

Promoting Building and Technical Skilled Trades and Not Leaving Engineering Out of the Equation

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Engineering out of the Equation**

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Abstract

First, let's be clear; the building and technical skilled trades cannot exist without engineering. They are based on standard engineering principles and require knowledge and understanding of basic engineering concepts. For various reasons, the demand for workers trained and educated in the skilled trades is higher today than it has ever been; and for equally various reasons, enrollment in building and skilled trades programs at community colleges and trade schools is on the rise throughout the U.S. What's more, the trades are attracting a wide range of people, from high school graduates to people looking for an alternative career, to military veterans. Hamid King, a skilled trades instructor at Wake Technical Community College in Raleigh, North Carolina reports that he has also seen a number of people who have been working in the skilled trades for a number of years – some of them with as many as 10 or 15 years of experience in the industry – returning to school to update their skills in hopes of increasing their earnings potential. And interestingly enough, he says some of his students include women as well as men. One significant advantage the building and skilled trades education programs offer students is apprenticeships with local employers, which allows them to earn money and gain valuable on-the-job experience at the same time they're getting an education. Sometimes these apprenticeships lead to full-time positions in the company. With the foregoing in mind, the goal of this paper is to clearly define the building and technical skilled trades, focusing on architectural technology, automotive systems technology, computer-integrated machining, construction trades, electrical systems technology, and electronics engineering technology. Added emphasis will be placed on the role of engineering in teaching these subjects and how it impacts the curriculum.

Introduction

It's no secret that there is a great demand for workers in the building (aka construction) and technical skilled trades today – more than ever before. So before getting started, it may be helpful to understand why there is such a demand for these workers and why these trades are becoming more attractive to more people. The sections below will answer these questions. Also provided are brief discussions on what these disciplines encompass and what the job opportunities are.

Building And Technical Skilled Trades Workers Are In Large Demand

According to the Associated General Contractors of America, 89% of construction contractors were having difficulty finding trained workers; and 61% reported project delays because of workforce shortages [1]. Contractors are frequently asking technical colleges if they have any students who can go to work immediately.

So why is there such a shortage? One reason is the aging workforce. In 2021 the Bureau of Labor Statistics estimated that there were almost 1.2 million people between the ages of 55 and 64 working in the construction and extraction (oil and mining) industries [2]. Also, according to the Glens Falls (NY) Business Journal, an estimated 31 million skilled trades workers retired in 2020, and some 10,000 continue to retire every day [3].

Another reason is due to the Great Recession of 2008 when large numbers of construction workers were laid off. The industry showed its first signs of growth in 2014 and has continued to strengthen ever since, and projections indicate continued growth until at least January of 2026. But due to the large number of layoffs in the recession and the ever-increasing number of retirees, the number of skilled labor employees hasn't caught up with the growth.

In addition to the Great Recession, the skilled trades were hit hard by the COVID-19 pandemic and shutdown. And even though skilled trades workers were considered essential during the pandemic, many of them were also laid off due to the business slowdown and never returned to work. Consequently, as business slowly began to increase after the restrictions were lifted, there weren't enough workers available to adequately handle the increase.

As of this writing, things haven't improved all that much. According to the Bureau of Labor Statistics, we're going to need more than four million skilled laborers to replace the nearly eight million lost from the labor force during the pandemic [4]. Recognizing this situation, a multitude of skilled trade positions are opening up, or new ones are being created. For example, some 2.8 million skilled trade jobs were posted during the one-year period between October 2021 and October 2022, according to an analysis by the PeopleReady Skilled Trades staffing agency [5]. The agency also reported that some 388,345 job openings were posted in just one month alone, from May to June 2021 [2]. In addition, the Bureau of Labor Statistics (BLS) reports that the number of total construction jobs is expected to increase to 7.5 million in 2026 [6]. But the dilemma remains: finding qualified workers to fill these projected job openings.

Now for some good news: enrollment in skilled trades training and education programs at community colleges and trade schools is rising. Data from the National Student Clearinghouse show that enrollment in construction trades programs grew 5% from 2019 to 2021, and enrollment in architecture and related services grew 4% during the same period [1]. As mentioned in the Abstract, enrollment increases have been experienced across the whole country, particularly during and after the COVID-19 shutdown, ranging from 8.1% at Lake Area Technical College in South Dakota, to a whopping 54% at East Valley Institute of Technology (EVIT) in Mesa, Arizona – all between 2018 and 2021 [7]. And while these numbers are encouraging, there's still a long way to go to catch up with the demand.

The Building and Technical Skilled Trades are Becoming More Attractive

So why are the building and skilled trades becoming more attractive to potential workers? Perhaps the number-one reason, as already mentioned, is the fallout from the COVID-19 pandemic and resulting shutdown. The building and skilled trades were one of the few industries that offered a semblance of job stability during the pandemic, even though they too had workforce reductions. Nonetheless, non-trades people who were forced out of work viewed the

building and skilled trades as being more stable and pandemic proof while also offering a decent salary.

The pandemic was also the primary reason why those enrolled in (or thinking about enrolling in) technical training schools and programs did so. In an article written by Zander Buel for the Tulsa Welding School in Jacksonville, Florida, a survey found that 57% of these people said that COVID-19 was their main motivation; and of that 57%, more than half of them said they were motivated by the fact that the skilled trades offered a more stable source of income [8]. Another 29% said they wanted to become an essential worker – one whose job was less subject to elimination in another pandemic or major recession.

Another reason why the building and skilled trades are becoming more attractive is that many of them offer immediate employment, even for those just starting out in the industry. Many employers are offering in-house apprenticeships or are partnering with technical community colleges and vocational and trade schools to provide apprenticeships for the students. They're even reaching out to high schools to attract younger students who hopefully will want to join the industry and make it a lifelong career. In either situation, the participants are getting immediate employment with a salary attached, and the employer is getting some much-needed help.

Some employers are also turning to technology to train new employees. With the advent of virtual reality, VR simulators allow new workers to train in a safe, realistic, life-like environment, allowing them to become familiar with the tools and equipment they will be using without the dangers associated with using them on the actual job site.

So, what else besides the pandemic, job security, and having a reliable source of income has sparked this new interest in the trades? One thing is the variety of jobs available, ranging from carpenters, welders and plumbers to electricians and electrical systems designers, to machinists, toolmakers, and robotics designers and programmers. It's a wide-open field as far as careers go.

