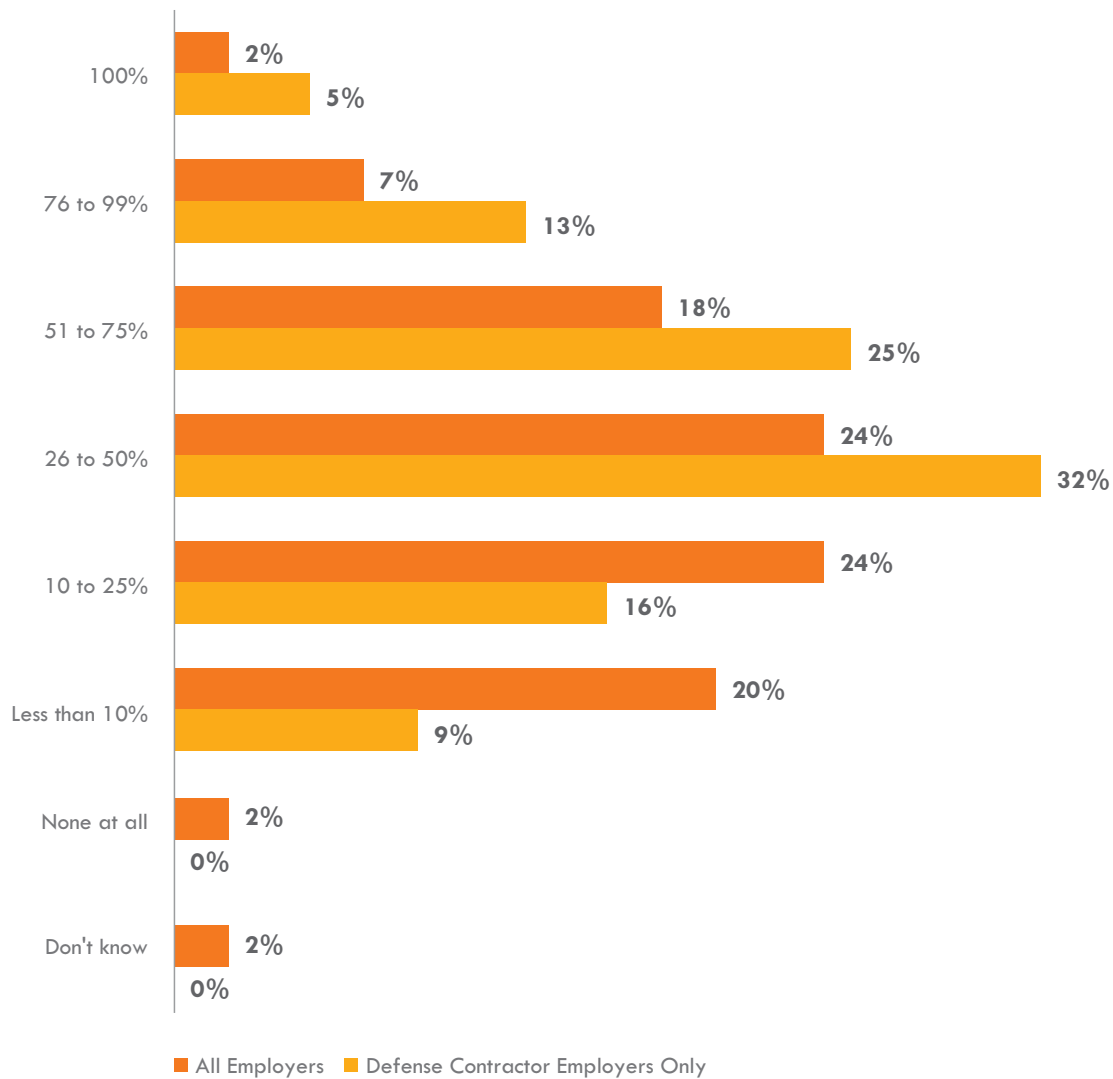


TIME SPENT ON SECURITY/ CYBERSECURITY ISSUES

Exhibit 25 shows that 52% of employers compared to 75% of defense contractors said that software developers spend more than a quarter of their time on security/cybersecurity issues.

