher-than-average job growth), and
- Face low competition, relative to employer demand.

Throughout the US, the ratio of job seekers to open jobs is two-to-one. The highlighted programs below provide far more favorable employment outcomes to students. In each case, the number of local job postings outpaces the number of qualified graduates statewide. The analysis considers statewide completion rates to account for candidate relocation upon graduation. Local employer demand data removes the Los Angeles, San Francisco, and San Jose metropolitan areas, which may differ in demand.

The Forum initially analyzed the number of relevant associate's degree programs to identify potential sources for student recruitment. However, contacts at profiled institutions observe most community college transfer students do not complete associate's degrees. Most transfer students complete general education requirements and lower-division math and science requirements for an engineering bachelor's degree. Individuals that complete associate's degrees typically pursue math or physics associate's degrees, rather than a specialized engineering associate's degree.

Immediate Undergraduate Engineering Program Opportunities for California State University-San Marcos[5]

Degree	Number of Job Postings	Number of Competitor Bachelor's Degree Completions	Number of Job Postings per Relevant Degree Completions	Projected Relevant Job Growth 2012 to 2022	Number of Relevant Existing Courses
1. Software Engineering	8,308	2,096*	4.0	24.2%	11
2. Electrical Engineering	1,649	1,717	1.0	6.9%	11
3. Mechanical Engineering	1,763	2,317	0.8	4.7%	8

*Total includes computer science and computer software engineering bachelor's degrees

5) See Appendix E for definitions of table variables.

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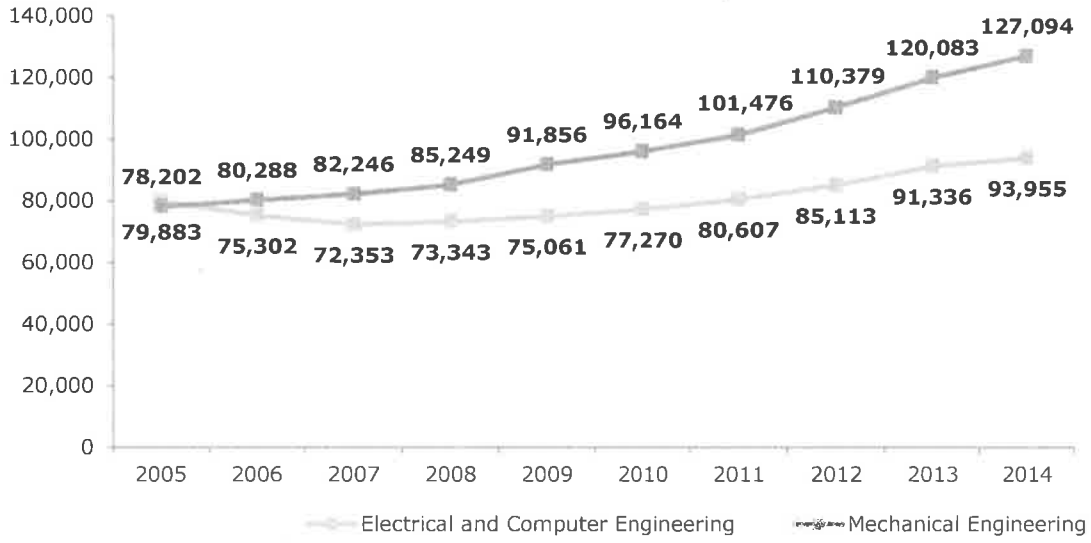
Develop Mechanical and Electrical Engineering Bachelor's Degree Programs to Attract a Sustainable Audience

In addition to offering students a positive employment outlook, mechanical and electrical engineering curricula are the foundation of many other engineering specializations, like aerospace engineering and computer engineering. Prioritizing mechanical and electrical engineering programs will help ensure **California State University-San Marcos** is best positioned to expand its engineering portfolio in the years to come.

Local employers indicate high demand for mechanical and electrical engineers relative to the number of mechanical and electrical engineering bachelor's degree completions in the state of California. Mechanical engineering and electrical engineering bachelor's degree programs attract the highest engineering student enrollments nationwide. According to the American Society for Engineering Education, electrical and computer engineering and mechanical engineering students compose 16.5 and 22.3 percent of all undergraduate-level engineering enrollments, respectively. Mechanical engineering undergraduate enrollments increased 62.5 percent from 2005 to 2014, and electrical and computer engineering undergraduate enrollments grew 17.6 percent.

Electrical and Computer Engineering and Mechanical Engineering Bachelor's Degree Program Enrollments

American Society for Engineering Education, 2005 to 2014, National Data

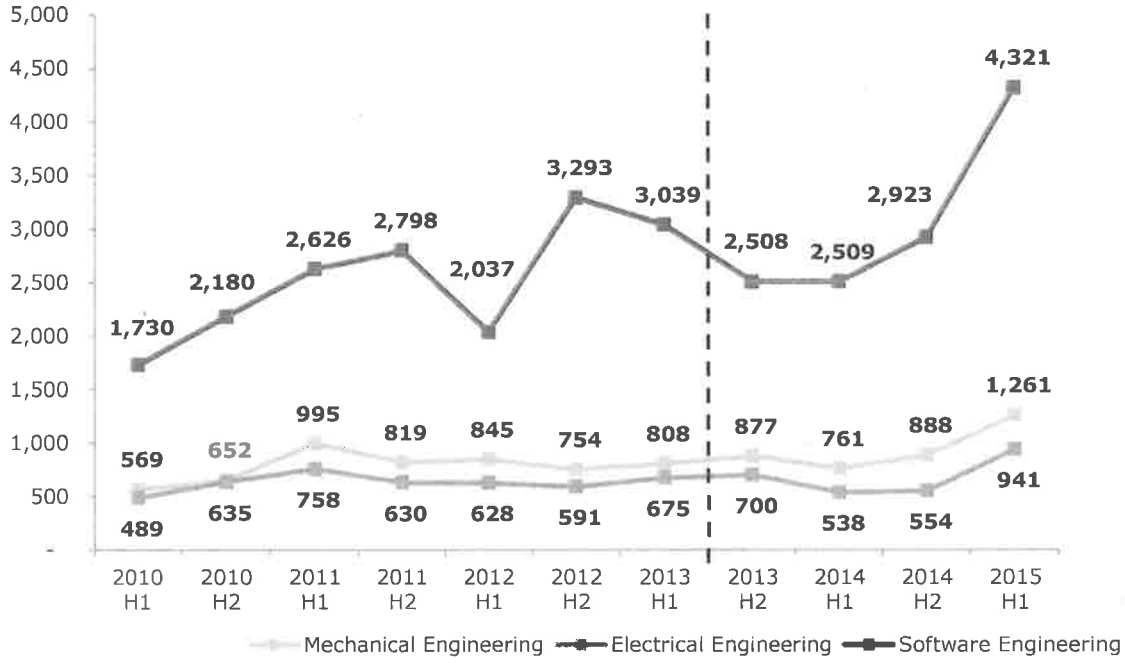


Local Employers Indicate Increasing Demand for Mechanical, Electrical, and Software Engineers

Employer demand for mechanical, electrical, and software engineers may surpass the enrollment capacity of existing degree programs, particularly the capacity of impacted (i.e., selective and enrollment-limited) degree programs. Local employer demand for software engineering-related positions increased 72.3 percent from July 2013 to June 2015. Employer demand for mechanical engineers and electrical engineers increased 43.8 percent and 34.4 percent from July 2013 to June 2015, respectively.

Mechanical, Electrical, and Software Engineering-Related Job Postings

January 2010 to June 2015, Bachelor's Degree Required, Local Data[6]



6) Burning-Glass Labor/Insight™.

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Future Program Opportunities

Develop Computer and Aerospace Engineering Bachelor's Degree Programs to Share Resources with Existing Electrical and Mechanical Engineering Degree Programs

After the development of immediate program opportunities, administrators at **California State University-San Marcos** should expand undergraduate engineering offerings in two stages. First stage program expansion opportunities build upon coursework from immediate program opportunities.

Profiled institutions often include aerospace engineering bachelor's degree programs within mechanical engineering departments and computer engineering bachelor's degree programs within computer science or electrical engineering departments. Institutions with existing mechanical and electrical engineering bachelor's degree programs could relatively easily expand offerings to include aerospace and computer engineering bachelor's degree programs. Mechanical engineering serves as the foundation for aerospace engineering degrees, while electrical engineering and computer science serve as the foundation for computer engineering degrees. For example, aerospace engineering bachelor's degree programs share several upper division courses with mechanical engineering bachelor's degree programs. Aerospace engineering requires specialized mechanical engineering coursework related to flight mechanics and aerodynamics. Computer engineering focuses on the development and design of computer hardware, which requires knowledge of circuits, electronics, and computer architecture.

Due to the high degree of overlap between mechanical engineering and aerospace engineering training and electrical engineering and computer engineering training, program graduates may also qualify for similar jobs. The Forum's initial analysis indicated a low number of local job postings relative to California degree completions for computer engineers and aerospace engineers. However, graduates of aerospace engineering bachelor's degree programs may work in positions classified as mechanical engineering, while graduates of computer engineering bachelor's degree programs may work in positions classified as electrical or electronics engineering.

First Stage Undergraduate Engineering Program Expansion Opportunities for California State University-San Marcos

Degree	Number of Job Postings	Number of Competitor Bachelor's Degree Completions	Number of Job Postings per Relevant Degree Completions	Projected Relevant Job Growth 2012 to 2022	Number Relevant Existing Courses
4. Computer Engineering	203	682	0.3	14.3%	11
5. Aerospace Engineering	94	450	0.2	18.5%	7

Industrial and Systems Engineering, Civil Engineering, and Environmental Engineering Offer Opportunities for Second Stage Engineering Program Expansion

Second stage program expansion opportunities do not align with immediate or fist stage program expansion opportunities. Instead, second stage program opportunities will expand the breadth of undergraduate engineering offerings at **California State University-San Marcos**. Second stage program expansion opportunities indicate high rates of projected employment growth and low or moderate market saturation. After successful development of immediate opportunities and first stage program expansion opportunities, the University will offer a broader catalog of engineering coursework and expertise. Local community colleges may also begin preparing students for more engineering-related bachelor's degrees after demonstrated engineering program success.

Second Stage Undergraduate Engineering Program Expansion Opportunities for California State University-San Marcos

Degree	Number of Job Postings	Number of Competitor Bachelor's Degree Completions	Number of Job Postings per Relevant Degree Completions	Projected Relevant Job Growth 2012 to 2022	Number Relevant Existing Courses
6. Industrial and Systems Engineering	602	201	3.0	8.5%	7
7. Civil Engineering	1,160	1,994	0.6	18.3%	8
8. Environmental Engineering	227	192	1.2	24.7%	8

Unsupported Programs

Do Not Pursue Program Development in Engineering Specializations with Low Employer Demand and Limited Compatibility with Current Resources

The Forum excluded certain engineering specialties from its recommendations due to:

- Low employer demand,
- Low projected job growth,
- Limited compatibility with current course offerings at **California State University-San Marcos**, or
- A combination of those factors.

For instance, the Forum does not recommend the University open a program in marine engineering and naval architecture despite a 144 percent increase in local employer demand for marine engineers. Local employers only posted 14 jobs in marine engineering and naval architecture last year, and marine engineering requires a high level of technical expertise incompatible with current course offerings with California State University-San Marcos. The Forum excluded other highly specified and technical engineering specialties (e.g., petroleum engineering, nuclear engineering) due to low overall employer demand and a lack of relevant existing courses.

Undergraduate Engineering Program Opportunities to Avoid

Degree	Number of Job Postings	Number of Competitor Bachelor's Degree Completions	Number of Job Postings per Relevant Degree Completions	Projected Relevant Job Growth 2012 to 2022	Number Relevant Existing Courses
7. Materials Engineering	104	93	1.1	3.7%	7
8. Chemical Engineering	233	657	0.4	21.7%	9
9. Marine Engineering and Naval Architecture	14	0	Undefined (divided by zero)	Unavailable	7
10. Biomedical Engineering	12	847	0	42.6%	10
11. Agricultural Engineering	0	24	0	Unavailable	8
12. Petroleum Engineering	7	0	Undefined (divided by zero)	13.0%	3
13. Nuclear Engineering	5	13	0.4	20.0%	6
14. Mining Engineering	0	0	Undefined (divided by zero)	Unavailable	7

4) Regional Bachelor's Engineering Program Competition

Competitor Offerings

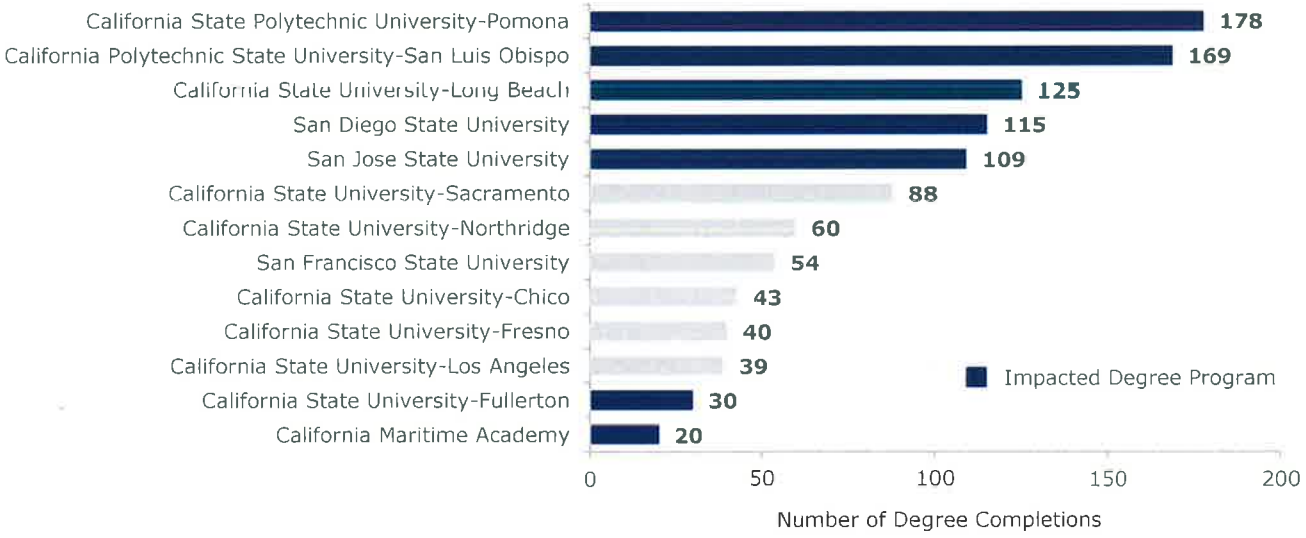
Frequency of Impacted Engineering Programs in the CSU System Suggests Unmet Student Demand for Engineering

Many competitor institutions in the **California State University System** offer mechanical and electrical engineering bachelor's degree programs, which potentially indicate market saturation. However, many institutions operate impacted mechanical and electrical engineering bachelor's degree programs, in which administrators limit the number of students admitted to each degree program. In these cases, admission to the university does not guarantee admission to the engineering program. Aspiring engineering majors must meet additional requirements or undergo a separate application process to apply.

A high number of impacted mechanical and electrical engineering bachelor's degree programs indicate excess student demand in the state of California. Local competitors, **San Diego State University** and **California State University-Fullerton**, operate impacted (i.e., selective and enrollment-limited) mechanical and electrical engineering bachelor's degree programs. Only **California Polytechnic State University-San Luis Obispo** and **San Jose State University** offer software engineering bachelor's degree programs in the state of California. Administrators at both institutions operate impacted software engineering bachelor's degree programs, which also indicate excess student demand.

Number of Mechanical Engineering Bachelor's Degree Completions

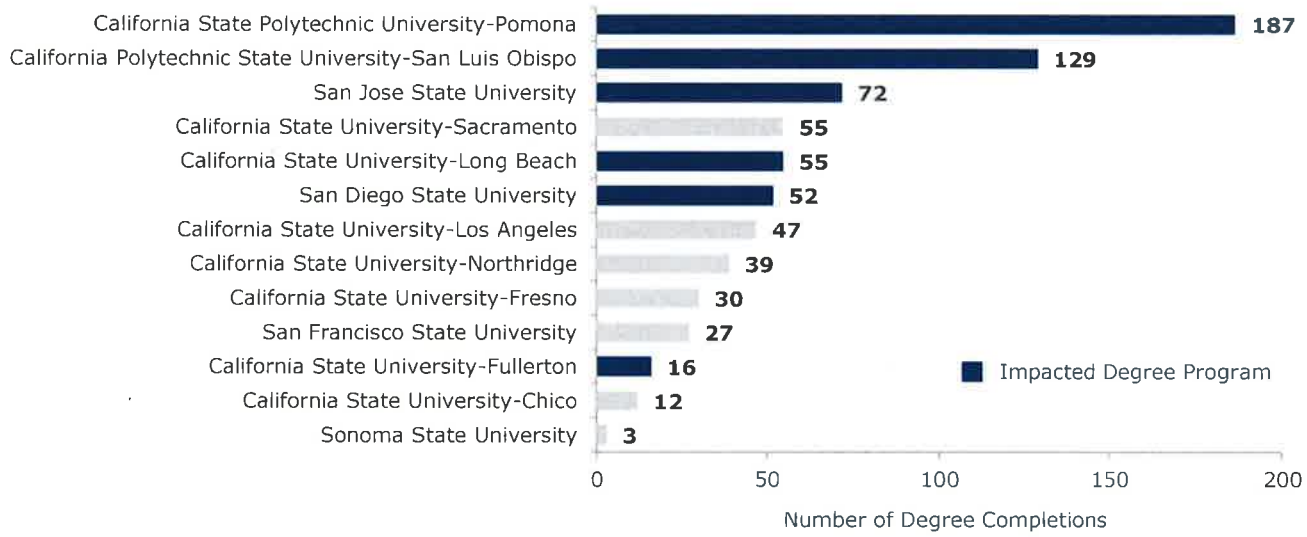
2013 Academic Year, California State University System[7]



7) Integrated Postsecondary Education Data System.

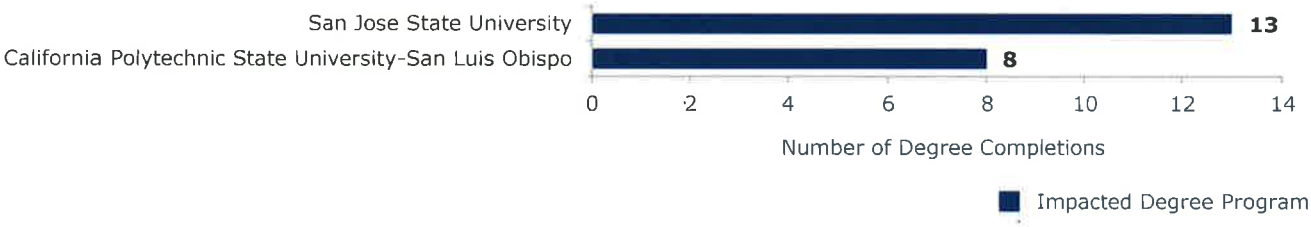
Number of Electrical Engineering Bachelor's Degree Completions

2013 Academic Year, California State University System[8]



Number of Software Engineering Bachelor's Degree Completions

2013 Academic Year, California State University System[9]



8) Integrated Postsecondary Education Data System.

9) Integrated Postsecondary Education Data System.

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Section III: Engineering Program Foundations

1) Research Methodology

Purpose

Review aspects of undergraduate engineering programs that exist across all engineering disciplines (e.g., a core curriculum). This section includes no discipline-specific recommendations.

Sources

- Interviews with directors of comparable undergraduate engineering programs
- Secondary programmatic research

2) Academic Program Design

Core Curriculum

Require All Engineering Students to Complete a Core Curriculum of Fundamental Calculus and Physics

All engineering programs require multiple levels of calculus and physics. These courses provide students the quantitative skills needed to succeed in upper-level and specialty-focused engineering courses. Beyond these requirements, institutional perspectives on core curricula differ. Some programs keep core requirements to a minimum to give students a better ability to personalize their engineering experiences; others expand core requirements with the goal of producing well-rounded graduates.

Sample Core Engineering Curriculum
California State University-Long Beach

- ENGR 101: Intro to the Engineering Profession
- ENGR 102: Academic Success Skills
- MATH 122: Calculus I
- MATH 123: Calculus II
- MATH 224: Calculus III
- PHYS 151: Mechanics & Heat

California State University-San Marcos already offers most of these courses through the math and physics departments, meaning the University could begin the engineering core curriculum with minimal additional investment. Community colleges also offer core coursework in math and less commonly in engineering, enabling students to begin coursework and then transfer to the University.

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Include Liberal Arts Courses in the Engineering Core Curriculum to Produce Well-Rounded Graduates Prepared for Employment in the San Marcos Region

Administrators at **California State University-San Marcos** should build communication-based assignments and courses into the engineering core curriculum to ensure graduates can find jobs in the area. Local employers emphasize the importance of clear communication, particularly in writing.

Employers Value Soft Skills

Contacts at **Thermo Fisher Scientific** report, "When we recruit, we always have a very deep technical interview including a technical test. But the other soft skills and team skills are equally important. We're looking for people who can work in a very agile work environment."

The **University of San Diego** offers undergraduate degrees in three areas of engineering: electrical engineering, industrial and systems engineering, and mechanical engineering. All students in the University's undergraduate engineering programs complete a dual Bachelor of Science and Bachelor of Arts (BS/BA) degree. In addition to the University's core liberal arts requirements, all engineering students complete an engineering core curriculum and an engineering professional practice curriculum. Administrators note the twofold benefits of this system:

1. Students may explore engineering for 1.5 to 2 years (the time needed to complete the core curricula) before they choose a technical specialty (e.g., mechanical engineering). This ensures students choose the specialty most likely to keep them engaged throughout the final two years of undergraduate education.
2. Engineering graduates leave the University as well-rounded future professionals, because they spend a significant amount of time in liberal arts courses. Students understand their engineering discipline in the context of the wider world.

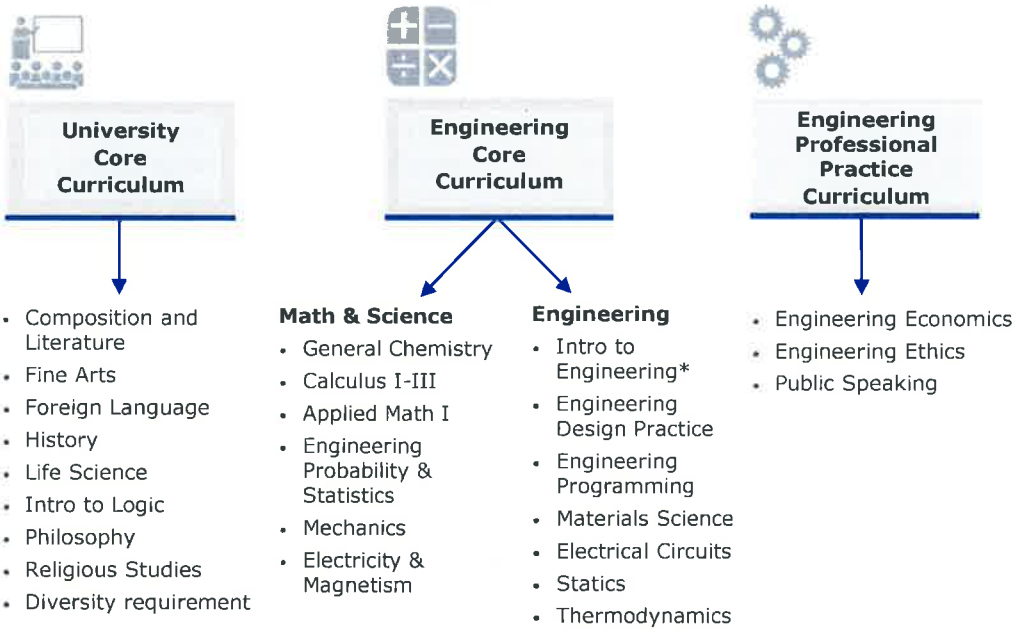
Employers Seek Engineering Professionals with Good Writing Skills

Contacts at **General Atomics** list basic writing skills among the qualifications entry-level engineering candidates often lack. Include writing-intensive courses and assignments in the engineering program at **California State University-San Marcos** to best prepare graduates for employment.

Administrators built the engineering program to include liberal arts courses due to the University of San Diego's reputation as a strong liberal arts institution. Contacts report the dual BS/BA program's popularity among students and employers.

Dual BS/BA Core Requirements for Engineering Students

University of San Diego



*The University now accepts certain military training in place of this course, after administrators noticed an increase in the number of veterans applying to the engineering program.

Delivery Format

Deliver the Undergraduate Engineering Program Face-to-Face to Provide Students Practical Experience

Administrators frequently cite the applied nature of an engineering degree to explain faculty resistance to online delivery. Engineering courses involve not only hands-on lab experience, but professors also report classes often complete problem sets and other work during course sessions. This format would be difficult to replicate in an online delivery format.

When asked what courses could eventually transition to online delivery, multiple program directors replied that introductory and theoretical courses represent the best options for online delivery. These courses require fewer practical assignments and no lab time.

Employers Prefer Graduates of Face-to-Face Engineering Programs

Maintaining a face-to-face engineering program not only ensures students gain practical engineering experience, it also elevates the program's reputation. Because they value hands-on experience so highly, contacts at **Hunter Industries** report they would consider graduates of an online engineering program less qualified than graduates of a face-to-face program.

Alternate Delivery Format Profile: CUNY-Brooklyn College's 2+2 Coordinated Engineering Program

CUNY-Brooklyn College operates a 2+2 undergraduate program, meaning the College provides students an introductory engineering education before they transfer to other institutions to complete an engineering degree. The College has articulation agreements with three local universities (i.e., Polytechnic Institute of New York University, City College, and College of Staten Island). Articulation agreements ensure students can transfer all courses from the CUNY-Brooklyn College coordinated engineering curriculum to the program's partner universities (see CUNY-Brooklyn College's agreements with the Polytechnic Institute of New York University here).

Administrators note that the coordinated engineering curriculum also matches the first two years of study at most engineering schools throughout the country, and report students frequently matriculate to other universities (e.g., Stony Brook University, the University of Wisconsin, the University of Michigan, the University of Buffalo).

Contacts note the substantial difference in the program's tuition compared to traditional undergraduate engineering programs; a student at CUNY-Brooklyn College pays only $2,565 per semester. This adds up to significant long-term savings, especially given that many students at CUNY-Brooklyn College work while going to school and will therefore take longer than four years to earn a degree.

CUNY-Brooklyn College Coordinated Engineering Program Outcomes

100 percent of students who finish the coordinated engineering program go on to get a bachelor's degree in engineering.

In the last five years, two coordinated engineering students were valedictorian at the **Polytechnic Institute of New York University**.

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3) Practical Experience

Importance

Encourage Students to Participate in Engineering-Related Extracurricular Activities to Gain Skills and Experience

Practical experiences at the undergraduate level offer participants a variety of benefits, from leadership to hands-on projects to employer networking. While some employers rank technical skills gained in the classroom over practical experiences, others specifically seek candidates with hands-on experience. Give students the option to apply lessons learned in their engineering classes to real world situations to prepare them for success in the engineering workforce.

Extracurricular Activities

Start Branches of National Engineering Clubs and Societies to Tap Existing Networks

Contacts report engineering students frequently participate in engineering-related extracurricular activities. These include active campus chapters of national societies, university-specific clubs (e.g., a general engineering club that brings in speakers and arranges field trips), and competitive teams (e.g., formula racing teams, programming teams). Sample engineering societies at profiled institutions include:

- National Society of Black Engineers
- Engineers Without Borders
- Society for Women Engineers

California State University-San Marcos should prioritize the creation of chapters of existing, national engineering societies and clubs over campus clubs. Existing organizations have infrastructures that can help students and faculty as the undergraduate program develops (e.g., scholarships for minority groups, networking opportunities, active email list-serves).

Internships

Develop an Internship Program to Promote Hands-On Experience among Undergraduate Students

Internships represent a good way for students to gain practical experience and network with potential future employers. Many profiled institutions help students find internships through a centralized career center within the school of engineering rather than through specific engineering departments. This format works particularly well in the San Marcos area, where many companies hire a variety of engineers (e.g., mechanical, electrical), because it gives employers a single point of contact.

Consider Student Demographics When Developing Practical Experience Requirements

Directors of programs that enroll working and part-time students note they do not require internship experience because students would not be able to maintain a schedule that includes work, school, and an internship.

The percentage of engineering students who participate in internships at the undergraduate level ranges from ten percent to over 50 percent. Many factors contribute to a student's ability to complete an internship, including the number of credits required for degree completion.

See Strengthening Internship Programs at Small Institutions for Internship program creation strategies relevant to small, new, or otherwise fast-growing programs.

4) External Program Considerations

Employer Partnerships

Offer Local Employers Multiple Avenues for Engagement in the Undergraduate Engineering Program

Administrators at California State University-San Marcos should engage local employers through a program advisory board. Contacts note the importance of advisory boards in keeping curricula relevant to industry needs. An advisory board also represents a low-resource commitment to help the University establish a good reputation with employers in the area. Employers in the San Marcos area contribute to local undergraduate engineering programs with both financial and in-kind support, though employers reserve most financial support for well-established programs. This makes the establishment of employer relationships highly important for a new engineering program.

Undergraduate engineering programs can build employer relationships over time by allowing employers to engage at different levels of commitment. Commitments range from employer-hosted field trips to established internship programs.

Companies tailor program support according to their priorities. Contacts at **Hunter Industries**, for example, stress the importance of applied experience at the undergraduate level. Accordingly, the company sponsors a formula racing team at the **University of California-San Diego** that builds and competes with a formula race car. Contacts at Hunter Industries note an applied engineering experience like participation in a formula racing team sets entry-level engineering candidates apart from those with only classroom and lab experience.

Employers Guide Hands-On Design Projects

Administrators at the **University of San Diego** require all engineering students to complete a capstone design project. Local employers have the option to submit ideas for teams' design projects. If a team chooses that project, the school pays the employer a small fee and employees guide the student design team throughout the two-semester project.

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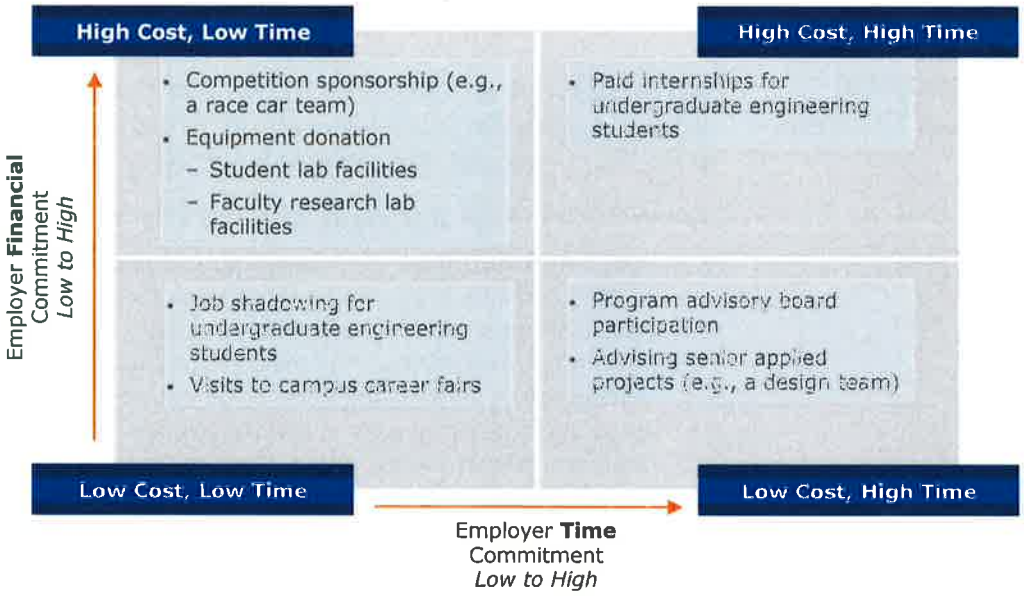
Employer Support for Undergraduate Engineering Programs



5) Program Evaluation

Methods to Assess Success

Administrators Assess Program Success through the ABET Accreditation Renewal Process and Program Advisory Board Member Feedback

Administrators gauge program success according to three metrics:

1. **ABET Accreditation**: The Accreditation Board for Engineering and Technology (ABET) assesses programs every three to six years to maintain accreditation. Administrators consider renewed accreditation an indicator of program success, and employers consider it an indicator of program quality. ABET accreditation renewal often involves granular "direct course assessments" that allow program directors to determine the successful courses within a given engineering program. "Direct course assessments" refer to specific student assignments or exams sampled by program administrators to assess student learning outcomes throughout a course.
2. **Advisory Board Input**: Administrators employ industry advisory boards to keep curriculum as up-to-date as possible. Though ABET reviews undergraduate engineering programs every three to six years, advisory boards meet much more frequently. Some administrators report curriculum revisions on a yearly basis.
3. **Student Employment Outcomes**: Contacts administer alumni surveys to determine graduate outcomes and measure program success. Contacts report a range of graduate employment from 50 percent to 95 percent. Some administrators segment employment data by students employed within three, six, and 12 months after graduation, while others only survey students after one year.

Student Surveys Receive Low Response Rates

ABET no longer considers employment rates in the accreditation renewal process due to unreliable data and low student survey response rates.

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Section IV: Concentrations for Immediate Launch

1) Research Methodology

Purpose

Review discipline-specific recommendations and profiles program characteristics. This section uses qualitative recommendations and observations collected from research interviews, as well as secondary research from competitor program websites. Qualitative findings inform aspects of program design, such as curriculum development, faculty requirements, and lab requirements. The Forum coupled the qualitative data with quantitative data collected from the Burning Glass Labor/Insight™ tool and the Integrated Postsecondary Education Data System to identify local and state-wide employer needs and identify potential community college and employer partnerships for **California State University-San Marcos**. Local data refers to the counties in California State University-San Marcos' service area, Orange County, Riverside County, and San Diego County.

Sources

- Interviews with competitor institutions, local employers, and community colleges
- Competitor program websites
- Integrated Postsecondary Education Data System
- Burning Glass Labor/Insight™

2) Software Engineering

Curriculum Design

Software Engineering Bachelor's Degree Programs Confer Software Design, Development, and Deployment Skills

Although software engineering, computer science, and computer engineering bachelor's degree programs often share courses and include similar course content, each discipline maintains a distinct focus.

- **Software engineering** bachelor's degree programs focus on software design and project management
- **Computer science** bachelor's degree programs focus on programming, formal language, and computability theory
- **Computer engineering** bachelor's degree programs focus on computer hardware and circuit design

Software engineering bachelor's degree programs overlap heavily with computer science bachelor's degree programs in content areas such as programming, systems software, and algorithms. Computer science and software engineering bachelor's degree programs also overlap slightly with computer engineering bachelor's degree programs, in topics such as computer architecture and systems programming. However, computer engineering bachelor's degree programs overlap most heavily with electrical engineering bachelor's degree programs, due to the emphasis on hardware and circuit design.

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Develop a Software Engineering Bachelor's Degree Program Based on Lower-Division Computer Science Courses

Administrators at **California State University-San Marcos** could develop a software engineering bachelor's degree program with few additional courses. Software engineering bachelor's degree programs share all lower-division courses and several upper-division courses with computer science bachelor's degree programs. Software engineering students may require additional course sections, but the University will benefit from existing courses and curricula during that expansion. A software engineering bachelor's degree program would attract students interested in software engineering who do not seek a computer science degree. Growing employer demand for software engineers specifically highlights a growing need for these specialized employees.

Additional Course Requirements for a Software Engineering Bachelor's Degree Program

California Polytechnic State University-San Luis Obispo

Course Title	Course Level
Individual Software Design and Development	300
Software Construction	400
Software Deployment	400
Software Engineering II	300
Software Requirements Engineering	400
User-Centered Interface Design and Development	400

Shared Course Requirements between Software Engineering and Computer Science Bachelor's Degree Programs

California Polytechnic State University-San Luis Obispo

Course Title	Course Level
Design and Analysis of Algorithms	300
Discrete Structures	300
Fundamentals of Computer Science I	100
Fundamentals of Computer Science II	100
Fundamentals of Computer Science III	100
Introduction to Computer Organization	200
Introduction to Computing	100
Professional Responsibilities	300
Programming Languages I	400
Senior Project Lab I	400
Senior Project Lab II	400
Software Engineering I	300
Systems Programming	300

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Maintain the Same Support and Lower-Division Course Requirements for Software Engineering and Computer Science Bachelor's Degree Programs

Software engineering and computer science bachelor's degree program curricula at profiled institutions require the same support and lower-division courses. Administrators at **California State University-San Marcos** should maintain the same support and lower-division courses for a new software engineering bachelor's degree program as the existing computer science bachelor's degree program. Administrators should add Calculus with Applications, III to the support course requirements, as profiled software engineering bachelor's degree program curricula require Calculus I through III. Administrators may also include some upper-division computer science courses in a software engineering bachelor's degree program curriculum, such as data structures, computer architecture, and programming languages.