Finally, earnings potential is another drawing card. In the Zander Buel article mentioned earlier, an overwhelming majority of the respondents said that prospective salaries were the most important advantage of working in the trades [8]. And many of the jobs do offer attractive salaries, ranging from \$50,000 to \$55,000/year for plumbers, welders, electricians and HVAC (heating/ventilation/air-conditioning) technicians, and as high as \$77,000/year for construction managers [9]. Even entry level jobs also pay a surprisingly good wage. According to Hamid King, a skilled trades instructor at Wake Technical Community College in Raleigh, North Carolina, entry level wages can be as high as \$15/hr to \$20/hr, which works out to more than \$31,000 - \$41,000 per year, based on a 40-hour work week [10]. Another thing is that some of those entering the skilled trades want to eventually start their own business, which offers almost unlimited potential earnings.

The Building and Skilled Trades are Attracting a Wide Variety of People

For many years the building and skilled trades have had a bad reputation in the minds of most people. They have been under the misconception that these types of jobs are dirty, menial, low paying, and that they attract only certain types of people – mostly those who seemingly can't or

don't want to do anything else. Slowly, this mindset is changing, due to a number of factors, some of which I've already mentioned, like the rapidly changing job market and people's desire for more secure types of jobs while also making a decent salary. As people have become more educated and knowledgeable about the building and technical skilled trades, they're finding that many of the jobs require a high degree of independent thinking, along with problem-solving, organizational, and decision-making skills, and that they pay more than first thought. They're also finding out that not all of the jobs are menial, get your hands dirty types of grunt work. Many of the technical skilled trades are clean, labor-free operations requiring skill, education and intelligence, not to mention that they pay extremely well.

As the general perception of the trades slowly changes, more people have become interested in this career field and are enrolling in skilled trades educational programs. What's interesting is who these students are. Number one, of course, are those who have been impacted by the pandemic. Right behind them are high school or college students who have changed majors, while still others are those who just want to make a career change, pandemic or no pandemic. Among the latter are retired or recently separated veterans who are looking for a second career, along with trades workers themselves who want to upgrade their skills and education. Women are also entering the trades in surprising numbers; but more about that later.

Unfortunately, there isn't much (in fact hardly any) statistical data regarding the number of these various types of students. The only statistics I could find involved veterans and women. (Again, I'll discuss the women as a separate topic below.) In regard to veterans, 6.2% of them are employed in construction, and 12.1% are employed in manufacturing which utilizes many of the skilled trades, according to Satista.com [11]. Employers value veterans, since many of them bring usable experience with them from their previous jobs in the military, along with many of the needed and valuable skills mentioned earlier.

Women in the Skilled Trades

Women working in the skilled trades is nothing new. Back in World War II, they filled many of the essential jobs in the skilled trades, working as welders, mechanics, and electricians. Remember the ads featuring Rosie the Riveter? But this all changed after the war when men started returning home needing work and most women decided to become homemakers or find less physically demanding work. But the fact remains: they were and still are capable of doing the work. Below are some of the statistics backing this up, as shown in an analysis conducted by the Institute for Women's Policy Research (IWPR) [12].

- Women accounted for 3.4% of the construction trades workers in 2018, but are still greatly underrepresented.
- Between 2017 and 2018, the number of women working in construction trades increased by 17.6 percent, rising to some 276,000. This growth is nearly five times faster than the overall 3.7% job growth in construction jobs, and is the highest share of these jobs in 20 years.

- Women are receiving wages well above the national average, earning a median income of \$785/week (\$40,820/year) on average, though still below the \$834/week (\$43,368/year) the men are making.

Finally, it should be noted that community colleges, trade schools, and vocational schools are seeing an increase in women enrolling in building and technical skilled trades programs. And as Hamid King at Wake Tech Community College has observed, those who participate in apprenticeship programs have shown a particular ability to handle the detailed nature of skilled trades. Women have also shown the willingness and ability to take initiatives when learning a trade and working on the job, almost to the point of being like a group leader. It seems that once they understand what they're doing, they are proactive in relating what they have learned to others around them. Hamid also notes that "A lot more Women in Skilled Trades organizations are coming into existence, which is great; but we still need more."

Hopefully, as these and other women's advocate organizations take up the cause of women in the building and technical skilled trades, the disparagements noted above won't last indefinitely.

What the Building and Skilled Trades Encompass

It needs to be pointed out that skilled trades cover a vast spectrum of careers and disciplines that touch on every aspect of life. But for the purposes of this paper, the discussion is being limited to the building and technical skilled trades, and more specifically, the engineering aspects of these disciplines. Also, as noted earlier, keep in mind that the terms "building trades" and "construction trades" are used interchangeably.

So, what, exactly, do the building and technical skilled trades encompass? The best way to discuss this is in terms of the training and education programs offered primarily at community colleges. These institutions provide hands-on learning experiences with career skills that prepare their students for the workforce or for further education if they so desire. They also offer both short-term and long-term courses leading to an associate of applied science (AAS) degree and/or certification for specific trades and skills. The courses include, but are not limited to: architecture, automotive mechanics, biomedical equipment design/repair/maintenance, construction, engineering, machining, electrical systems, electronics, and industrial systems technology. For a more complete rundown of available programs and courses, students should talk with an academic advisor.

Building and Technical Skilled Trades Opportunities

As mentioned above, these disciplines offer a wide variety of job opportunities within several key industries. A few examples include the following:

- **Industrial skilled trades:** jobs include welders, mechanics, machinists, millwrights, tool and die makers, electricians, logistics technicians, maintenance technicians, field superintendents, and computer programmers.

- **Construction skilled trades:** jobs include carpenters, electricians, bricklayers, masons, tile setters, insulation installers, ironworkers, plumbers, welders, pipefitters/steamfitters/gasfitters, and HVAC (heating, ventilation and air-conditioning) technicians.
- **Manufacturing skilled trades:** jobs include tool and die makers, machinists, assemblers, welders, fabricators (who make new creations and raw supplies for manufacturers), robotics technicians, mechatronics technicians (who make operate, test, and maintain electromechanical and robotic equipment, including computer numerical control [CNC] machines, package-sorting equipment, and automated assembly lines), python and C++ programmers (who tell computers and machines what to do), production managers, and quality control inspectors.

While this is not an all-inclusive list of industries or all of the jobs within each one, it serves as a good indicator of what is available. More detailed information can be obtained from a career advisor, or career “coach”, as some colleges call them.

The remainder of this paper will focus on the following building and skilled trades programs available at our community college:

- Architectural Technology
- Automotive Systems Technology
- Computer-Integrated Machining (CIM)
- Construction Trades
- Electrical Systems Technology
- Electronics Engineering Technology

The specific courses for each of these programs will also be described, along with the applicable engineering components. These programs and courses will also be discussed in terms of the three major industry areas mentioned earlier: industrial skilled trades, construction skilled trades, and manufacturing skilled trades. Table 1 below shows the curricula programs (i.e., disciplines) for each of the technology and trades programs listed above (not the specific courses themselves). It also shows whether the curricula programs are credit or non-credit continuing education (CE), and the level of education students can achieve in each discipline, i.e., a certificate, a diploma, or an associate of applied science (AAS) degree. Finally, the table shows which of the three major industries these programs are suited for.