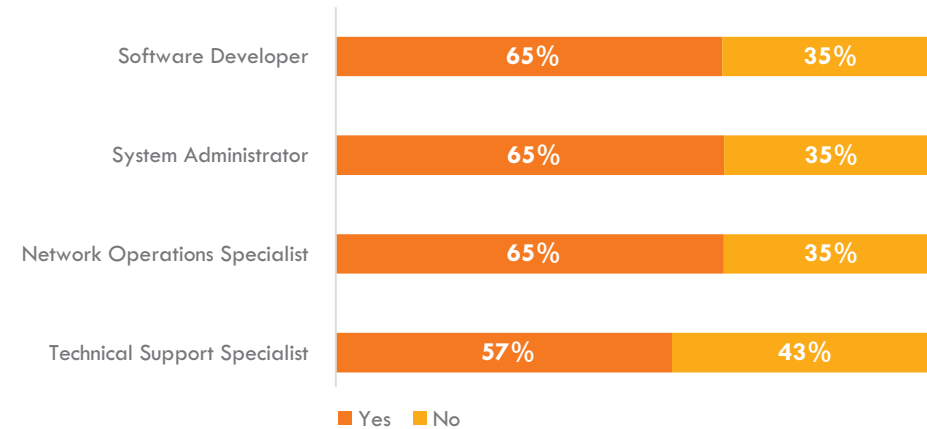
Exhibit 25. Percentage of time software developers spend on security/cybersecurity issues, all employers and defense contractors



TIME SPENT ON SECURITY/ CYBERSECURITY ISSUES

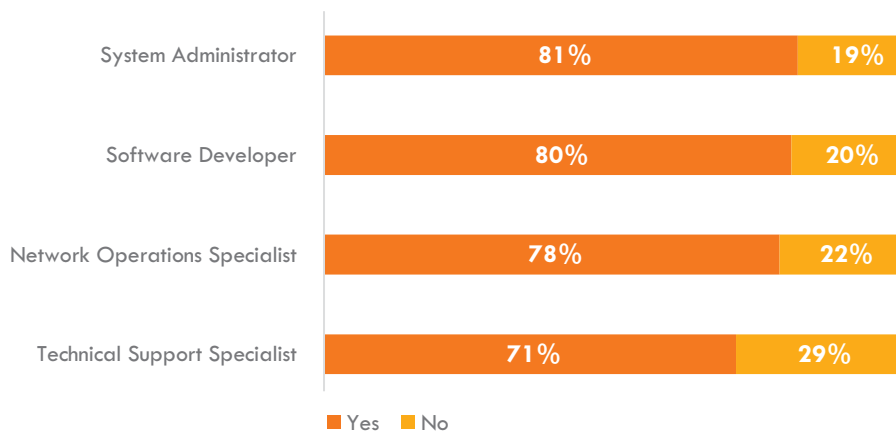
As a follow-up question, employers were asked if the percentage of time spent on security/cybersecurity issues for the four work roles had increased compared to 12 months ago. For three of the four work roles—network operations specialist, system administrator and software developer—65% of employers said the percentage of time spent on security/cybersecurity issues had increased compared to 12 months ago (Exhibit 26). By comparison, 57% of employers said that for technical support specialist the percentage of time had increased.

Exhibit 26. Increased time spent on security/cybersecurity issues compared to 12 months ago, all employers



There is a higher percentage of defense contractors who indicated that these four work roles are spending more time on security/cybersecurity issues compared to 12 months ago, than for employers in the overall sample (Exhibit 27). For all four work roles, 70% or more of defense contractors said the percentage of time spent on security issues had increased compared to 12 months ago. For system administrators and software developers, 80% or more of defense contractors said the percentage of time had increased compared to 12 months ago.