Existing Core Courses

Course Title	Course Number
Computer Science I	CS 111
Computer Science II	CS 211
Assembly and Digital Circuits	CS 231
Data Structures	CS 311
Computer Architecture	CS 331
Programming Languages	CS 351
Software Engineering	CS 441

Existing Support Courses

Course Title	Course Number
Calculus with Applications, I	MATH 160
Calculus with Applications, II	MATH 162
Calculus with Applications, III	MATH 260
Introduction to Statistics or **Introduction to Mathematical Probability and Statistics**	MATH 242 or MATH 440
Introduction to Linear Algebra or **Linear Algebra**	MATH 264 or MATH 374
Introduction to Discrete Mathematics or **Discrete Mathematics**	MATH 270 or MATH 370
Physics of Mechanics and Sound	PHYS 201
Physics of Electromagnetism and Optics	PHYS 202
Digital Electronics	PHYS 301

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Develop Courses that Confer Software Design and Project Management Skills to Prepare Program Graduates for Software Development Positions

Software engineering bachelor's degree programs confer computer science theory and practical software development techniques. Administrators at **California State University-San Marcos** should develop courses on software design, development, construction, and testing. Software engineers must possess project management skills in addition to programming skills. Administrators should develop a course in project management and a senior design project to prepare students for employment.

Additional Core Course Topics for Software Engineering Bachelor's Degree Programs

Profiled Competitor Curricula

Software Architecture and Design

- **Content:** best practices for software architecture, including architectural styles, design patterns, and design reuse. Students often complete projects to practice applications of software architecture techniques.
- **Sample Course:** Software Architecture

Software Engineering Project Management

- **Content:** team management skills for software development projects, such as project planning and tracking, process evaluation, risk management, and quality assurance.
- **Sample Course:** Software Engineering Process Management

Software Testing and Verification

- **Content:** concepts and methods to verify, validate, and test software systems, such as mathematical and statistical testing and reliability models.
- **Sample Course:** Software Verification, Validation, and Testing

Software Engineering Project

- **Content:** two semester team-based senior design project to design and implement a software project.
- **Sample Course:** Design Seminar for Software Engineers I and II

Require Senior Design Projects to Provide Practical Experience for Students Unable to Complete Internships

Employers seek program graduates with practical software development experience. Students often gain practical experience through internship programs and senior design projects. Computer science and computer engineering administrators at **California State University-Long Beach** observe low-income students often work part-time jobs while attending school and cannot complete internships. Additionally, non-traditional students work full-time and cannot complete internships. Senior design projects build practical experience into the curriculum and better prepare program graduates for employment.

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Confer C-Based Programming Language Skills in Software Engineering Bachelor's Degree Program Curricula

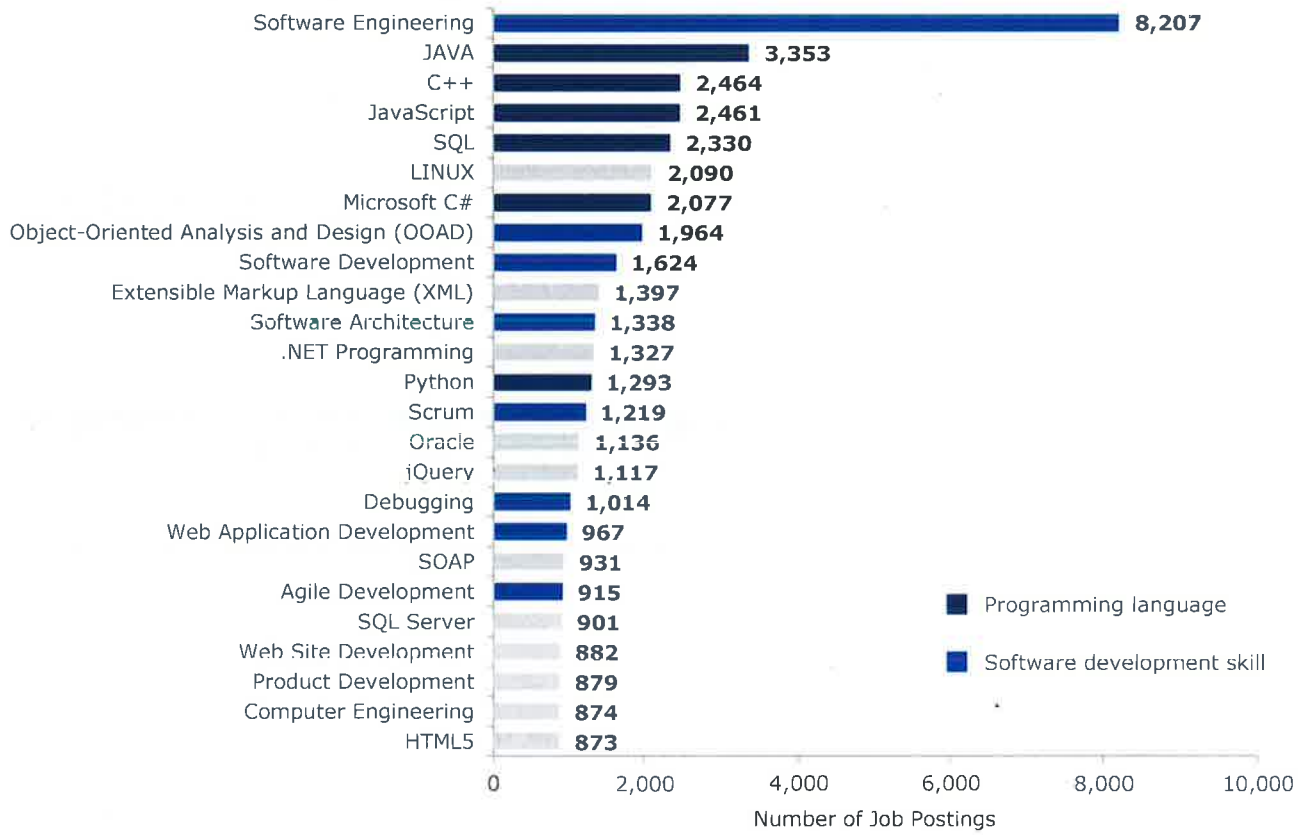
As expected, most local and state employers seek software engineering professionals with programming language and software development skills. The most commonly sought programming languages include C-based languages, such as 'JAVA,' 'C++,' and 'Microsoft C#.' Employers also seek software engineering professionals with knowledge of high-level programming languages, such as 'JavaScript' and 'Python.' High employer demand for 'SQL' also indicates a need for relational database management skills.

Software development skills with high local and state-wide employer demand include tasks from all stages of the software development process. For example, employers seek software engineering professionals with software design skills, such as 'software architecture,' as well as 'debugging' skills. Employers also seek professionals with knowledge of software development methodologies, such as 'Agile development' and 'Scrum.' Contacts at **Thermo Fisher Scientific** specifically name the Agile and Scrum development processes as desired skills for entry-level software engineers.

Top Skills for Software Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[10]

n=8,207 job postings, 232 unspecified postings



10) Burning-Glass Labor/Insight™.

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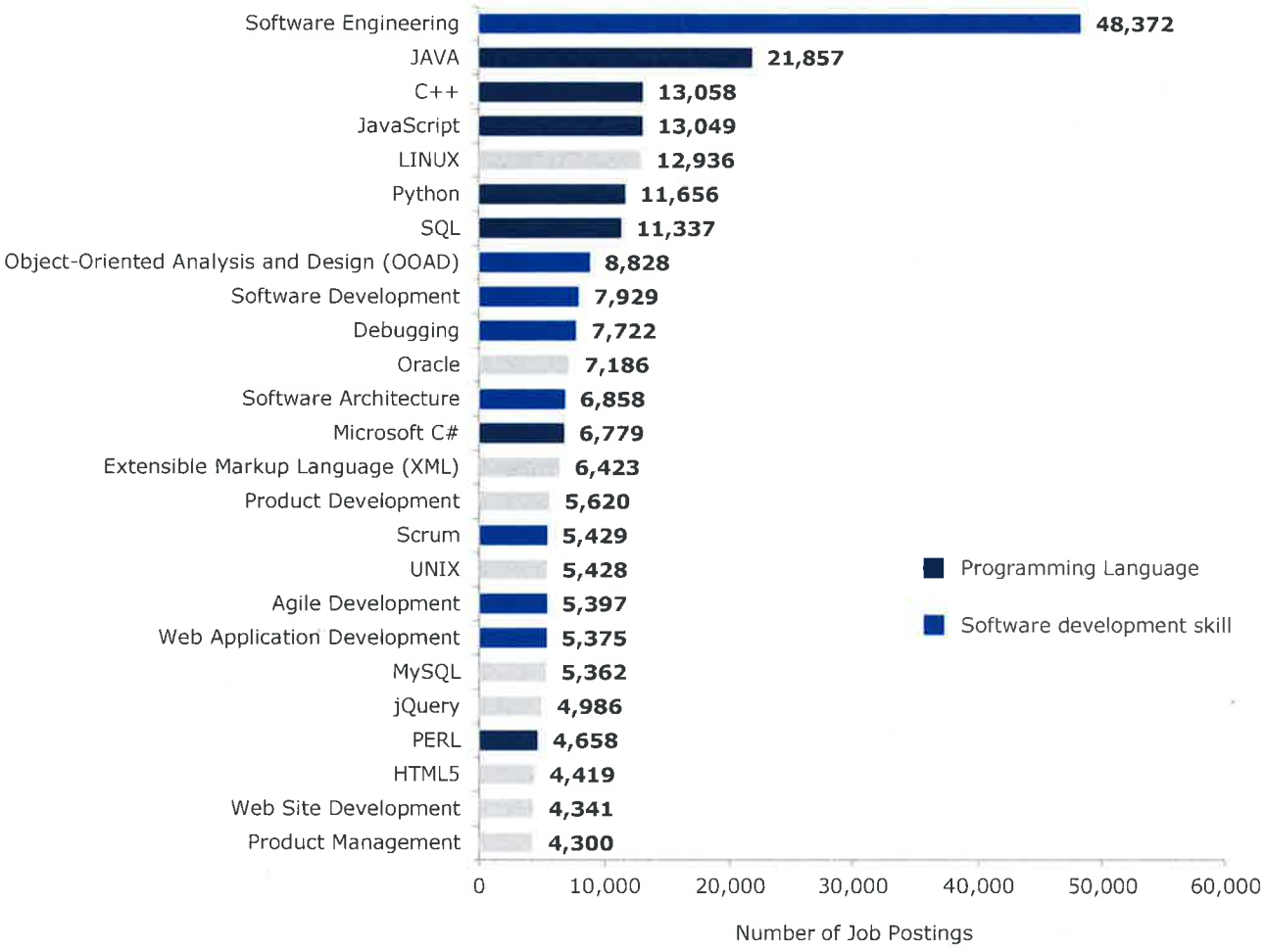
Top Skills for Software Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[11]

n=48,372 job postings, 1,020 unspecified postings



Employers Seek Cloud Computing Skills

Contacts at **Thermo Fisher Scientific** note software engineers with practical exposure to Amazon Web Services and experience with other aspects of modern cloud computing require less on-the-job training.

11) Burning-Glass Labor/Insight™.

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Software Engineering Bachelor's Degree Programs Often Share Computer Lab Space with Computer Science Bachelor's Degree Programs

Computer science and software engineering bachelor's degree programs require instructional computer labs equipped with programming and engineering software. **Monmouth University** operates two instructional labs shared by computer science and software engineering students. One lab contains 25 LINUX computers for programming-specific courses, such as Introduction to Computer Science I and II. The other instructional lab contains 17 Windows computers used for student research projects and .NET programming courses. Computer science and software engineering students may also complete assignments at ten computer labs available to all students.

Software Engineering Computer Labs Require Little Hardware besides Computers, Servers, Projectors, and Speakers

Computers labs at **California State University-Long Beach** possess 30 to 35 work stations. Work stations include a desktop computer, or a space for students to connect a laptop. Instructional labs may also require a projector and speakers for lectures. Administrators maintain desktop-based computer labs to ensure students do not need to purchase a laptop. Computer labs each require a maintenance staff member. Administrators at the **University of Wisconsin-Milwaukee** report lab equipment updates usually cost $20,000 to $30,000.

Students Pay a Lab Fee to Cover Maintenance Expenses in Addition to State Funding

Administrators at profiled institutions primarily rely on state funding to purchase and maintain lab equipment. Student lab fees and equipment donations from employers supplement state funding.

Software engineering computer labs used for embedded system design courses may require field programmable gate array (FPGA) development boards, a signal and function generator, and oscilloscopes. Software requirements often include integrated development environments, such as Microsoft Visual Studio and Eclipse IDE, to write code. Profiled institutions also often purchase licenses for Oracle database administration software and MATLAB.

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Software Engineering Lab Equipment

Boston University, Monmouth University

See Appendix B for software engineering lab hardware equipment cost estimates. The Forum was unable to estimate cost data for software licenses due to variable pricing based on the number of licenses and users.

Hardware

- **Computers**
- **Server (LINUX or UNIX)**
- **Projector**
- **Speakers**
- **Field programmable gate array (FPGA) development boards**
- **Signal and function generator**

Software Programs

- **Adobe Reader DC**
- **Altium 15.0**
- **Eclipse IDE**
- **Firefox ESR**
- **Google Chrome**
- **LaTex**
- **MATLAB/Simulink 2015a**
- **McAfee 8.8**
- **Microsoft Office 2013 with Visio & Project**
- **MobaXterm**
- **Modelsim SE**
- **Oracle**
- **Tex**
- **TI Code Composer Studio**
- **Visual Studio .NET 2013**
- **VMWare**
- **Xen**
- **Xilinx ISE Design Suite**

Profiled Computer Science Departments Require Four to 25 Tenure-Track Faculty Members

Administrators at **California State University-San Marcos** may need to hire fewer tenure-track faculty members for a software engineering bachelor's degree program than other engineering programs, due to existing faculty members in the computer science department; non-tenure track instructors could teach course sections not related to faculty member specialties. Profiled computer science and software engineering departments employ a median of 14 tenure-track faculty members and 10 non-tenure track instructors.

Administrators at **California State University-Long Beach** employ approximately 60 faculty members and instructors. Contacts report tenure-track faculty members earn $75,000 to $110,000 per year, while adjunct faculty members earn $40,000 to $70,000 per year. Tenure-track faculty members earn salaries and adjunct faculty members receive payment for each course taught. Administrators at the **University of Wisconsin-Milwaukee** pay adjunct faculty $5,000 to $6,000 per course based on educational attainment.

Most Computer Science and Software Engineering Faculty Members Possess PhDs in Computer Science

Computer science and software engineering faculty members without PhDs in computer science often possess PhDs in a related field, such as math or electrical engineering. Non-tenure track instructors often work in industry and possess master's degrees or PhDs.

Number of Computer Science and Software Engineering Bachelor's Degree Completions per Tenure-Track Faculty Member

In-State Institutions and Peer Institutions, Computer Science Departments, 2010 through 2013 Academic Years

Institution	Number of Tenure-Track Faculty Members	Number of Relevant Degree Completions from 2010 through 2013	Number of Relevant Degree Completions per Tenure-Track Faculty Member
California State Polytechnic University-Pomona	12	304	25.3
California State University-Long Beach	8	143	17.9
California State University-Fullerton	14	188	13.4
California Polytechnic State University-San Luis Obispo	24	295	12.3
San Diego State University	16	197	12.3
California State University-Chico	9	87	9.7
California State University-Northridge	21	202	9.6
The University of Tennessee-Martin	4	34	8.5
California State University-Sacramento	21	164	7.8
California State University-Bakersfield	8	61	7.6
California State University-Fresno	8	46	5.8
California State University-Los Angeles	25	75	3.0

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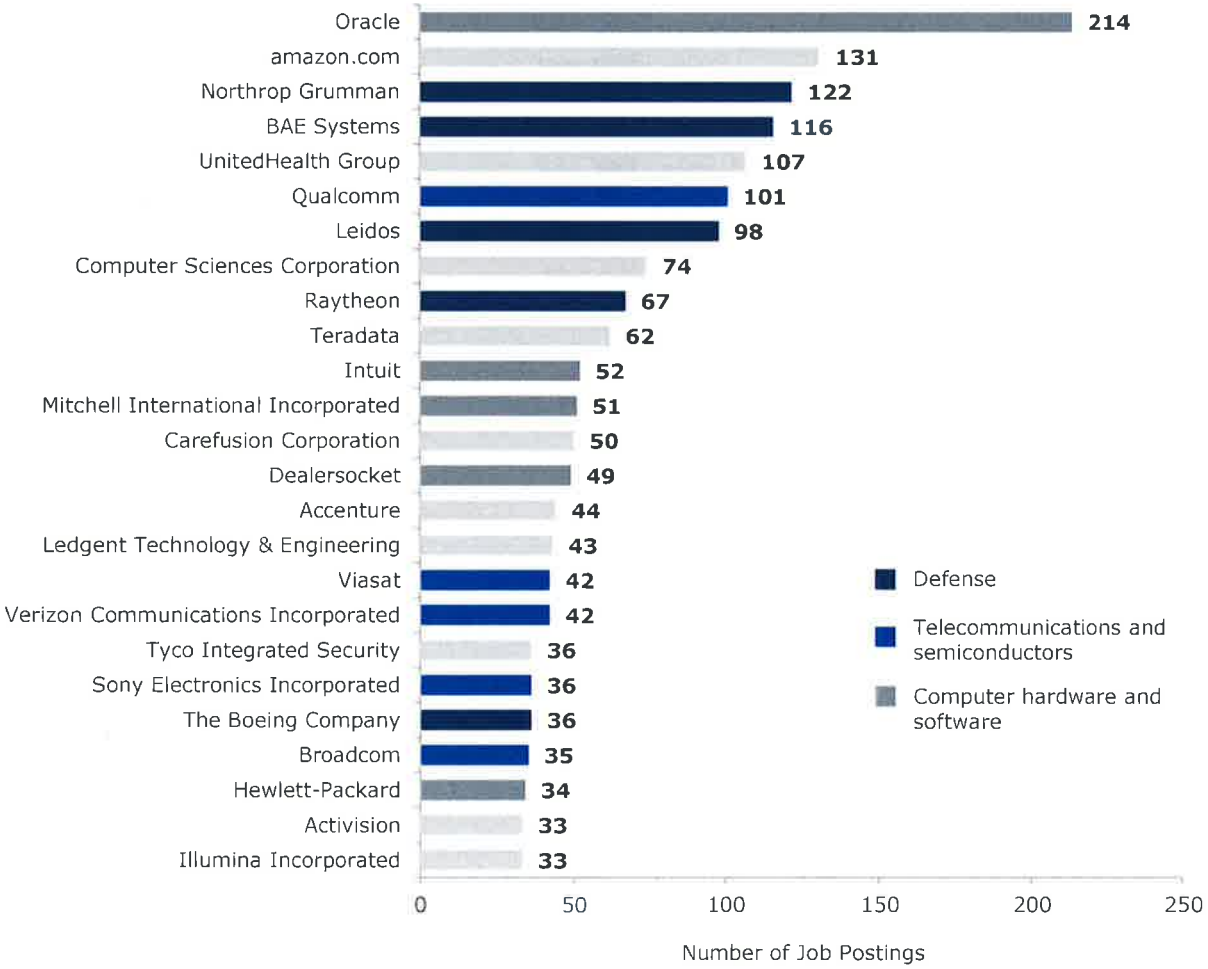
Local Employers of Software Engineers Work in the Defense, Telecommunications and Semiconductor, and Computer Hardware and Software Industries

Computer hardware and software manufacturers indicate the highest demand for software engineers in California; locally, defense contractors, telecommunications companies, and semiconductor manufacturers also indicate high demand for software engineers. Administrators at **California State University-San Marcos** should partner with organizations in the defense, telecommunications and semiconductor, and computer hardware and software industries based on local employer demand. Administrators should align program curricula with local industries to prepare students for internships and full-time employment. For example, offer elective courses on information security to prepare students for positions in the defense industry. Preparing students for positions in prominent local industries will improve program reputation among local organizations.

Top Employers of Software Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[12]

n=8,205 job postings, 2,939 unspecified postings



12) Burning-Glass Labor/Insight™.

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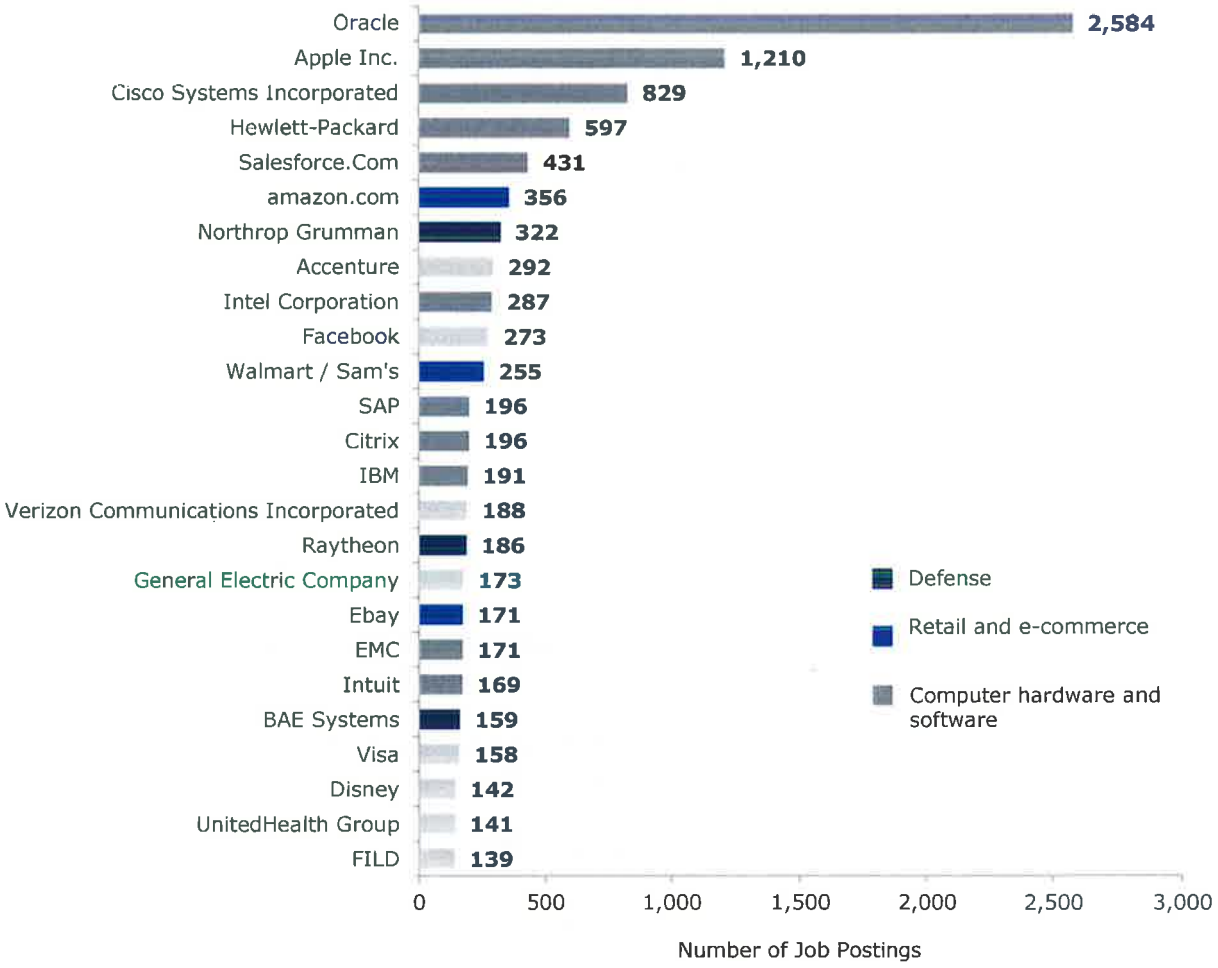
Top Employers of Software Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[13]

n=48,372 job postings, 15,209 unspecified postings



13) Burning-Glass Labor/Insight™.

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Recruit Graduates of Computer Science Associate's Degree Programs for Software Engineering Bachelor's Degree Programs

Computer science associate's degree core program curricula align closely with several lower-division and support courses for software engineering or computer science bachelor's degree programs. All core courses in the computer science associate's degree program at **Mt. San Jacinto College** align with support or lower-division courses in the computer science bachelor's degree program at **California State University-San Marcos**; a new software engineering bachelor's degree program would likely require the same support and lower-division courses as a computer science bachelor's degree program. The computer science associate's degree program also includes over 30 credit hours of general education courses, further preparing transfer students for a bachelor's degree program.

Sample Associate of Science Degree in Computer Science Core Program Curricula

Mt. San Jacinto College

Computer Science Associate's Degree Core Coursework
Analytic Geometry and Calculus I
Analytic Geometry and Calculus II
C++ Programming - Level 1
Computer Organization and Assembly Language
Discrete Structures
Electricity and Magnetism
Introduction to Data Structures and Algorithms
Mechanics and Wave Motion

Market Software Engineering Bachelor's Degree Programs to Students at Mt. San Jacinto College, Palomar College, and Southwestern College

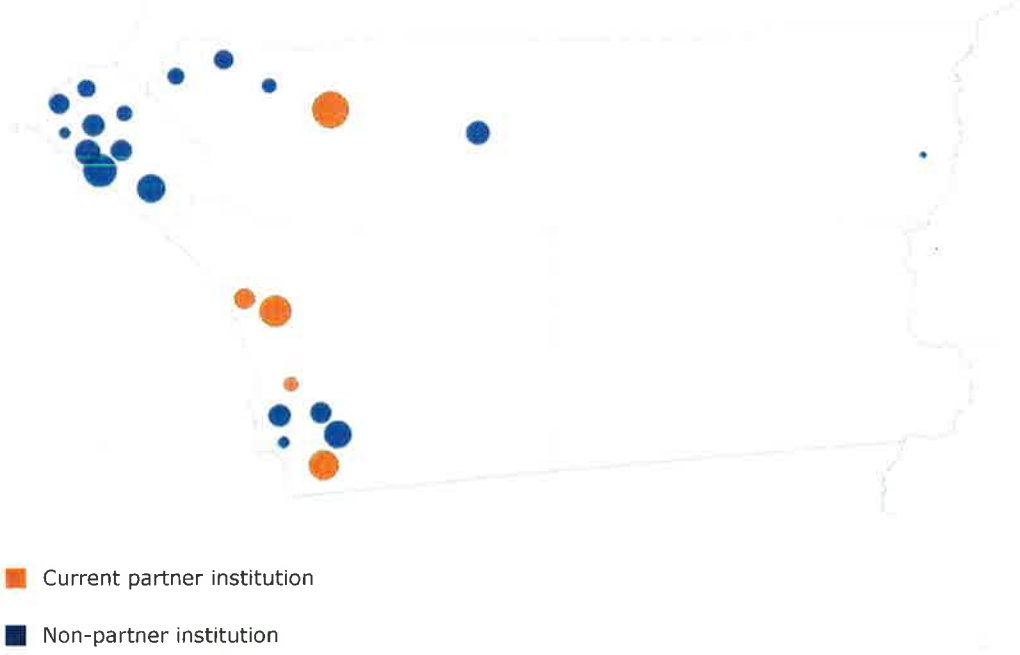
Mt. San Jacinto College conferred the most computer science associate's degrees in 2013 locally. Administrators at **California State University-San Marcos** should continue to recruit students from Mt. San Jacinto College for a new software engineering bachelor's degree program. Potential additional community college partners include **Coastline Community College**, **Saddleback College**, and **Cuyamaca College**. Prospective community college partners maintain high numbers of computer science associate's degree completions. Many community college transfer students do not complete an associate's degree, but complete the necessary prerequisites to transfer to a four-year institution; however, programs with high numbers of associate's degree completions also likely possess high course enrollments from non-degree seeking students.

Local Community Colleges Report Increasing Computer Science Enrollments

Contacts at **Mt. San Jacinto College** and **MiraCosta College** report significant enrollment increases in associate's-level computer science courses. Administrators at Mt. San Jacinto College note the all five of the institution's C++ courses have waitlists, and contacts at MiraCosta College note they have added sections recently to accommodate student demand for computer science courses.

Computer Science-Related Associate's Degree Completions

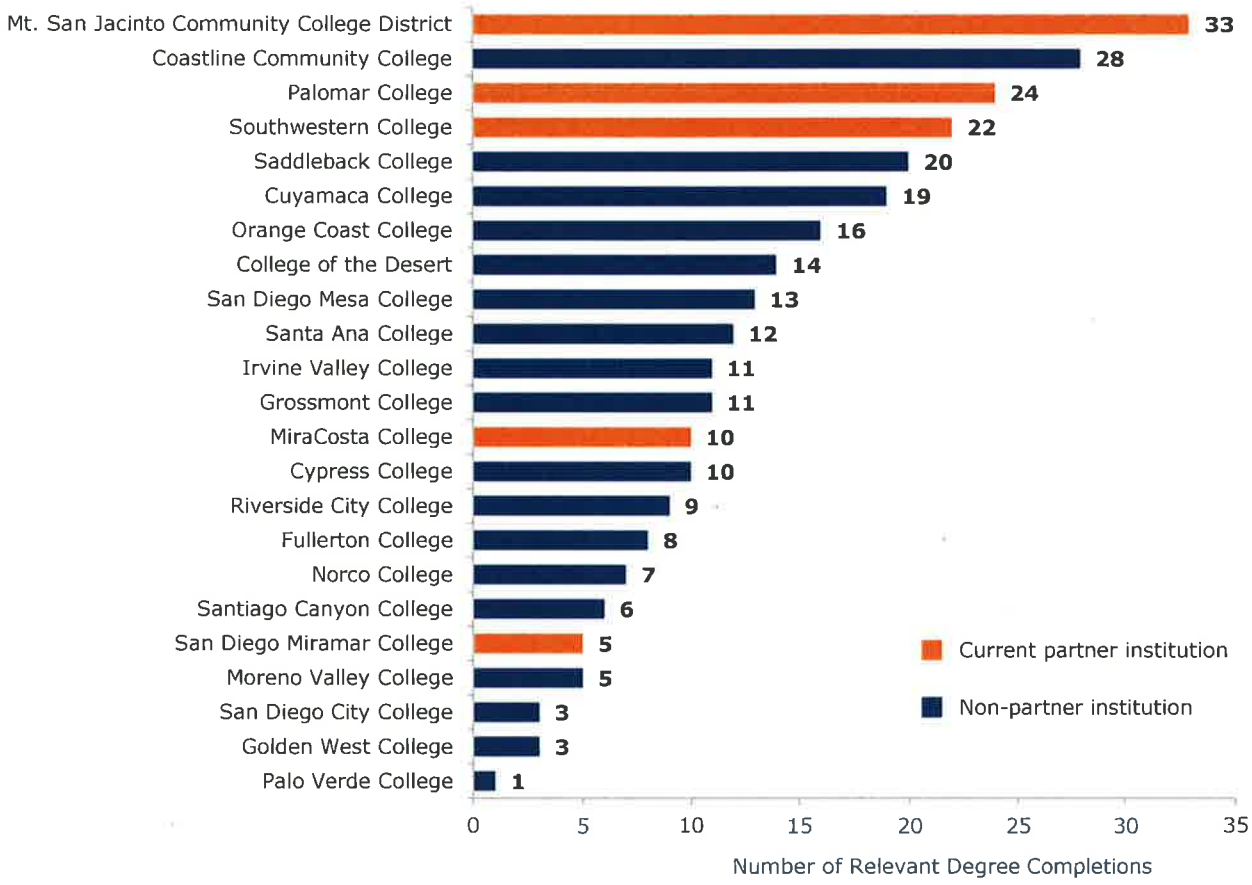
2013, Local Data[14]



14) Integrated Postsecondary Education Data System.

Computer Science-Related Associate's Degree Completions

2013, Local Data[15]



15) Integrated Postsecondary Education Data System.

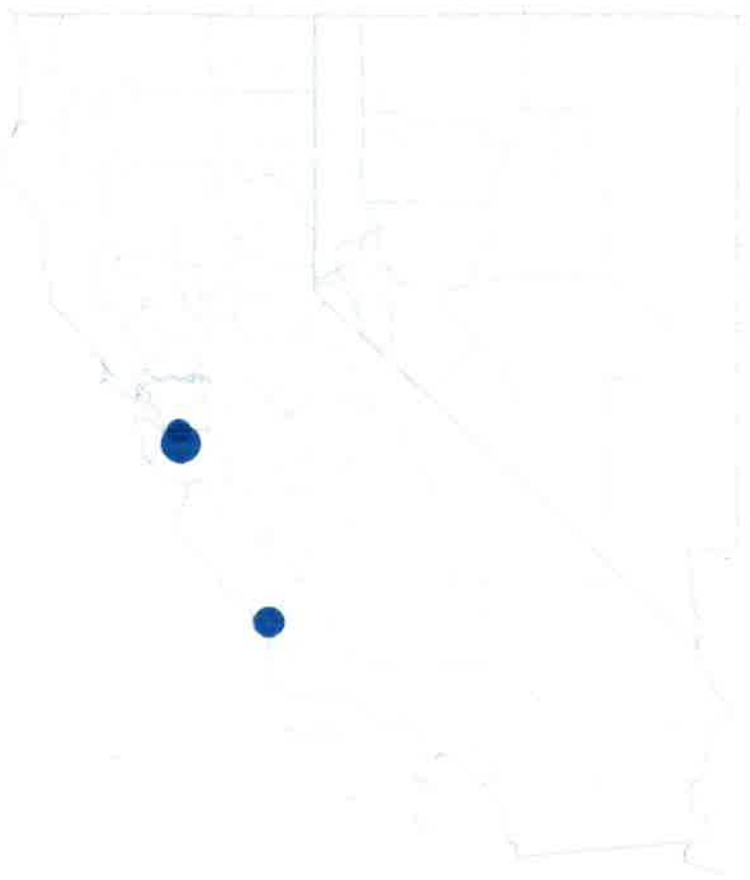
Potential Graduate Outcomes

California Polytechnic State University-San Luis Obispo Offers the Only ABET-Accredited Software Engineering Bachelor's Degree Program in California

Only three California institutions offer bachelor's degree programs in software engineering, **California Polytechnic State University-San Luis Obispo**, **Northwestern Polytechnic University**, and **San Jose State University**. San Jose State University conferred the most relevant degrees in 2013, with 13 degree completions. Despite little market saturation for software engineering bachelor's degree programs, institutions also face competition from institutions offering software engineering concentrations within a computer science bachelor's degree program.

Software Engineering Bachelor's Degree Completions

2013, California Data[16]



Software Engineering Bachelor's Degree Completions

2013, California Data[17]

16) Integrated Postsecondary Education Data System.

17) Integrated Postsecondary Education Data System.

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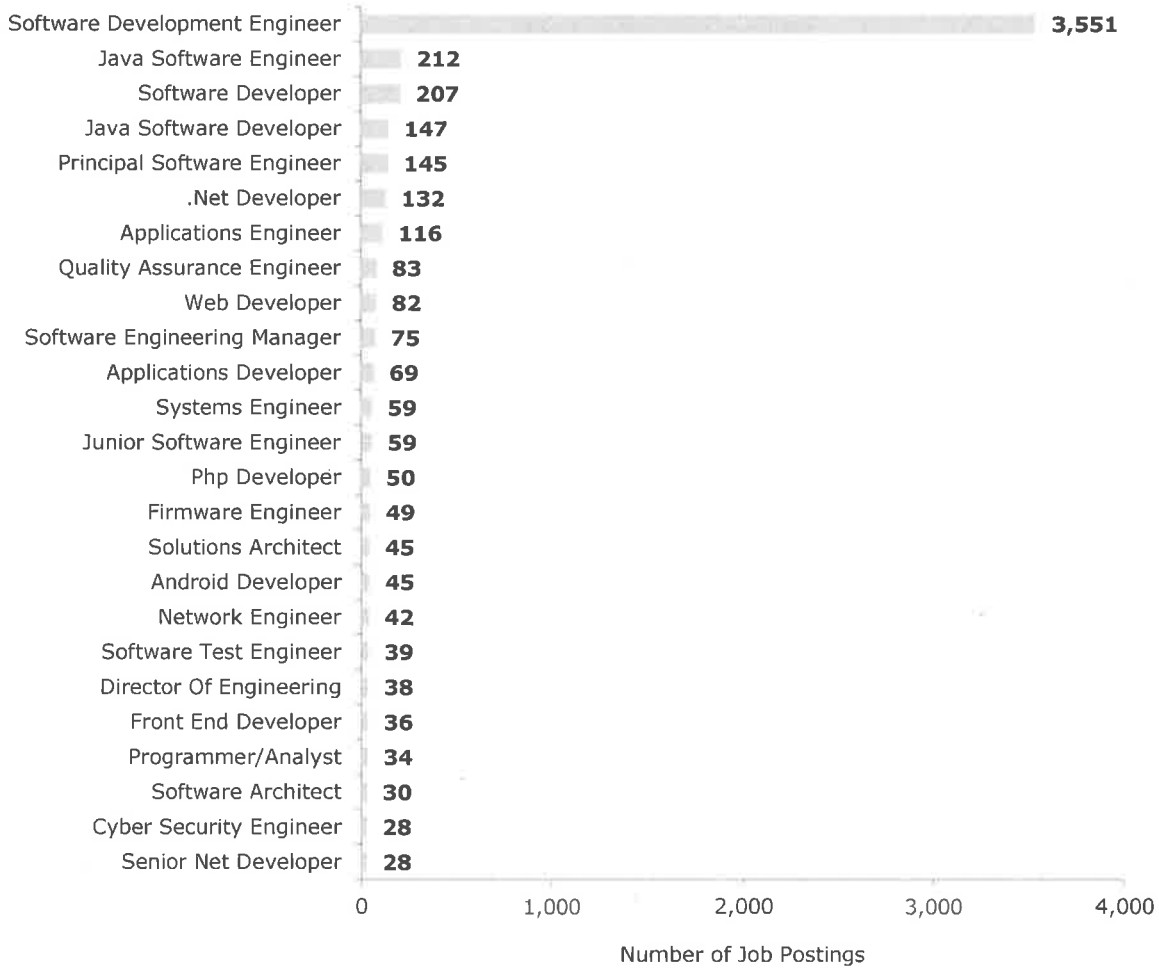
Local Employers Most Commonly Seek Software Engineering Professionals for 'Software Development Engineer' Positions

The majority of local and California employers seek general 'software development engineers' and do not specify languages or software types in the job title. Software engineering bachelor's degree programs should instill general programming, software development, and project management skills to prepare graduates for general developer positions. The most commonly sought specialized positions include 'JAVA software engineer,' 'JAVA software developer,' and '.NET developer.' Demand for JAVA and .NET developers may indicate local employer demand for JAVA and .NET programming skills.