As you will note on Table 1, both the credit and non-credit continuing education (CE) curricula programs offer a certificate upon completion; however, the non-credit CE programs offer just a certificate or an industry credential. The reason for this is that these programs are short-term in duration, with minimal hours required to earn the certificate. Students who take them are mostly interested in getting just enough education to qualify them for an entry level job in their chosen profession, which the certificate allows them to do. For example, a few of our construction trades programs, like carpentry, plumbing and welding, have non-credit certificate options which allow the students to take a course in a semester to obtain a certificate so they can begin work

immediately in the industry and obtain a certificate. On the other hand, students who earn a certificate in the credit programs, such as machining in Automotive Systems Technology, can continue on to a higher level of education, earning a diploma or an AAS degree, if they so desire.

Using the Automotive Systems Technology program as an example again, it offers primarily credit curricula programs, leading to the full range of completion awards (certificate, diploma, and AAS degree). Table 2 lists the various curricula programs and shows the number of semesters and total number of semester hours required for program completion and for earning each type of award.

It should be noted that the EV (electric vehicle)/Hybrid program in Automotive Systems Technology is shown as both a credit and non-credit CE program on Table 1, but doesn't appear on Table 2. The reason is that this program has not yet started at our college, but will be available in the near future. Also, when it does start, it will initially be offered only as a non-credit CE program. However, as more students show interest in attaining a higher level of education in this program, it will eventually become a credit program. As of this writing, it is estimated that earning a non-credit certificate for this program will require completion of 3 semesters and 15 credit hours (330 contact hours).

Building & Skilled Trades						
	Industrial Skilled Trades		Construction Skilled Trades		Manufacturing Skilled Trades	
Programs	Credit (CU)	Non-Credit (CE)	Credit (CU)	Non-Credit (CE)	Credit (CU)	Non-Credit (CE)
Architectural Technology						
- Architectural CAD Certificate						
- Associate						
Automotive Systems Technology						
- Diploma						
- Drivetrain Certificate						
- Electrical Certificate						
- Machining Certificate						
- Under Car Certificate						
- Motorcycle Safety						
- EV/Hybrid						
- Associate						
Computer - Integrated Machining (CIM)						
- Basic Machining Certificate						
- Computer Numerical Control (CNC) Certificate						
- Diploma						
Construction Trades						
- Carpentry						
- HVAC						
- Plumbing						
- Welding						
Electrical Systems Technology						
- Construction Electrician						
- Control Electrician						
- Maintenance Electrician						
- Diploma						
- Associate						
Electronics Engineering Technology						
- Associate						

Table 1: Program Summary, Certifications and Industry Opportunities

Notations:

Credit (CU): Credit curricula that award an Associate of Applied Science (AAS) degree, a diploma, or a certificate.

CE: Non-credit (short – term) continuing education courses that award a specialized certificate.

Curricula Programs/Awards	Required Semesters	Total Semester Hours
Drivetrain Certificate	2	17
Electrical Certificate	2	15
Machining Certificate	1	13
Under Car Certificate	2	15
Diploma	3	38
AAS - Degree	5	66

Table 2 Automotive Credit Curricula Programs

Literature Review

The following articles pertaining to the building and skilled trades were reviewed as sources for further reading and research.

Aperture Content Marketing in their article “Building a Community College Recruitment Plan for Skilled Trades” focuses on the difficulty of recruiting students into the building and technical skilled trades and the strategies for doing so [13]. Skilled trades jobs still hold the stigma of not being “good jobs” and are undervalued. In addition, the potential income that can be made in these jobs is not widely known, hence bringing people into the trades continues to be very difficult. The strategies mentioned in the article included outreach to high schools, building relations with unions, and creating apprenticeships. There was a focus on being up front with students, sharing the pros and cons of working in these fields, and not sugar-coating things. It is important to relate that these jobs can be physically demanding, sometimes seasonal, and include traveling at times. One main take away from the article was that unions are important. They offer many positive benefits to students, and colleges should work to establish and maintain a strong relationship with them to support students in their endeavors and provide them future opportunities for employment and growth. The article emphasizes that the primary message to colleges is to market the careers and not the degrees!

Trevor Monk’s article “Philadelphia Apprenticeship Program Preparing Women and Veterans for Careers in Insulation” focuses on the support of apprenticeships and partnering with the union [14]. The article specifically cited the Heat and Frost Insulators Union apprenticeship training program in Pennsylvania as an example. Pennsylvania Department of Labor Secretary Jennifer Berrier visited this union’s training location and found that workers are earning family-sustaining wages and are becoming highly skilled, giving them an advantage in the competitive job market. Grants from the Biden administration are in full support of these apprenticeship programs. Most people coming out of programs like this are making approximately \$70,000/year

starting wage, with the potential of progressing into jobs making up to \$300,000. Employers also benefit from these programs, getting more qualified, productive workers after the students complete these apprenticeship programs.

“Finding Their Spark” by Madeline Patton focuses on student recruitment and bringing new students into career pathways [15]. Several examples were given, including a high school student enrolled in cybersecurity courses at a community college; a native of Mexico who took English as a second language (ESL) courses at a community college on his way to becoming a U.S. citizen; a female veteran who enrolled in the male-dominated welding construction trades program; and a recruiter who talks to prospective students who are undecided about a college major – particularly female students – about entering one of the science, technology, engineering and math (STEM) career fields. The article also described a college recruitment event at the Mall of America that included hands-on activities for teens and adults, competitions, and a career fair, all to expose the public to the many types of skilled trades careers, training and education, and job opportunities. Emphasis was also placed on listing salaries for both entry-level and non entry-level positions, along with job placement rates.

In this three-article dissertation with two literature reviews and one case study, Nzingha Williams examines the perception of career and technical education (CTE) among Black American communities [16]. It also provides an in-depth look at the philosophies of Booker T. Washington and W.E.B Du Bois. The research is particularly applicable to the problems facing Black students in the U.S. today, namely the tremendous skills gap throughout the country and the increasing economic mobility problem. The author states that if Black students take advantage of CTE, there is a greater opportunity for them to improve both their skills and economic mobility.

Building and Skilled Trades Programs Defined

To keep things as brief as possible, the building and skilled trades programs defined below are limited to the following: architectural technology, automotive systems technology, computer-integrated machining, construction trades, electrical systems technology, and electronics engineering technology. They are programs currently available at our community college, Durham Technical Community College in Durham, North Carolina. While not all-inclusive of programs available throughout the community college system in the United States, they provide a good representative sampling. Descriptions of the courses available in each of these programs is available on our website at <https://durhamtech.edu>. Click on Programs & Pathways, then Building, Engineering & Skilled Trades, and go to the Pathways Map, which provides course descriptions for each of the major career categories for both short-term and long-term programs.

