



Development of an Electronics Manufacturing Technician Program for Community College Students

Nicholas Langhoff (Professor - Engineering / Engineering Technology)

Nicholas Langhoff is the founder and Chair of the Engineering, Engineering Technology, and Computer Science Program at Skyline College, in San Bruno, California. His educational background is in Electrical and Computer Engineering with expertise in electronics hardware design and manufacturing. He has extensive experience in developing and implementing grant-funded programs from the U.S. Department of Education, the National Science Foundation, and private foundations bringing over \$5M in funding to the college. Most recently, he is working on the development of an electronics manufacturing technician program along with the construction of a completely new and modernized electronics design lab space.

Julie A. Shattuck

Development of an Electronics Manufacturing Technician Program for Community College Students

Abstract

The Silicon Valley and San Francisco tech region in California is growing rapidly and has an increasing need for skilled technicians with integrated abilities in electronics manufacturing, advanced R&D testing and troubleshooting, and automation and controls. This work-in-progress details the development of the SkyBayTech Electronics Technician program at Skyline Community College, a small Hispanic Serving Institution (HSI) in the San Francisco Bay Area. Funded by the National Science Foundation's Advancing Technological Education (ATE) program, the SkyBayTech program is designed to meet current local workforce needs through hands-on and project-based learning experiences for students to gain the knowledge, skills, and competencies needed within the local technician workforce. The paper and poster detail: (1) needs assessment within the local workforce, (2) newly developed curriculum and stackable certificates in electronics technology aligned with key Institute of Printed Circuits (IPC) standards, (3) faculty professional development as IPC certified instructors, (4) development of a cutting-edge electronics manufacturing lab facility, (5) an intensive student support program that includes dual-enrollment high school partners to recruit, retain, and graduate students, and (6) collaborative partnerships and a workforce placement program with integrated support from industry partners and research facilities. Early lessons learned within the first year of program development are also shared.

1. Introduction

The San Francisco Bay Area and Silicon Valley represent a global center for technological innovation, with many high-tech businesses and manufacturers in the region. The area is home to industry leaders and research facilities such as Apple, Tesla, Zoox, SA Photonics, Lam Research, Sanmina Corp, NASA Ames, and Department of Education Laboratories, including Stanford Linear Accelerator, Lawrence Berkeley, and Lawrence Livermore. Despite housing many of the largest manufacturing and electronics companies, there has been a significant shortage and critical need of skilled entry-level and mid-level electronics technicians in the Bay Area. In this region alone, there are a total of 10,200 electronics and electrical technician and related jobs with a projected growth of 21% in San Francisco and San Mateo County, and 19% in Alameda County in the next ten years [1]. An industry assessment surveying 44 industry partners across the nation demonstrated that 40.9% of respondents perceived that there was an insufficient future supply of workers with a two-year engineering technology degree [2]. Additionally, a closer look at the engineering technologist workforce shows an aging workforce (Figure 1). From 2004 to 2015, the average age was 43.5 years, compared to 35.4 years from 1974 to 1983, showing that the current rate of younger technicians entering the field has significantly declined compared to previous cohorts [2].

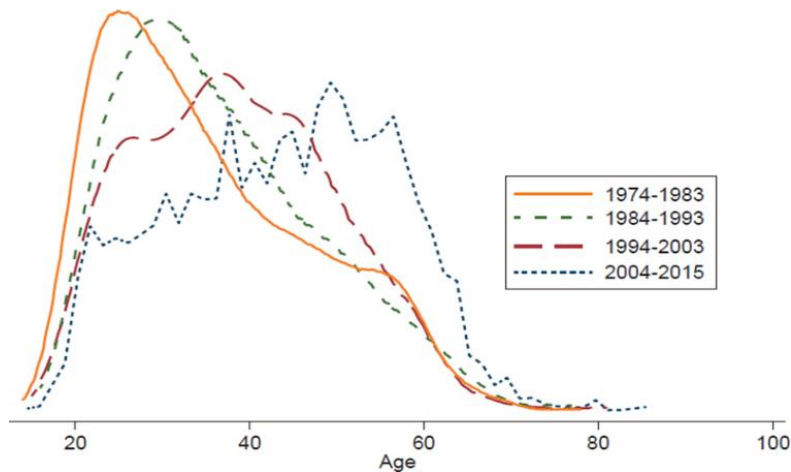


Figure 1 - Age distribution of engineering technicians and technologists

Currently, there are few electronics technology programs in the local area that yield enough graduates to reverse these trends to meet the demands of the local workforce. The SkyBayTech program aims to address the local and national shortage of electronics technicians. The project’s management team conducted a local workforce needs and skills assessment with several local companies and analyzed over 50 electronics technician job postings.