Top Titles for Software Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[18]

n=8,205 job postings, 0 unspecified postings



18) Burning-Glass Labor/Insight™.

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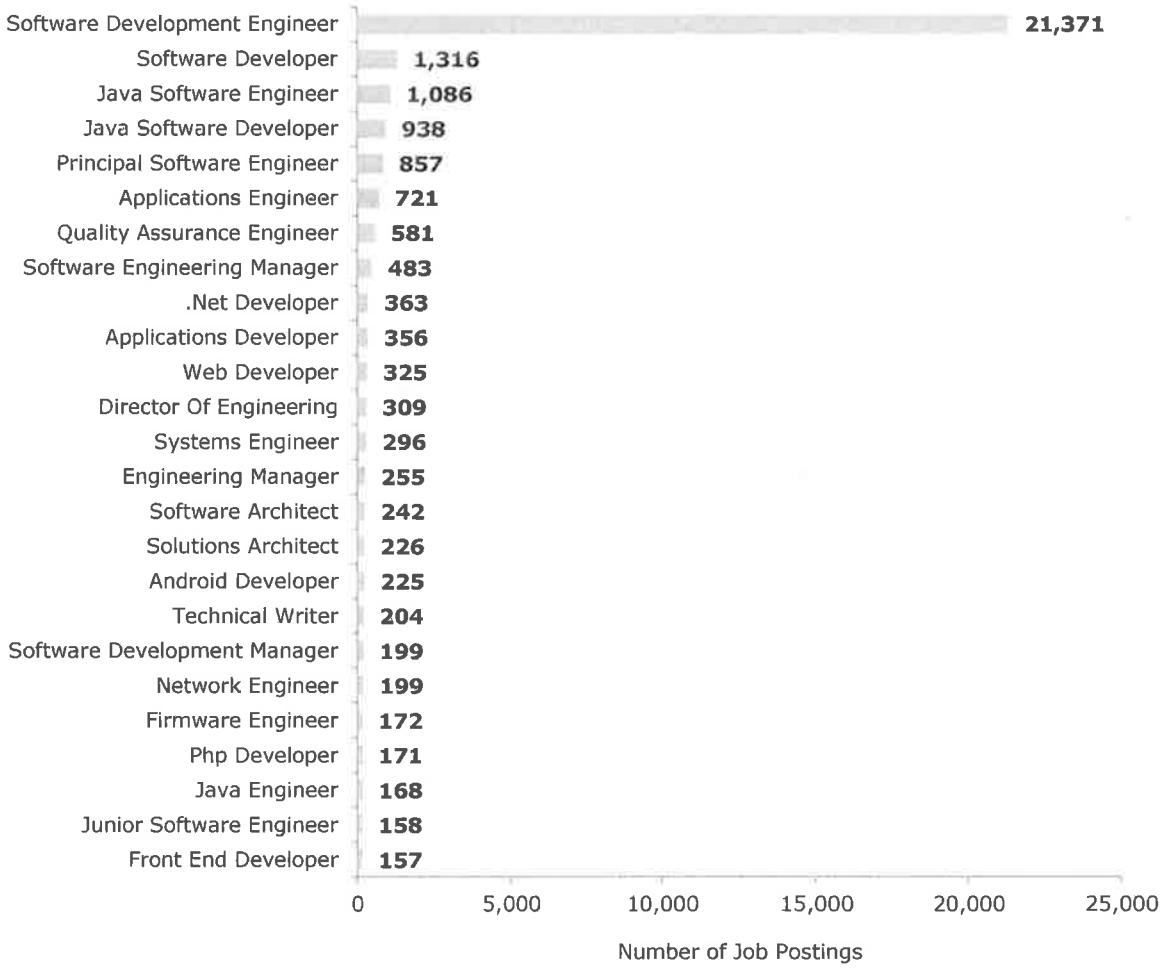
Top Titles for Software Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[19]

n=48,372 job postings, 15,209 unspecified postings



19) Burning-Glass Labor/Insight™.

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3) Electrical Engineering

Curriculum Design

California State University-San Marcos Offers All Support Courses Required for an Electrical Engineering Bachelor's Degree Program

Electrical engineering bachelor's degree program curricula include math and physics support courses as the foundation for higher-level engineering coursework. **California State University-San Marcos** currently offers nine relevant support courses for an electrical engineering bachelor's degree program curriculum. Most engineering disciplines require Calculus with Applications I through III, a statistics course, and an introductory computer science course in a C programming language. The electrical engineering bachelor's degree program at **California State University-Los Angeles** also requires a differential equations course.

Electrical engineering program curricula also require physics courses on topics such as mechanics, electromagnetism, and thermodynamics. Profiled programs require an electric circuit lab course, which may include similar material as the Introduction to Electronics course at California State University-San Marcos.

Relevant Existing Support Courses

California State University-San Marcos

Course Title	Course Number
Computer Science I	CS 111
Calculus with Applications, I	MATH 160
Calculus with Applications, II	MATH 162
Calculus with Applications, III	MATH 260
Introduction to Statistics or **Introduction to Mathematical Probability and Statistics**	MATH 242 or MATH 440
Introduction to Differential Equations	MATH 262
Physics of Mechanics and Sound	PHYS 201
Physics of Electromagnetism and Optics	PHYS 202
Modern Physics	PHYS 203

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Existing Upper-Division Physics Courses Align with Core Electrical Engineering Bachelor's Degree Program Curricula

Administrators at **California State University-San Marcos** should include existing physics and computer sciences courses for an electrical engineering bachelor's degree program curriculum. Relevant physics and computer science courses relate to electromagnetism, thermodynamics, circuit design, and controls. A new electrical engineering bachelor's degree program will require approximately 18 additional electrical engineering-specific courses, however. For example, electrical engineering bachelor's degree programs require courses and labs in analog circuit design and control systems. A new degree program should also include a senior design project to prepare students for employment upon graduation.

Existing Core Electrical Engineering Courses at California State University-San Marcos

California State University-Long Beach, California State University-San Marcos

Required Electrical Engineering Courses at CSU-Long Beach	Existing Courses at CSU-San Marcos
Digital Logic Design (EE 201)	**Assembly and Digital Circuits (CS 231)**
Electromagnetic Fields (EE 360)	**Classical Electromagnetism (PHYS 321)**
Applied Mathematics I (MATH 370A)	**Differential Equations (MATH 362)**
Analog Electronic Circuits I (EE 330)	**Introduction to Electronics (PHYS 280)**
Digital Signal Processing (EE 386)	**Signals and Systems (PHYS 403)**

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Additional Electrical Engineering Course Requirements

California State University-Long Beach

Course Title	Course Level
Academic Success Skills (ENGR 102)	Lower-division
Computer Methods in Engineering (EE 202)	Lower-division
Electric and Electronic Circuits (EE 211)	Lower-division
Electric Circuits Laboratory (EE 211L)	Lower-division
Intro to the Engineering Profession (ENGR 101)	Lower-division
Introduction to Programming and Applications for Electrical Engineers (EE 186)	Lower-division
Trends in Electrical Engineering (EE 200)	Lower-division
Analog Electronic Circuits II (EE 430)	Upper-division
Analog Electronics II Laboratory (EE 430L)	Upper-division
Communications Systems I (EE 382)	Upper-division
Control Systems (EE 370)	Upper-division
Control Systems Laboratory (EE 370L)	Upper-division
Digital System Design (EE 301)	Upper-division
Electrical Engineering Design Project (EE 400D)	Upper-division
Energy Conversion Principles (EE 350)	Upper-division
Microprocessor Principles and Applications (EE 346)	Upper-division
Probability, Statistics & Stochastic Modeling (EE 380)	Upper-division
Signals and Systems (EE 310)	Upper-division

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Confer Design and Testing Skills in Electrical Engineering Bachelor's Degree Program Curricula to Satisfy Local Employer Demand

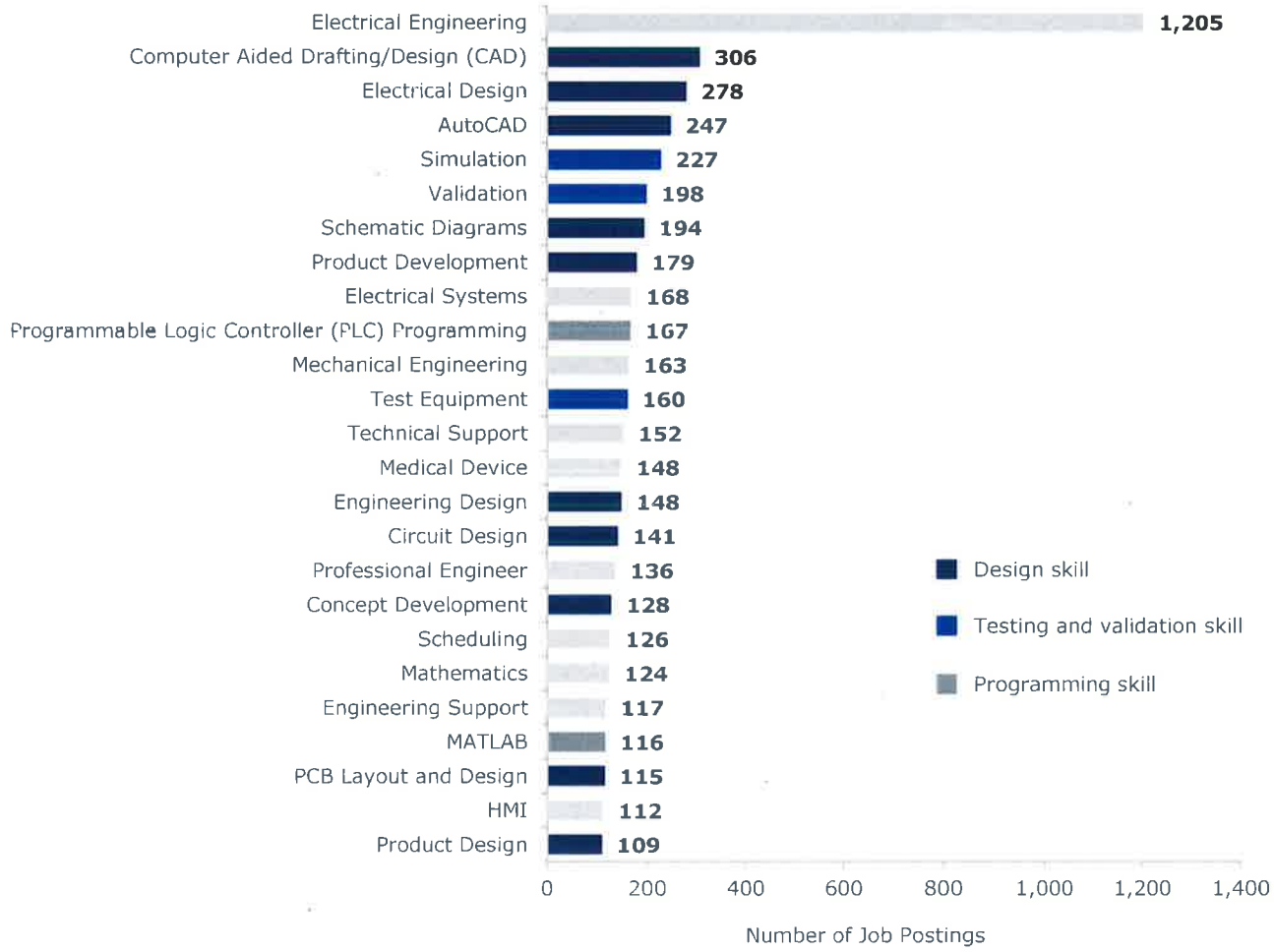
Local employers indicate high demand for design skills, such as 'computer aided drafting/design (CAD),' 'electrical design,' and 'AutoCAD.' High local employer demand for design skills indicates a need for design theory courses, such as Analog Electric Circuits I, in electrical engineering bachelor's degree program curricula. Local employers also seek electrical engineering professionals with testing and validation skills, such as 'simulation,' 'validation,' and 'test equipment.' High local employer demand for testing and validation skills indicates a need for lab and project-based coursework, such as a senior design project. Electrical engineering positions also commonly require programming competencies, such as 'programmable logic controller programming' and 'MATLAB.'

As expected, local employers most commonly seek the skill 'electrical engineering' in electrical engineering-related job postings.

Top Skills for Electrical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[20]

n=1,795 job postings, 65 unspecified postings



20) Burning-Glass Labor/Insight™

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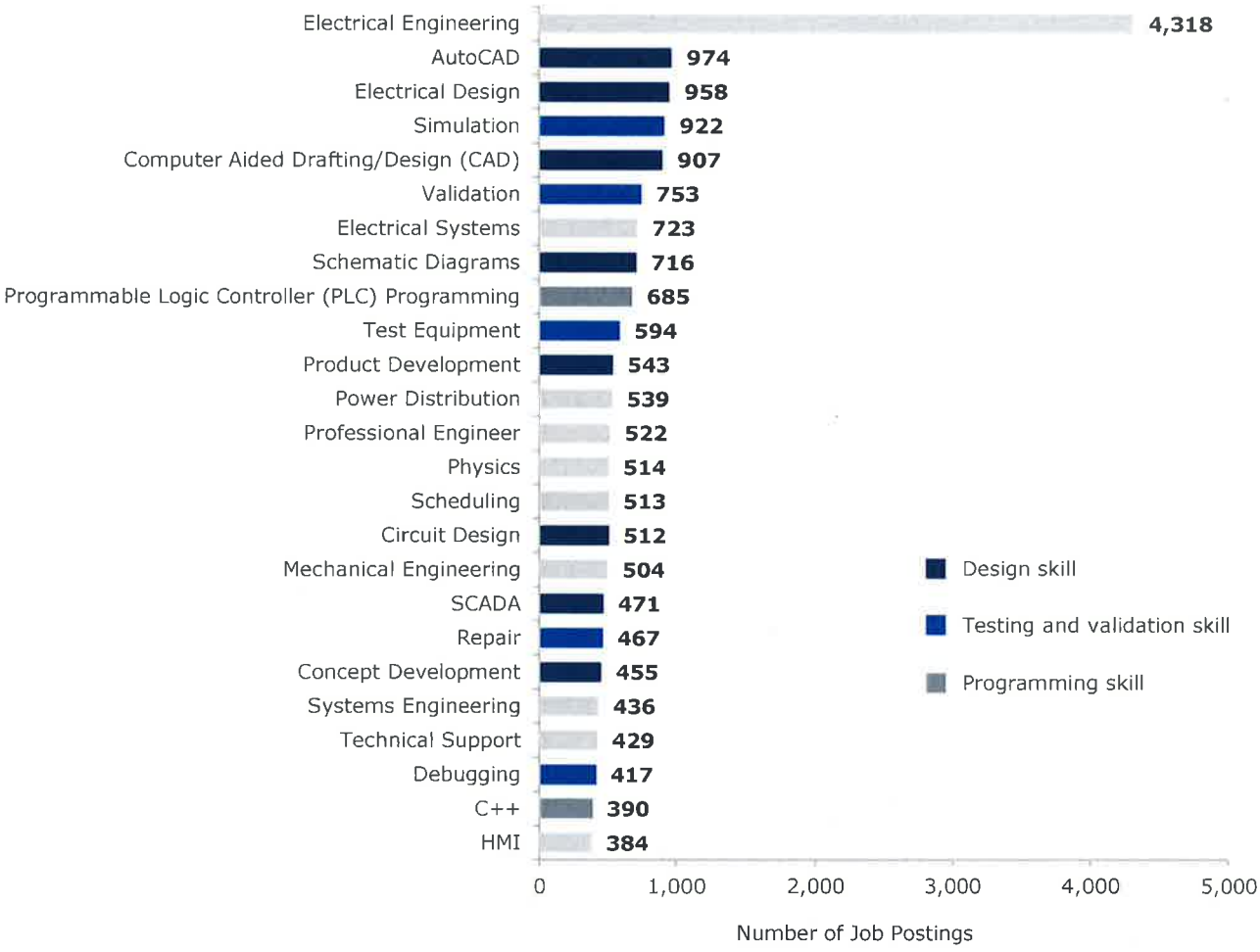
Top Skills for Electrical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[21]

n=6,858 job postings, 264 unspecified postings



Local Employers Seek Entry-Level Electrical Engineers with Circuit and Integrated Chip Design Skills

Executive leaders at **General Atomics** seek electrical engineers with strong circuit design and analysis skills. Additionally contacts seek electrical engineers with course experience in SPICE (Simulation Program with Integrated Circuit Emphasis) and firmware design skills, such as Xilinx.

21) Burning-Glass Labor/Insight™.

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Build Electronics Labs to Design and Test Circuits, Analog Electronics, and Microcontrollers

Large electrical engineering bachelor's degree programs typically require multiple electronics labs as well as computer labs. For example, the electrical engineering bachelor's degree program at **California State University-Long Beach** maintains a current enrollment size of 400 students and requires ten labs. Similarly, the electrical engineering department at **California State Polytechnic University-Pomona** maintains a current enrollment size of over 1,000 students. Administrators at California State Polytechnic University-Pomona operate five instructional labs for undergraduate electrical engineering students. The five labs provide space for 12 to 25 students and range in size from 1,226 to 1,531 square feet. Three labs include basic electronics equipment and include equipment for circuit, analog electronic, and microcontroller experiments. The other two labs feature specialized equipment, one for power system and the other for analog and digital communication projects.

Electrical Engineering Lab Equipment

California State University-Long Beach, California State Polytechnic University-Pomona

See Appendix B for electronic test equipment cost estimates. The Forum was unable to estimate cost data for software licenses due to variable pricing based on the number of licenses and users.

Electronic Test Equipment

- **Multimeters**
  - Rigol DM3058 Digital Multimeter
  - Tektronix, DM502
- **Power supply**
  - Lab Volt 1224 AC/DUAL DC
  - Agilent (Hewlett Packard) 6200B Power Supply
  - Mastech HY3000-HY5000 DC Power Supply
- **Dual power supply**
  - PS503A Tektronix
- **Function generator**
  - Tektronix FG 502 , 11MHz
  - Rigol DG1000 series Dual-Channel Function/Arbitrary Waveform Generator
- **Oscilloscope**
  - HP54600B Oscilloscope
  - Tektronix 2225 Oscilloscope

Software Programs

- **Cadence**
- **Java Web Start**
- **Eclipse**
- **Cypress**
- **Lightning Analysts**
- **MathSoft Apps**
- **MATLAB**
- **Microsoft Developer Network**
- **Microsoft Office Tools**
- **Microsoft Visual Studio**
- **ModelSim SE**
- **National Instruments LabVIEW**
- **Xilinx ISE**
- **Xterm to es-sun-00**

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Computer Science or Physics Faculty Members May Teach Some Required Electrical Engineering Courses

Profiled electrical engineering departments require a median of 15 tenure-track faculty members. However, electrical engineering bachelor's degree programs require physics and computer science courses. Administrators at **California State University-Long Beach** report the majority of electrical engineering faculty members possess electrical engineering degrees, while a minority possess physics degrees. Shared courses among physics, computer science, and electrical engineering undergraduate students may reduce the need for new tenure-track faculty members.

Tenure-track faculty members compose over 62 percent of electrical engineering electrical staff at profiled institutions. A high proportion of tenure-track faculty members will increase compensation costs for a new electrical engineering bachelor's degree program. Newly hired tenure-track electrical engineering faculty members at **California State Polytechnic University-Pomona** earn approximately $85,000 per year. However, electrical engineering faculty members earn significantly lower salaries than the average salary of a doctoral-level electrical engineer in private industry. According to PayScale, Inc., an electrical engineer in San Diego with a Ph.D. and ten years of industry experience earns a median salary of $116,000.

Profiled electrical engineering departments conferred 10 bachelor's degrees from 2010 through 2013 per tenure-track faculty member, despite the high proportion of tenure-track faculty members required to offer an electrical engineering bachelor's degree program. A high number of relevant degree completions per tenure-track faculty member indicate a low faculty member compensation cost relative to program enrollment size.

Number of Electrical Engineering Bachelor's Degree Completions per Tenure-Track Faculty Member

In-State Institutions and Peer Institutions, Electrical Engineering Departments, 2010 through 2013 Academic Years

Institution	Number of Tenure-Track Faculty Members	Number of Relevant Degree Completions from 2010 through 2013	Number of Relevant Degree Completions per Tenure-Track Faculty Member
California State Polytechnic University-Pomona	18	610	33.9
California Polytechnic State University-San Luis Obispo	25	457	18.3
California State University-Los Angeles	9	164	18.2
San Diego State University	19	214	11.3
California State University-Sacramento	15	167	11.1
California State University-Long Beach	21	211	10.0
The University of Texas at Tyler	6	50	8.3
California State University-Fullerton	9	72	8.0
California State University-Fresno	12	95	7.9
California State University-Northridge	21	151	7.2
California State University-Chico	8	57	7.1

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Prepare Electrical Engineering Program Graduates for Defense and Telecommunications Industry Careers to Develop Partnerships with Local Employers

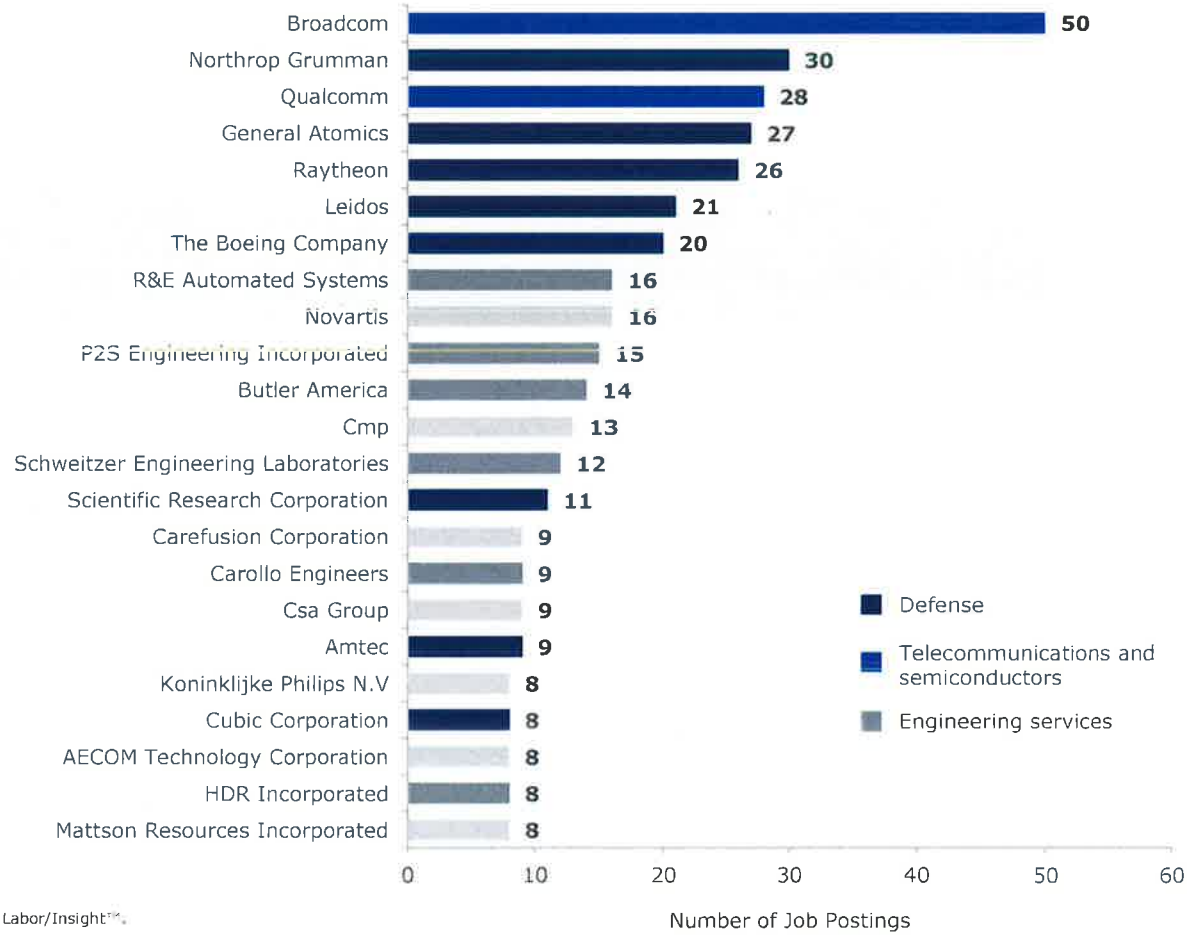
Recruitment professionals at **Qualcomm** and **General Atomics** suggest aligning program curricula to local industries and hiring needs to develop partnerships with employers. Employers often partner with institutions that produce interns and employees with strong job performance. Many large local employers primarily recruit from institutions with highly ranked engineering programs, such as the **University of California-San Diego** and **Stanford University**. Administrators at **California State University-San Marcos** should partner with local employers to include industry-specific projects and assignments and prepare students for potential job responsibilities upon graduation. For example, hire industry professionals as lecturers to teach instructional lab courses or ask electrical engineers at local companies to oversee students' senior design projects.

Local students with industry-specific project experience may compete for positions with students from more established engineering programs. Employers in the defense, telecommunications, and semiconductors industries indicate the highest demand for electrical engineering professionals locally. Employers in the computer hardware and software industry and the power and utilities industry also indicate high demand for electrical engineering professionals statewide.

Top Employers of Electrical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[22]

n=1,795 job postings, 649 unspecified postings



22) Burning-Glass Labor/Insight™.

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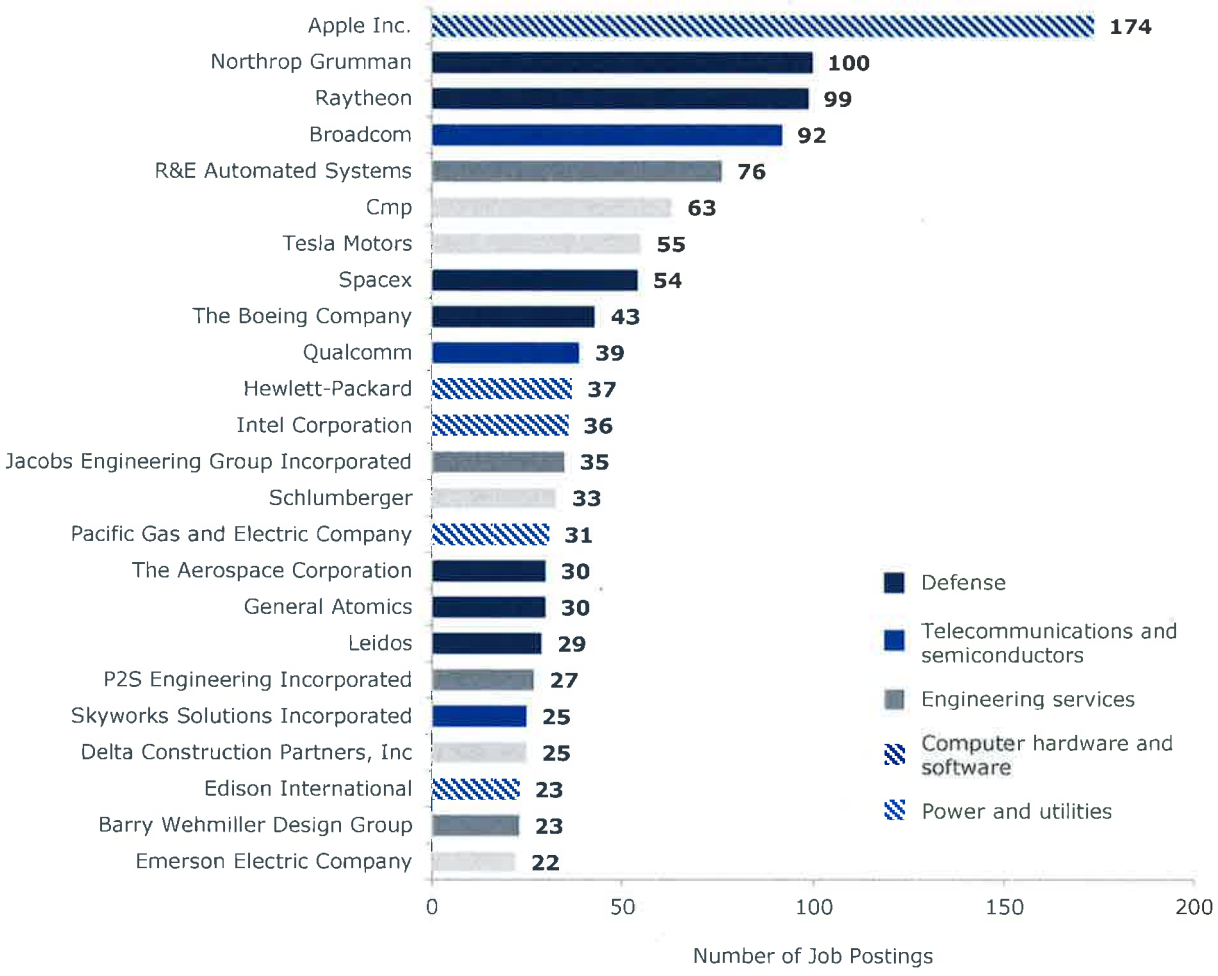
Top Employers of Electrical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[23]

n=6,858 job postings, 2,166 unspecified postings



23) Burning-Glass Labor/Insight™.

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Recruit Engineering, Physics, or Math Associate's Degree Students for Electrical Engineering Bachelor's Degree Programs

Engineering associate's degree programs allow students to complete support courses and a small number of lower-division core courses before transferring to an engineering bachelor's degree program. **California State University-Long Beach** maintains an articulation agreement with **Palomar College** for the electrical engineering bachelor's degree program. The engineering associate's degree program at Palomar College allows students to complete most support courses, such as Calculus with Applications I through III and Principles of Physics. Associate's degree students may also complete lower-division core courses, such as Electrical Network Analysis, before transferring to the bachelor's degree program.

Math and physics associate's degree students may also transfer to electrical engineering bachelor's degree programs. Math and physics associate's degree students often complete most support courses required for an electrical engineering bachelor's degree program. Math associate's degrees allow transfer students to complete necessary math courses for engineering, such as calculus, differential equations, statistics, and linear algebra. Similarly, physics associate's degree programs include courses on calculus, mechanics, electromagnetism, and modern physics.

Sample Associate of Science Degree in Engineering Core Program Curricula

Palomar College

Engineering Associate's Degree Core Coursework
Calculus with Analytic Geometry I
Calculus with Analytic Geometry II
Calculus with Analytic Geometry III
Calculus with Differential Equations
Principles of Physics (Mechanics, Thermodynamics, Fluid Mechanics)
Principles of Physics (Classical Electromagnetism, Electromagnetic Waves, and Optics)
Principles of Physics (Modern Physics)
SolidWorks Introduction to 3D Design and Presentation
Introduction to Electrical and Computer Engineering
Electrical Network Analysis
Electrical Network Analysis Laboratory

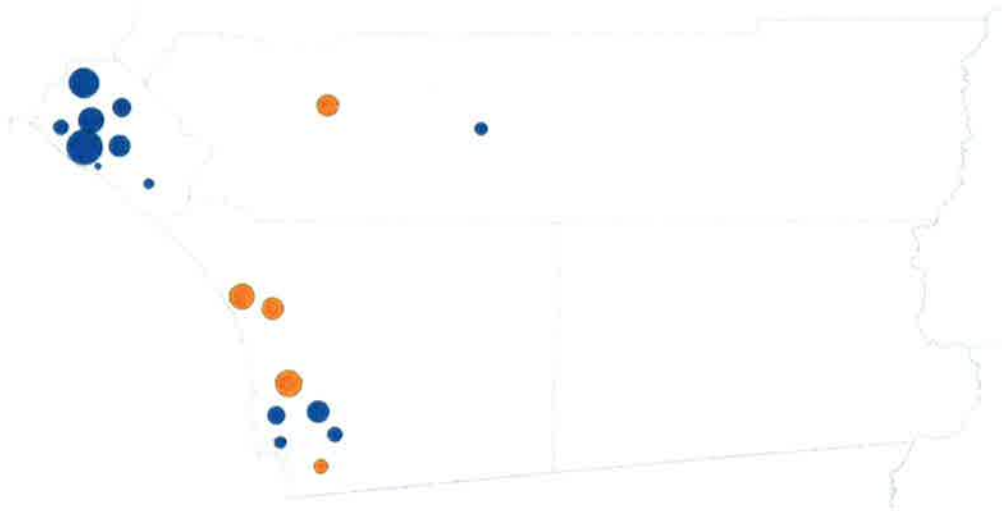
Market Electrical Engineering Bachelor's Degree Programs to Students at Mt. San Jacinto College, Palomar College, and Southwestern College

Administrators at **California State University-San Marcos** should continue to recruit students from partner community colleges for a new electrical engineering bachelor's degree program. **San Diego Miramar College** and **MiraCosta College** conferred the highest number of engineering, physics, and math associate's degrees in 2013, and indicate strong potential partners for the electrical engineering degree program.

Prospective community college partners maintain high numbers of engineering, physics, and math associate's degree completions. Many community college transfer students do not complete an associate's degree, but complete the necessary prerequisites to transfer to a four-year institution; however, programs with high numbers of associate's degree completions also likely possess high course enrollments from non-degree seeking students. Potential new community college partners include **Orange Coast College**, **Fullerton College**, and **Santa Ana College**.

Engineering, Physics, and Math-Related Associate's Degree Completions

2013, Local Data[24]



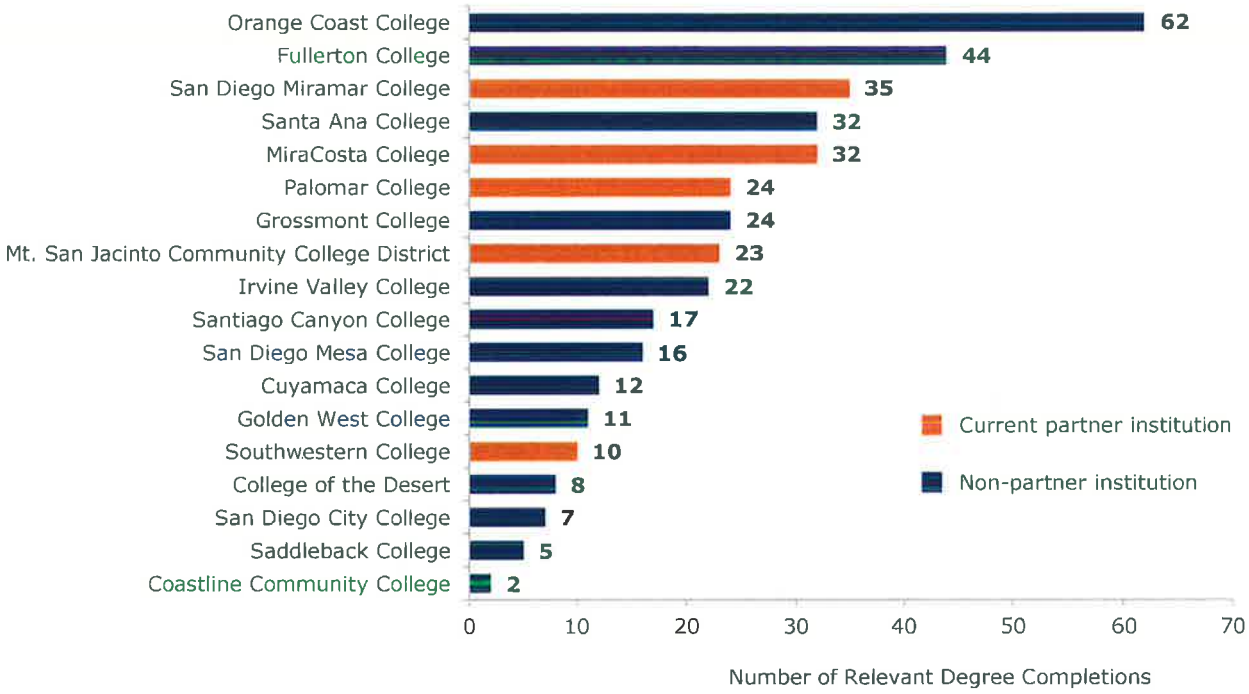
Current partner institution

Non-partner institution

24) Integrated Postsecondary Education Data System.

Engineering, Physics, and Math-Related Associate's Degree Completions

2013, Local Data[25]



25) Integrated Postsecondary Education Data System.