Architectural Technology

This program prepares individuals to apply technical knowledge and skills to the fields of architecture, construction, construction management, and other associated professions. Course work includes instruction in sustainable building and design, blueprint reading, building codes, estimating, construction materials and methods, and other topics related to design and construction occupations. Graduates will qualify for entry-level jobs in the architectural, engineering, and construction trades, either within the industries themselves or in government.

Automotive Systems Technology

This program prepares individuals to apply technical knowledge and skills to repair, service, and maintain all types of automobiles. It includes instruction and training in brake systems, electrical systems, engine performance, engine repair, suspension and steering, automatic and manual transmissions and drivetrains, and heating and air conditioning systems. This hands-on program helps a student develop technical and manual skills through class assignments, discussions, and practical lab experiences. Graduates should be prepared to take professional licensing exams and to enter careers as entry-level technicians in the transportation industry.

Computer-Integrated Machining

This program provides students with the analytical, creative and innovative skills necessary to take a production idea from an initial concept through design, development and production, resulting in a finished product. Coursework may include manual machining, computer applications, engineering design, computer-aided drafting (CAD), computer-aided machining (CAM), blueprint interpretation, advanced computerized numerical control (CNC) equipment training, basic and advanced machining operations, precision measurement and high-speed multi-axis machining. Graduates will qualify for employment as machining technicians in high-tech manufacturing, rapid-prototyping and rapid-manufacturing industries, specialty machine shops, fabrication industries, and high-tech or emerging industries such as aerospace, aviation, medical, and renewable energy. They will also be qualified to take machining certification examinations.

Construction Trades

This program provides training for entry-level positions in the various construction trades, as well as for increasing the skill levels of those currently employed. Short-term training and non-credit courses are offered to assist students in becoming more marketable in this industry. Courses include plumbing, welding, heating/ventilation/air-conditioning (HVAC), cabinetry, carpentry, pre-construction, and general home repair. Particularly helpful for students is the availability of apprenticeships in some of these trades, offering full-time employment and on-the-job training while the students continue their education at the college. Students may qualify for certification in their chosen field upon completion of the proscribed course of study.

Electrical Systems Technology

This program is designed to provide training for persons interested in the installation and maintenance of electrical systems found in residential, commercial, and industrial facilities. Coursework, most of which is hands-on, will include subjects such as AC/DC theory, basic wiring practices, programmable logic controllers, industrial motor controls, applications of the National Electric Code, and other subjects as local needs require. Graduates will qualify for a variety of jobs in the electrical field as an on-the-job trainee or apprentice assisting in the layout, installation, and maintenance of electrical systems.

Electronics Engineering Technology

This program provides theory and hands-on practical training in repairing electronic equipment, including computers, stereos, and hand-held microprocessor equipment. Students are trained to use measurement tools such as digital multimeters and oscilloscopes. Circuit construction techniques include printed circuit board fabrication and both surface-mount and through-hole component soldering. Graduates qualify for employment as an electronics engineering technician, field service technician, instrumentation technician, maintenance technician, electronics tester, electronic systems integrator, bench technician, or production control technician.

Program Demand and Analysis

As previously discussed in the Introduction, interest in the building and technical skilled trades has increased in recent years, as has enrollment in education programs for these trades. Table 3 shows recent enrollment figures (Fall semesters 2020 and 2021) for various construction and technical skilled trades programs offered at our community college, Durham Technical Community College, in Durham, North Carolina. While a few of the disciplines showed a slight decline between the two years, others increased, particularly the construction trades, which showed significant increases. Figure 1 below presents the information in graph form. Also presented on the succeeding pages is an analysis of these programs, along with a discussion of the engineering aspects, and how engineering interfaces with the program curricula.

Discipline	Fall 2020	Fall 2021
Architectural Technology	29	25
Automotive Systems Technology	50	52
Computer – Integrated Machining	7	10
Electrical Systems Technology	27	25
Electronics Engineering Technology	18	14
Construction Trades – Carpentry	18	27
Construction Trades – HVAC	9	24
Construction Trades – Plumbing	8	30
Construction Trades - Welding	10	11

Table 3: Current Enrollment Data at the Skilled Trades Institution

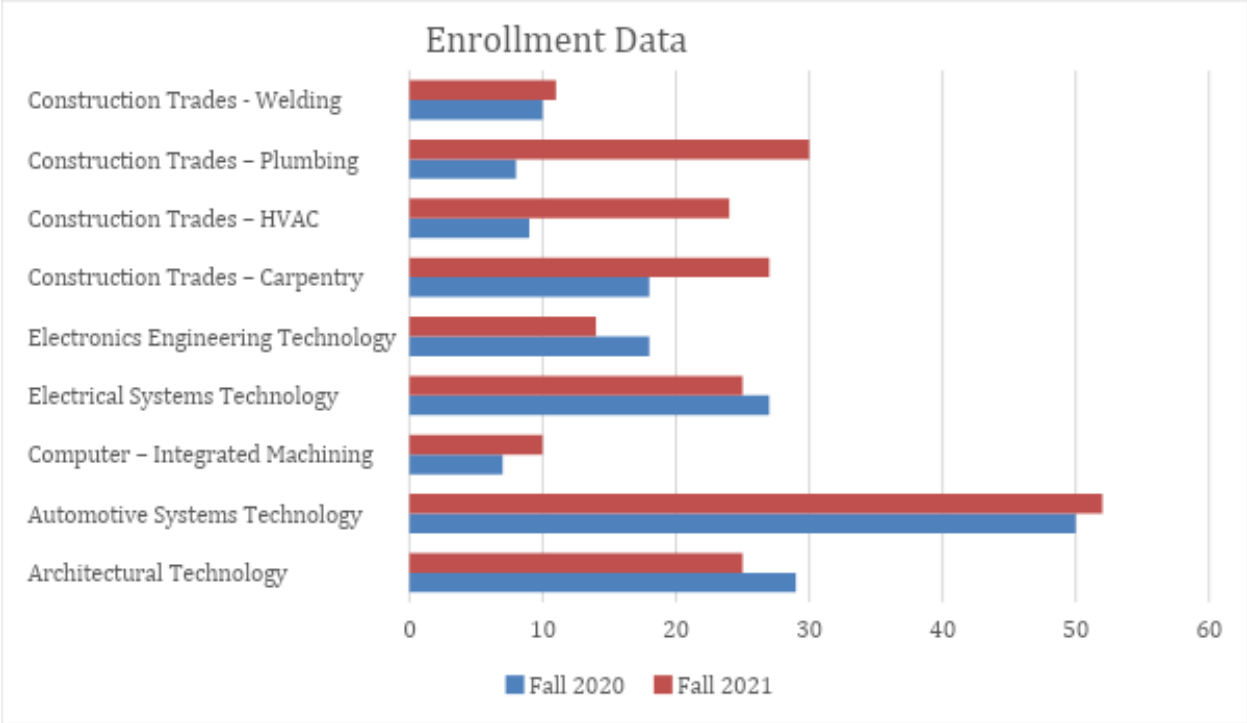


Figure 1: Current Enrollment Data Graph

Where is the “Engineering” in Building and Technical Skilled Trades?