2. Overview of the SkyBayTech Program at Skyline College

Skyline College, located in the San Francisco Bay Area, is a Hispanic-serving community college, and is one of three colleges in the San Mateo Community College District. During the 2020-21 academic year, Skyline College enrolled 16,631 unique students. The student body is genuinely multi-cultural with Hispanic students as the largest single group at 30.0%; Asian students comprise 22.4%, Caucasians 20.9%, Filipinos 13.37%, African-Americans 2.8%, American Indian/Alaska Natives 0.1%, Pacific Islanders 1.3%, multi-ethnic 6.3%.

Approximately 19% attend college full time, taking 12 or more units per semester. Like all California community colleges, Skyline College is an open-enrollment institution, designed to welcome students of all backgrounds. Starting in 2014, the college began development of a transfer Engineering Program that offers a comprehensive set of lower-division engineering courses needed to transfer to any four-year engineering program in any field of engineering. With the program fully developed, the program turned their attention to engineering technician education and direct pathways into local workforce.

In response to industry need, the authors set out to develop the SkyBayTech Electronics Manufacturing Technician program. The program focuses on knowledge, skills, and abilities (KSAs) emphasized in the needs assessment and analysis, especially test and measurement

equipment, reading electrical schematics, circuit debugging and troubleshooting, custom cabling and wire harnesses, Printed Circuit Board (PCB) rework skills of through-hole (TH) and surface mount (SMD) components, and battery testing and management. The program is the College's first Engineering Technology program, and a breakthrough opportunity for the institution and its students.

2.1 Curriculum Design

To date, the team has developed the first set of courses and a Certificate of Specialization. Courses cover DC and AC circuits, contextualized math for electronics, electronics test and measurement, schematic entry, custom cabling, basic Printed Circuit Board (PCB) design and manufacturing, and soldering aligned to the IPC J-STD-001 (see section 2.2 – Faculty Training and IPC certification below). Mathematics is taught in context to electronics applications completely within the program by SkyBayTech faculty, a strategy shown to be effective as alternative math pathways [3]. The program is also designed to align with the eleven elements of high-quality Career Technical Education (CTE) programs as outlined by the California Department of Education [4], and includes strategies to place students in job shadowing, internship, and gainful employment opportunities within local industry.

Table 1 – SkyBayTech First Year Curriculum

SkyBayTech Program			
Course (** TBD)	Contact Hours	Units	Description
Core Courses—Total Units 12			
ELEC 111 Electronics Fundamentals	32 lecture 48 lab	3	Introduction to DC and AC electricity; reading simple schematic diagrams and construction of elementary circuits; using multimeters and oscilloscopes; using DC power supplies and AC power sources; exploration of induction and capacitance in DC and AC voltage circuits.
ELEC 112 Advanced Electronics Fundamentals	32 lecture 48 lab	3	Introduction to more advanced electrical/electronics circuits. Includes linear and switched power supply circuits, filtering circuits, amplifier and oscillator circuits using BJT, FET, and Op-amp devices; examination of digital circuits.
ELEC 231 Applied Math for Electronics	32 lecture	2	Basic principles: algebra, trigonometry, logarithms, graphing, and scientific calculator use as applied to DC/AC circuits.
ELEC 231 Applied Math for Electronics	16 lecture	1	Advanced principles: algebra, trigonometry, logarithms, and graphing as applied to amplifier, filter, microwave, oscillator, and digital circuits.
ELEC 265 Electronic Fabrication and Assembly	32 lecture 48 lab	3	Manufacturing and fabrication processes associated with the electronics industry. Printed circuit board (PCB) design from conception to completion. Emphasizes electrical schematics, bill of material (BOM), component selection, layout design, manufacturability, assembly, soldering, de-soldering, and surface-mount technology. Soldering aligns to IPC J-STD-001.

Table 1 shows the program courses taken within the first year. These five courses all culminate with a certificate of specialization “Electronics Assembly and Fabrication”. The team plans to implement later courses including, PCB Rework and Repair, Advanced Electronics Diagnostic Testing, and Introduction to Programmable Logic Controllers (PLCs). These courses, along with existing courses in the Engineering program, will be packaged into other local certificates that each stack upon the first level certificate. Figure 2 below shows the first level, and later proposed certificates.