Exhibit 27. Increased time spent on security/cybersecurity issues compared to 12 months ago, defense contractors



EDUCATION, WORK EXPERIENCE AND SOFT SKILLS

For all nine work roles studied, employers were asked about the minimum level of education required for qualified candidates. For each of the nine work roles, 40% or more of employers selected a bachelor's degree as the minimum education level required. The percentages ranged from 40% for technical support specialists and vulnerability assessment analysts, to 58% for systems security analysts.

Employers were asked about the minimum prior work experience required for qualified candidates. For four work roles, the highest percentage of employers indicated one to two years of prior work experience when hiring for qualified candidates. One to two years of experience was preferred by 40% or more of employers for: technical support specialists, network operations specialists, vulnerability assessment analysts, and cyber defense forensics analysts.

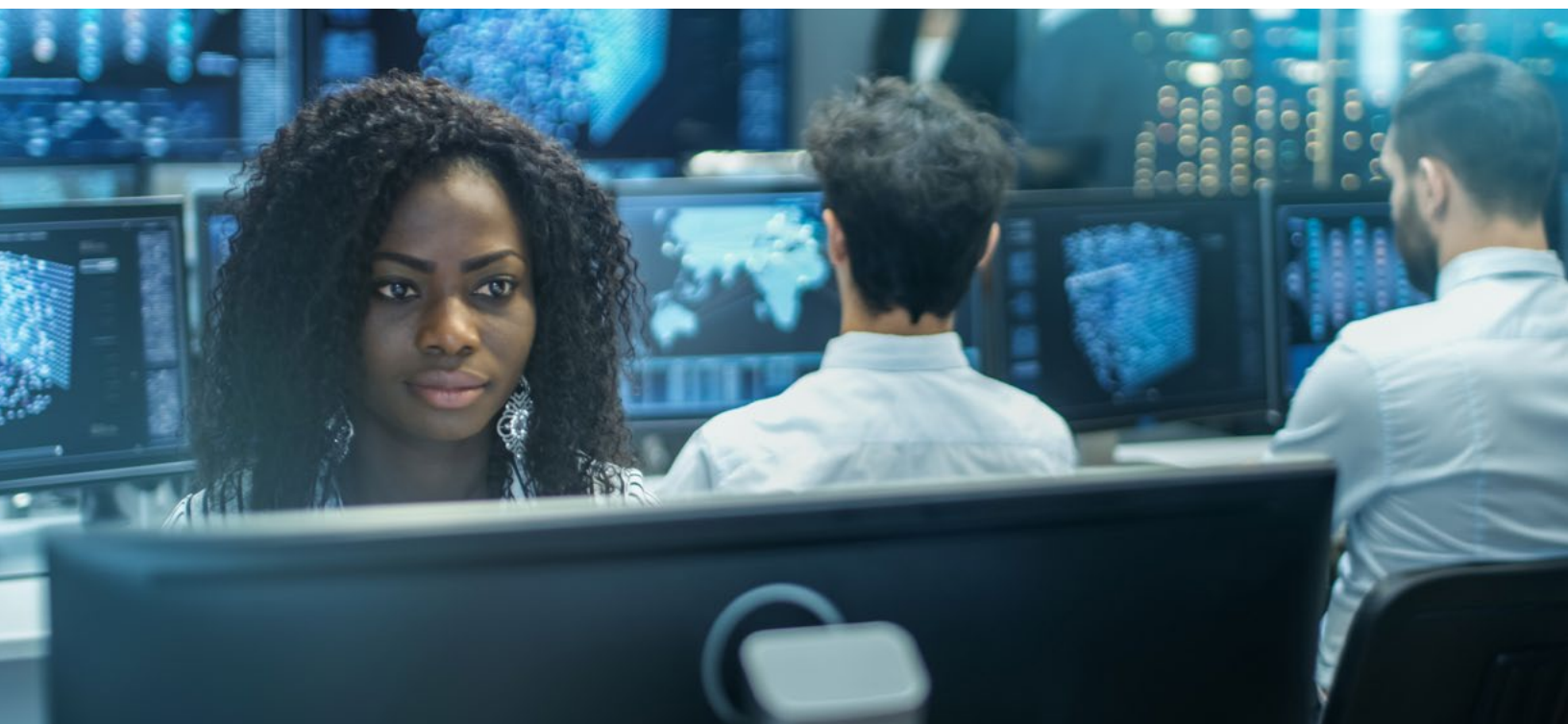
For the other five work roles, the highest percentage of employers indicated they preferred three to five years of prior work experience when hiring for qualified candidates. Three to five years of work experience was preferred by 39% or more of employers for: system administrator, software developer, systems security analyst, cyber defense analyst, and cyber defense infrastructure support specialist.