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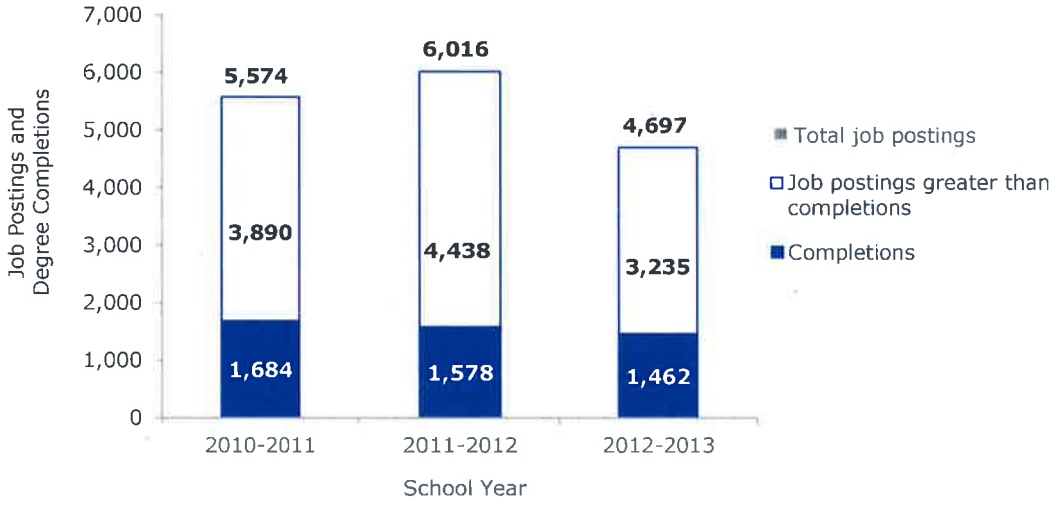
Potential Graduate Outcomes

Employers in California Seek More Bachelor's-Level Electrical Engineering Professionals than Students who Complete Electrical Engineering Degrees

Employers in California exhibit higher demand for electrical engineers than the number of qualified candidates who graduate from California institutions per academic year. In the most recent year of comparable data, the 2012-2013 school year (i.e., July 2012-June 2013), employers posted 4,697 jobs for bachelor's-level electrical engineering professionals. California institutions conferred only 1,462 electrical engineering bachelor's degrees in the 2012 to 2013 academic year. The consistent statewide gap between degree completions and employer demand indicates a good market for **California State University-San Marcos** to open a new electrical engineering bachelor's degree program.

Electrical Engineering Degree Completions and Employer Demand

2010-2013, State Data, Bachelor's Degree Completions and Bachelor's Degree Required for Job Postings[26]



26) Job postings: Burning Glass Labor/Insight™; Completions: Integrated Postsecondary Education Data System.

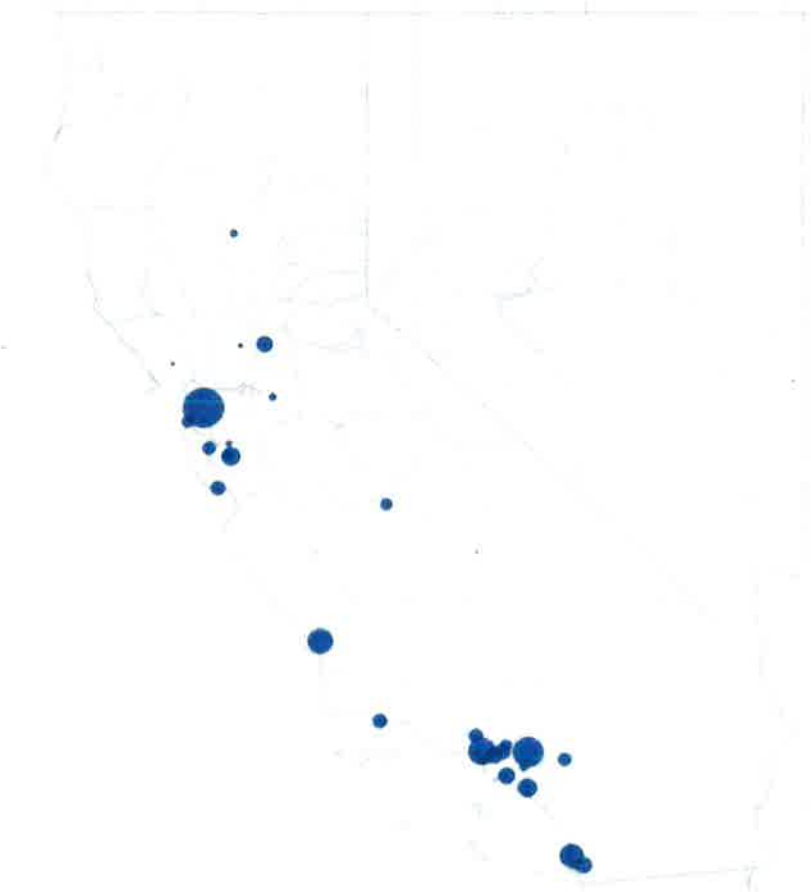
Local Institutions Conferred Nearly 18 Percent of California Electrical Engineering Bachelor's Degrees in 2013

Graduates of an electrical engineering bachelor's degree program at **California State University-San Marcos** will likely compete for jobs with graduates of other local institutions, such as the **University of California-San Diego**, **California State University-Long Beach**, and **San Diego State University**.

Thirty public and private non-profit California institutions offer bachelor's degree programs in electrical engineering. The **University of California-Berkeley** reported the highest number of electrical engineering bachelor's degree completions in 2013. **California Polytechnic State University-San Luis Obispo** and **California State Polytechnic University-Pomona** reported highest number of electrical engineering bachelor's degree completions in 2013 among institutions in the California State University System.

Electrical Engineering Bachelor's Degree Completions

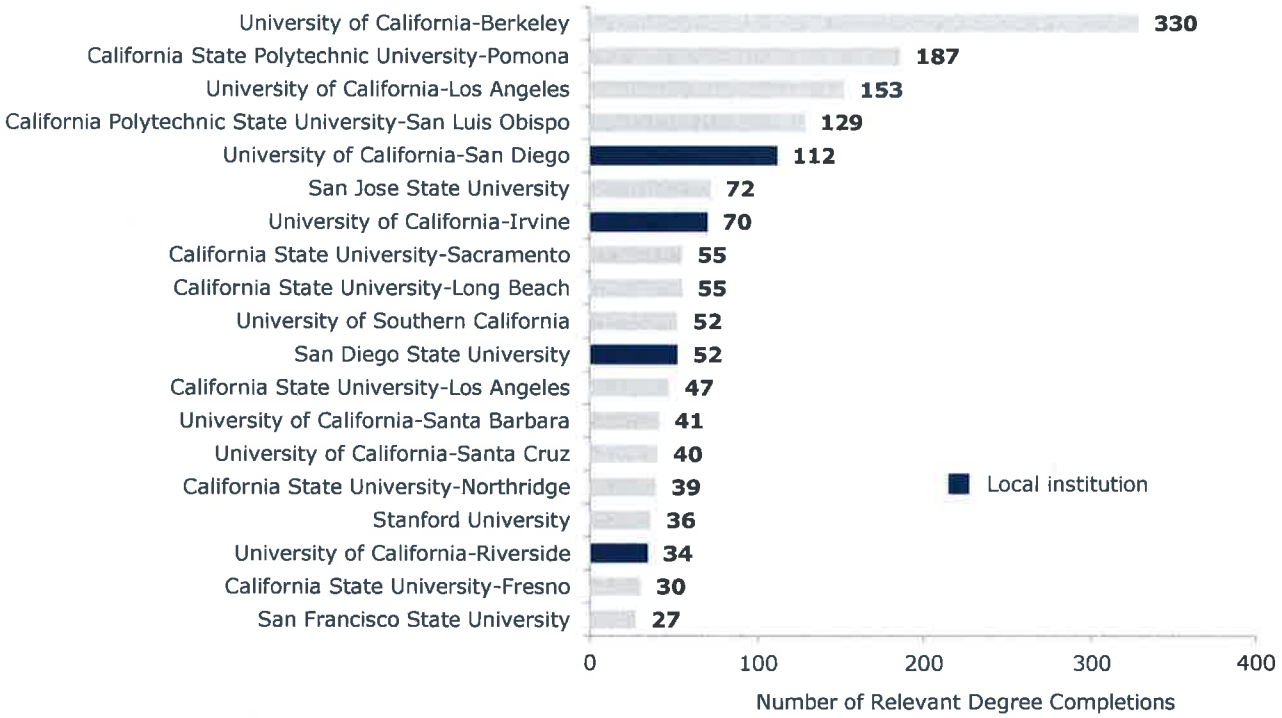
2013, California Data[27]



27) Integrated Postsecondary Education Data System.

Electrical Engineering Bachelor's Degree Completions

2013, California Data[28]



28) Integrated Postsecondary Education Data System.

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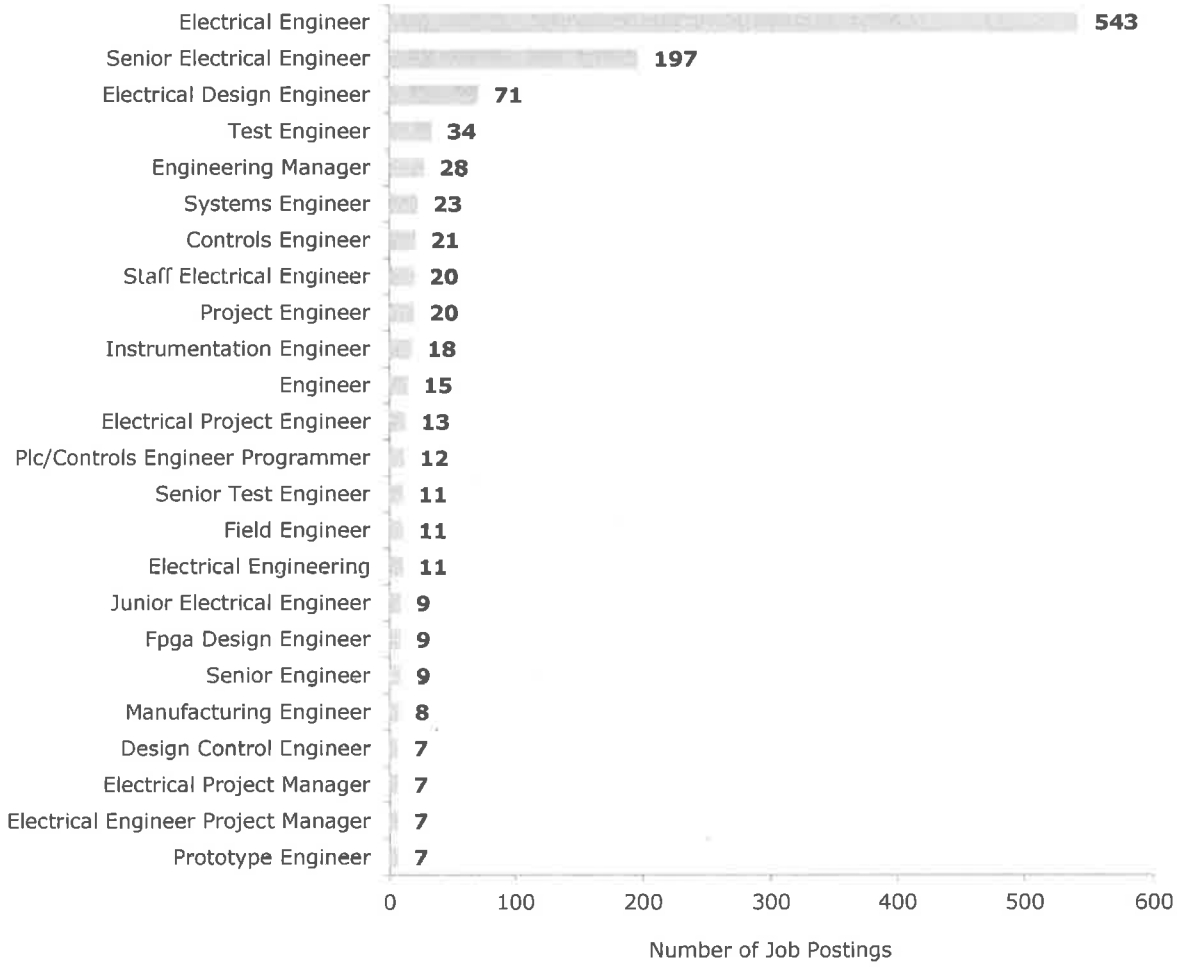
Local Employers Most Commonly Seek Electrical Engineering Professionals for 'Electrical Engineer' Positions

An electrical engineering bachelor's degree program at **California State University-San Marcos** should instill broad electrical engineering skills to prepare program graduates for non-specialized positions. Most local employers seek electrical engineering professionals for general 'electrical engineer' or 'senior electrical engineer' positions. The most commonly sought specialized positions locally include 'electrical design engineer' and 'test engineer.' The most commonly sought specialized positions statewide include 'electrical design engineer' and 'instrumentation engineer.'

Top Titles for Electrical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[29]

n=1,795 job postings, 0 unspecified postings



29) Burning-Glass Labor/Insight™.

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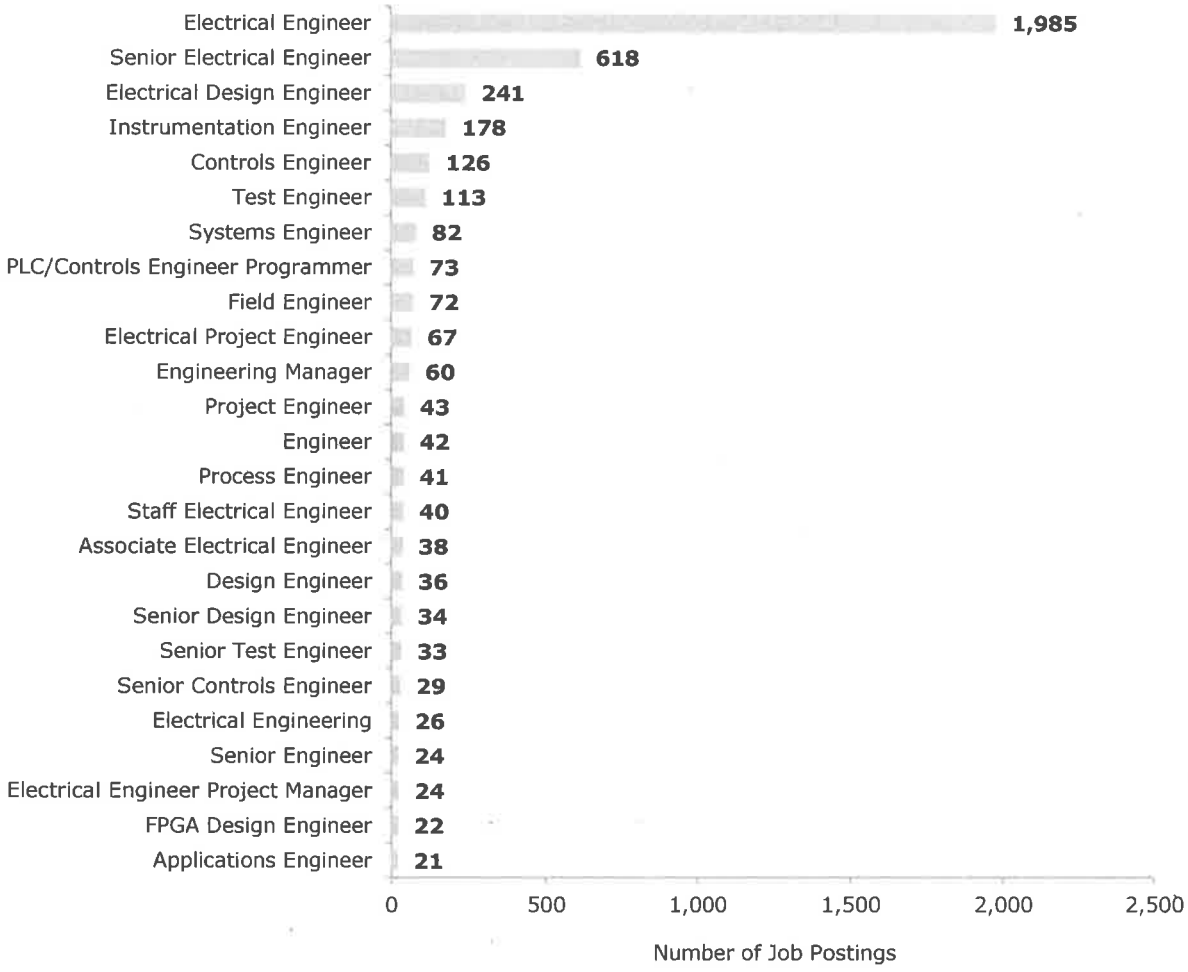
Top Titles for Electrical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[30]

n=6,858 job postings, 0 unspecified postings



30) Burning-Glass Labor/Insight™.

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4) Mechanical Engineering

Curriculum Design

California State University-San Marcos Offers All Support Courses Required for a Mechanical Engineering Bachelor's Degree Program

Existing courses at **California State University-San Marcos** compose part of an undergraduate engineering core curriculum. In addition to that core curriculum, lower-division mechanical engineering students usually take an introductory course in the discipline (e.g., Introduction to Mechanical Engineering) as well as a computer methods and design graphics or visualization course.

Relevant Existing Support Courses

California State University-San Marcos

Course Title	Course Number
General Chemistry	CHEM 150
Calculus with Applications, I	MATH 160
Calculus with Applications, II	MATH 162
Calculus with Applications, III	MATH 260
Introduction to Statistics or **Introduction to Mathematical Probability and Statistics**	MATH 242 or MATH 440
Introduction to Linear Algebra	MATH 264
Physics of Mechanics and Sound	PHYS 201
Physics of Electromagnetism and Optics	PHYS 202

Additional Mechanical Engineering Upper-Division Course Requirements

California State University-Long Beach

Course Title
Academic Success Skills (ENGR 102)
Analytical Mechanics I (CE 205)
Computer Methods in Mechanical and Aerospace Engineering (MAE 205)
Engineering Design Graphics I (MAE 172)
Introduction to Engineering Profession (ENGR 101)
Introduction to Manufacturing Processes (MAE 272)
Introduction to Mechanical Engineering (MAE 101B)

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California State University-San Marcos Offers Only One Relevant Upper-Division Course for a Mechanical Engineering Bachelor's Degree Program

The upper division of an undergraduate mechanical engineering curriculum includes thermodynamics, fluid mechanics, and systems design. Many upper-level courses require lab work. Popular topics within mechanical engineering include robotics, mechatronics, medical devices, and aerospace. Contacts at the **University of California-San Diego** report the popularity of any classes with labs, and explain that students desire hands-on experience.

Existing Upper-Division Mechanical Engineering Courses at California State University-San Marcos

California State University-Long Beach, California State University-San Marcos

Required Mechanical Engineering Courses at CSU-Long Beach	Existing Courses at CSU-San Marcos
Applied Mathematics I (MATH 370A)	Differential Equations (MATH 362)

Additional Mechanical Engineering Upper-Division Course Requirements

California State University-Long Beach

Course Title
Analytical Mechanics Dynamics (MAE 371)
Design and Analysis of Mechanical Engineering Systems I (MAE 471)
Design and Analysis of Mechanical Engineering Systems II (MAE 472)
Engineering Instrumentation and Measurement (MAE 300)
Engineering Materials and Materials Processes (MAE 322)
Engineering Thermodynamics I (MAE 330)
Fluid Mechanics (CE 335)
Fluid Mechanics Lab (CE 336)
Heat Transfer Systems Design (MAE 431)
Kinematics and Dynamics of Mechanisms (MAE 375)
Materials and Properties Lab (MAE 361)
Mechanical Control Systems I (MAE 476)
Mechanics of Deformable Bodies (MAE 373)
Modeling and Analysis of Dynamic Systems (MAE 376)
Modern Computational Aspects in Mechanical Engineering (MAE 409)
Numerical Methods in Mechanical and Aerospace Engineering (MAE 305)
Power Plant Design (MAE 336)
Professional Practice Seminar (MAE 459)
Project Cost-Benefit Analysis (CE 406)
Special Topics (MAE 490)
Thermal Engineering Lab (MAE 337)

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Build Applied Assignments into the Mechanical Engineering Curriculum to Prepare Graduates for Area Employment

Administrators at **California State University-San Marcos** should require an applied project (e.g., a capstone) to allow students to practice skills beyond courses and labs. Local employers emphasize the importance of applied experience in assessing applicants' candidacy for entry-level mechanical engineering positions.

Seniors at the **University of San Diego** complete a two-semester capstone senior design project. The University dedicates two full-time faculty members to the two-course series that accompanies the project. In the first semester of the senior design project students take a three-hour weekly lecture course. In the second semester students take a two-hour lecture course and a three-hour lab course each week. Students complete the project in teams and every project undergoes a design review by a faculty member or industry partner at the end of the first semester.

Contacts at **San Diego State University** report a similar structure for senior design projects; students work on projects in groups of three to six throughout their senior year. Administrators at the **University of Maryland-Baltimore County** plan to adopt a two-semester capstone format as well; professors do not consider three months sufficient time for students to complete the capstone.

Gain Hands-On Experience via Extracurricular Activities

Contacts at **Hunter Industries** report they discuss candidates' extracurricular activities and hobbies during entry-level mechanical engineering interviews to assess candidates' mechanical aptitude.

Programs that require less hands-on work encourage applied experience through extracurricular activities. Mechanical engineering-specific groups at profiled institutions include:

- Formula racing teams (e.g., Triton, Baja)
- Robotics design competitions
- American Society of Mechanical Engineers
- Society of Automotive Engineers
- Society of Manufacturing Engineers
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Assemble a Program Advisory Board to Ensure the Curriculum's Relevance to Industry Trends

Profiled programs employ industry advisory boards to review curricula and advise changes. Administrators at the **University of Maryland-Baltimore County** review the mechanical engineering curriculum annually and implement changes every three to four years. Administrators present changes suggested by faculty members to the program's advisory board for feedback. This process helps to keep the program's content on pace with industry trends.

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Confer Computer Design and Product Development Skills in the Mechanical Engineering Program to Meet Regional Employer Demand

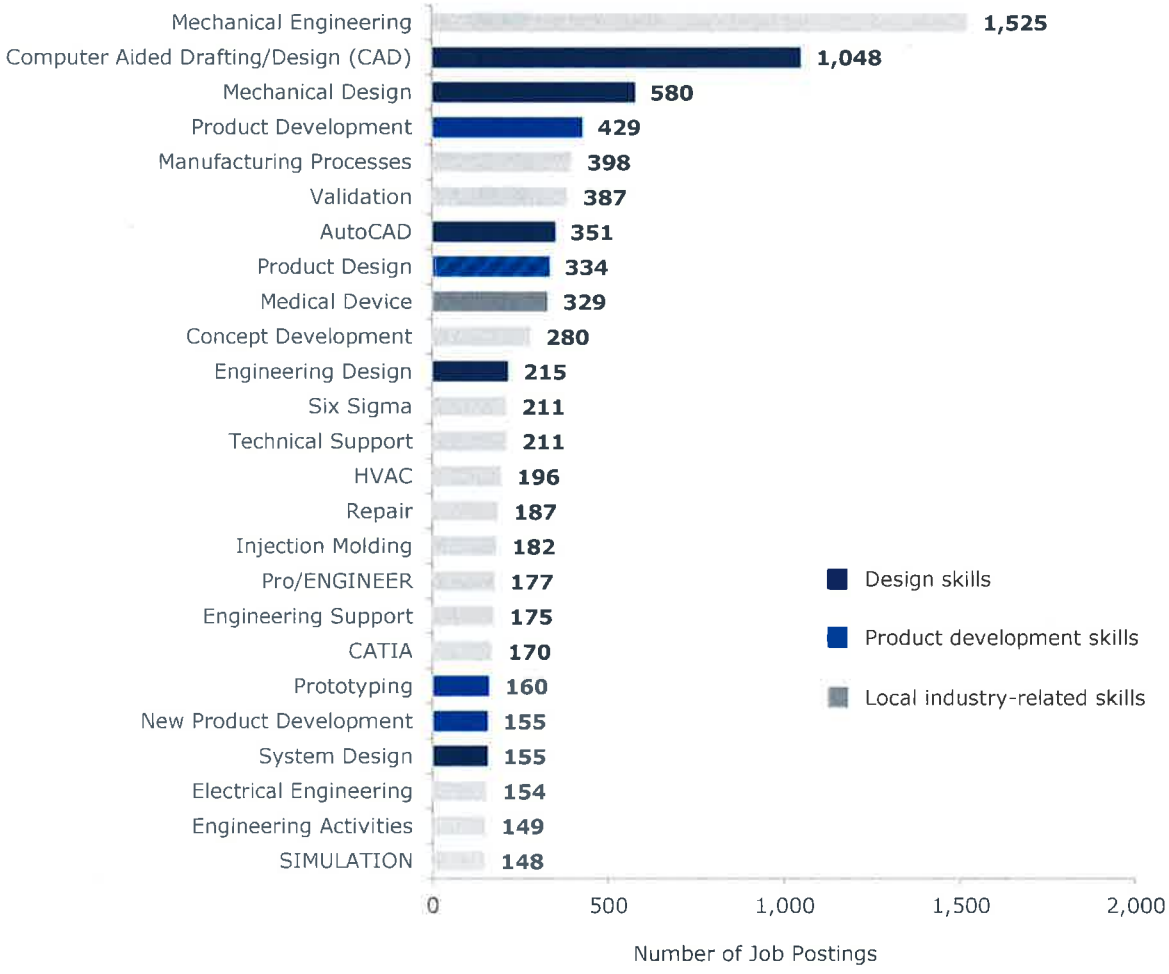
Forty-one percent of all relevant jobs posted last year list 'computer aided drafting/design' as a desired skill for mechanical engineers with bachelor's degrees. Other commonly sought design-related skills include 'mechanical design,' 'AutoCAD,' 'engineering design,' and 'system design.' Local and statewide employers also frequently seek mechanical engineers with product development and related skills (e.g., 'prototyping'). High demand for product design skills reinforces the importance of applied design experiences in mechanical engineering bachelor's degree programs, such as a senior design project.

The presence of 'medical devices' among the top skills indicates the growth of the biotechnology industry locally and statewide and suggests administrators at **California State University-San Marcos** should address the topic in the mechanical engineering program, potentially as an elective topic. The mechanical engineering program at **San Diego State University** recently added a concentration in biotechnology due to the growth of that industry in the area.

Top Skills for Mechanical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[31]

n=2,499 job postings, 105 unspecified postings



31) Burning-Glass Labor/Insight™.

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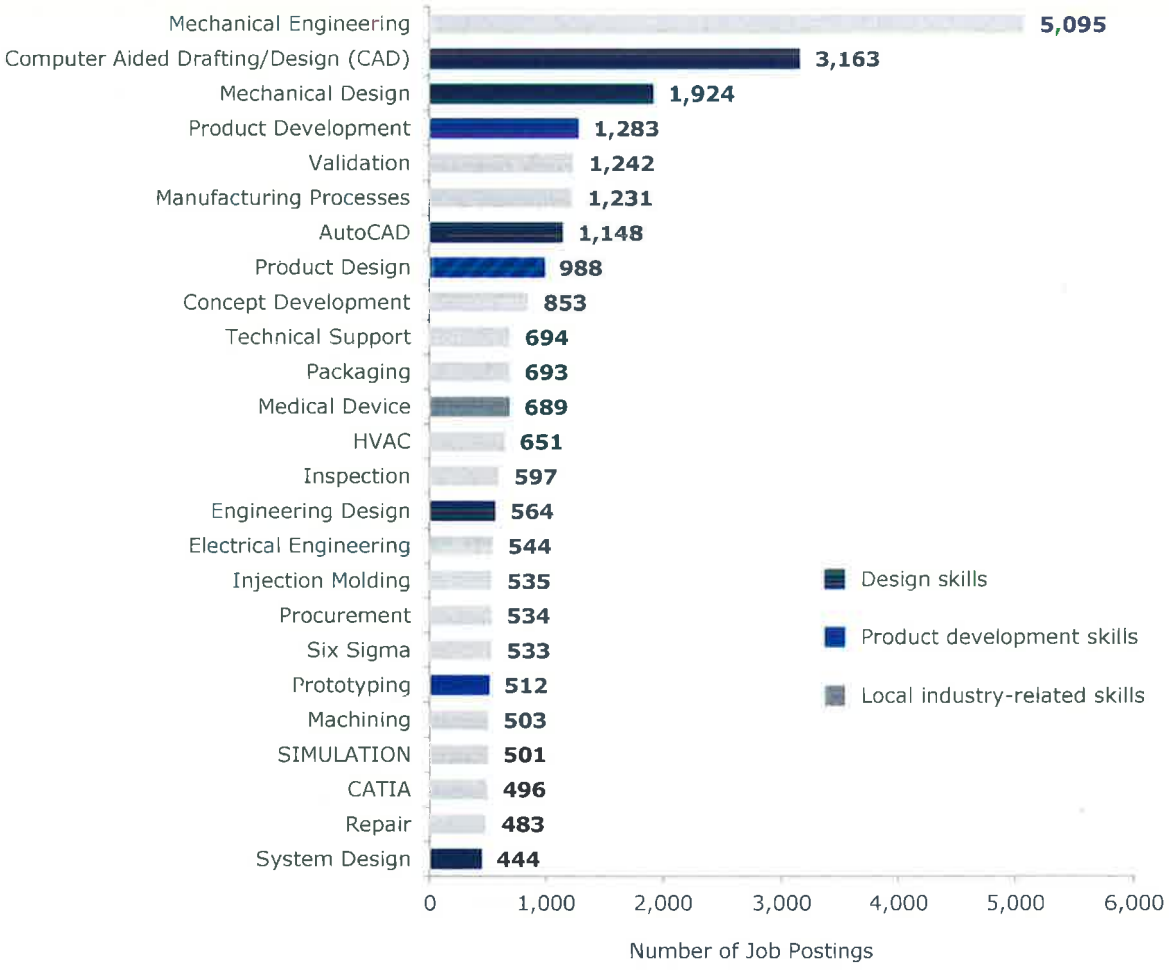
Top Skills for Mechanical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[32]

n=8,483 job postings, 357 unspecified postings



Employers Seek Mechanical Engineers with CAD Skills

Contacts at **General Atomics** prefer entry-level mechanical engineering candidates to have at least one computer-aided design (CAD) course. They specifically list CAD software programs 'SolidWorks,' 'Pro/ENGINEER,' and 'ANSYS' as desirable qualifications.

32) Burning-Glass Labor/Insight™.

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Mechanical Engineering Instruction Requires Significant Investment in Lab Equipment and Infrastructure

Of the engineering programs for immediate launch profiled in this section, mechanical engineering requires the greatest investment in laboratory infrastructure. Mechanical engineering programs require labs to accommodate experiments in heat transfer, thermal sciences, and fluid mechanics. All profiled mechanical engineering programs also require students to spend time in a computer lab. In addition to instructional and computer labs, administrators at the **University of San Diego** maintain a machine shop lab that includes tools for woodworking and welding, as well as hand tools.

Ways to Reduce Computer Lab Expenses

- Students **at California State University-Long Beach** learn in a computer lab shared with students in other disciplines
- Administrators at the **University of Maryland-Baltimore County** plan to transition to a bring-your-own-machine computer lab, since faculty members report students prefer to work on their own laptops

Profiled programs maintain between five and twenty labs for both instruction and research. The mechanical engineering program at the **University of California-San Diego** employs five to six labs for instruction, and administrators allow student researchers to do their work in faculty research labs. These labs measure approximately 30 feet by 40 feet.

Profiled programs employ between one and four lab technicians to maintain mechanical engineering lab equipment. Administrators of the mechanical engineering program at the **University of Maryland Baltimore County** also employ a separate computer technician. Lab technicians at profiled institutions earn around $45,000 annually.

Contacts note most state universities receive state funding for lab equipment, though many institutions also charge students a per-course lab fee between $30 and $50 to assist with equipment maintenance. Administrators at California State University-Long Beach report that they ask industry partners for donations (of machines or money) for particularly expensive equipment.

Necessary Equipment for Mechanical Engineering Labs

Profiled Competitor Curricula

Machines

- **Dynamometer**
- **Thermocouple amplifier**
- **Linear amplifier**
- **Linear shaker**
- **Shake table II** with active mass dropper
- **Accelerometer**
- **Displacement transducer**
- **Digital oscilloscope**
- **3D printer**
- **Computer Numerical Control (CNC) machines:**
  - Lathe: Haas ST-10Y with Y-axis
  - Mill (or a manual lay mill)
  - Laser cutter
- **Drop tower** for impact testing

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Software Programs

- **Computer Aided Design and Computer Aided Manufacturing (CAD/CAM)** programs:
  - CREO
  - SURFCAM
  - SOLIDWORKS
  - Autodesk
- **MATLAB:** for data analysis
- **Simulink:** a graphical modelling and simulation software integrated with MATLAB
- **Microsoft Office** suite

Profiled Mechanical Engineering Programs Employ between Seven and 27 Tenure-Track Faculty Members

Administrators at **San Diego State University** employ approximately 30 faculty members in the undergraduate mechanical engineering program; 17 tenure-track professors and 10 to 12 lecturers per semester. Not all lecturers possess doctoral degrees; lecturers who teach upper-division courses must have a PhD, while lecturers who teach lower-division courses sometimes possess only a master's degree. Only **California State University-Long Beach** employs more adjuncts in the mechanical engineering program than tenure-track professors (35 adjuncts and 22 tenure-track professors).

Profiled institutions report mechanical engineering faculty member salaries range from $65,000 for a nine-month appointment to $140,000 per year. The same institutions pay adjunct mechanical engineering faculty members between $4,500 and $6,500 per course.

The majority of mechanical engineering faculty members at profiled institutions hold a PhD in mechanical engineering, though some hold degrees in related fields such as physics, aerospace engineering, or electrical engineering. Mechanical engineering professors rarely teach courses in other disciplines. Two mechanical engineering faculty members at the **University of California-San Diego**, however, hold joint appoints in related engineering disciplines (i.e., mechanical engineering and nanoengineering, mechanical engineering and bioengineering).

Hire Faculty Researchers for a Competitive Program

Administrators at **California State University-Long Beach** report a current effort to hire mechanical engineering faculty members away from research universities to compete with the University of California system's mechanical engineering programs. Some area employers consider faculty research when evaluating program quality, and may donate equipment specifically for that research.

Number of Mechanical Engineering Bachelor's Degree Completions per Tenure-Track Faculty Member

In-State Institutions and Peer Institutions, Mechanical Engineering Departments, 2010 through 2013 Academic Years

Institution	Number of Tenure-Track Faculty Members	Number of Relevant Degree Completions from 2010 through 2013	Number of Relevant Degree Completions per Tenure-Track Faculty Member
California State University-Northridge	8	228	28.5
California Polytechnic State University-San Luis Obispo	27	739	27.4
California State Polytechnic University-Pomona	25	541	21.6
California State University-Sacramento	14	288	20.6
San Diego State University	17	349	20.5
California State University-Chico	9	171	19.0
California State University-Fresno	9	156	17.3
California State University-Long Beach	22	356	16.2
California State University-Los Angeles	10	129	12.9
The University of Texas at Tyler	7	88	12.6
California State University-Fullerton	11	114	10.4

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Employer Partnerships

Local Employers Provide Internships and Project Support for Profiled Mechanical Engineering Programs

Most profiled mechanical engineering programs report employer support in the form of internships. Other ways local employers support mechanical engineering programs include donations of technology for faculty research (and later used for instruction) as well as financial and in-kind support for senior design projects (e.g., mentoring a design team). **California State University-San Marcos** should engage local employers for senior design project guidance to acquaint local employers with the new mechanical engineering program.

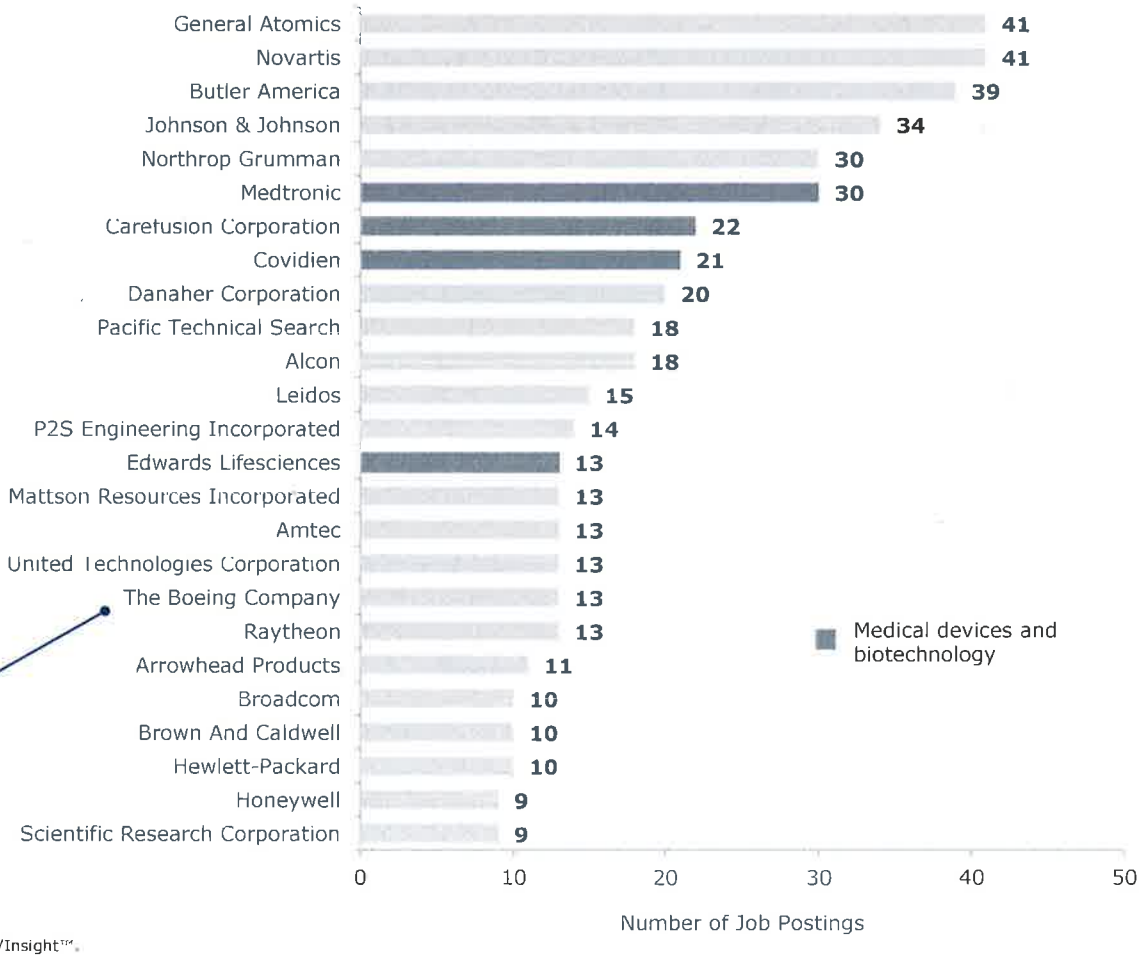
Administrators at the **University of California-San Diego** help local employers recruit graduates via an engineering school-wide Corporate Affiliates Program (CAP). The CAP also allows employers access to faculty and research, as well as a seat on the executive board that guides the school.