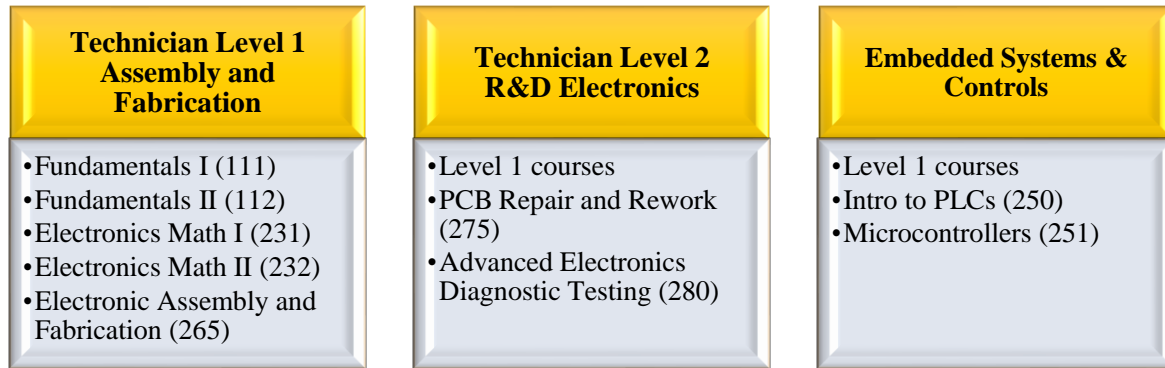


Figure 2 – SkyBayTech Stackable Certificates

The first foundational four courses in the Level 1 certificate (ELEC 111, 112, 231, 232) align with the electronics program at the college’s sister campus, College of San Mateo. The alignment supports students to these take courses at either campus in the district and has enhanced collaboration between faculty at the respective programs. This arrangement also allows students to complete pre-requisites for specialization courses and certificates at either campus and choose to specialize and gain certificates from either school.

2.2 Faculty Training and Certification

SkyBayTech faculty have completed training from the Association Connecting Electronics Industries, formerly known as and commonly referred to as the Institute of Printed Circuits (IPC) to become certified IPC instructors. IPC exams are administered within the courses by SkyBayTech faculty, saving each student thousands of dollars in IPC preparatory coursework, and providing them with a certified competitive edge for job placement. SkyBayTech faculty completed their IPC training with Eptac soldering training solutions. The SkyBayTech PI has formed a good relationship with Eptac, and their support and training materials have helped identify equipment needed in setting up the new electronics lab and further shape SkyBayTech curriculum.

2.3 The SkyBayTech Electronics Design Laboratory

Through support from the college administration and federal grant awards (see acknowledgements), in the Summer and Fall of 2021 the college renovated one half of its fabrication makerspace lab into its premier Electronics Technology Design Lab (EDL). The space is well-stocked with high-quality electronics test, manufacturing, and repair equipment, and has taken shape as the cornerstone of the new program. Figure 3 below shows the EDL floorplan. There are ten workstations around the room, each with a dedicated 20-Amp circuit to power all the test and manufacturing equipment. The EDL is an inspiring space for creativity and simply its presence on campus has already begun attracting students to the program.

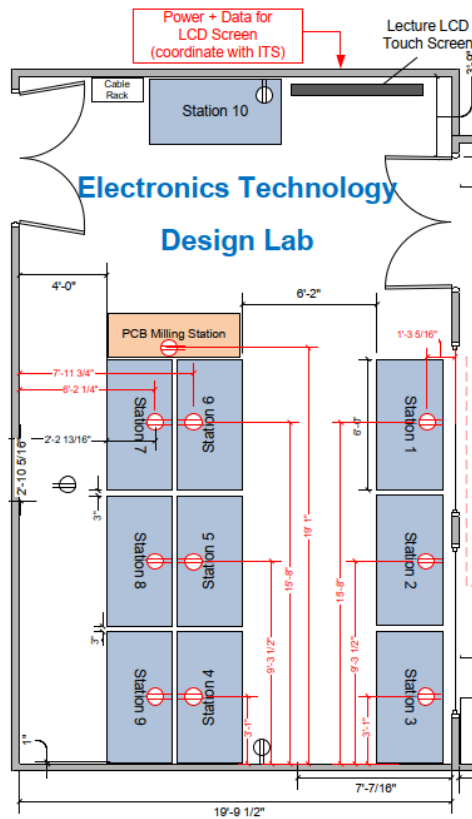


Figure 3 – Floorplan: SkyBayTech Electronics Design Lab (EDL)

2.4 Student Support Program and High School Pipeline

SkyBayTech students are placed into a cohort within the college's Engineering and Technology Scholars (ETS) learning community. They are provided with wraparound support from a STEM counselor and instructional faculty with the intention of integrating students in a community of academic and social support early on in their academic journey. A large body of research [5], [6], [7], [8] supports these approaches to impact persistence, engagement, and completion.