Employers were asked to select the top three soft skills most important for the work roles they employ. For all nine work roles, problem solving is one of the top three soft skills important to employers.

Several other soft skills topped the list:

- Troubleshooting is one of the top three soft skills for five of the nine work roles.
- Communication skills is one of the top three soft skills for four of the nine work roles.
- Teamwork/collaboration is one of the top three soft skills for four of the nine work roles.

Work role profiles in Appendix D have more details on education and work experience requirements as well as the top three soft skills for each work role.



SECTION III: EDUCATIONAL SUPPLY ASSESSMENT

CYBERSECURITY PROGRAMS ASSESSMENT

An assessment of the postsecondary educational supply of cybersecurity students in California was conducted to gauge whether educational training programs throughout the state are meeting workforce demand.

In order to access appropriate data from the Integrated Postsecondary Education Data System (IPEDS), National Center for Educational Statistics, it was first necessary to determine the list of Classification of Instructional Programs (CIP) codes relevant to cybersecurity training and education. CIP codes are used nationally to classify all postsecondary instructional programs, and the codes are determined by the U.S. Department of Education through the National Center for Education Statistics. The CIP codes used in this report were chosen based on programmatic focus on cybersecurity, or programs/curriculum likely to include elements of cybersecurity (Exhibit 28). The criteria used to identify cybersecurity CIP codes are:

- 1. Cybersecurity Focused**—If both the CIP title and the description of the CIP code addressed cybersecurity, then a program was coded as “Cybersecurity Focused.” Three CIP codes met the criteria. (See Exhibit 28.)
- 2. Includes Aspects of Cybersecurity**—If the CIP title was related to cybersecurity and the description of the CIP code included aspects of cybersecurity (including phrases such as “information security,” “cybersecurity,” “data storage and security”) then the program was coded as “Includes Aspects of Cybersecurity.” Eleven CIP codes met these criteria.
- 3. Likely Includes Cybersecurity**—If the CIP title is in a field known to include cybersecurity as an important topic, such as computer and information science, and computer engineering and technology, and the CIP description included knowledge that is impacted by cybersecurity (such as database administration, operational systems, networking, information systems, computer systems) then the program was coded as “Likely Includes Cybersecurity.” Twenty CIP codes met these criteria.

Exhibit 28. Cybersecurity-related CIP codes and titles

| Cybersecurity Focused | |
|-----------------------------------|---|
| 11.1003 | Computer and Information Systems Security/Information Assurance |
| 29.0207 | Cyber/Electronic Operations and Warfare |
| 43.0116 | Cyber/Computer Forensics and Counterterrorism |
| Includes Aspects of Cybersecurity | |
| 11.0802 | Data Modeling/Warehousing and Database Administration |
| 11.0901 | Computer Systems Networking and Telecommunications |
| 11.1001 | Network and System Administration/Administrator |
| 11.1002 | System, Networking, and LAN/WAN Management/Manager |
| 11.1004 | Web/Multimedia Management and Webmaster |
| 15.1204 | Computer Software Technology/Technician |
| 43.0301 | Homeland Security |
| 43.0303 | Critical Infrastructure Protection |