'General Atomics' and 'Novartis' posted the most job openings for bachelor's-level mechanical engineers last year. Many biotechnology companies appear on the list of top employers, including 'Medtronic,' 'Carefusion Corporation,' and 'Edwards Lifesciences.' Job openings at biotechnology companies compose over three percent of all relevant jobs posted in the area last year.

Top Employers of Mechanical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[33]

n=2,499 job postings, 855 unspecified postings



Administrators at **California State University-Long Beach** report a partnership with Boeing; the school is a "Boeing Focus School," meaning that Boeing operates a center on campus where Boeing employees work with engineering students and faculty members.

33) Burning-Glass Labor/Insight™.

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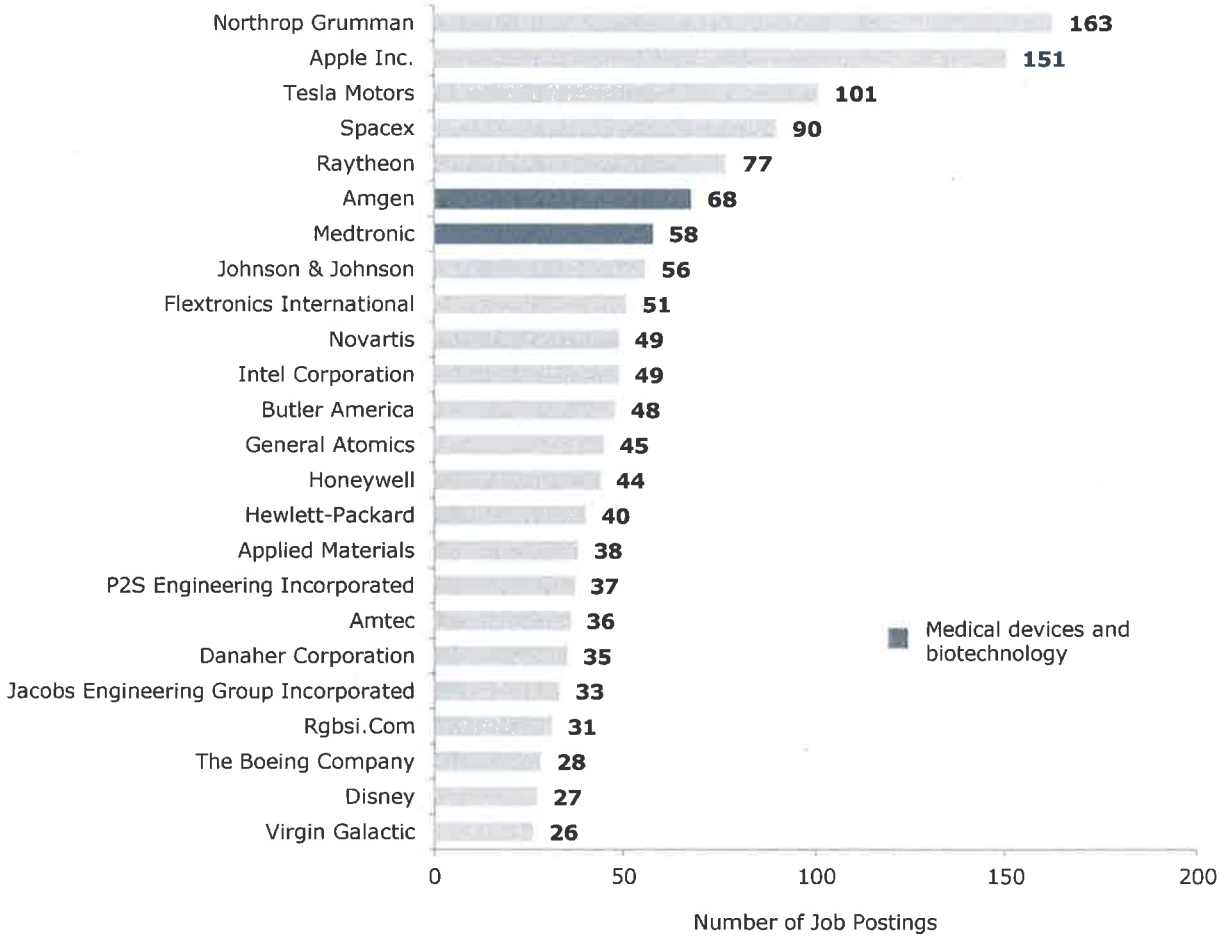
Top Employers of Mechanical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[34]

n=8,483 job postings, 2,731 unspecified postings



Community College Partnerships

Recruit Students with Math and Physics Courses for the Mechanical Engineering Bachelor's Degree Program

Transfer students complete general education requirements as well as the math and physics courses that compose lower-level engineering curricula. Contacts report students who transfer into undergraduate mechanical engineering programs from community colleges do not achieve associate's degrees before transfer.

Between 14 and 33 percent of mechanical engineering students at profiled institutions transfer into the bachelor's degree programs from community college.

34) Burning-Glass Labor/Insight™.

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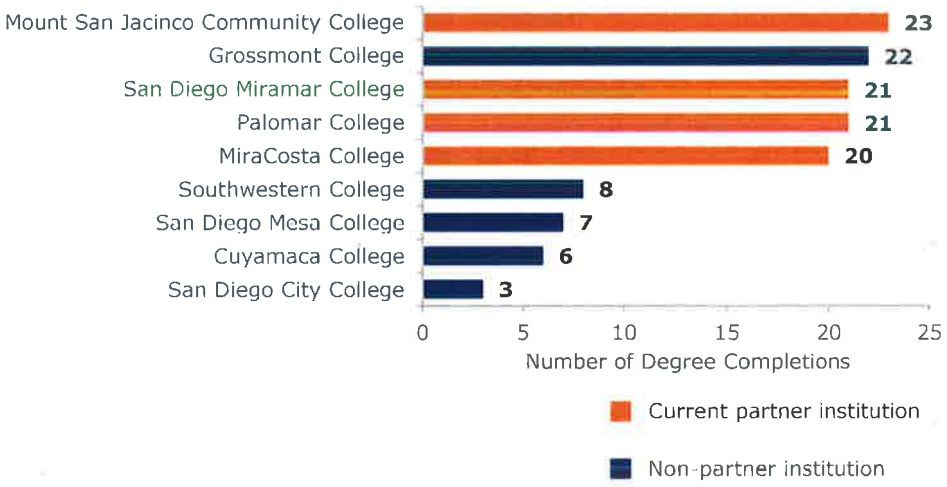
Market the Mechanical Engineering Bachelor's Degree Program to Students at Mt. San Jacinto College and MiraCosta College

California State University-San Marcos should continue to recruit students from **Mt. San Jacinto College** and **MiraCosta College**; these schools conferred the most associate's degrees in 2013 in math and physics, respectively. Potential additional community college partners include **Grossmont College**, **Southwestern College**, and **San Diego Mesa College**. Though many community college transfer students do not complete an associate's degree, programs with high numbers of associate's degree completions also likely possess high course enrollments from non-degree seeking students. For a sample mechanical engineering articulation agreement between the University of San Diego and San Diego Miramar College, see Appendix C.

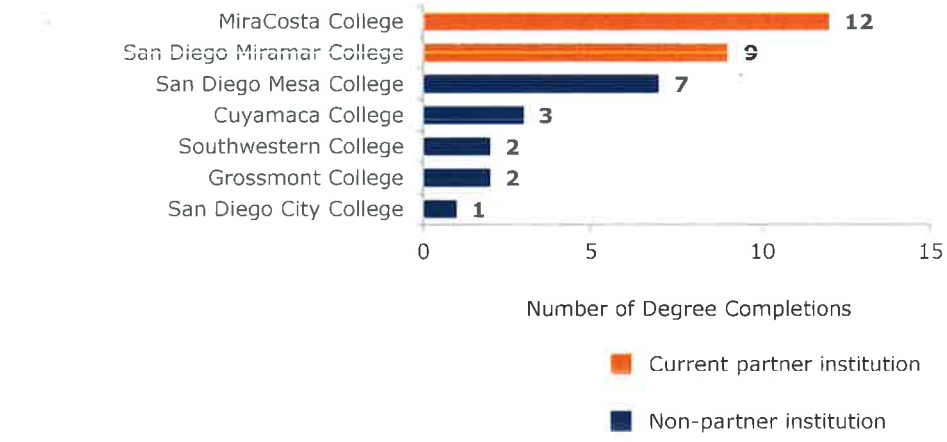
Mechanical Engineering-Related Associate's Degree Completions

2013, Local Data[35]

Mathematics



Physics



35) Integrated Postsecondary Education Data System.

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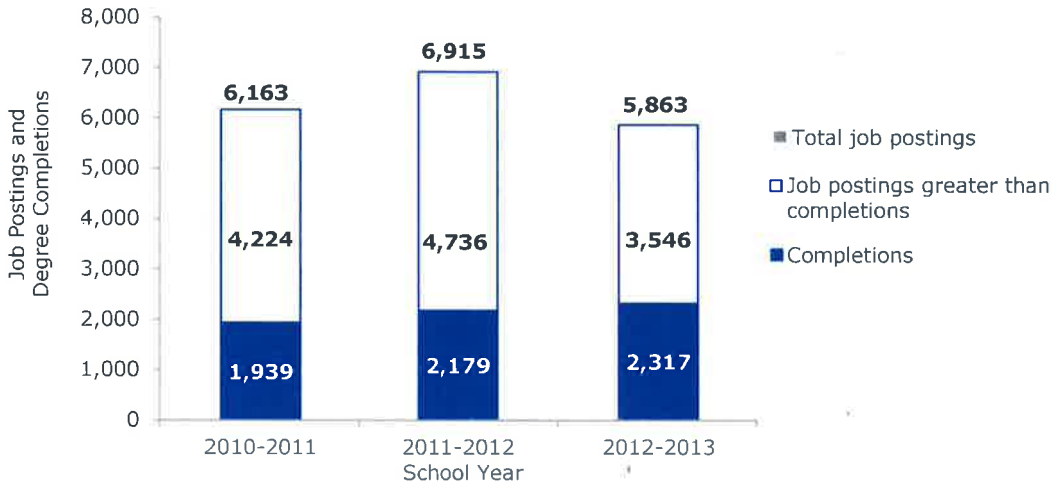
Potential Graduate Outcomes

Employers in California Seek More Bachelor's-Level Mechanical Engineering Professionals than Students who Complete Mechanical Engineering Degrees

Across three years of comparable data, employers in California exhibit higher demand for mechanical engineers than the number of qualified candidates who graduate from California institutions. In the most recent year of comparable data, the 2012-2013 school year (i.e., July 2012-June 2013), employers posted 5,863 jobs for mechanical engineering professionals with bachelor's degrees. California institutions only graduated 2,317 mechanical engineers at the bachelor's level that year. The consistent statewide gap between degree completions and employer demand indicates a good market for **California State University-San Marcos** to open a new mechanical engineering program.

Mechanical Engineering Degree Completions and Employer Demand

2010-2013, State Data, Bachelor's Degree Completions and Bachelor's Degree Required for Job Postings[36]



36) Job postings: Burning Glass Labor/Insight™; Completions: Integrated Postsecondary Education Data System.

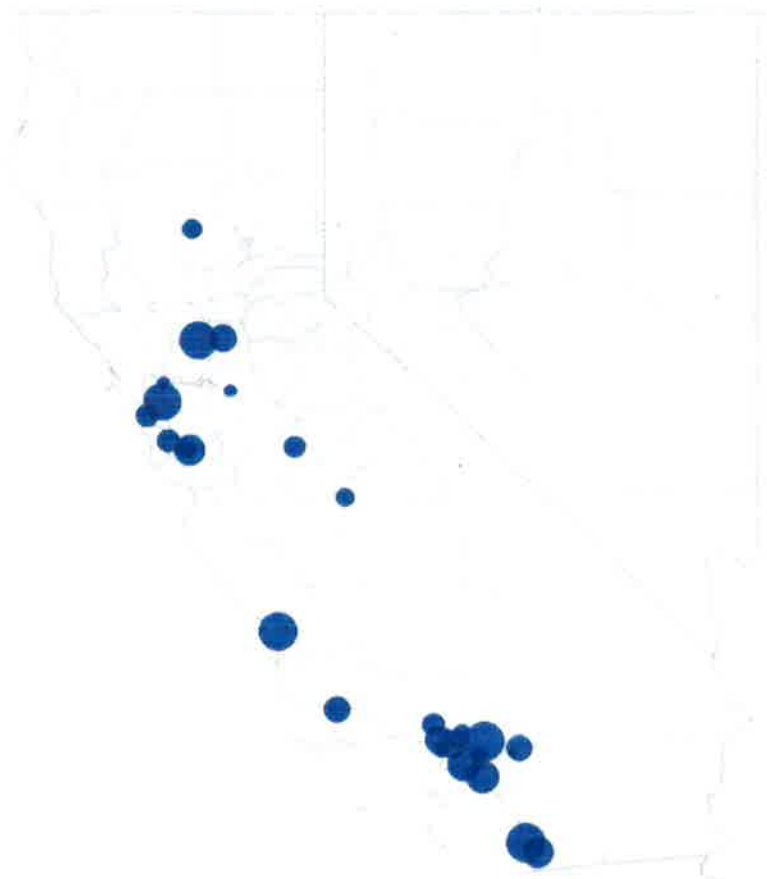
Local Institutions Conferred Nearly 25 Percent of California Mechanical Engineering Bachelor's Degrees in 2013

Graduates of a mechanical engineering bachelor's degree program at **California State University-San Marcos** will likely compete for jobs with graduates of other local institutions, such as the **University of California-San Diego**, **California State University-Long Beach**, and **San Diego State University**.

Twenty-nine public and private non-profit California institutions offer bachelor's degree programs in mechanical engineering. The **University of California-San Diego** reported the highest number of mechanical engineering bachelor's degree completions locally and statewide in 2013. **California Polytechnic State University-San Luis Obispo** and **California State Polytechnic University-Pomona** reported highest number of mechanical engineering bachelor's degree completions in 2013 among institutions in the California State University System.

Mechanical Engineering Bachelor's Degree Completions

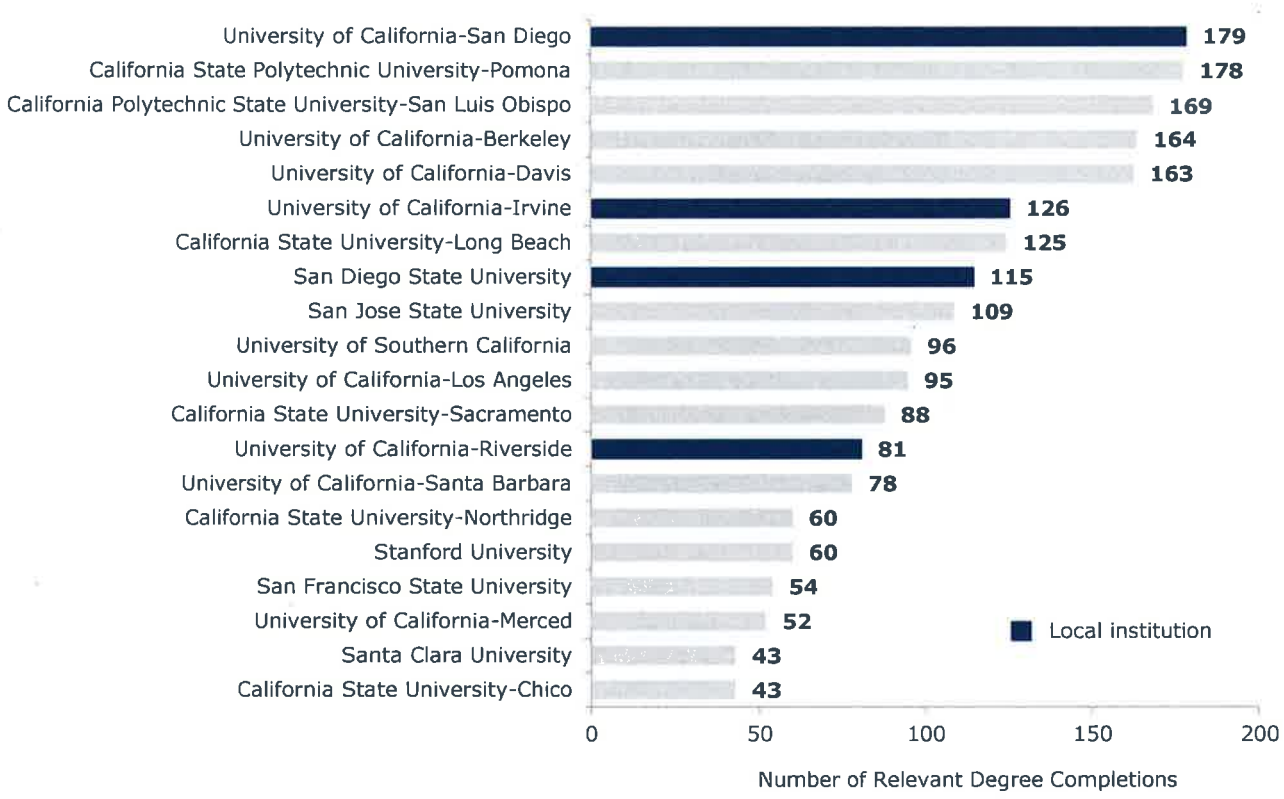
2013, California Data[37]



37) Integrated Postsecondary Education Data System.

Mechanical Engineering Bachelor's Degree Completions

2013, California Data[38]



38) Integrated Postsecondary Education Data System.

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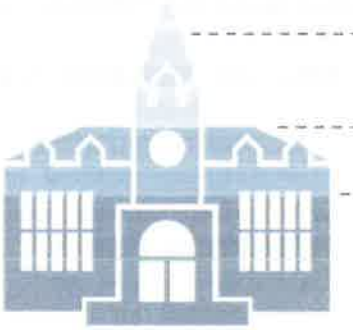
Profiled Institutions Report High Employment Rates for Mechanical Engineering Program Graduates

Reported employment rates (within one year) range from 65 to 95 percent. Contacts report 20 percent of graduates or fewer go directly into a master's program.

Mechanical Engineering Six-Year Graduation Rates

Profiled Institutions



San Diego State University: 85 to 90 percent

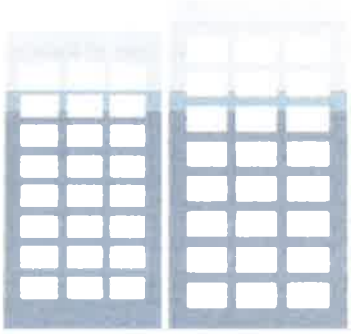
University of California-San Diego: 60 percent*

California State University-Long Beach: 40 percent

*Contacts did not specify a time to completion

Mechanical Engineering Employment Rates in a Related Field within One Year of Graduation

Profiled Institutions



University of San Diego: 95 percent

University California-San Diego: 71 percent

California State University-Long Beach: 65 percent

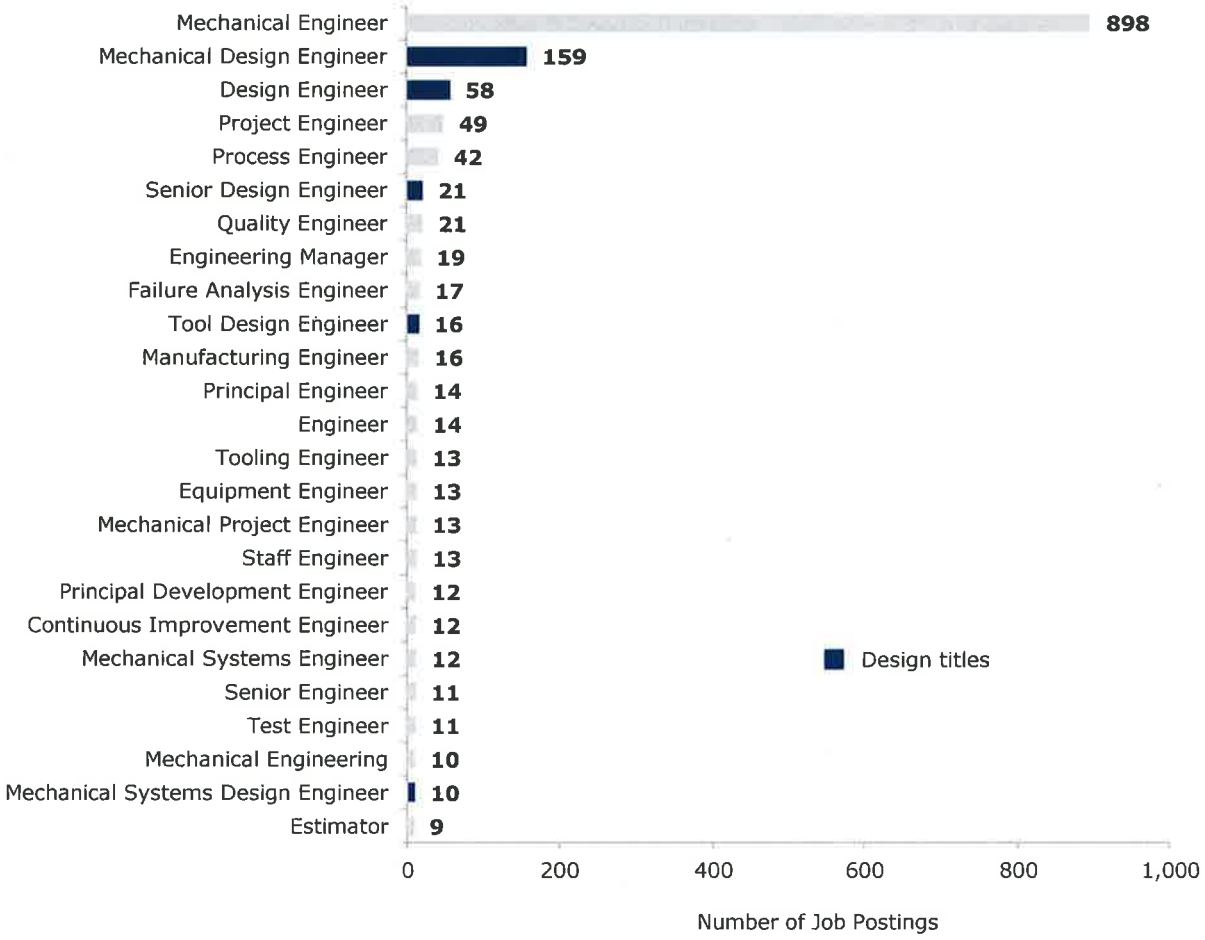
Local Employers Frequently Seek Mechanical Engineers to Fill Design Roles

Thirty-six percent of all relevant jobs posted last year list 'mechanical engineer' as the job title. Other commonly sought titles include 'mechanical design engineer' and 'design engineer,' proving the importance of building design experience into the undergraduate mechanical engineering curriculum at **California State University-San Marcos**. Design-related titles compose 10.6 percent of all relevant jobs posted in the San Marcos area last year.

Top Titles for Mechanical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, Local Data[39]

n=2,499 job postings, 0 unspecified postings



39) Burning-Glass Labor/Insight™.

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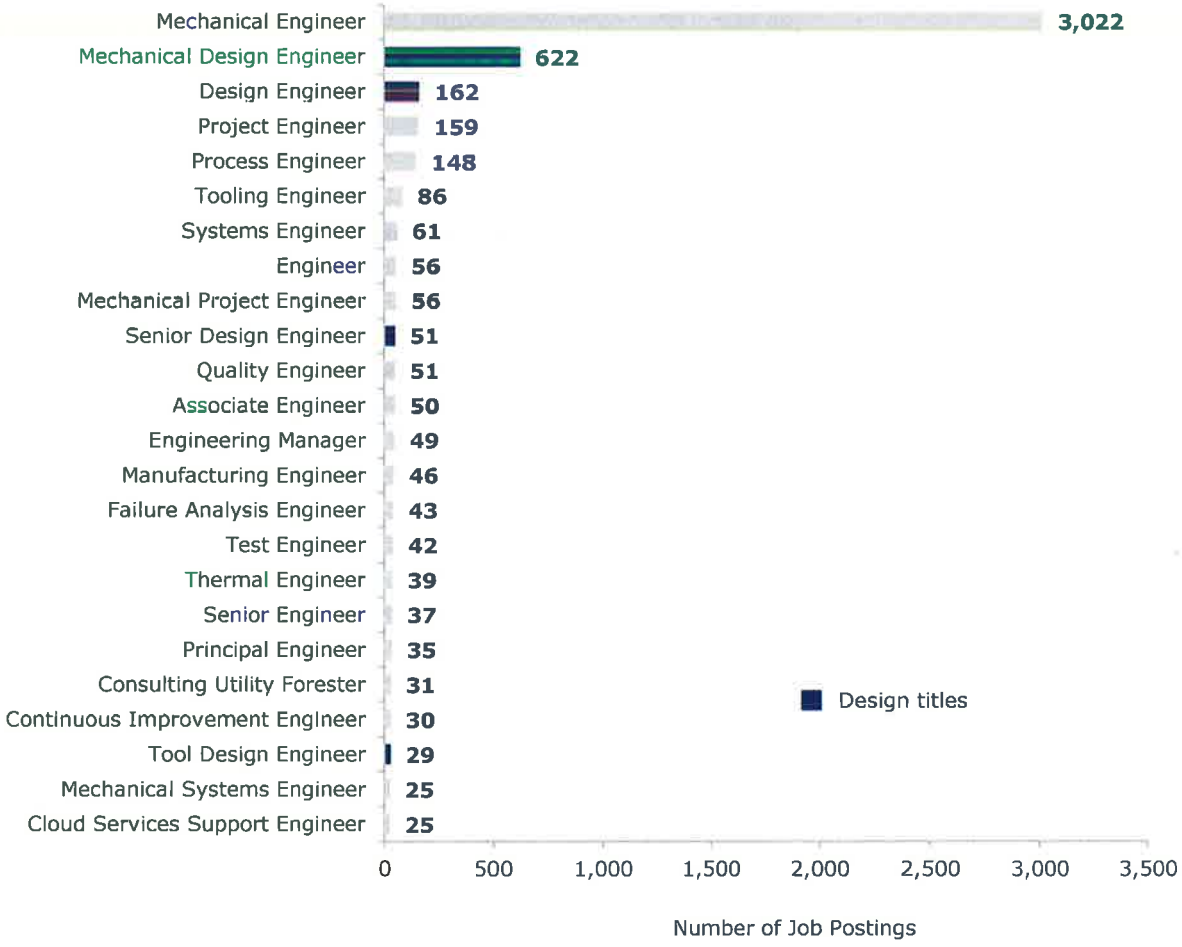
Top Titles for Mechanical Engineering Professionals

October 2014-September 2015, Bachelor's Degree Required, California Data[40]

n=8,483 job postings, 0 unspecified postings



40) Burning-Glass Labor/Insight™.

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Section V: Audiences and Recruitment Strategies

1) Section Research Methodology

Purpose

Identify target audience segments for a new undergraduate engineering program, with a focus on the University's uniquely diverse student populations, including recent high school graduates, the community college transfers that make up half the student body, and thousands of local residents with ties to the area's military community.

Sources

- Local high school student performance data
  - SAT performance
- ACT intended major data
- Local population demographics from the US Census Bureau
- Reported associate's degree completions in engineering-related programs at local community colleges
- Interviews with directors of comparable undergraduate engineering programs
- EAB's internal and online research libraries (eab.com)

2) High School Students

Interest

Intended Majors

11%

In California, 11 percent of students who take the ACT identify engineering as their intended college major.

California Students Report Greater Interest in Engineering Majors than Students Nationwide

Over two-thirds of students who report they intend to study engineering as their major when taking the ACT ultimately declare engineering majors in college. Intended engineering students are among the most certain of their future major; Californians who intend to major in computer science and mathematics do so less than half of the time, for example. This certainty indicates a strong potential to recruit future engineering students while still in high school, and to target traditionally aged college students once on campus.

Californian students select engineering as their intended major 22 percent more often than the national average.

Preparedness

Orange and San Diego County Students Demonstrate Greatest Preparedness for Engineering Programs

Prioritize recruitment within districts with SAT scores above the state average, particularly on the math portion of the exam. Focusing recruitment on second-tier districts (i.e., districts with high scores, but not the highest scores regionally) offers new programs the greatest potential recruitment success. These highest potential districts include Laguna Beach Unified and Placentia-Yorba Linda Unified.

Higher scores indicate districts with a greater likelihood to graduate students prepared to study engineering. Within those districts, aim to recruit students whose math section scores exceed 573. Students who intend to major in engineering score an average of 573 on the math section of the SAT, and an average of 525 on the reading section. Approximately 20 districts achieved average math section scores above the state average of 506, offering better prepared students overall.

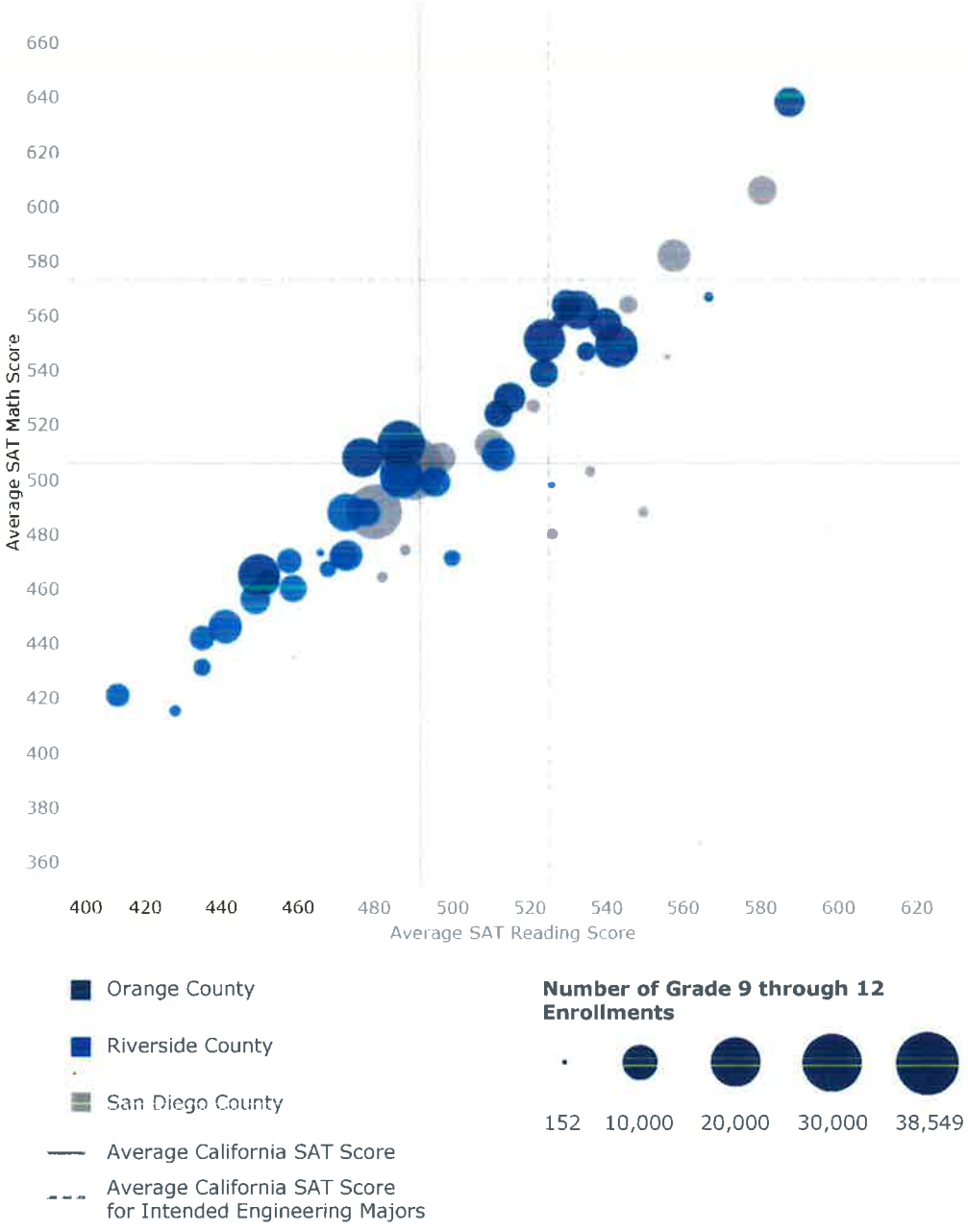
Only three districts' average math SAT scores exceeded the 573 average:

- Irvine Unified (638 average math score)
- San Dieguito Union High (606)
- Poway Unified (582)

These districts likely experience the most competitive recruiting for future engineering students, however.

Average SAT Math and Reading Scores

2013 to 2014, Local School District Data[41, 42]



41) California Department of Education.

42) CollegeBoard.

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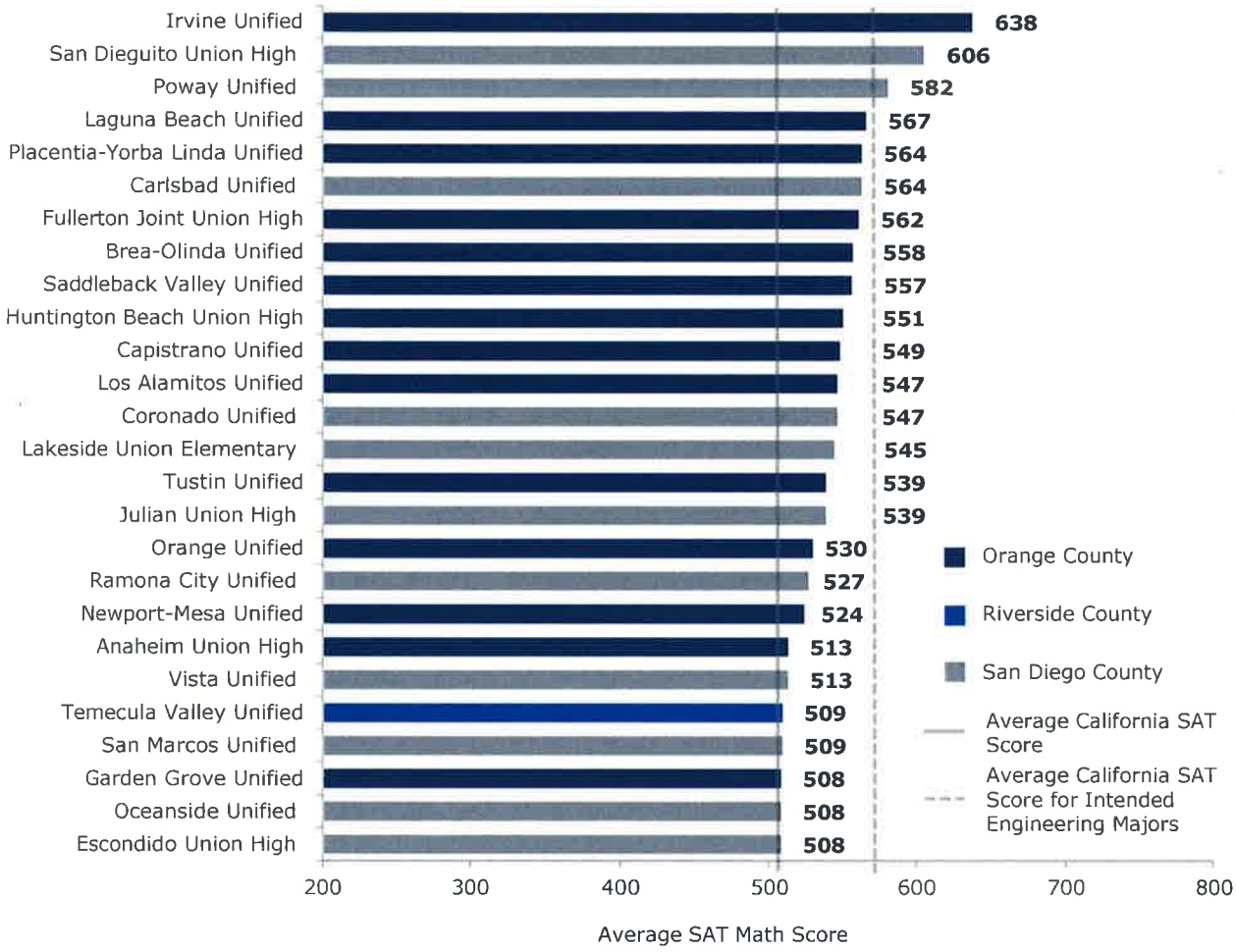
Average SAT Math Scores

2013 to 2014, Local School District Data[43, 44]



43) California Department of Education.