Engineering is such a vital part of these disciplines that many technical community colleges include it in the same division. For example, one technological community college in North Carolina labels their program as “Building, Engineering, and Skilled Trades” (BEST). In addition to curricula in the various building and technical skilled trades, this college also offers basic engineering classes and instruction, including the same type of hands-on learning provided in the building and technical skilled trades programs. And this isn’t the only community college doing so. It isn’t an uncommon practice by any means.

In its simple definition, engineering is the application of science and mathematics to solve problems. This is also true of the building and skilled trades, so that’s why the community colleges also include basic engineering courses as part of the education program curricula for these disciplines. They also go a step further by providing practical hands-on curricula not often found at four-year colleges and universities. The hands-on experiences in these courses go beyond that obtained in labs, research facilities, and testing facilities, allowing students to actually apply what they learn in the classroom to practical real-life situations. For example, in the architectural technology program, students can design their dream home with all the required specifications and codes, and it will be ready to build whenever the opportunity presents itself. As another example, students taking carpentry and welding courses can actually build and construct something of practical use, and not just test it to see if it works, like you would in a laboratory situation at a four-year institution. All of this allows students to actually experience the things they want to do, not just visualize or theorize about them.

Table 4 shows the required math, science and computer courses that constitute the engineering aspect of the building and skilled trades programs. Please note that general education courses are not listed. The goal is to focus solely on the required and elective courses, helping to better identify the engineering and science components needed for the programs. Please note that the abbreviations shown on this table will be used to identify the applicable engineering and science components associated with the various building and technical skilled trades curricula presented in later tables.

Math, Science and Computer Courses	Abbreviation
Basic Algebra	BA
Basic Chemistry	BC
Calculus	CC
Chemistry Metallurgy	CM
Computer Programming	CP
Computer Science	CS
Electricity and Magnetism	EM
Geometry	GM
Instrumentation Analysis	IA
Mechanics	MC
Physics	PH
Precision Measurement	PM
Quality Control/Quality Assurance	QC/QA
Trigonometry	TG

Table 4: Required Math, Science and Computer Courses for Skilled Trades Programs

Architectural Technology

Table 5 shows the required and elective courses for the architectural technology program, along with the applicable engineering and science (AES) components, which are required courses. (As a reminder, the AES component abbreviations used on this table and tables 6 through 13 correspond to the courses listed in Table 4 above.) Figure 2 shows a list of careers that are available for architectural technology majors.

Architectural Technology

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
ARC 111	Introduction to Architectural Technology	3	BA/CP/GM
ARC 112	Construction Materials and Methods	4	BA/CP/GM
ARC 114	Architectural CAD	2	BA/CP
ARC 113	Residential Architectural Technology	3	BA/GM
ARC 211	Light Construction Technology	3	BA/CP/GM
ARC 220	Advanced Architectural CAD	2	BA/CP
ARC 212	Commercial Construction Technology	3	BA/CP/GM
ARC 213	Design Project	4	BA/CP/GM
ARC 230	Environmental Systems	4	BA/CP/TG
ARC 235	Architectural Portfolio	3	BA/CP

Table 5: Required and Elective Courses in Architectural Technology

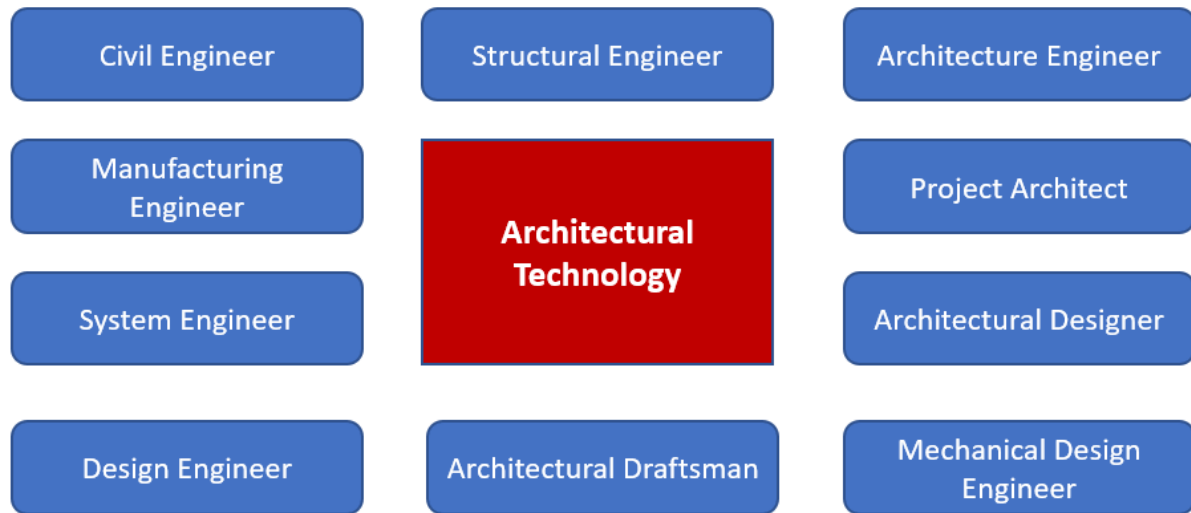


Figure 2: Career Paths for Architectural Technology

Automotive Technology

Table 6 shows the required and elective courses for the automotive technology program, along with the applicable engineering and science components. Figure 3 shows a list of careers that are available for automotive technology majors.