continued

CYBERSECURITY PROGRAMS ASSESSMENT

Exhibit 28. Cybersecurity-related CIP codes and titles (continued)

| Includes Aspects of Cybersecurity (continued) | |
|---|---|
| 52.1201 | Management Information Systems, General |
| 52.1206 | Information Resources Management |
| 52.2101 | Telecommunications Management |
| Likely Includes Cybersecurity | |
| 11.0101 | Computer and Information Sciences, General |
| 11.0102 | Artificial Intelligence |
| 11.0103 | Information Technology |
| 11.0104 | Informatics |
| 11.0199 | Computer and Information Sciences, Other |
| 11.0201 | Computer Programming/Programmer, General |
| 11.0202 | Computer Programming, Specific Applications |
| 11.0299 | Computer Programming, Other |
| 11.0401 | Information Science/Studies |
| 11.0501 | Computer Systems Analysis/Analyst |
| 11.0601 | Data Entry/Microcomputer Applications, General |
| 11.0701 | Computer Science |
| 11.0801 | Web Page, Digital/Multimedia and Information Resources Design |
| 11.0899 | Computer Software and Media Applications, Other |
| 11.1005 | Information Technology Project Management |
| 11.1006 | Computer Support Specialist |
| 11.1099 | Computer/Information Technology Services Administration and Management, Other |
| 11.9999 | Computer and Information Sciences and Support Services, Other |
| 15.1201 | Computer Engineering Technology/Technician |
| 15.1202 | Computer Technology/Computer Systems Technology |
| 15.1203 | Computer Hardware Technology/Technician |
| 15.1299 | Computer Engineering Technologies/Technicians, Other |

Note: Full descriptions of the above CIP codes are included in Appendix G of this report.

Cybersecurity Programs at Postsecondary Institutions

In 2016, there were 242 accredited postsecondary institutions in the state of California offering programs that either focused on or included cybersecurity. Also in 2016, the most recent year of available data, there were 1,177 programs related to cybersecurity at postsecondary institutions in California (Exhibit 29).

Of those, 61 were programs that were clearly “cybersecurity focused,” and the majority of those were in the area of Computer and Information Systems Security (CIP 11.1003) rather than the newer emerging cybersecurity fields of Cyberwarfare (CIP 29.0207) or Homeland Security (CIP 43.0116). An additional 258 programs are offered in the category of “includes aspects of cybersecurity,” and 858 in programs that “likely include cybersecurity.”

CYBERSECURITY PROGRAMS ASSESSMENT

Of the 1,177 cybersecurity programs offered, 130 (11%) are taught exclusively online. Interestingly, cybersecurity-focused programs are more likely to be taught exclusively online than the cybersecurity-related programs. While data is not available to confirm, it is likely many programs might be offered partially online, or in a hybrid format.