44) CollegeBoard.

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Regional High Schools Offer Preparatory Engineering Coursework as well as Math and Science Courses

California high school students must complete two mathematics courses (one of which must meet or exceed the rigor of Algebra 1) and two science courses (in biological and physical sciences) to graduate[45]. Engineering students, however, receive encouragement to complete the most challenging math courses available. This typically includes calculus coursework. Local high schools offer courses such as Introduction to Calculus and AP Calculus. Physics coursework also prepares students for rigorous undergraduate engineering courses. Introduction to Physics and AP Physics are available at local high schools.

Relevant elective engineering coursework at local high schools includes:

- Pre-Engineering and Design A/B (Escondido Union High)
- Principles of Engineering A/B (Escondido Union High)
- Rapid Prototype Development (Saddleback Valley Unified)
- Robotics (Fullerton Joint Union High, Placentia-Yorba Linda Unified)
- STEM Careers (Laguna Beach Unified)

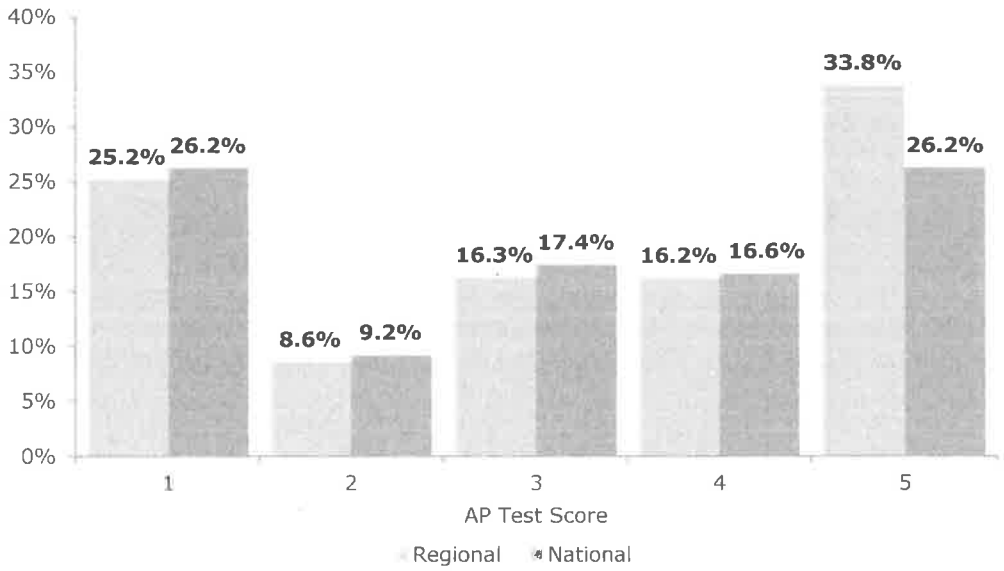
California Students More Frequently Achieve Scores of 5 on AP Calculus Exams than Students Nationwide

Thirty-four percent of California students achieve scores of 5 on the AP Calculus AB or BC exam. Below the highest student scores, California students perform on par with the rest of the nation.

California students also increasingly take AP exams across all subjects; 127 percent more students took AP exams in 2014 than in 2003.

AP Calculus Score Distribution[46]

2014



45) California Department of Education.
46) CollegeBoard.

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Approach High School Students Early via Direct Mail and Email

Students demonstrate interest in engineering by the time they take the ACT, typically a student's junior year. Begin outreach to students within high-priority school districts during their sophomore or junior year as students begin to identify their interest in engineering.

High School Student Recruitment Principles[47]

Start Early

Begin high school student recruitment during students' sophomore or junior years. Over 40 percent of students report beginning their college search process by the end of their first high school fall semester. Information on majors and careers increases in relevance during their high school experience, suggesting students' sophomore and junior years offer the best timing for engineering program recruitment.

Send Direct Correspondence

Contact students directly via direct mail and email. Direct mail and email remain a top source of college information for students, despite competing media outlets. Low- and middle-income students exhibit the greatest reliance on institutional communication to inform their college choice. Half of high school students will evaluate a previously unconsidered institution if they receive direct correspondence.

Optimize Program Website

School and program websites represent another primary source of college information. High-income students more often incorporate school specific websites in their college search process; encourage students to visit program website via direct correspondence to increase visits across socioeconomic lines. Optimized websites include key information on program structure, cost, and outcomes within a clean and navigable presentation.

Prioritize Messages Addressing Cost Concerns

Highlight information on program cost and opportunity for financial aid. College cost undeniably influences students' institution and program choice, and as expected more strongly impacts low-income students' decisions. Ensure all correspondence and program website communicate program cost and affordability. Provide information on career outcomes for engineering majors as well; salary information, in particular, demonstrates students' return on their educational investment.

Encourage Faculty Participation in Recruitment

Opportunity for increased department enrollment and interaction with senior institutional leadership attract faculty involvement with recruitment. Faculty contributions include:

- Direct correspondence with prospective students (templates and contact management tools increase efficiency)
- Phone conversations with students who demonstrate engineering program interest
- Luncheons and small gatherings with prospective students during open house and admitted student events

See Encouraging Faculty Participation in Student Recruitment for more information.

47) EAB. The Who, What, When, Where, and Why of College Choice. (2014)

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3) Community College Transfer Students

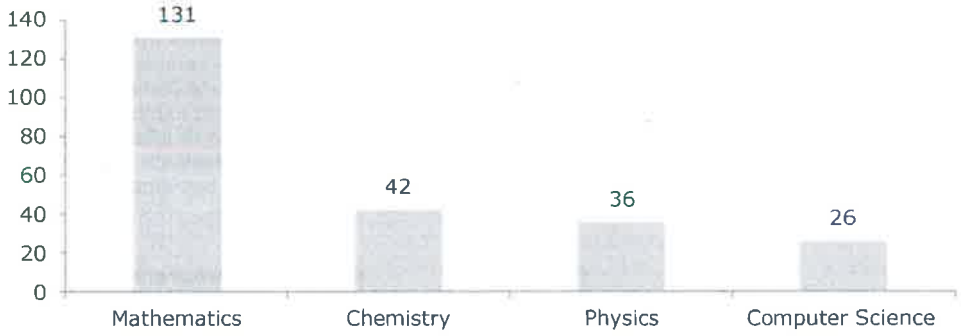
Interest and Preparedness

Local Community Colleges Reported over 200 Relevant Associate's Degree Completions in 2013

Nationwide, two-thirds of community college students report they aim to transfer to a four-year institution; only 30 percent ultimately transfer, but this still represents a significant audience of prospective students. Over 1.5 million students were enrolled in California community colleges in the spring of 2015.

Relevant Associate's Degree Completions by Program and Community College

Reported Degree Completions for Relevant Programs, 2012-2013[48]



Mathematics

Institution	Completions
Mount San Jacinto Community College	23
Grossmont College	22
Palomar College	21
San Diego Miramar College	21
MiraCosta College	20
Southwestern College	8
San Diego Mesa College	7
Cuyamaca College	6
San Diego City College	3

48) Integrated Postsecondary Education Data System.

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Chemistry

Institution	Completions
San Diego Miramar College	23
MiraCosta College	10
San Diego Mesa College	5
Southwestern College	2
Cuyamaca College	1
Grossmont College	1
Palomar College	0

Physics

Institution	Completions
MiraCosta College	12
San Diego Miramar College	9
San Diego Mesa College	7
Cuyamaca College	3
Grossmont College	2
Southwestern College	2
San Diego City College	1

Computer Science

Institution	Completions
California College San Diego	22
MiraCosta College	2
Southwestern College	2

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Community College Partnerships and Articulation Agreements Encourage Eventual Four-Year University Enrollment

California institutions benefit from statewide articulation agreements. In particular, students who complete an associate degree for transfer receive guaranteed admission to a California State University school if they meet minimum eligibility requirements.[49] The program does not list any available engineering degrees, but other sciences such as computer science and mathematics offer potential models for transfer degree programs.

Rely on Online Recruitment to Attract Students from Non-Partner Community Colleges

Without partnerships or physical presence on community college campuses, online recruitment strategies (e.g., program website, social media) offer universities the most efficient recruitment. Ensure engineering program website directly addresses transfer student concerns such as credit articulation and time to completion.

Host transfer student open houses for students who seek in-person interaction before application.

Consider reverse articulation agreements to reward students for academic progress and support community college partners' completion rates. Reverse articulation agreements award students associate's degrees after completion of 60 credits across the community college and the partner university. Reverse articulation ensures community colleges receive credit for successful students who transfer shy of an associate's degree or who transfer without completing paperwork for associate's degree receipt. Associate's degrees also offer transfer students recognition of sustained academic progress.

Embed Academic Advising at Community College Partners

Preemptive academic advising helps students exceed minimum requirements to transfer from community college, increasing likelihood students will successfully complete bachelor's degrees. Previous EAB research found students who transferred to one university after meeting minimum requirements only graduated at a 30 percent rate. Students who were on track in their major and had completed an associate's degree successfully completed their bachelor's degree at a rate of 90 percent.

University advisors on community college campuses offer a high-resource integration. Lower cost options include:

- Training for community college advisors on engineering program transfer requirements
- Brief transfer guides that summarize more complicated transfer handbooks, highlighting engineering course requirements and transfer timelines
- Engineering program staff visits to community college campuses to meet with advisors and students

See Transfer Student Recruitment and Admissions at Public Research Universities for more information.

49) Associate Degree for Transfer Program.

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4) Active Duty Service Members and Veterans

Interest

Engineering Programs Offer Veterans Highly Compensated Post-Service Careers

Veterans Affairs materials encourage veterans to select degrees by opportunity to recoup educational investment, and to review majors' potential earnings[50]. The Veterans Affairs Administration refers students to the PayScale College Salary Report. Regarding engineering, the report notes "a degree in engineering is the first step toward a challenging, high-paying career." The report continues to describe engineering as "a smart choice if you love math and want a high-paying career."

PayScale's Highest Paying Bachelor's Degrees by Salary Potential[51]

Rank	Major	Early Career Pay	Mid-Career Pay	Perceived Meaning[52]
1	Petroleum Engineering	$101,000	$168,000	71%
2	Nuclear Engineering	$68,200	$121,000	58%
3	Actuarial Mathematics	$58,800	$119,000	48%
4	Chemical Engineering	$69,500	$118,000	61%
5	Electronics & Communications Engineering	$65,000	$116,000	55%
6	Computer Science (CS) & Engineering	$69,100	$115,000	43%
7 (tie)	Electrical & Computer Engineering (ECE)	$67,000	$114,000	53%
7 (tie)	Systems Engineering	$67,100	$114,000	60%
9	Aeronautical Engineering	$65,100	$113,000	61%
10 (tie)	Computer Engineering (CE)	$68,400	$109,000	48%
10 (tie)	Mining Engineering	$71,500	$109,000	79%
12 (tie)	Electrical Engineering (EE)	$66,500	$108,000	55%
12 (tie)	Mechanical & Aeronautical Engineering	$61,100	$108,000	58%
14 (tie)	Aerospace Engineering	$64,800	$107,000	57%
14 (tie)	Computer Science (CS) & Mathematics	$62,900	$107,000	36%

50) U.S. Department of Veterans Affairs. Choosing a School. (2015)
51) PayScale. College Salary Report. (2015)
52) The percent of alumni who report their work makes the world a better place.

Civilian Veteran Population Location

Local Counties Report Populations of 27,000 to over 50,000 Civilian Veterans

Areas with large veterans populations in which veterans compose a significant portion of the population offer the greatest opportunity for veteran-specific recruitment. These high-potential areas include:

- Oceanside
- Temecula
- Fallbrook
- Poway

The largest veteran populations live in Temecula, Murrieta, Oceanside, and Escondido; each city houses at least 40,000 civilian veterans. Proportionally, veterans compose the largest percentage of the population in Rancho Santa Fe (25.5 percent of the zip code 92091 population); this high proportion only accounts for 306 total veterans, however.

Military Experience

4-8 yrs

Undergraduate veteran students typically possess four to eight years of military experience.

Oceanside and Temecula Offer the Greatest Recruitment Potential

Zip codes within Oceanside and Temecula present large populations of veterans without a college degree, but who have completed at least a high school degree, both in absolute population and relative to their larger populations. The 92056, 92057, 92058 zip codes (all Oceanside) and the 92592 zip code (Temecula) offer the largest and most concentrated veteran populations most likely to enroll.

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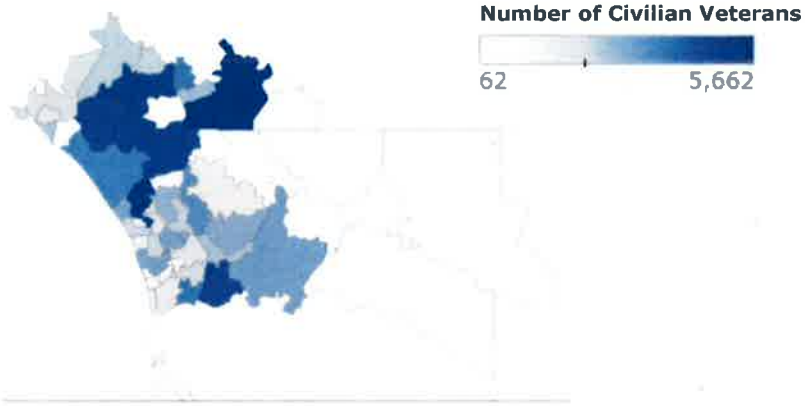
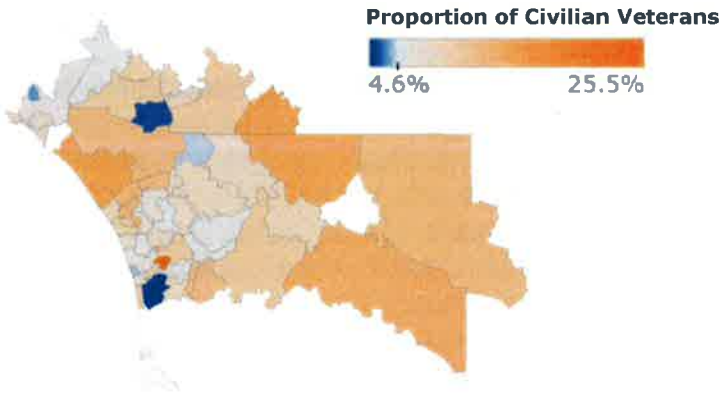
Number of Civilian Veterans Age 18 or Older

2009 to 2013; Southern Orange County, Southern Riverside County, and Northern San Diego County Data[53]



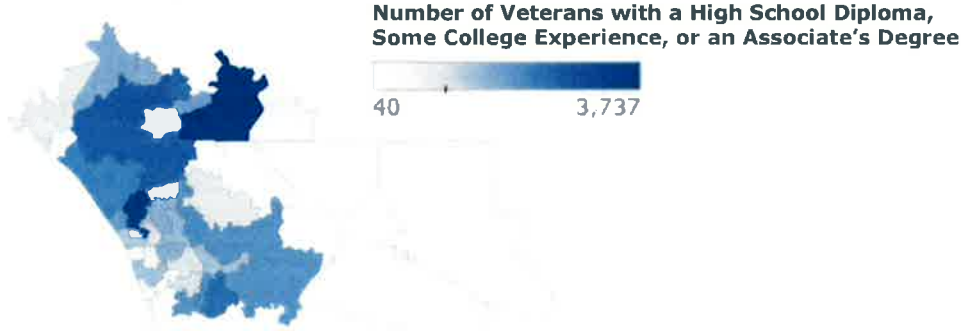
Proportion of Veterans among the Civilian Population Age 18 or Older

2009 to 2013; Southern Orange County, Southern Riverside County, and Northern San Diego County Data[54]



Number of Civilian Veterans Age 25 or Older with a High School Diploma, Some College Experience, or an Associate's Degree

2009 to 2013; Southern Orange County, Southern Riverside County, and Northern San Diego County Data[55]



53) U.S. Census Bureau: American Community Survey.
54) U.S. Census Bureau: American Community Survey.
55) U.S. Census Bureau: American Community Survey.

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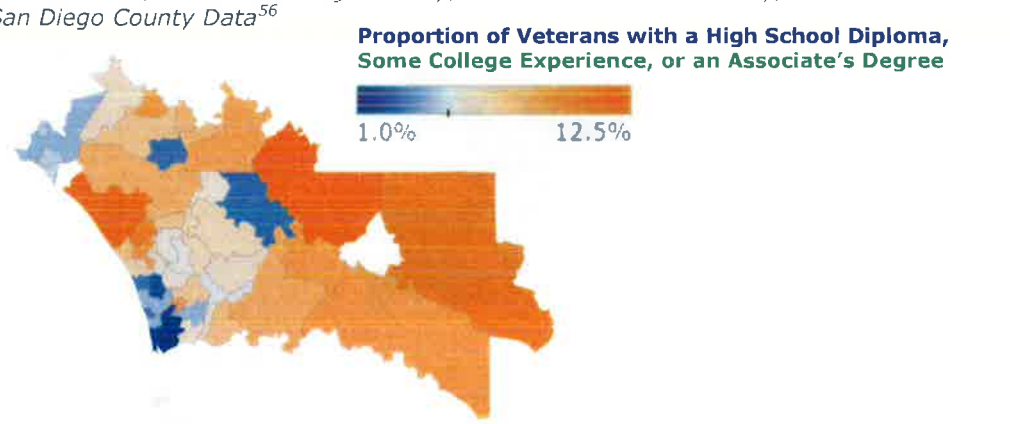
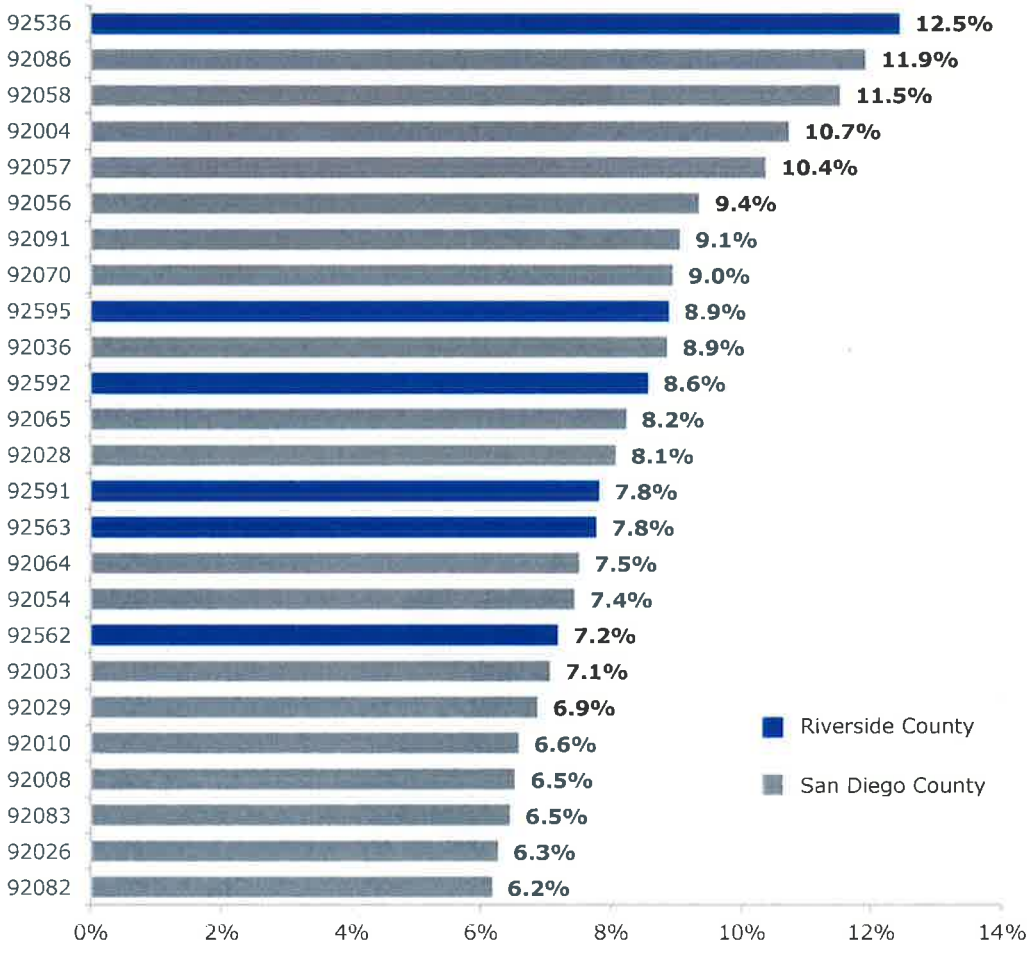
Proportion of Veterans with a High School Diploma, Some College Experience, or an Associate's Degree among the Civilian Population Age 25 or Older

2009 to 2013; Southern Orange County, Southern Riverside County, and Northern San Diego County Data[56]



Proportion of Veterans with a High School Diploma, Some College Experience, or an Associate's Degree among the Civilian Population Age 25 or Older

2009 to 2013; Southern Orange County, Southern Riverside County, and Northern San Diego County Data[57]



56) U.S. Census Bureau: American Community Survey.

57) U.S. Census Bureau: American Community Survey.

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Outreach to Active Duty Military, Veterans, and their Families during Each Stage of Military Careers

Focus messages on student support services, program affordability, and career preparation. Promote the personal interaction with classmates and accessibility of student services to distinguish the engineering program from highly advertised online competitors.

Student services staff must be equipped to support students through financial aid processes, a significant obstacle for military-affiliated students. Program staff must either know military-affiliated financial aid details, or must know where on campus to refer students for expert help. Half of all student questions involve benefits (e.g., application procedures, delays).

Outreach Strategies across Military Careers

Career Stage	*Institutional / High Resource Strategy*	*Program / Low Resource Adaptation*
Recruitment and Pre-Deployment	Military recruiters encourage enlistees to apply concurrently to college before deployment, often in collaboration with campus staff. Veterans affairs staff coordinate "Future Soldiers, Future Students" events quarterly to introduce the campus and financial aid options to recruits and their parents.	Within Military/Veterans section of the program website, provide a timeline for when recently recruited servicemembers should apply to program.
Deployment	Host resource events for military families during deployment to support the community and develop institutional recognition. Collaborative events with the Department of Veterans Affairs and non-profit and religious organizations provide medical check-ups, help with paperwork, and loan and benefits information.	Participate in family resource events on campus and in the community. Ensure program recruitment staff and faculty can refer military families to military and veterans resources on campus.
Return to Civilian Life	Campuses host post-deployment "re-integration" workshops and job fairs after soldiers finish their service and return to civilian life. Contributions include providing space for military-organized post-deployment events. Institutional veterans staff ensure military recruiters receive informational materials; many veterans solicit their recruiters' guidance for pots-service options.	Designate open houses for military and veteran prospective students. Provide re-integration materials alongside program information and academic advising. Promote events through local non-profits such as the Wounded Warriors Project as well as Veterans Affairs divisions.

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Explain Financial Aid and Offer Assistance with Veterans Benefits Applications

Similar to other target audiences, veterans prioritize financial aid in their education searches. Research has found veterans will prioritize available financial aid over program content in their decision-making process[58].

"Next Steps for Veterans" Flyer with Suggested Program Actions

1. **Complete the online application.** Include the admissions website and office phone number for student questions.

2. **Complete the VA application.** Direct students to http://www.benefits.va.gov/gibill/apply.asp to receive the letter of eligibility and call the VA Hotline (1-888-442-4551) with questions. Have students complete the Change of Place of Training Form 22-1995 if transferring programs.

3. **File the FAFSA.** Include the school code (e.g., 001864) and website (**fafsa.gov**). Instruct students to file early to ensure processing before the semester starts.

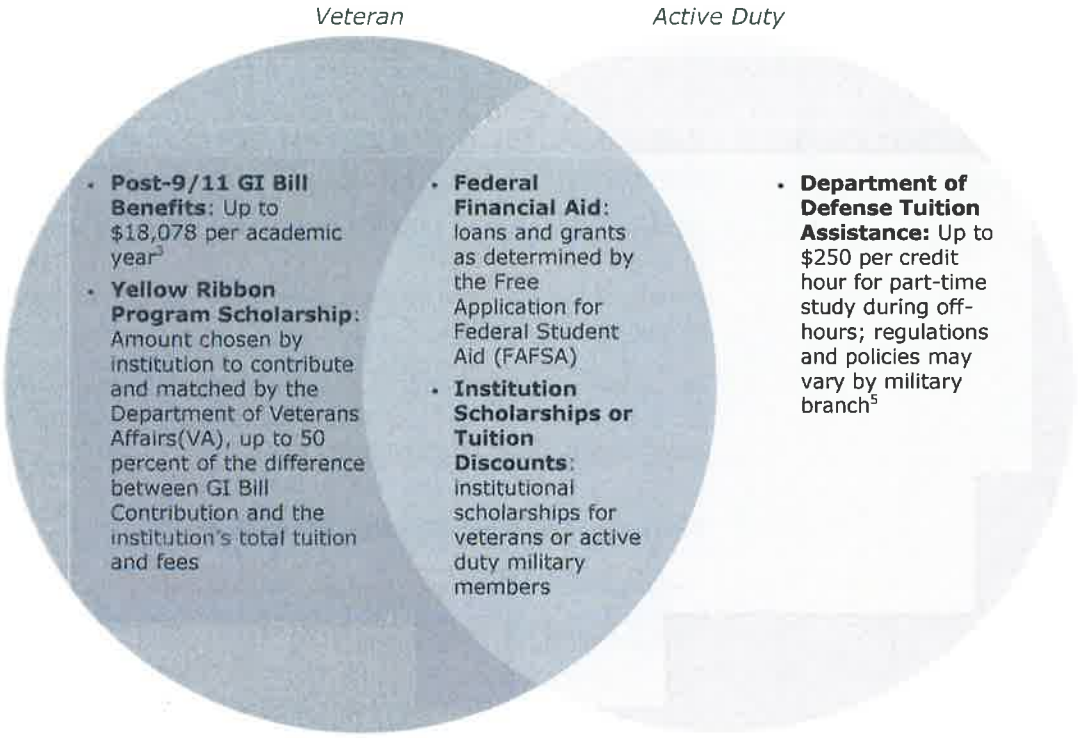
4. **Schedule orientation, advising, and registration sessions.** Remind students they must finish placement testing and submit transcripts and financial aid acceptance forms before orientation.

5. **Complete veterans benefit certification request form.** Post forms on financial services website and remind students to complete forms each semester.

6. **Create institutional email account to receive progress updates.** Provide information to set up college email address and provide Information Technology's service number.

58) EAB. Veteran Demographics and Marketing Strategies. (2015)

Financial Aid Available to Servicemembers



Emphasize How Engineering Program Can Transform Military Experience into Civilian Employment

Employ the ACE Guide to the Evaluation of Educational Experiences in the Armed Services to evaluate students' military training for academic credit.

Demonstrate Potential to Receive Credit for Military Training in Recruitment Materials

"Did you receive training as a Telecommunications Systems Engineer? You may qualify for three credit hours in systems integration – talk to an advisor to learn more."

Advertise Campus Recognition for Active Military and Veteran Support Services

Campus veterans affairs staff complete questionnaires they receive from external organizations about veterans support campus-wide; institutions do not proactively seek awards or recognition. These evaluations typically measure institutions' student support, academic quality, academic policies, and financial aid.

California State University-San Marcos has received acknowledgment from:

- Military Friendly Schools
- The Military Times' Best for Vets Colleges List (ranked 20th of 100 four-year institutions)
- Military Advanced Education's 2014 Guide to Military-Friendly Colleges and Universities

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5) Engineering Student Qualifications and Support Services

Program Entry Qualifications

Establish Entry Requirements above Institutional Acceptance Standards

Competitor programs often hold additional requirements to enter engineering programs above university admissions standards. Additional requirements limit enrollment to prepared students who understand the hard work required to succeed in engineering courses.

For a newly launched engineering program, a pre-major requirement establishes program selectivity and demonstrates applicant motivation without creating significant barriers to enrollment.

Engineering Program Requirements

- **No additional pre-requisites**: At CUNY-Brooklyn, anyone admitted to the institution can enroll in engineering program
- **Higher standardized test requirements**: University of Wisconsin-Milwaukee students' ACT scores must exceed institutional minimum to enroll
- **Completion of pre-major status**: Students must complete calculus, physics I, and a programming course within three semesters before they can declare a computer science major at CSU-Long Beach; retention has increased since administrators instituted the pre-major status in 2013
- **Competitive application**: Applicants to the University of California-San Diego apply to the engineering program specifically. If students apply to the University generally, they can apply to the engineering program once per year (in June). Internal applicants after one year must have completed Math 20A-C, Physics 2A-B, Chemistry 6A; internal applicants after two years must have completed Math 20A-F, Physics 2A-C, Chemistry 6A, and MAE98 (a MATLAB course).

Support Services

Engineering Students Require Dedicated Academic Support

Program staff typically organize tutoring services, but peers deliver tutoring rather than university staff or instructors. Encourage students to develop study groups to supplement tutoring services as well.

Schedule services and space open hours to accommodate working students. For example, ensure lab spaces remain accessible after 6pm. Offer tutoring appointments in evenings and on weekends.

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Programs less often provide professional development services; peers generally provide the mentoring that composes professional development help. Most engineering programs also coordinate with a specialized career services staff member who supports engineering students' job search. The mechanical engineering program at the University of California-San Diego aims to develop a dedicated professional development program. University of California-San Diego engineering students already receive general professional development support through the IDEA Center (the School Of Engineering's student center).

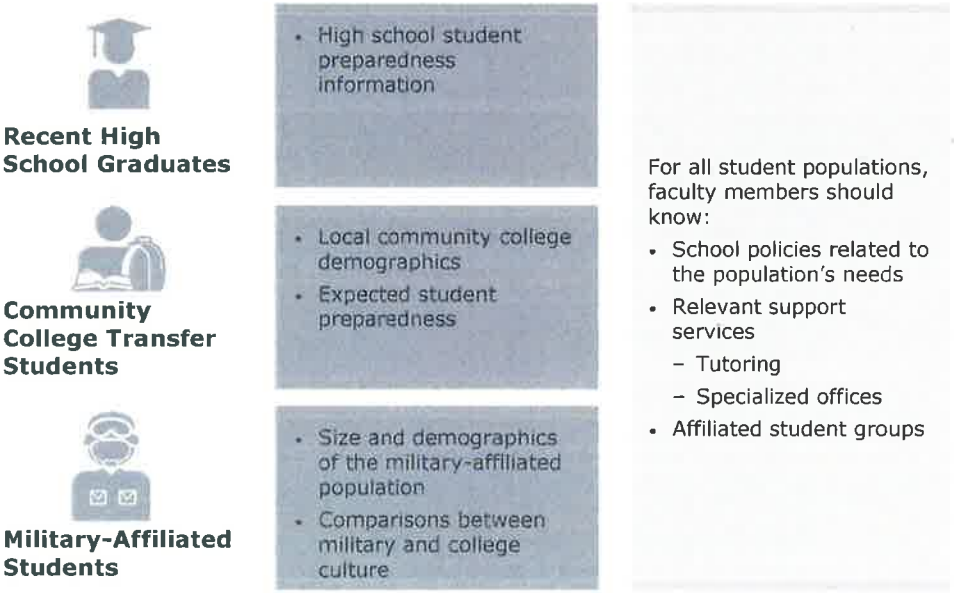
Consider Cohorts to Support Less-Prepared Students

Cohorts offer structure and community for less-prepared students to complete core courses. Contacts commonly offer cohort programs for full-time students; part-time students may require adapted cohorts. Students may not be able to take all courses within the cohort if they require schedule flexibility, but any structure possible creates a positive environment. Limiting the cohort to introductory courses, for example, might develop networks students can maintain into future semesters.

Train New Engineering Faculty to Serve the Engineering Programs' Expected Student Audiences

Host orientation sessions for new faculty to familiarize them with California State University-San Marcos' major student populations.

Student Populations and Associated Faculty Information



Section VI: Engineering Program Expansion Opportunities

1) Section Research Methodology

Purpose

Identify programs to launch after success of initial recommendations (i.e., in five years).

Sources

- Burning Glass Labor/Insight data on employer demand
- Review of competitor program offerings
- Comparison to community college program offerings
- National Center for Education Statistics degree completions data
- Bureau of Labor Statistics data

2) First Stage Engineering Program Expansion

Program Expansion Selection

Develop Computer and Aerospace Engineering Bachelor's Degree Programs Based on Existing Mechanical and Electrical Engineering Degree Programs

First stage engineering program expansion opportunities allow administrators to develop new engineering bachelor's degree programs with minimal new course development and faculty hiring. First stage program expansion opportunities will expand the depth of undergraduate engineering programs within existing academic departments. Specialized engineering undergraduate degrees bear higher risk to attract sufficient student enrollments than broad engineering fields.

Institutions with existing mechanical and electrical engineering bachelor's degree programs could relatively easily expand offerings to include aerospace and computer engineering bachelor's degree programs. Mechanical engineering serves as the foundation for aerospace engineering degrees, while electrical engineering and computer science serve as the foundation for computer engineering degrees. For example, aerospace engineering bachelor's degree programs share several upper division courses with mechanical engineering bachelor's degree programs. Aerospace engineering requires specialized mechanical engineering coursework related to flight mechanics and aerodynamics. Computer engineering focuses on the development and design of computer hardware, which requires knowledge of circuits, electronics, and computer architecture.

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Graduates of Computer and Aerospace Engineering Bachelor's Degree Programs May Qualify for Mechanical or Electrical Engineering Positions

Due to the high degree of overlap between mechanical engineering and aerospace engineering training and electrical engineering and computer engineering training, program graduates may also qualify for similar jobs. An analysis of local job postings by occupation indicates a low number of postings relative to California degree completions for computer engineers and aerospace engineers. However, graduates of aerospace engineering bachelor's degree programs may work in positions classified as mechanical engineering, while graduates of computer engineering bachelor's degree programs may work in positions classified as electrical or electronics engineering.

First Stage Undergraduate Engineering Program Expansion Opportunities for California State University-San Marcos

Degree	Number of Job Postings	Number of Competitor Bachelor's Degree Completions	Number of Job Postings per Relevant Degree Completions	Projected Relevant Job Growth 2012 to 2022	Number Relevant Existing Courses
Computer Engineering	203	682	0.3	14.3%	11
Aerospace Engineering	94	450	0.2	18.5%	7

Aerospace Engineering

Aerospace Requires Little Additional Lower Division Coursework, but Significant Upper Division Course Expansion

Aerospace programs require upper level coursework highly distinct from the mechanical engineering program.