Automotive Technology

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
TRN 110	Introduction to Transportation Technology	2	IA/PM/CC
TRN 120	Basic Transportation Electricity	5	EM/PH/BA
AUT 113	Automotive Servicing, I	2	MC
AUT 141	Suspension and Steering Systems	3	GM/PH/BA
AUT 151	Brake Systems	3	EM/PH/BA
AUT 163	Advanced Auto Electricity	3	EM/PH/BA
AUT 181	Engine Performance I	3	EM/PH/BA
AUT 116	Engine Repair	3	IA/PM/CC
AUT 183	Engine Performance II	4	EM/PH/BA
AUT 213	Automotive Servicing II	2	MC
AUT 221	Automatic Transmissions/Transaxles	3	PH/BA
MAC 141	Machining Applications I	3	MC
MEC 111	Machine Processes I	4	MC
AUT 114	Safety and Emissions	2	CM/IA
AUT 231	Manual Transmissions/Axles/Drivetrains	3	GM/PH/BA
TRN 140	Transportation Climate Control	2	PH/BA
TRN 140A	Transportation Climate Control Lab	2	PH/BA

Table 6: Required and Elective Courses in Automotive Technology

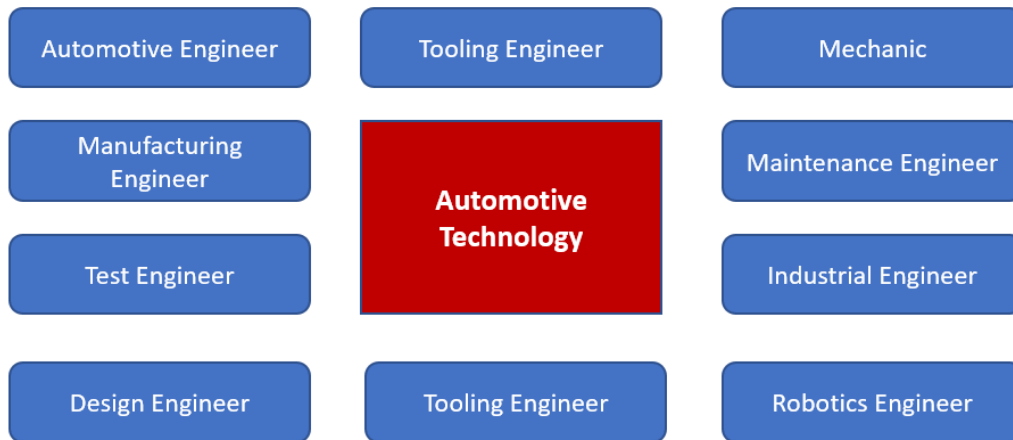


Figure 3: Career Paths for Automotive Technology

Computer–Integrated Machining

Table 7 shows the required and elective courses for the computer-integrated machining (CIM) program, along with the applicable engineering and science components: robotic engineering, manufacturing engineering, etc. Figure 4 shows a list of careers that are available for CIM job seekers.

Computer-Integrated Machining

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
DFT 119	Basic CAD	2	GM/CP
MAC 121	Introduction to CNC	2	PM/CP/GM
MAC 131	Blueprint Reading Machinist I	2	QA/QC
MAC 122	CNC Turning	2	PM/CP/GM
MAC 124	CNC Milling	2	PM/CP/GM
MAC 151	Machining Calculations	2	PM/CP/GM

Table 7: Required and Elective Courses in Computer–Integrated Machining

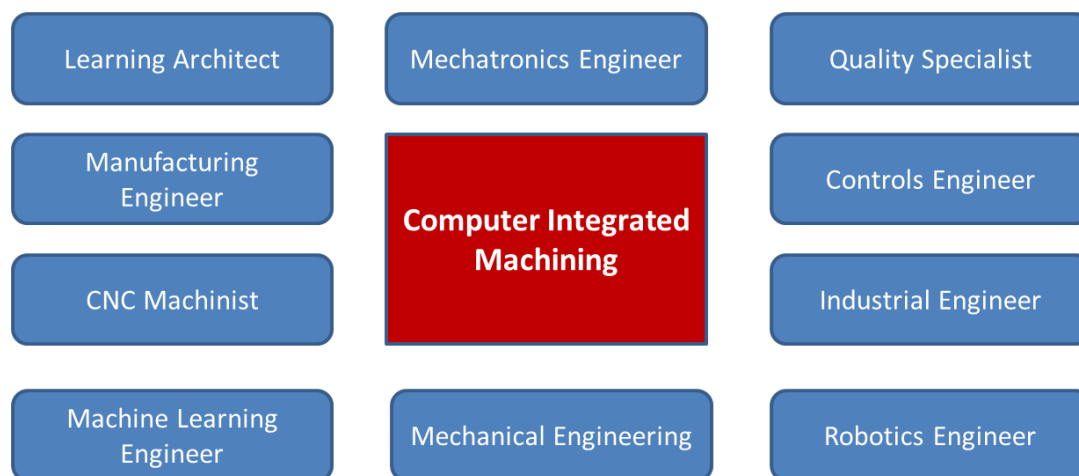


Figure 4: Career Paths in Computer-Integrated Machining

Electrical Systems Technology

Table 8 shows the required and elective courses for the electrical systems technology program, along with the applicable engineering and science components. Figure 5 shows a list of careers that are available for electrical systems technology majors.

Electrical Systems Technology

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
ELC 112	DC/AC Electricity	5	EM/PH
ELC 113	Residential Wiring	4	EM/IA
ELC 115	Industrial Wiring	4	EM/IA
ELC 117	Motors and Controls	4	EM/IA
ELC 118	National Electrical Code	2	QA/QC
ELC 128	Introduction to Programmable Logic Controller (PLC)	3	EM/CP
ELC 228	Programmable Logic Controller (PLC) Applications	4	EM/CP/IA
MNT 110	Introduction to Maintenance Procedures	2	QA/QC
ELC 213	Instrumentation	4	IA/PM
ELC 215	Electrical Maintenance	3	IA/QA/QC

Table 8: Required and Elective Courses in Electrical Systems Technology

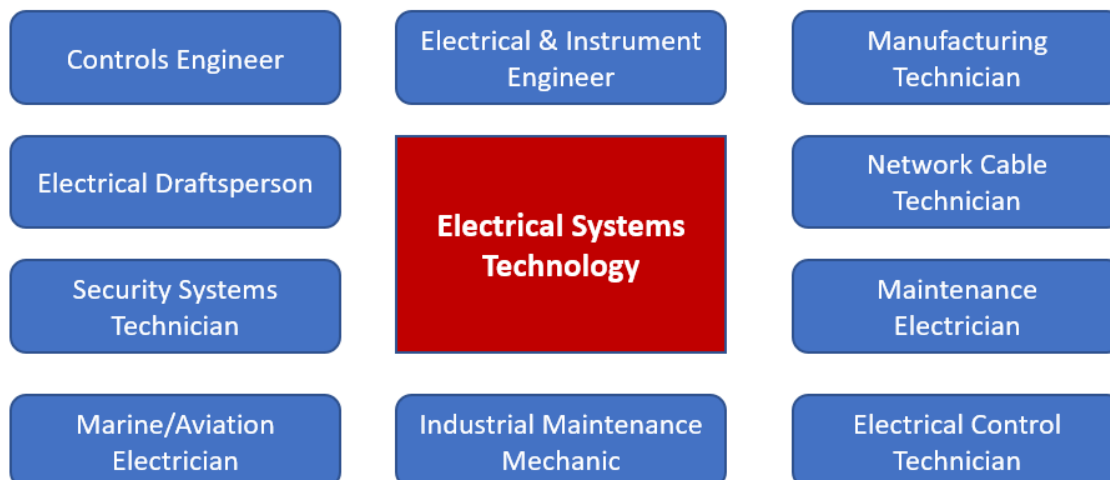


Figure 5: Career Paths in Electrical Systems Technology

Electronics Engineering Technology

Table 9 shows the required and elective courses for the electronics engineering technology program, along with the applicable engineering and science components. Figure 6 shows a list of careers that are available for electrical systems technology majors.