Exhibit 29. Postsecondary cybersecurity-related programs offered in California

| | | Total Programs Offered | Total Programs Offered Exclusively Online | Percent of Programs Offered Exclusively Online |
|--|---|------------------------|---|--|
| Cybersecurity Focused | | 61 | 12 | 20% |
| 11.1003 | Computer and Information Systems Security/Information Assurance | 58 | 9 | 16% |
| 29.0207 | Cyber/Electronic Operations and Warfare | 2 | 2 | 100% |
| 43.0116 | Cyber/Computer Forensics and Counterterrorism | 1 | 1 | 100% |
| Includes Aspects of Cybersecurity | | 258 | 32 | 12% |
| 11.0802 | Data Modeling/Warehousing and Database Administration | 23 | 4 | 17% |
| 11.0901 | Computer Systems Networking and Telecommunications | 130 | 5 | 4% |
| 11.1001 | Network and System Administration/Administrator | 14 | 6 | 43% |
| 11.1002 | System, Networking, and LAN/WAN Management/Manager | 2 | 0 | 0% |
| 11.1004 | Web/Multimedia Management and Webmaster | 42 | 1 | 2% |
| 15.1204 | Computer Software Technology/Technician | 1 | 0 | 0% |
| 43.0301 | Homeland Security | 23 | 8 | 35% |
| 43.0303 | Critical Infrastructure Protection | 1 | 0 | 0% |
| 52.1201 | Management Information Systems, General | 13 | 3 | 23% |
| 52.1206 | Information Resources Management | 5 | 2 | 40% |
| 52.2101 | Telecommunications Management | 4 | 3 | 75% |
| Likely Includes Cybersecurity | | 858 | 86 | 10% |
| 11.0101 | Computer and Information Sciences, General | 67 | 10 | 15% |
| 11.0102 | Artificial Intelligence | 1 | 0 | 0% |
| 11.0103 | Information Technology | 163 | 14 | 9% |
| 11.0104 | Informatics | 3 | 1 | 33% |
| 11.0199 | Computer and Information Sciences, Other | 7 | 0 | 0% |
| 11.0201 | Computer Programming/Programmer, General | 124 | 12 | 10% |
| 11.0202 | Computer Programming, Specific Applications | 2 | 1 | 50% |
| 11.0299 | Computer Programming, Other | 1 | 0 | 0% |
| 11.0401 | Information Science/Studies | 18 | 2 | 11% |
| 11.0501 | Computer Systems Analysis/Analyst | 8 | 3 | 38% |
| 11.0601 | Data Entry/Microcomputer Applications, General | 79 | 3 | 4% |

continued

CYBERSECURITY PROGRAMS ASSESSMENT

Exhibit 29. Postsecondary cybersecurity-related programs offered in California

(continued)

| | | Total Programs Offered | Total Programs Offered Exclusively Online | Percent of Programs Offered Exclusively Online |
|--------------------------------------|---|------------------------|---|--|
| Likely Includes Cybersecurity | | 858 | 86 | 10% |
| 11.0701 | Computer Science | 174 | 10 | 6% |
| 11.0801 | Web Page, Digital/Multimedia and Information Resources Design | 109 | 15 | 14% |
| 11.0899 | Computer Software and Media Applications, Other | 7 | 0 | 0% |
| 11.1005 | Information Technology Project Management | 3 | 3 | 100% |
| 11.1006 | Computer Support Specialist | 54 | 3 | 6% |
| 11.1099 | Computer/Information Technology Services Administration and Management, Other | 8 | 4 | 50% |
| 11.9999 | Computer and Information Sciences and Support Services, Other | 23 | 4 | 17% |
| 15.1201 | Computer Engineering Technology/Technician | 2 | 1 | 50% |
| 15.1202 | Computer Technology/Computer Systems Technology | 3 | 0 | 0% |
| 15.1203 | Computer Hardware Technology/Technician | 1 | 0 | 0% |
| 15.1299 | Computer Engineering Technologies/Technicians, Other | 1 | 0 | 0% |
| Totals | | 1,177 | 130 | 11% |

Source: National Center for Educational Statistics, IPEDS Data

For more detailed information, see Appendix E: Inventory of Cybersecurity (and Closely Related) Programs at Postsecondary Institutions in California and Appendix F: Program Awards in Cybersecurity (and Closely Related Programs) at Postsecondary Institutions in California, Five-Year Trends.

There is diversity in the types of institutions providing cybersecurity programs, from non-degree granting institutions to two-year colleges and universities offering bachelor's degrees to doctoral degrees. Most cybersecurity programs reported to IPEDS (96%) are offered by degree-granting institutions (Exhibit 30). Within degree-granting institutions, the majority of cybersecurity-related programs are at public two-year (56%) and public four-year (16%) colleges, resulting in public colleges offering 72% of cybersecurity-related programs. Costs also vary by type of institution. Tuition and fees, and average net price of attendance are significantly lower at public colleges than at private colleges.