Sample Aerospace Engineering Coursework

California State University-Long Beach

Shared Coursework, Lower Division

- ENGR 101 Introduction to Engineering Profession
- ENGR 102 Academic Success Skills
- CHEM 111A General Chemistry
- MATH 122 Calculus I
- MATH 123 Calculus II
- MATH 224 Calculus III
- PHYS 151 Mechanics and Heat
- MAE 172 Engineering Design Graphics I
- MAE 205 Computer Methods in MAE
- CE 205 Analytical Mechanics I (Statics)

Aerospace Coursework

- MAE 101B Introduction to Mechanical Engineering
- MAE 272 Introduction to Manufacturing Processes

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Shared Coursework, Upper Division

- MATH 370A Applied Mathematics I
- MAE 300 Engineering Instrumentation and Measurement
- MAE 305 Numerical Methods in MAE
- MAE 330 Engineering Thermodynamics I
- MAE 371 Analytical Mechanics Dynamics
- MAE 373 Mechanics of Deformable Bodies

Aerospace Coursework, Upper Division

- CE 335 Fluid Mechanics
- CE 336 Fluid Mechanics Laboratory
- CE 406 Project Cost-Benefit Analysis
- MAE 322 Engineering Materials and Materials Processes
- MAE 336 Power Plant Design
- MAE 337 Thermal Engineering Laboratory
- MAE 361 Materials and Properties Laboratory
- MAE 375 Kinematics & Dynamics of Mechanisms
- MAE 376 Modeling & Analysis of Dynamic Systems
- MAE 409 Modern Computational Aspects in Mechanical Engineering
- MAE 431 Heat Transfer Systems Design
- MAE 459 Professional Practice Seminar
- MAE 471 Design and Analysis of Mechanical Engineering Systems I
- MAE 472 Design and Analysis of Mechanical Engineering Systems II
- MAE 476 Mechanical Control Systems I
- MAE 490 Special Topics

As the foundational program, mechanical engineering skills contribution to student preparation for aerospace engineering roles; 44 percent of aerospace engineering positions requested mechanical engineering skills. Skills most specific to aerospace engineering positions (which experienced the greatest gap in demand between aerospace and mechanical engineering positions) include:

- Software and programming competencies
  - CATIA
  - NASTRAN
- Management abilities
  - Engineering management
  - Personnel management
- Technical writing / editing
- Mathematics

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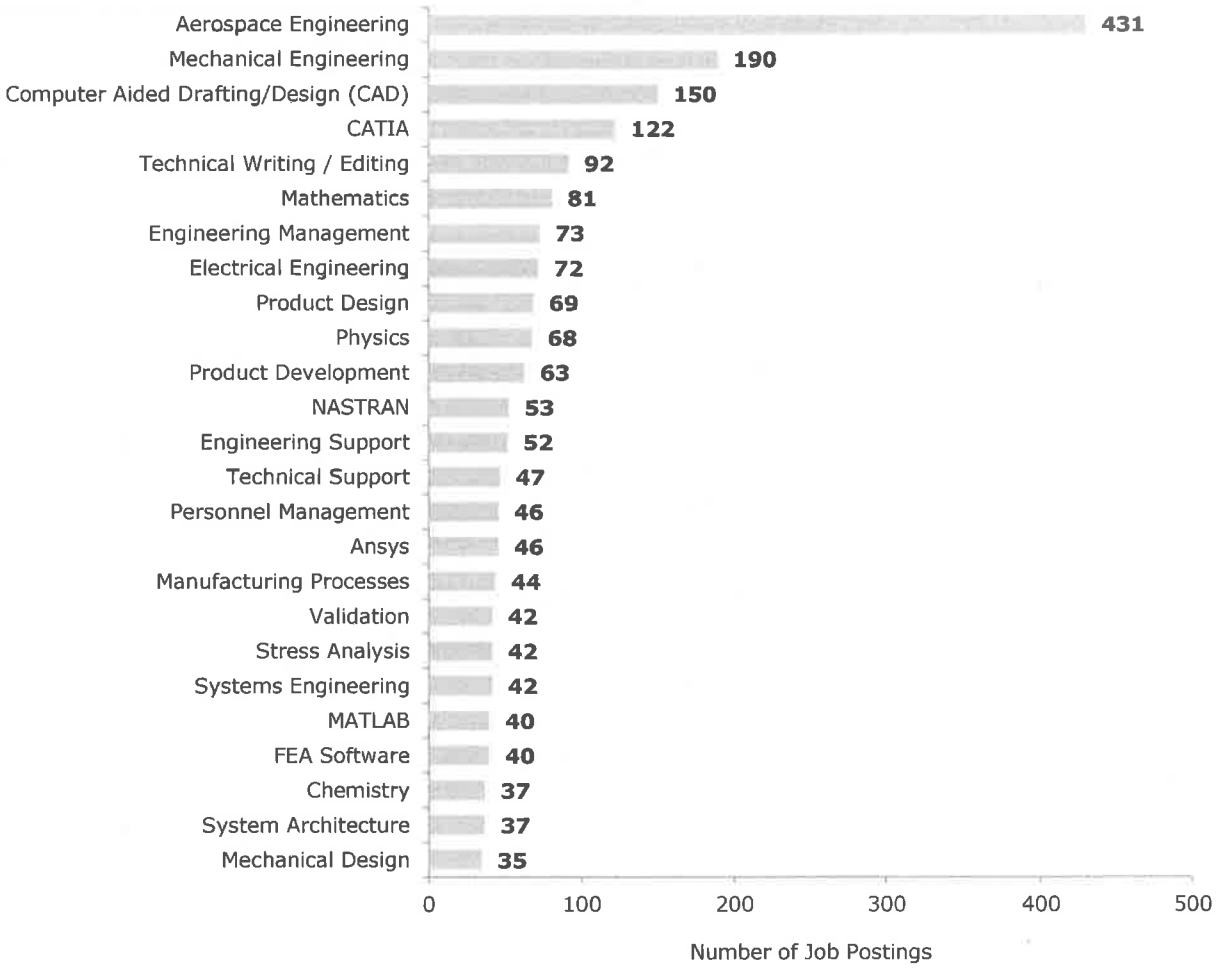
Top Skills for Aerospace Engineering Professionals

November 2014-October 2015, Bachelor's Degree Required, Local Data[59]

n=431 job postings, 6 unspecified postings



Solicit Mechanical Engineering Program Partners in Development of Aerospace Engineering Program

Major employers who seek both mechanical and aerospace engineers include:

- Northrop Grumman
- United Technologies Corporation
- Butler America
- Raytheon

Employers with more specialized demand for aerospace engineers include Naval Sea Systems Command and Naval Air Systems Command, as well as Arrowhead Products.

59) Burning-Glass Labor/Insight™.

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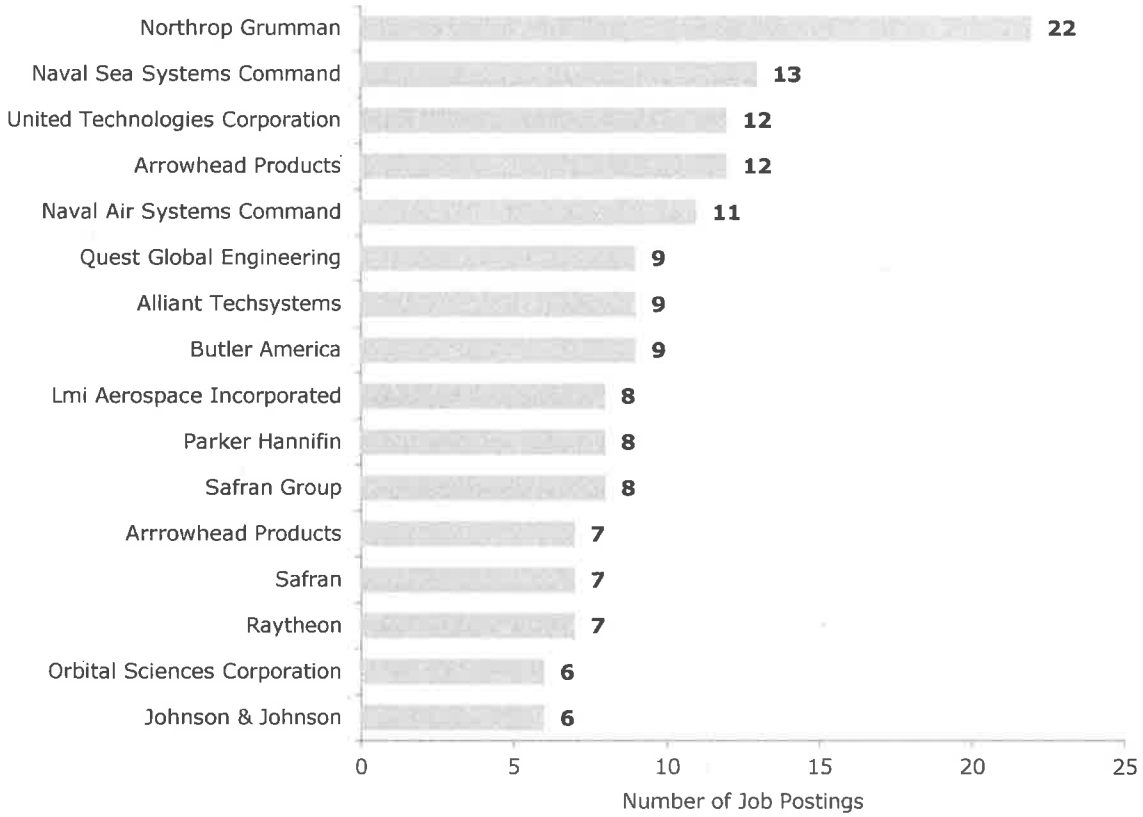
Top Employers Seeking Professionals with Aerospace Engineering Skills

November 2014-October 2015, Bachelor's Degree Required, Local Data[60]

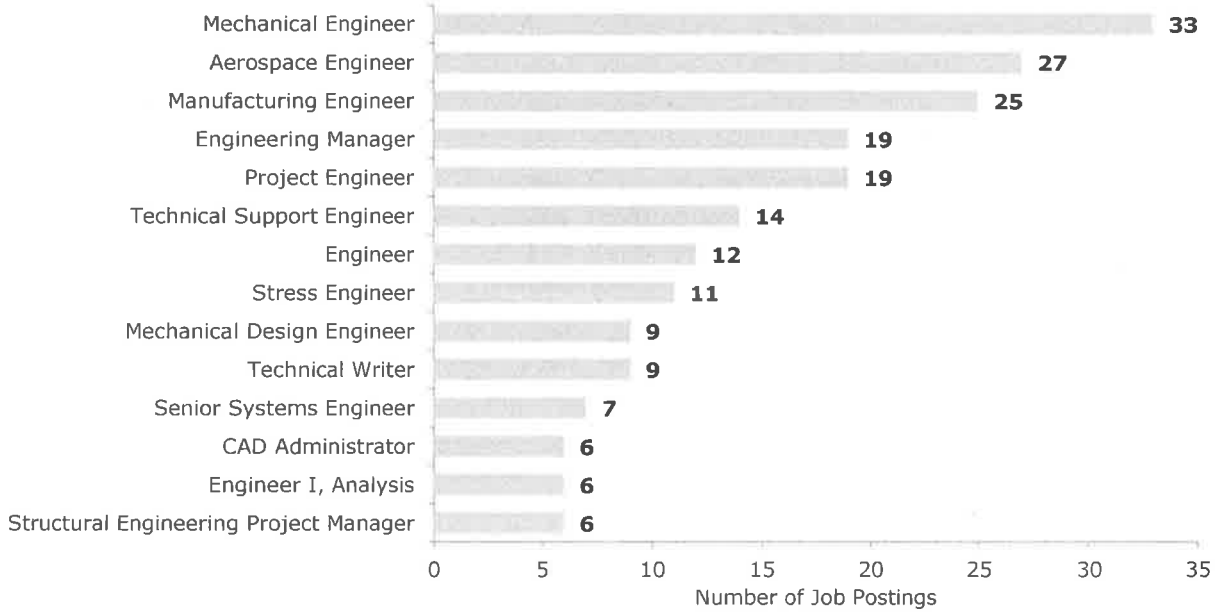
n=431 job postings, 146 unspecified postings



Top Titles for Professionals with Aerospace Engineering Skills

November 2014-October 2015, Bachelor's Degree Required, Local Data[61]

n=431 job postings, 0 unspecified postings



60) Burning-Glass Labor/Insight™.

61) Burning-Glass Labor/Insight™.

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Computer Engineering Blends Skills from Software Engineering and Electrical Engineering

Similar to the relationship between aerospace engineering and mechanical engineering, computer engineering postings more often require electrical engineering skills than electrical engineering postings require computer engineering skills. Thirty-nine percent of computer engineering postings require electrical engineering skills.

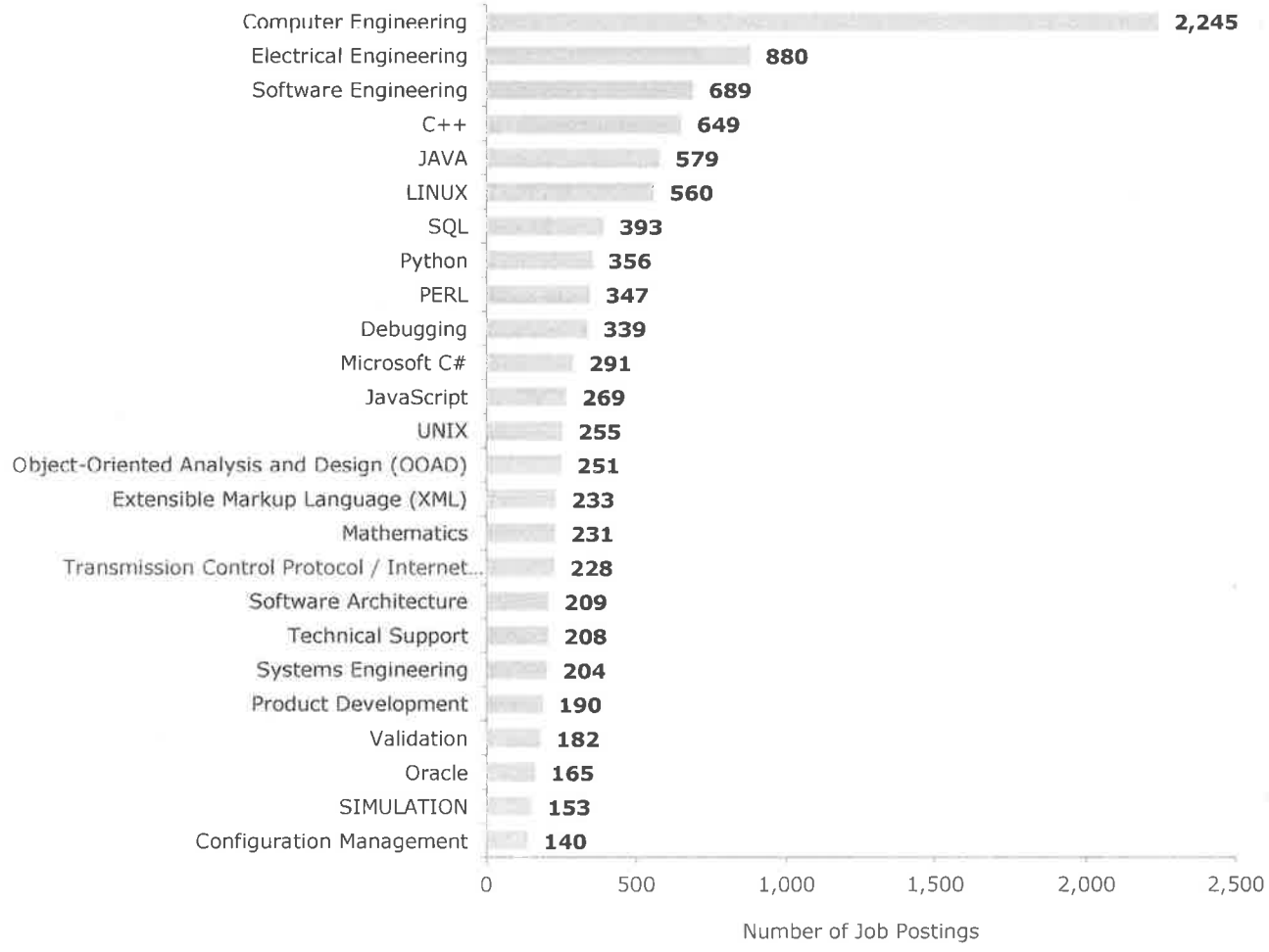
While more closely related to electrical engineering, computer engineering roles frequently require software skills. Positions that seek computer engineering skills more often require software-related skills than electrical engineering roles as well. Software skills requested more often for computer engineering professionals include:

- Software engineering
- Programming languages such as SQL, C++, Microsoft C#, JAVA
- LINUX

Top Skills for Computer Engineering Professionals

November 2014-October 2015, Bachelor's Degree Required, Local Data[62]

n= 2,245 job postings, 24 unspecified postings



62) Burning-Glass Labor/Insight™.

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Computer engineering curricula reflect the overlap between electrical engineering and software engineering content. Computer engineering majors at the University of Wisconsin-Milwaukee share eight courses with electrical engineering majors. Computer engineering majors also take eleven courses from the computer science department.

Sample Computer Engineering Coursework

University of Wisconsin-Milwaukee

Shared Coursework

- EAS 200 Professional Seminar
- ElecEng 301 Electrical Circuits I
- ElecEng 305 Electrical Circuits II
- ElecEng 310 Signals and Systems
- ElecEng 330 Electronics I
- ElecEng 335 Electronics II
- ElecEng 354 Digital Logic
- ElecEng 367 Introduction to Microprocessors

Computer Engineering Coursework

- CompSci 201 Introductory Computer Programming
- IndEng 360 Engineering Economic Analysis
- CompSci 251 Intermediate Computer Engineering
- CompSci 317 Discrete Information Structures
- CompSci 337 Systems Programming
- CompSci 351 Programming Data Structures
- CompSci 361 Introduction to Software Engineering
- CompSci 395 Social, Professional, and Ethical Issues
- ElecEng 457 Digital Logic Laboratory
- CompSci 458 Computer Architecture
- CompSci 520 Computer Networks
- CompSci 535 Data Structures and Algorithms
- CompSci 537 Introduction to Operating Systems

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Seek Input from Qualcomm in Computer Engineering Program Development

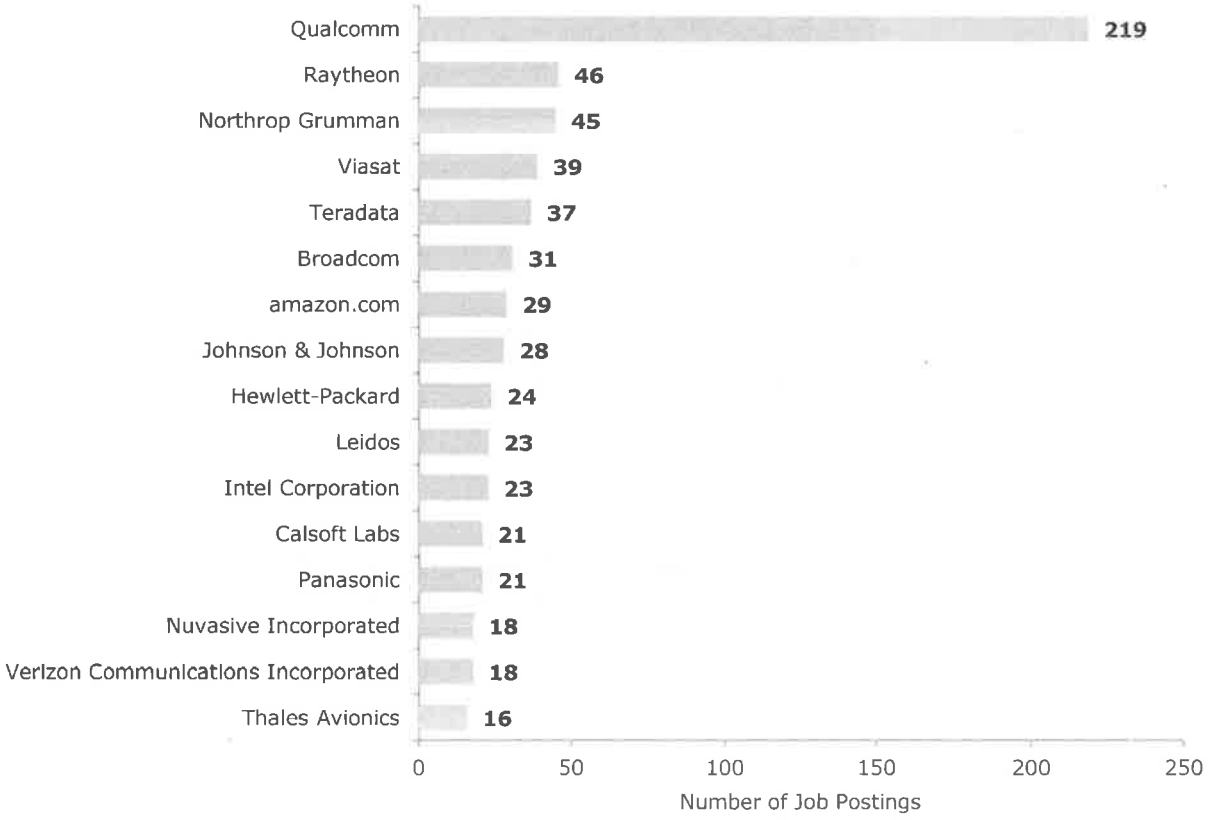
Telecommunications company Qualcomm sought the most computer engineering professionals from November 2014 to October 2015. After Qualcomm, defense contractors Raytheon and Northrop Grumman sought the largest numbers of computer engineering professionals.

Even positions that require computer engineering skills without software development engineering skills most often receive a "software development engineer" title. Other common titles include systems, applications, and network engineer.

Top Employers Seeking Professionals with Computer Engineering Skills

November 2014-October 2015, Bachelor's Degree Required, Local Data[63]

n=2,245 job postings, 527 unspecified postings



63) Burning-Glass Labor/Insight™.

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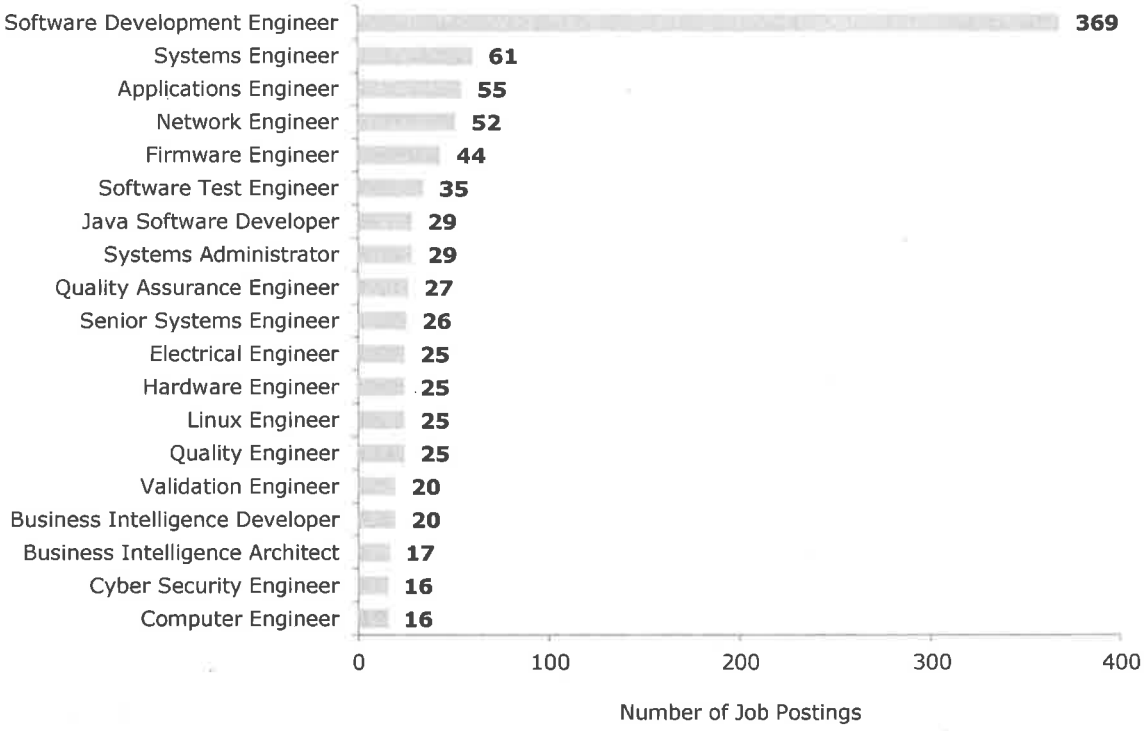
Top Titles for Professionals with Computer Engineering Skills

November 2014-October 2015, Bachelor's Degree Required, Local Data[64]

n=2,245 job postings, 0 unspecified postings



64) Burning-Glass Labor/Insight™.

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3) Second Stage Engineering Program Expansion

Program Expansion Selection

Second Stage Program Expansion Opportunities Include Industrial and Systems Engineering, Civil Engineering, and Environmental Engineering

Second stage program expansion opportunities serve to grow the overall breadth of engineering undergraduate program offerings at **California State University-San Marcos**. Second stage program expansion opportunities do not overlap with existing program offerings, but display high rates of projected employment growth and low or moderate market saturation. Second stage program expansion opportunities do not do not align with California State University-San Marcos' current course offerings and will require additional time to hire new faculty members and develop courses. After successful development of immediate and first stage expansion opportunities, the University will offer a broader catalog of engineering coursework and expertise. Local community colleges may also begin preparing students for more engineering-related bachelor's degrees after demonstrated engineering program success.

Second Stage Undergraduate Engineering Program Expansion Opportunities for California State University-San Marcos

Degree	Number of Job Postings	Number of Competitor Bachelor's Degree Completions	Number of Job Postings per Relevant Degree Completions	Projected Relevant Job Growth 2012 to 2022	Number Relevant Existing Courses
Industrial and Systems Engineering	602	201	3.0	8.5%	7
Civil Engineering	1,160	1,994	0.6	18.3%	8
Environmental Engineering	227	192	1.2	24.7%	8

Industrial Engineering

Employers Seek Industrial Engineering Professionals with Manufacturing and Process Skills

Employers request manufacturing skills such as manufacturing processes and manufacturing engineering. Industrial engineers must also demonstrate process improvement skills, including experience with methodologies such as Lean Six Sigma. Manufacturers and technology distributors most often sought industrial engineering professionals.

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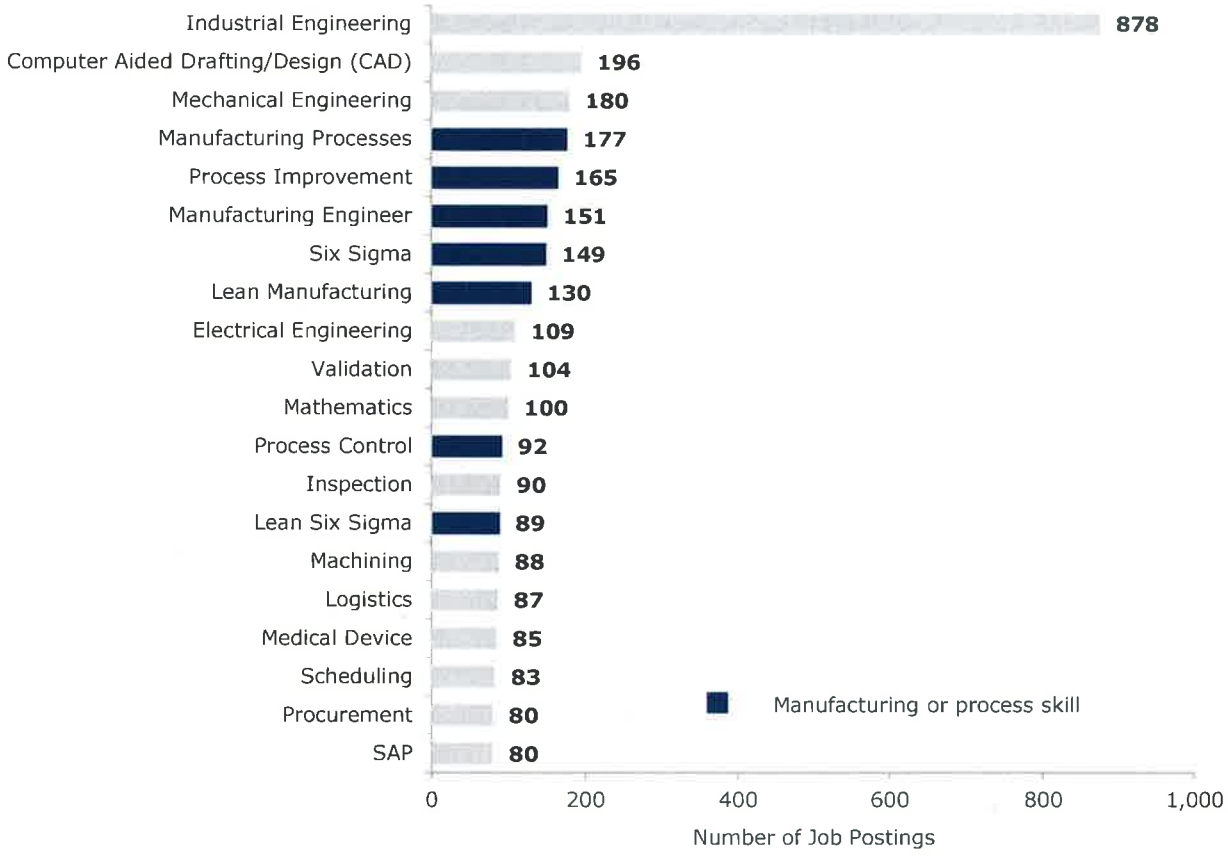
Top Skills for Industrial Engineering Professionals

November 2014-October 2015, Bachelor's Degree Required, Local Data[65]

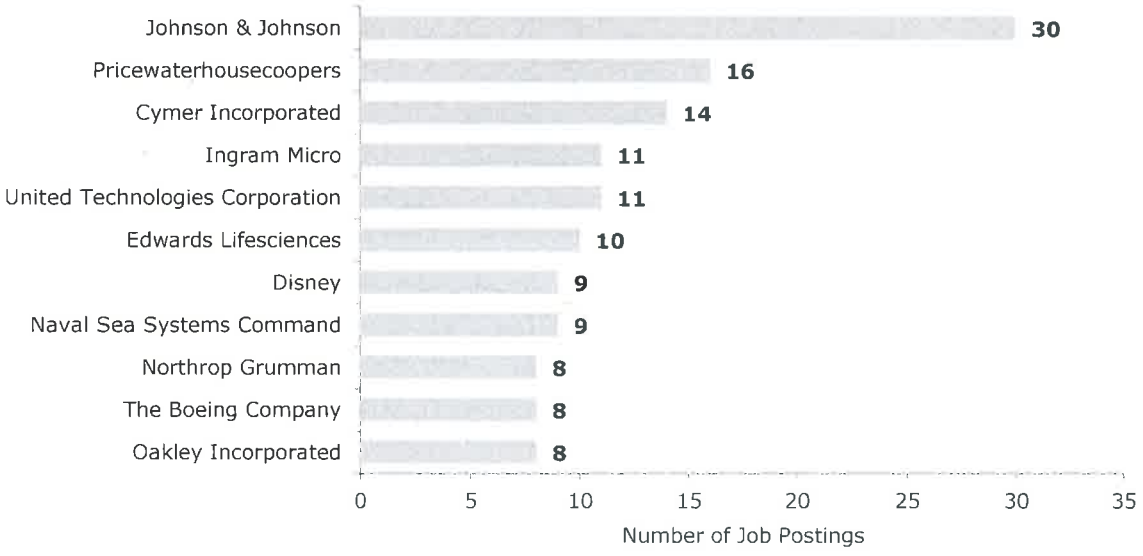
n= 878 job postings, 6 unspecified postings



Top Employers Seeking Professionals with Industrial Engineering Skills

November 2014-October 2015, Bachelor's Degree Required, Local Data[66]

n=878 job postings, 234 unspecified postings



65) Burning-Glass Labor/Insight™.

66) Burning-Glass Labor/Insight™.

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Environmental Engineers Must Display a Wide Range of Science Competencies

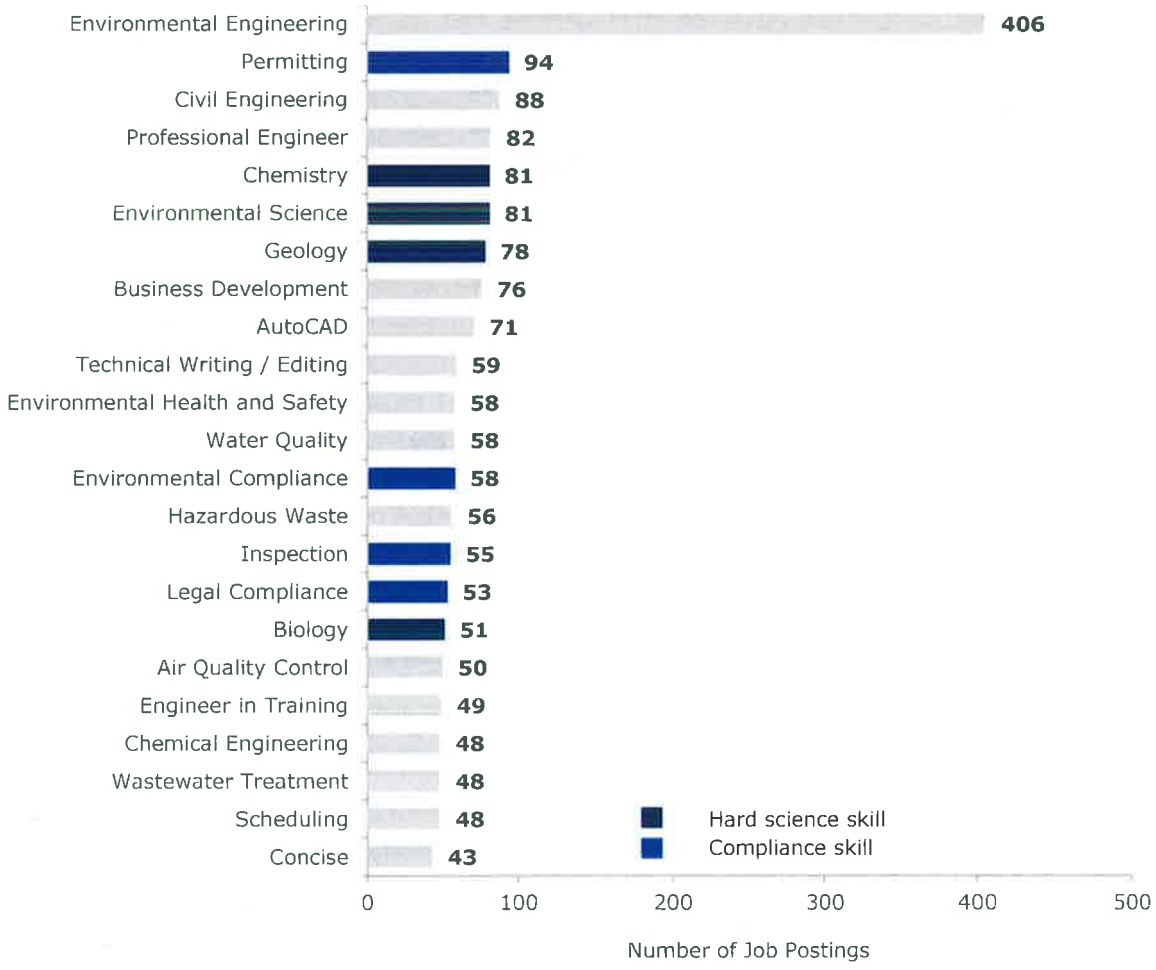
Employers expect environmental engineers to demonstrate skills in hard sciences such as chemistry, geology, and biology. Environmental engineers must also possess skills in compliance topics such as permitting.

Multidisciplinary architecture, science, and construction consultants most often seek environmental engineers. Employers seeking the most environmental engineers include Kleinfelder Incorporated, Brown and Caldwell, and URS Corporation.

Top Skills for Environmental Engineering Professionals

November 2014-October 2015, Bachelor's Degree Required, Local Data[67]

n= 406 job postings, 0 unspecified postings



67) Burning-Glass Labor/Insight™.

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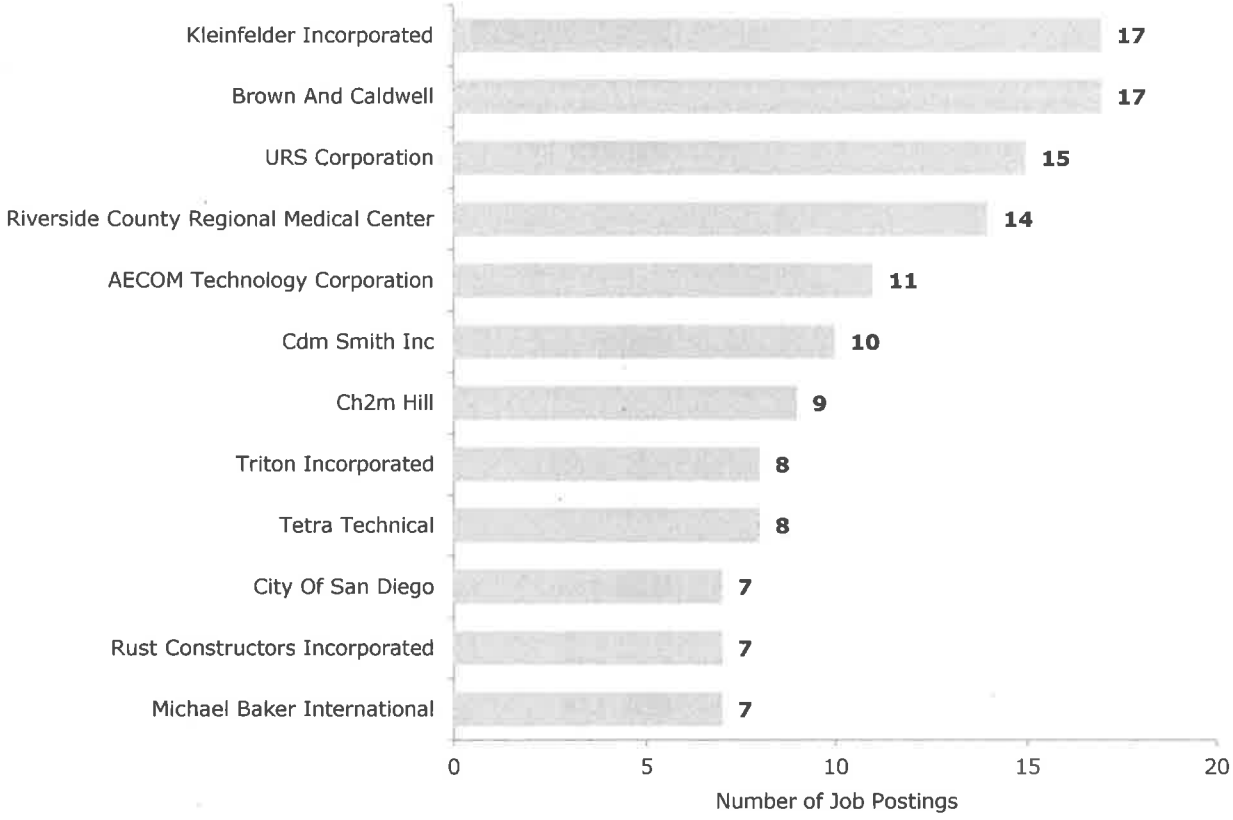
Top Employers Seeking Professionals with Environmental Engineering Skills

November 2014-October 2015, Bachelor's Degree Required, Local Data[68]

n=406 job postings, 59 unspecified postings



Civil Engineering

Civil Engineering Roles Most Often Seek Design and Business Competencies

In comparison to other engineering roles, civil engineers must more often demonstrate skills in design and business. Common design skills specify familiarity with AutoCAD products as well as more general design skills. Requested business skills include construction management, business development, and contract preparation and management.

Major employers include engineering consulting firms. The Riverside County Regional Medical Center also sought high numbers of professionals with civil engineering skills. The medical center sought civil engineering professionals for engineering technician, environmental planner, and transportation planner roles, among others.

68) Burning-Glass Labor/Insight™.