Electronics Engineering Technology

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
ELC 131	Circuit Analysis I	4	EM/BA/TG
ELC 131A	Circuit Analysis I Lab	1	EM/BA/TG
ELC 127	Software for Technicians	2	CS/EM
ELN 131	Analog Electronics I	4	BA/TG/EM
ELN 132	Analog Electronics II	4	BA/TG/EM
CTS 120	Hardware/Software Support	3	CS/EM
ELN 133	Digital Electronics	4	EM/BA/TG
CTI 120	Network and Security Foundations	3	CS/EM
ELN 232	Introduction to Microprocessors	4	EM/BA/TG
CTS 220	Advanced Hardware/Software Support	3	CS/EM

Table 9: Required and Elective Courses in Electronics Engineering Technology

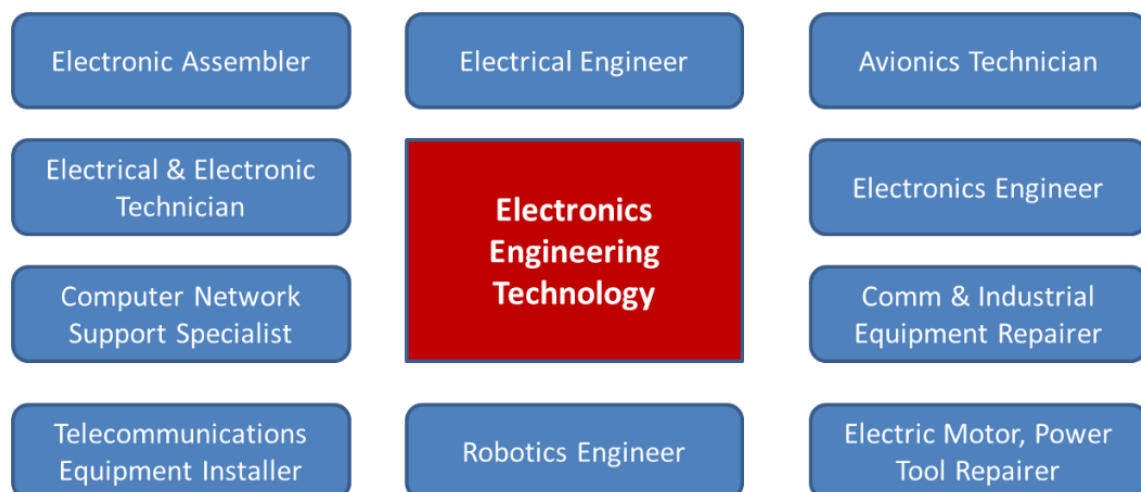


Figure 6: Career Paths in Electronics Engineering Technology

Construction Trades - Welding

Table 10 shows required and elective courses for the construction trades welding program, along with the applicable engineering and science components. There is currently no associate degree available for welding. However, a welding certificate is available upon completion of the program, which requires two semesters of study and accumulation of 18 semester credit hours. These hours are transferable to four-year engineering degree programs at most colleges and universities, including somewhat unique specializations such as aerospace, nuclear, and underwater welding engineering. Non-credit welding courses are also offered to adults and students for continuing education purposes or for company- and industry-specific requirements and specialties. Figure 7 shows a list of careers that are available for construction trades welders.

Construction Trades - Welding

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
WLD 112	Basic Welding Processes	2	CM/BA/GM
WLD 115	SMAW (Stick) Plate*	5	CM/BA/GM
WLD 121	GMAW (MIG) FCAW Plate*	4	CM/BA/GM
WLD 131	GTAW (TIG) Plate*	4	CM/BA/GM
WLD 141	Symbols and Specifications	3	BA/GM
WLD 3106E	Welding - Metal Inert Gas (MIG)	Non-credit	BA/GM
WLD 3106F	Welding - Tungsten Inert Gas (TIG)	Non-credit	BA/GM
WLD 3106G	Welding - Product Fabrication	Non-credit	IA/BA/GM/CM
WLD 3106H	Sculptural Welding and Metalwork	Non-credit	IA/BA/GM/CM
WLD 3106I	Welding - Stick	Non-credit	BA/CM
WLD 3106J	Advanced Welding and Metal Fabrication	Non-credit	IA/BA/GM/CM

Table 10: Required and Elective Courses in Construction Trades - Welding

* Notes: SMAW - Shielded Metal Arc Welding, aka Stick Welding

GMAW - Gas Metal Arc Welding, aka Metal Inert Gas (MIG) welding or Flux-Cored Arc Welding (FCAW)
 GTAW - Gas Tungsten Arc Welding, aka Tungsten Inert Gas (TIG) Welding

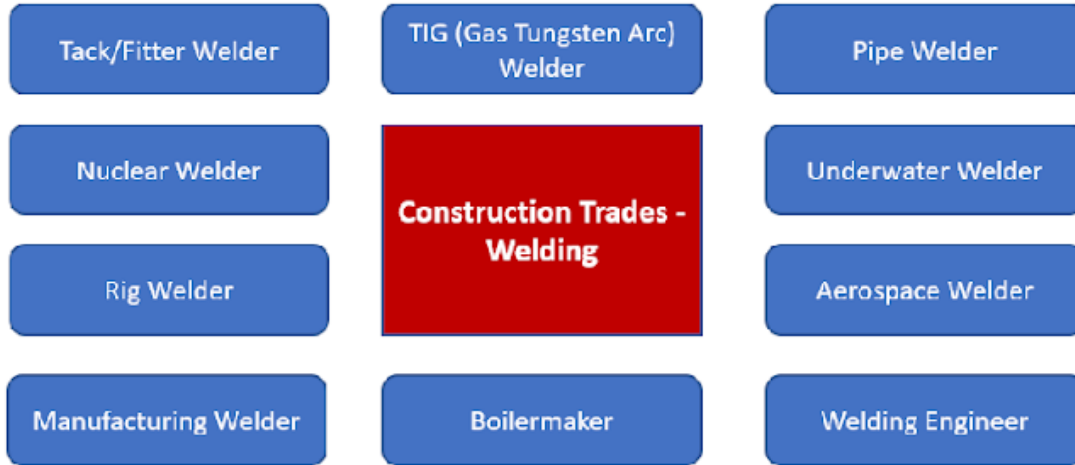


Figure 7: Career Paths in Construction Trades - Welding

Construction Trades - Carpentry

Table 11 shows the required and elective courses for the construction trades carpentry program, along with the applicable engineering and science components. It should be noted that while this is offered only as a non-credit continuing education program in most institutions. The skills learned can be applied to a very unique niche in the construction, industrial, structural and civil engineering fields – anywhere that form work is required. Figure 8 shows a list of careers that are available for construction trade carpenters.