The college has also partnered with one of its local high schools, Jefferson High School, to offer the first two courses in the Electronics Fabrication and Assembly certificate under a dual-enrollment contract. Students at Jefferson earn college credit for the two courses (ELEC 111 + ELEC 231), and are prepared to enter Skyline College's program. SkyBayTech and Jefferson faculty meet regularly to review and align curriculum and equipment needs between the two schools.

2.5 Workforce Placement Program

The SkyBayTech team have formed relationships with local industry partners to guide curriculum, provide professional development, and join the SkyBayTech workforce placement program, including Lawrence Livermore Labs, Stanford Linear Accelerator, SA Photonics, ABX Engineering. Industry partners are integrated into the program's Business and Industry Leadership Team (BILT), and support through co-led curriculum development, professional development and training, guest speaking, job shadowing, internship and job placement.

3. First-year Pilot Implementation

In response to the Covid-19 pandemic and the stay-at-home order and corresponding campus closure, the SkyBayTech project shifted the start of the first course offerings and first cohort back one year to Fall 2021. With this shift, the change provided opportunity for enhanced focus on program development, relationship development with high school and industry partners, research into professional training and instructor certification, and research, construction, and installation of the new electronics lab. This also included shifting support and assessment strategies into funding year two, including tutoring services and summer internships. The team also delayed implementation of the student evaluation program due to changes in the launch of the first cohort.

The college offered the first electronics courses this Fall 2021 and Spring 2022. Recruitment for this first cohort was challenging amid the pandemic with uncertain, unclear, and changing course modalities, which all exacerbated the typical challenge of getting the word out and student buy-in for a new program. The team recruited ten students to take the first two courses (ELEC 111 and 231) in the Fall 2021, and six students to take the capstone manufacturing course (ELEC 265) in the Spring of 2022. The second semester electronics fundamentals and mathematics courses had to be cancelled due to low enrollment.

4. Conclusion

Despite challenges with recruitment and enrollment to build a new program, further exacerbated by the Covid-19 pandemic, several significant achievements were made in the first year and a half of the program. The team developed a set of five courses and a first level certificate curriculum, designed with industry alignment to place students into internship and entry-level positions. The project has led to the development of several strong relationships with industry

partners, established a pipeline from local high school, and the design and installation of a brand-new electronics technology design laboratory.

Acknowledgements

The SkyBayTech program is supported by the National Science Foundation (NSF) through the Advancing Technological Education (ATE) program, Award No. 2000971, and the U.S. Department of Education (USDE) through the Developing Hispanic Serving Institutions (DHSI) program, Award No. P031S180169. The authors also acknowledge and extend their deep gratitude to the entire team in the MentorUp Project (NSF ATE award No. 2032835) for their guidance and support during the 2019 NSF ATE grant writer's workshop.

References

1. Employment Development Department, State of California (2019). Employment Projections. Retrieved from <https://www.labormarketinfo.edd.ca.gov/data/employment-projections.html>
2. Frase, K., Latanision R., and Pearson, G. (2017). *Engineering Technology Education in the United States*. Washington, DC: The National Academies Press. Retrieved from <https://doi.org/10.17226/23402>
3. Robertson, J. (2005, June), *What Math Do We Really Need?* Paper presented at 2005 Annual Conference, Portland, Oregon. <https://peer.asee.org/15518>
4. A Guide for High-Quality CTE Programs. (2008). *California State Plan For Career Technical Education*. Retrieved from <https://www.wested.org/wp-content/uploads/2016/11/1399075231CA5YearStatePlan-3.pdf>
5. Bettinger, E. P., & Baker, R. (2011). *The effects of student coaching in college: An evaluation of a randomized experiment in student mentoring* (Working Paper No. 16881). Retrieved from <http://www.nber.org/papers/w16881>
6. Kuh, G.D. (2008). *High-impact educational practices: What they are, who has access to them, and why they matter*. Washington, DC: Association of American Colleges and Universities.
7. Langhoff, N., & Le, J. N. (2018, June), *Development of a Cohort-Based Program to Strengthen Retention and Engagement of Underrepresented Community College Engineering and Computer Science Students* Paper presented at 2018 ASEE Annual Conference & Exposition , Salt Lake City, Utah. <https://peer.asee.org/30320>

8. Center for Community College Student Engagement, (2012). *A Matter of Degrees: Promising Practices for Community College Student Success (A First Look)*. Austin, TX: The University of Texas at Austin, Community College Leadership Program. Retrieved from https://www.ccsse.org/docs/Matter_of_Degrees.pdf