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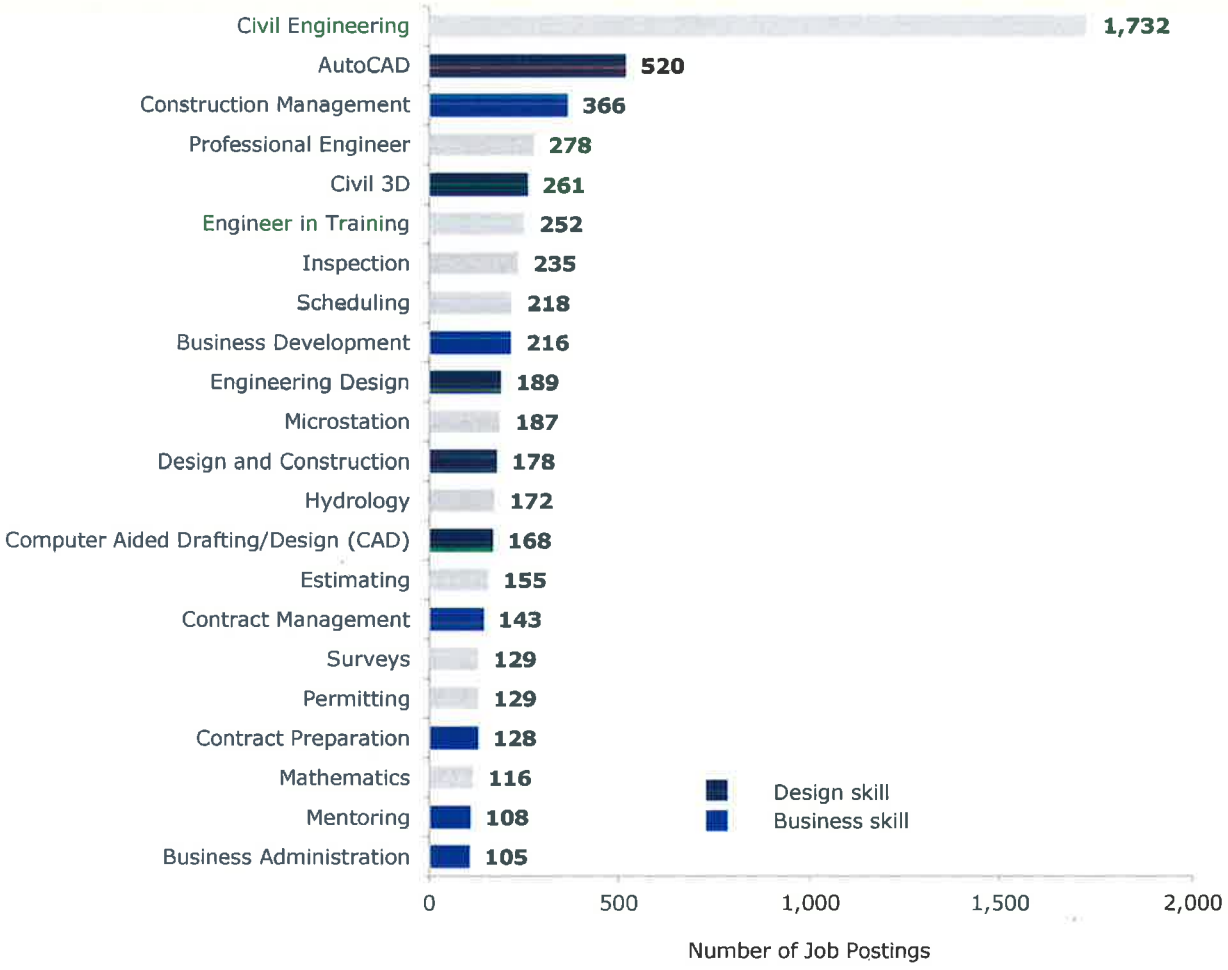
Top Skills for Civil Engineering Professionals

November 2014-October 2015, Bachelor's Degree Required, Local Data[69]

n=1,732 job postings, 6 unspecified postings



69) Burning-Glass Labor/Insight™.

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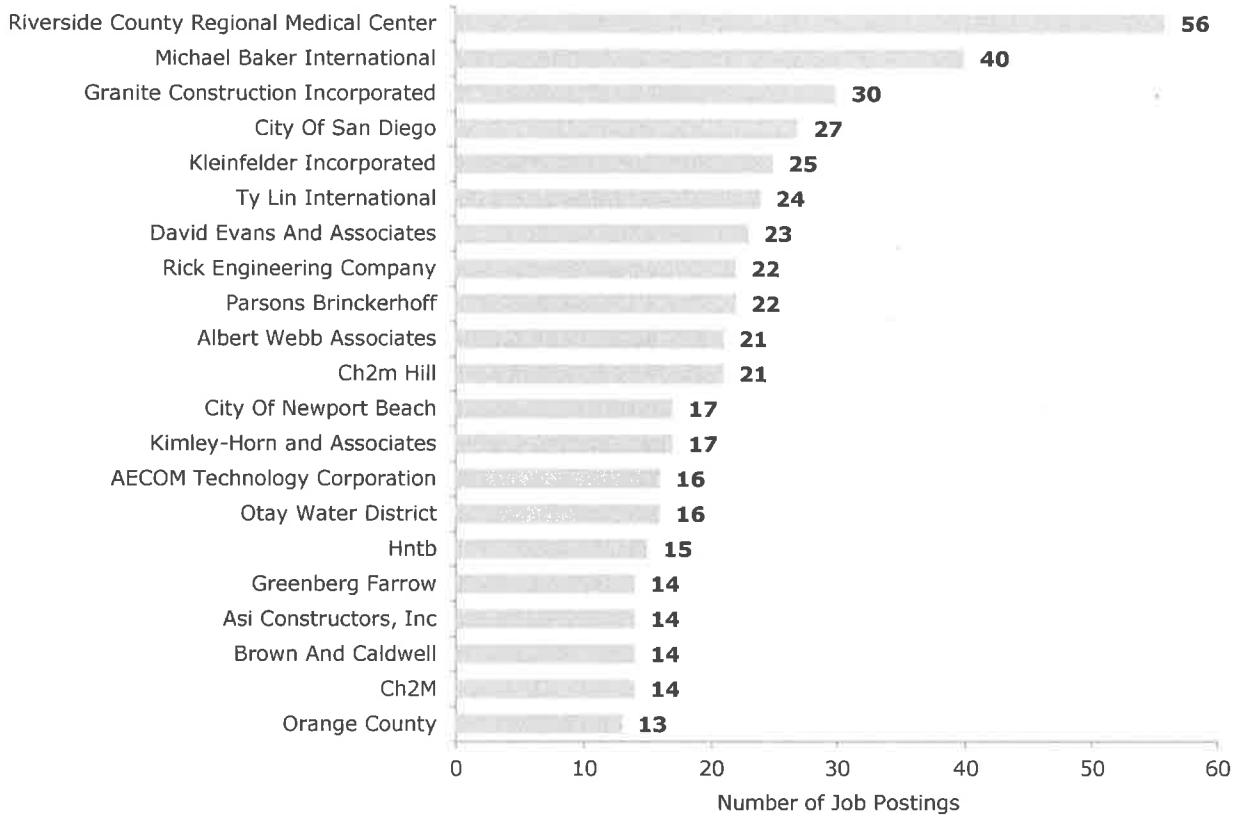
Top Employers Seeking Professionals with Civil Engineering Skills

November 2014-October 2015, Bachelor's Degree Required, Local Data[70]

n=1,732 job postings, 451 unspecified postings



70) Burning-Glass Labor/Insight™.

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Appendices

Appendix A: Unsupported Engineering Programs

Initial Analysis

Do Not Pursue Program Development in Engineering Specializations with Low Employer Demand and Limited Compatibility with Current Resources

The Forum excluded engineering specialties from its recommendations due to:

- Low employer demand,
- Low projected job growth,
- Limited compatibility with current course offerings at **California State University-San Marcos**, or

For instance, the Forum does not recommend the University open a program in marine engineering and naval architecture despite a 144 percent increase in local employer demand for marine engineers. Local employers only posted 14 jobs in marine engineering and naval architecture last year, and marine engineering requires a high level of technical expertise incompatible with current course offerings with California State University-San Marcos. The Forum excluded other highly specified and technical engineering specialties (e.g., petroleum engineering, nuclear engineering) due to low overall employer demand and a lack of relevant existing courses.

Computer engineering and aerospace engineering originally appeared on this list; however, local employers' anecdotal demand, and those programs' overlap with recommended programs in electrical and mechanical engineering provided opportunities to serve local needs with relatively little additional investment.

Undergraduate Engineering Program Opportunities to Avoid

Degree	Number of Job Postings	Number of Competitor Bachelor's Degree Completions	Number of Job Postings per Relevant Degree Completions	Projected Relevant Job Growth 2012 to 2022	Number Relevant Existing Courses	Number of Relevant Associate's Degree Programs
Materials Engineering	104	93	1.1	3.7%	7	0
Chemical Engineering	233	657	0.4	21.7%	9	0
Marine Engineering and Naval Architecture	14	0	Undefined (divided by zero)	Unavailable	7	0
Biomedical Engineering	12	847	0	42.6%	10	3
Agricultural Engineering	0	24	0	Unavailable	8	0
Petroleum Engineering	7	0	Undefined (divided by zero)	13.0%	3	0
Nuclear Engineering	5	13	0.4	20.0%	6	0
Mining Engineering	0	0	Undefined (divided by zero)	Unavailable	7	0

Appendix B: Engineering Program Supply Costs

Costs identified via manufacturer catalogs, third-party vendor offerings, and the EAB Cohort Price Pulse performance technology.

Software Engineering Supply Costs

Item	Cost
LINUX or UNIX server	$1,487 for Symantec NetBackup Enterprise Client 7.5 UNIX 1 Server
Projector	$634 for a Sanyo Projector
Speakers	$50 for C2G In-Ceiling Three-Way Speakers
Field programmable gate array (FPGA) development boards	$75 for Mojo V3 FPGA Development Board
Signal and function generator	$599 for 10Mhz function generator

Electrical Engineering Supply Costs

Expect one item per lab station minimum

Item	Cost
Multimeters • Rigol DM3058 Digital Multimeter • Tektronix, DM502	 • $695 • ($1,140 for the 2000 Model)
Power Supply • Lab Volt 1224 AC/DUAL DC • Agilent (Hewlett Packard) 6200B Power Supply • Mastech HY3000-HY5000 DC Power Supply	 • $611 • $65 used (manufacturer notes product is obsolete) • $90 for the HY3003D model
Dual Power Supply • PS503A Tektronix	 • $119
Function Generator • Tektronix FG 502 , 11MHz • Rigol DG1000 series Dual-Channel Function/Arbitrary Waveform Generator	 • $110 • $425 for the DG1022 model
Oscilloscope • HP54600B Oscilloscope • Tektronix 2225 Oscilloscope	 • ($3,350 for the DSOX3012A Oscilloscope, identified as replacement for obsolete product) • $235 used; $1,010 for the TDS2001C model new

Mechanical Engineering Supply Costs

Item	Cost
Dynamometer	$1,251 for the Dillon AP Mechanical Dynamometer
Thermocouple amplifier	$12 for an Analog Output K-Type Thermocouple Amplifier – AD8495 Breakout
Linear amplifier	$1,430 for the Ameritron AL-80B
Linear shaker	$398 for a SK-L180-E Analog Linear Shaker $696 for a SK-L180-Pro Digital LCD Linear Shaker
Accelerometer	$365 for an accelerometer with 10MV/G output
Displacement transducer	$650 for a displacement transducer with 4-20 mA output and 15mm (0.5") range
Digital oscilloscope	$3,350 for the DSOX3012A Oscilloscope
3D printer	$6,174 for a Makerbot Replicator Z18 model $85,300 reported for a Stratasys, Inc. model
Computer Numerical Control (CNC) Machines • Lathe, Haas ST-10Y with Y-axis • Mill, or manual lay mill • Laser cutter	• $80,000 • $1,275 for a Model 2000/2010 Deluxe 8-Direction CNC-Ready Mill • $5,495 for the FSL P-Series Laser Engraver / Laser Cutter CNC PRO 20x12

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Software Programs

Program
Adobe Reader DC
Altium 15.0
CAD and CAM programs • CREO • SURFCAM • SOLIDWORKS • Autodesk
Cadence
Eclipse IDE
Firefox ESR
Java Web Start
Eclipse
Cypress
LaTex
Lightning Analysts
MathSoft Apps
MATLAB • Simulink 2015a
McAfee 8.8
Microsoft Developer Network
Microsoft Office • Visio and Project
Microsoft Visual Studio
MobaXterm
ModelSim SE
National Instruments LabVIEW
Oracle
Simulink
Tex
TI Code Composer Studio
Visual Studio .NET 2013
VMWare
Xen
Xilinx ISE Design Suite
Xterm to es-sun-00

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Appendix C: Community College Partnerships

Identified Feeder Institutions

- Mira Costa College
- Miramar College
- Mount San Jacinto College
- Palomar College

Articulation Agreement Example

University of San Diego and San Diego Miramar College

Articulation Agreement 2011-2013, Mechanical Engineering

University of San Diego Lower division preparation for the major	**San Diego Miramar College**
CHEM 151/151L	CHEM 200/200L
COMM 203	SPEE 103
ECON 101	ECON 120 or ECON 121
ELEC 201	No comparable course
ENGR 101	No comparable course
ENGR 102	No comparable course
ENGR 121	CISC 205 or CISC 190 or CISC 192
ISyE 220 or ECON 101	ECON 120 or ECON 121 (EE or ME majors only, not ISyE majors)
MATH 150	MATH 150
MATH 151	MATH 151
MATH 250	MATH 252
MATH 310*	MATH 255
MENG 210	No comparable course
MENG 260	No comparable course
PHIL 102	PHIL 100
PHYS 270	PHYS 195
PHYS 271	PHYS 196

*Transfer work completed for 300-level courses at USD are granted content credit only and are not granted upper division credit; depending on other transfer coursework this upper division credit may need to be made up with upper division electives

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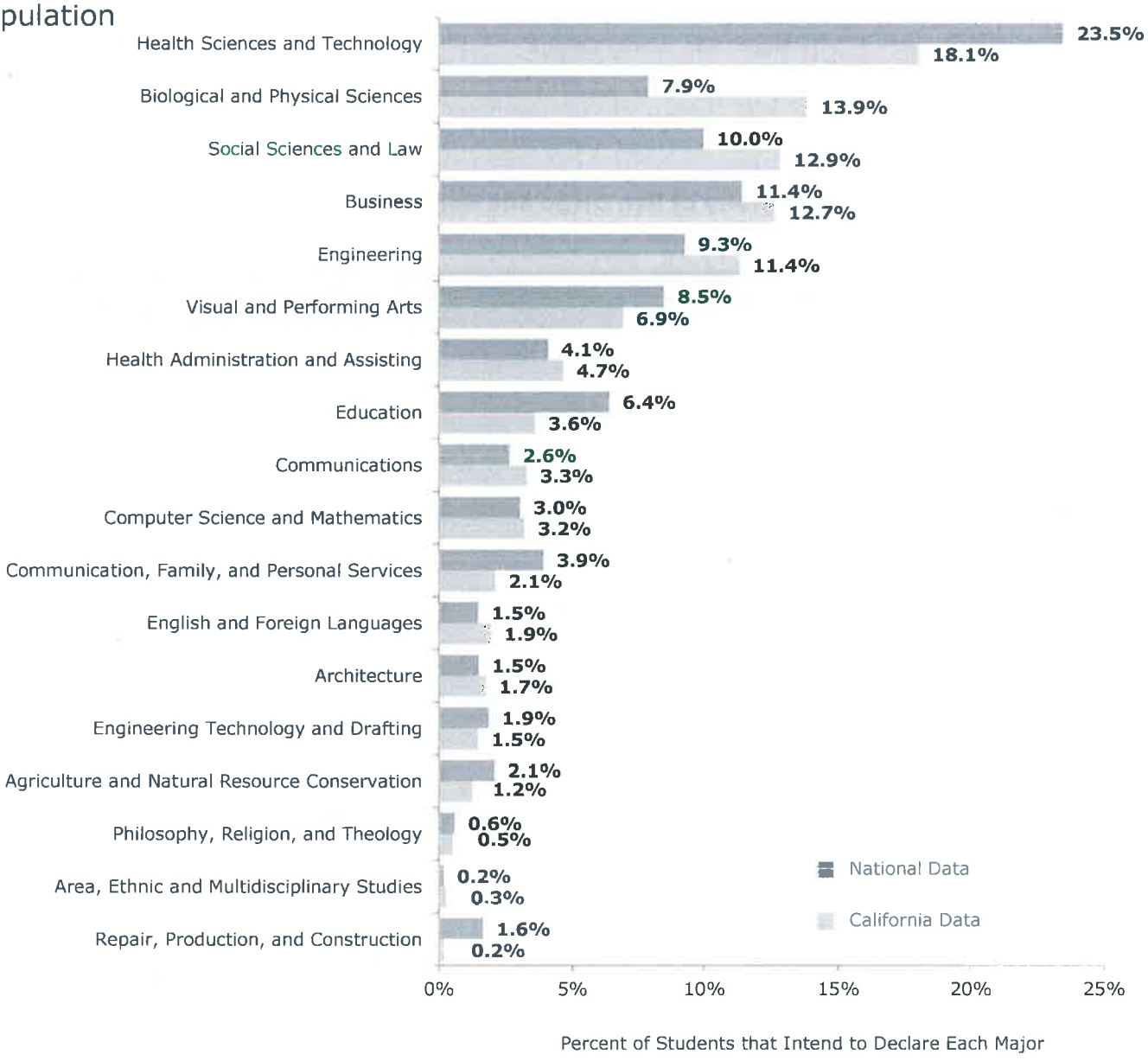
Appendix D: Additional Audience Demographic Data

High School Student Population

High School Student Intended College Majors

2013, ACT-Tested High School Graduating Class[71]



71) American College Testing (ACT).

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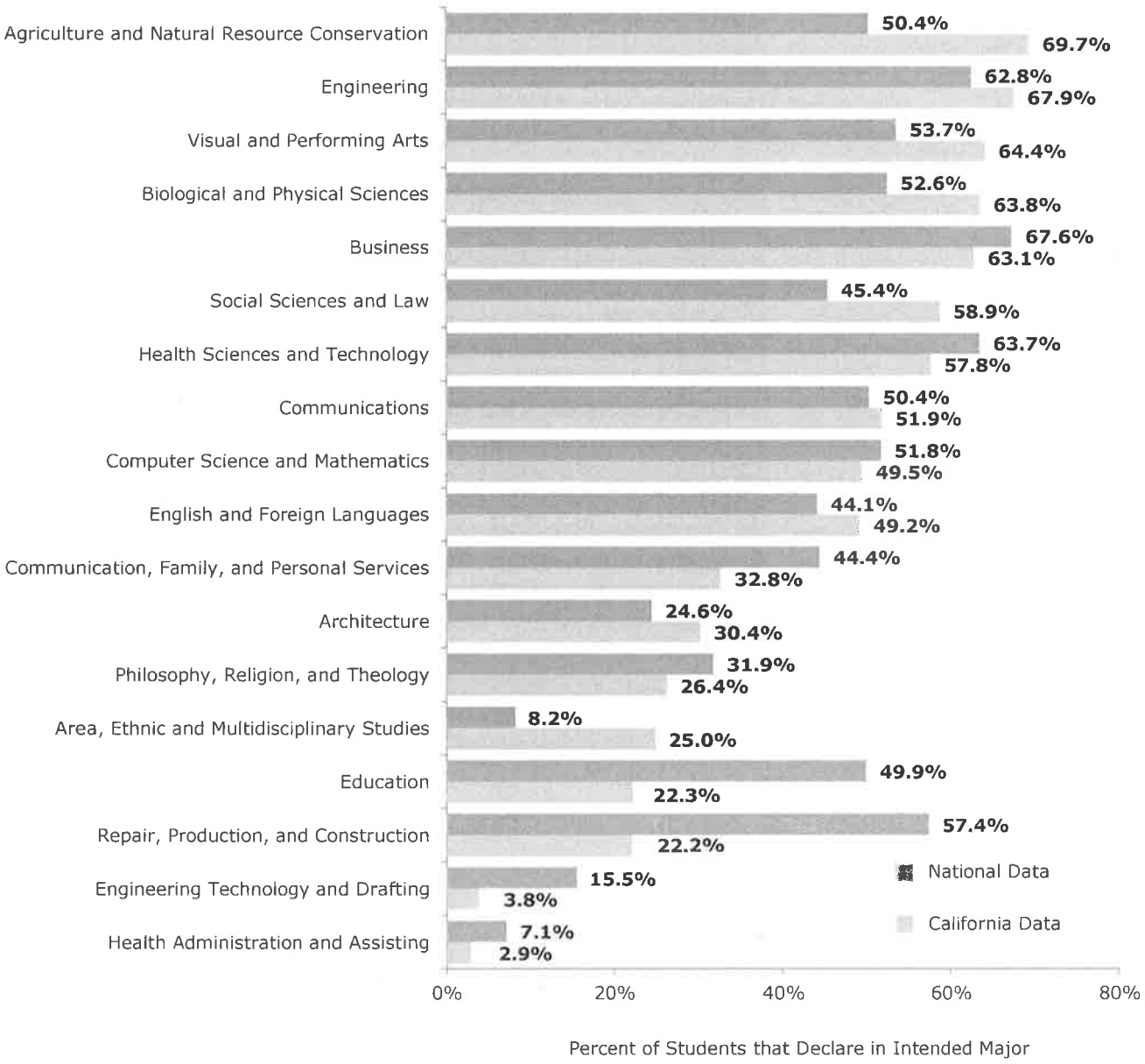
Percent of Students that Declare in their Intended College Major

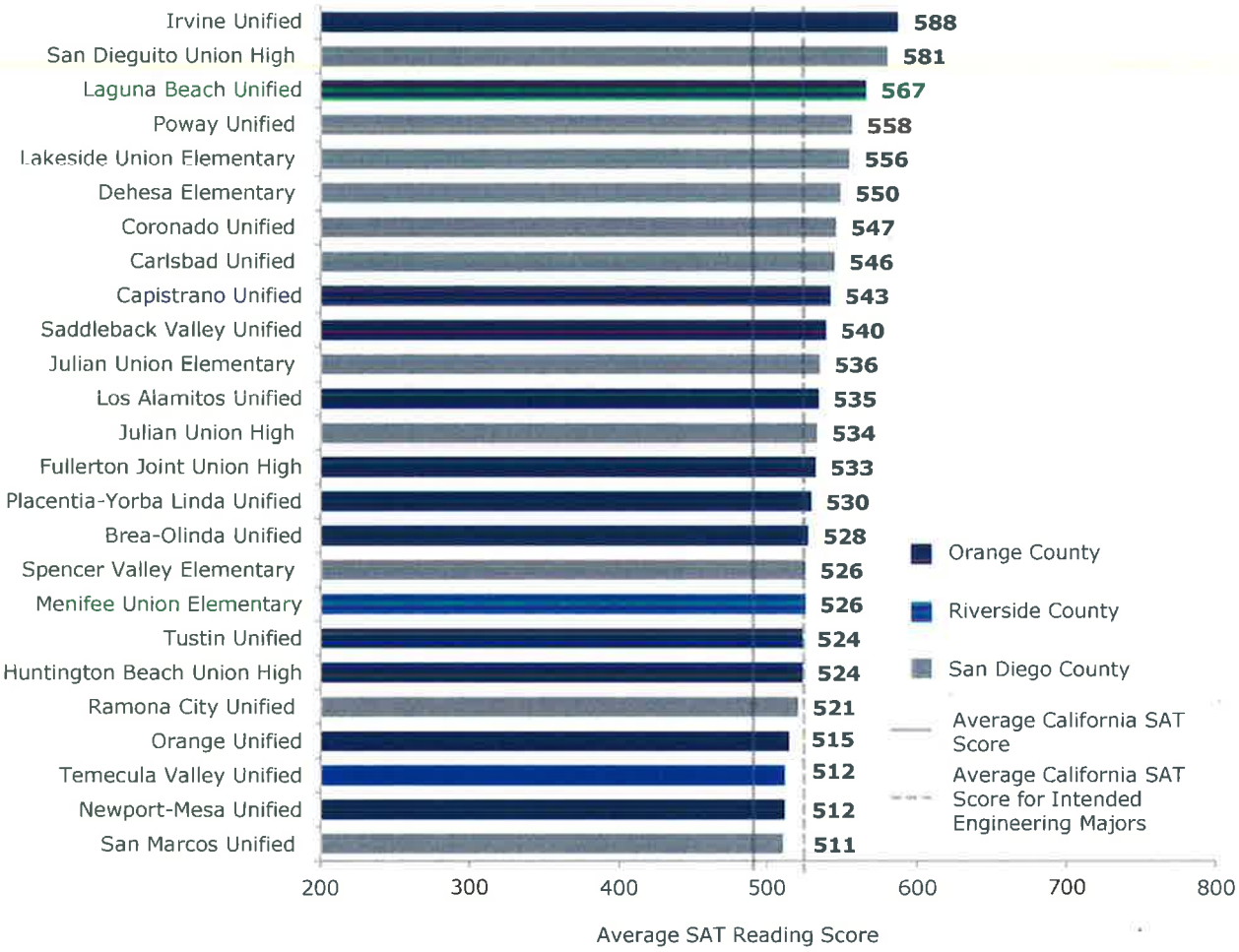
2013, ACT-Tested High School Graduating Class[72]



72) American College Testing (ACT).

Average SAT Reading Scores

2013 to 2014, Local School District Data[73, 74]



73) California Department of Education.

74) CollegeBoard.

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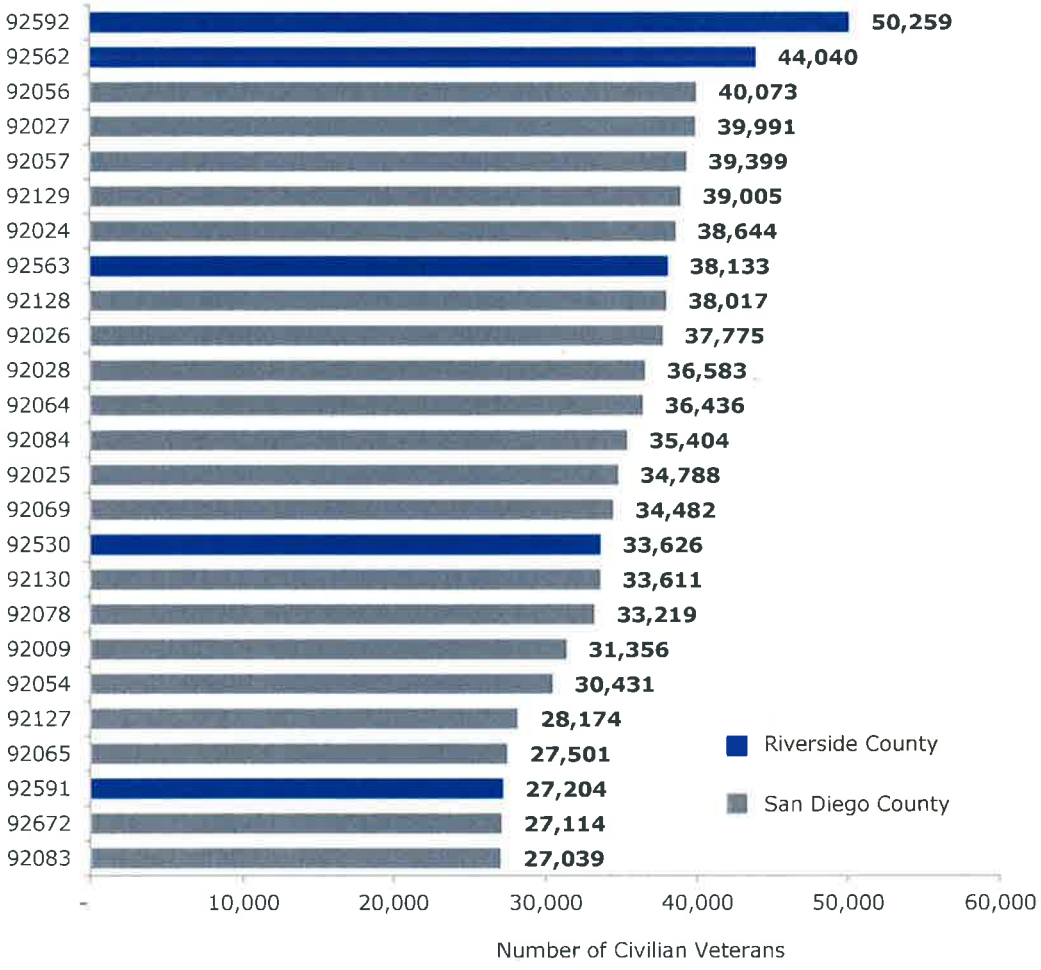
Civilian Veteran Population

Number of Civilian Veterans Age 18 or Older

2009 to 2013; Southern Orange County, Southern Riverside County, and Northern San Diego County Data[75]



75) U.S. Census Bureau: American Community Survey.

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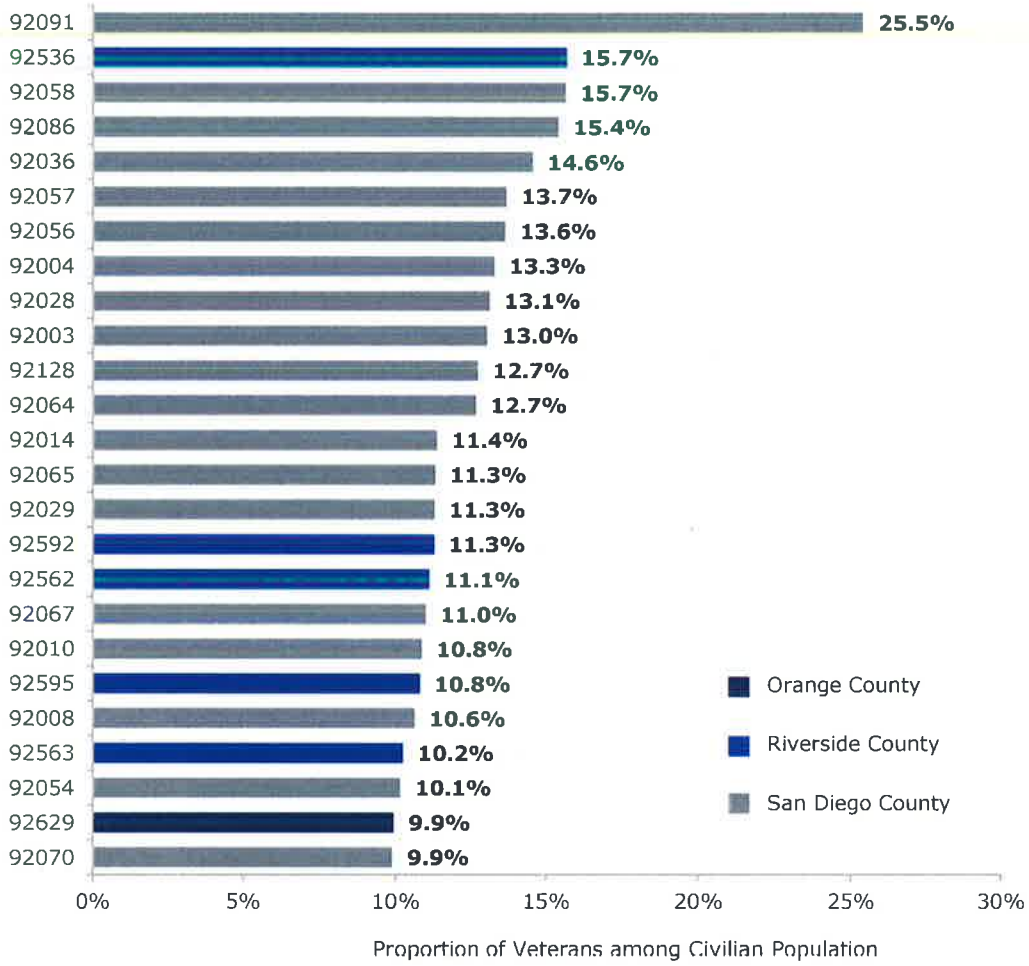
Proportion of Veterans among the Civilian Population Age 18 or Older

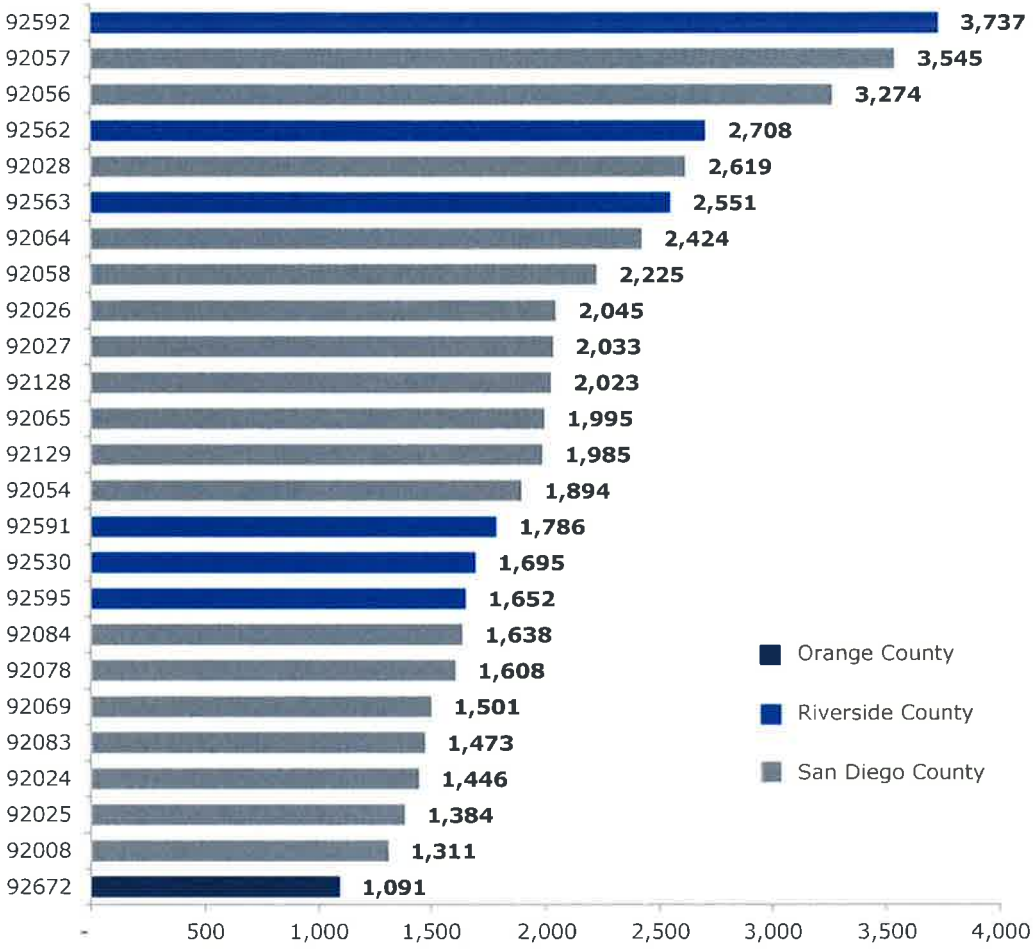
2009 to 2013; Southern Orange County, Southern Riverside County, and Northern San Diego County Data[76]



76) U.S. Census Bureau: American Community Survey.

Number of Civilian Veterans Age 25 or Older with a High School Diploma, Some College Experience, or an Associate's Degree

2009 to 2013; Southern Orange County, Southern Riverside County, and Northern San Diego County Data[77]



77) U.S. Census Bureau: American Community Survey.

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Appendix E: Definitions

"Local data" refers to the counties in the California State University-San Marcos service area (i.e., Orange, Riverside, and San Diego). The Forum used the Burning Glass Labor/Insight™ tool to identify engineering occupations with high employer demand and growth in demand over time.

The Forum compiled data sources into tables ranking program opportunities. Each data source corresponds with a column in the table:

- Degree: prospective engineering specialization for program development at California State University-San Marcos.
- Number of Job Postings: the number of local job postings for the relevant occupation according to Burning Glass Labor/InsightTM. High demand refers to occupations with more than the median of 233 job postings.
- Number of Competitor Bachelor's Degree Completions: the number of engineering bachelor's degree completions at California institutions according to the Integrated Postsecondary Education Data System. The Forum calculated totals at the state rather than the county level provide a basis for relative comparison of the popularity of various engineering degrees.
- Number of Job Postings per Relevant Degree Completions: the number of job postings divided by the number of competitor bachelor's degree completions. This ratio identifies potential market saturation for academic institutions. Past Education Advisory Board research suggests that employers post one job for every two job seekers. Degree programs with average market saturation usually possess a ratio of approximately 0.5.
- Projected California Job Growth 2012 to 2022: long term occupation growth rates from the Bureau of Labor Statistics. High growth occupations possess projected growth rates higher than the national average of 11 percent for all occupations.
- Number Relevant Existing Courses: the number of courses currently offered by the College of Science and Mathematics at California State University-San Marcos that correspond with the curriculum of a relevant program at another institution. Most degree program curricula include support courses such as "Calculus I" through "Calculus III" and "General Chemistry."
- Number of Relevant Associate's Degree Programs: the number of associate's-level engineering and engineering technician programs at San Diego County community colleges according to the Integrated Postsecondary Education Data System. Community colleges in San Diego County include institutions identified by the member and other institutions that offer relevant programs. The Forum included technology/technician degrees to account for institutions that do not offer engineering degrees at the associate's level.

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