CYBERSECURITY PROGRAMS ASSESSMENT

Exhibit 30. Postsecondary cybersecurity-related programs, by sector of institution and cost

| | Total Programs Offered | Average Annual Tuition & Fees | Average Net Price of Attendance ²⁷ |
|--|------------------------|-------------------------------|---|
| Degree-granting | 719 | \$7,448 | \$12,232 |
| Private for-profit, 2-year | 25 | \$12,648 | \$15,736 |
| Private for-profit, 4-year or above | 61 | \$14,634 | \$21,698 |
| Private not-for-profit, 4-year or above | 95 | \$33,520 | \$29,374 |
| Public, 2-year | 420 | \$1,251 | \$8,024 |
| Public, 4-year or above | 118 | \$5,533 | \$9,412 |
| Nondegree-granting, primarily postsecondary | 28 | | \$18,813 |
| Private for-profit, 2-year | 1 | | \$23,210 |
| Private for-profit, less-than 2-year | 25 | | \$19,244 |
| Public, less-than 2-year | 2 | | \$13,173 |
| Total/Overall Average | 747 | \$7,448 | \$12,408 |

Source: National Center for Educational Statistics, IPEDS Data

Note: Data are from 2016, the most recent year available.

For more detailed information, see Appendix H: List of IPEDS-reporting Postsecondary Institutions Providing Cybersecurity Programming in California, with Institutional Characteristics.

Nine of the colleges and universities identified above have been designated a “National Center of Academic Excellence” in cyber defense, cyber operations, or research (related to cybersecurity) by the National Security Agency (NSA) and the Department of Homeland Security (DHS) through a joint program that recognizes and grants distinction to “schools that offer rigorous degree programs in information security.”²⁸ (Colleges can receive more than one designation.)

The nine postsecondary institutions in California recognized as Centers of Academic Excellence are:

Cyber Defense

- California State Polytechnic University Pomona, Computer Information Systems Department
- California State University, Sacramento, Center for Information Assurance and Security
- California State University, San Bernardino, Cyber Security Center
- Coastline Community College, Cyber Security Center
- National University
- Naval Postgraduate School, Cyber Academic Group
- San Jose State University, Silicon Valley Big Data and Cybersecurity Center
- University of California, Davis, Computer Security Lab

Research

- Naval Postgraduate School, Cyber Academic Group
- University of California, Davis, Computer Security Lab
- University of California, Irvine, Secure Computing and Network Center

Cyber Operations

- Naval Postgraduate School, Cyber Academic Group

²⁷ In IPEDS, average institutional net price of attendance is generated by subtracting the average amount of federal, state/local government, or institutional grant and scholarship aid from the total cost of attendance. Total cost of attendance is the sum of published tuition and required fees (lower of in-district or in-state for public institutions), books and supplies, and the weighted average for room and board and other expenses.

²⁸ “National Centers of Academic Excellence in Cyber Education,” National Security Agency, Central Security Service, October 31, 2016, accessed June 11, 2018, <https://www.nsa.gov/resources/educators/centers-academic-excellence/cyber-operations/>.



PROGRAM AWARDS

While CIP codes classify instructional programs, program awards indicate the level of education and training associated with the programs. Awards range from certificates of less than one year to higher level certificates and degrees up to the doctoral level. Definitions of the different award levels are included in the notes of Appendix F: Program Awards in Cybersecurity (and Closely Related Programs) at Postsecondary Institutions in California, Five-Year Trends.

Overall, the number of cybersecurity-related awards increased between 2012 and 2016, rising from 12,227 awards to 15,721 awards in that time period, an increase of 29% (Exhibit 31). However, there were differences in growth by program, and by award levels.

Cybersecurity-focused program awards increased 80% between 2012 (452 awards) and 2016 (813 awards). This growth occurred mostly in awards of less than one academic year, associate degrees, post-baccalaureate certificates, and master's degrees. Bachelor's degree awards actually decreased in 2016 after peaking in 2015. It is interesting to note that no doctoral degrees were awarded in cybersecurity-focused programs during this time period.

Awards from programs in the category **"includes aspects of cybersecurity"** decreased 23% between 2012 (3,103 awards) and 2016 (2,401 awards). The decrease occurred across most award levels (most notably associate degrees and awards of less than two years). However, there was an increase in program awards for bachelor's, master's, and doctoral degrees.

Programs in the **"likely includes cybersecurity"** category increased awards 44% between 2012 (8,672 awards) and 2016 (12,507 awards). Most of this growth came in the associate, bachelor's, and master's degree categories. During the same time period, awards of at least one, but less than two academic years, decreased.

Because cybersecurity is an emerging field of study, it is possible that some of the fluctuations in program awards is due to the relatively new and emerging system for classifying these programs. Postsecondary institutions may not be current with the most recently added CIP codes to classify their cybersecurity-related programs. CIP code 43.0116 was recently created for Homeland Security, and only one program shows up with that CIP code in California in 2016, with no associated awards. Likely it is a new program that will take some years before students earn program awards. It is also likely that as curriculum and programs get updated, CIP codes will also be updated and newly added CIP codes can be considered.

Between 2012 and 2016, cybersecurity-related awards rose from 12,227 to 15,721, an increase of 29%.

PROGRAM AWARDS

Exhibit 31. Summary of cybersecurity (and closely related) awards from California postsecondary institutions, five-year trends

| | 2012 | 2013 | 2014 | 2015 | 2016 | 5-Year Total | 5-Year Annual Average |
|--|--------------|--------------|---------------|---------------|---------------|---------------|-----------------------|
| Cybersecurity Focused | 452 | 499 | 788 | 922 | 813 | 3,474 | 695 |
| Award of less than 1 academic year | 88 | 84 | 98 | 87 | 157 | 514 | 103 |
| Award of at least 1 but less than 2 academic years | 5 | 2 | 2 | 2 | 4 | 15 | 3 |
| Associate degree | 63 | 82 | 64 | 85 | 192 | 486 | 97 |
| Bachelor's degree | 195 | 217 | 399 | 450 | 132 | 1,393 | 279 |
| Post-baccalaureate certificate | 96 | 64 | 143 | 182 | 206 | 691 | 138 |
| Master's degree | 5 | 50 | 82 | 116 | 122 | 375 | 75 |
| Includes Aspects of Cybersecurity | 3,103 | 3,637 | 3,457 | 3,293 | 2,401 | 15,891 | 3,178 |
| Award of less than 1 academic year | 1,082 | 918 | 845 | 816 | 802 | 4,463 | 893 |
| Award of at least 1 but less than 2 academic years | 325 | 326 | 327 | 290 | 221 | 1,489 | 298 |
| Associate degree | 1,184 | 1,483 | 1,275 | 1,125 | 383 | 5,450 | 1,090 |
| Bachelor's degree | 289 | 548 | 649 | 619 | 568 | 2,673 | 535 |
| Post-baccalaureate certificate | 1 | 28 | 16 | 9 | 4 | 58 | 12 |
| Master's degree | 220 | 329 | 342 | 429 | 414 | 1,734 | 347 |
| Doctoral degree - research/scholarship | 2 | 5 | 3 | 5 | 9 | 24 | 5 |
| Likely Includes Cybersecurity | 8,672 | 8,685 | 10,712 | 10,605 | 12,507 | 51,181 | 10,236 |
| Award of less than 1 academic year | 1,270 | 1,281 | 2,417 | 1,728 | 1,448 | 8,144 | 1,629 |
| Award of at least 1 but less than 2 academic years | 1,064 | 775 | 745 | 425 | 412 | 3,421 | 684 |

Source: National Center for Educational Statistics, IPEDS Data

Note: For more detailed results, see Appendix F: Program Awards in Cybersecurity (and Closely Related Programs) at Postsecondary Institutions in California, Five-year Trends.