Construction Trades - Carpentry

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
CAR 3112A	Carpentry I	Non-credit	IA/PM/BA/GM
CAR 3112B	Carpentry II	Non-credit	IA/PM/BA/GM/TG

Table 11: Required and Elective Courses in Construction Trades (Carpentry)



Figure 8: Career Paths in Construction Trades - Carpentry

Construction Trades - HVAC

Table 12 shows the engineering and science courses for the heating, ventilation and air conditioning (HVAC) construction trades program. It should be noted that this program is offered as both a non-credit continuing education course of study and as an accredited associate degree program. This program serves a unique niche in the construction trades industry, since it provides education and training in all of the major engineering components that are needed – structural, architectural, mechanical, and electrical – and which can be applied to all types of development – residential, commercial and industrial. Figure 9 shows the careers available for HVAC graduates in the construction trade.

Construction Trades - HVAC

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
AHR 3131D	HVAC Heating	Non-credit	BA/PH/BC
AHR 3131E	HVAC Cooling	Non-credit	BA/PH/BC

Table 12: Required and Elective Courses in Construction Trades - HVAC

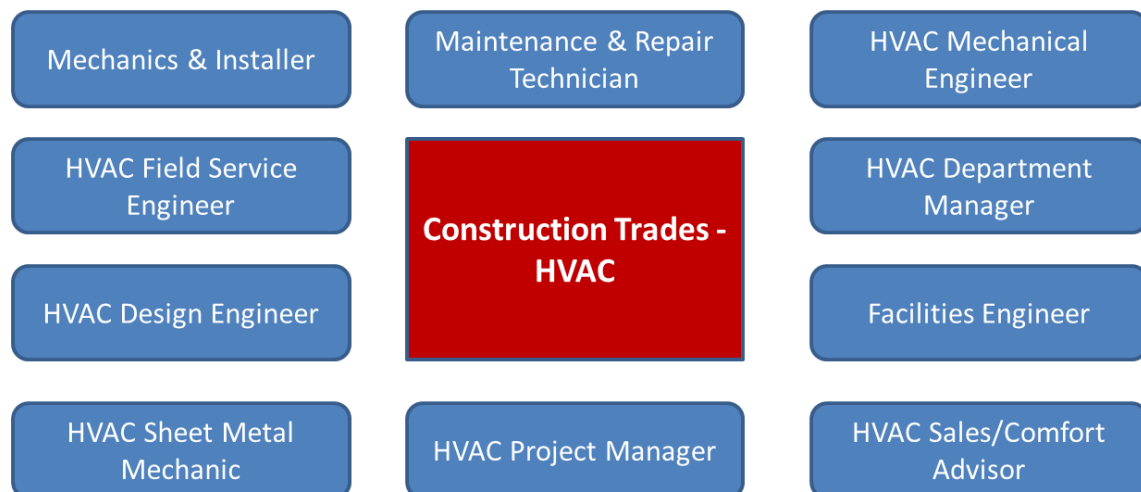


Figure 9: Career Paths in Construction Trades - HVAC

Construction Trades - Plumbing

Table 13 shows the engineering and science courses for the plumbing construction trades program. And like the HVAC construction trades program, the plumbing program also provides education and training in all of the major engineering components needed for the construction trades industry, and which can be applied to residential, commercial and industrial development. Figure 10 shows the types of jobs that are available in the plumbing construction trades career field.

Construction Trades - Plumbing

Course Prefix	Elective Course Name	Credit Hours	Applicable Engineering and Science Components (Required)
PLU 3024 B	Plumbing - Level I	Non-credit	BA/IA/GM
PLU 3024C	Plumbing - Level II	Non-credit	BA/IA/GM/PH/TG
PLU 3024D	Plumbing - Level III	Non-credit	BA/IA/GM/PH/TG
PLU 3024E	Plumbing - Level IV	Non-credit	BA/IA/GM/PH/TG

Table 13: Required and Elective Courses in Construction Trades - Plumbing

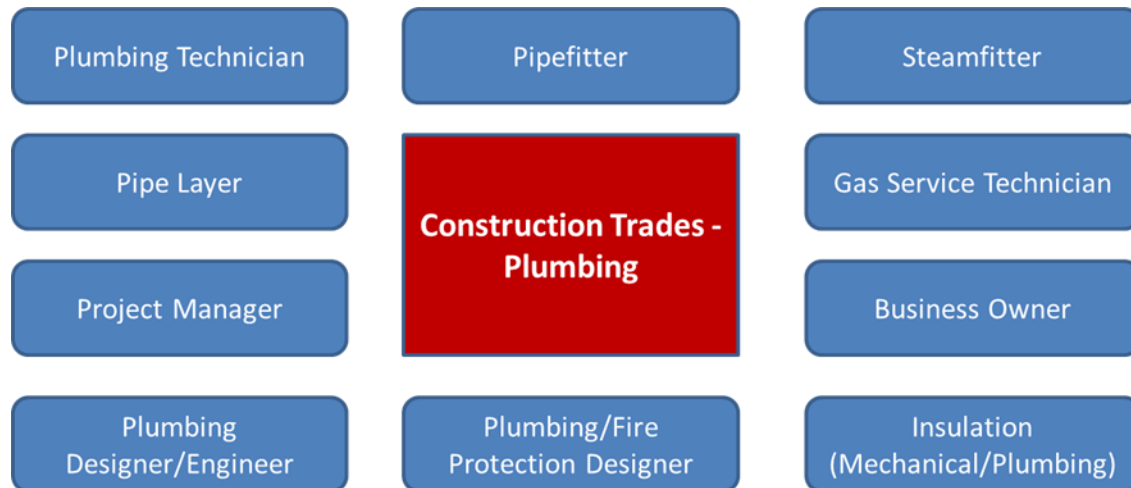
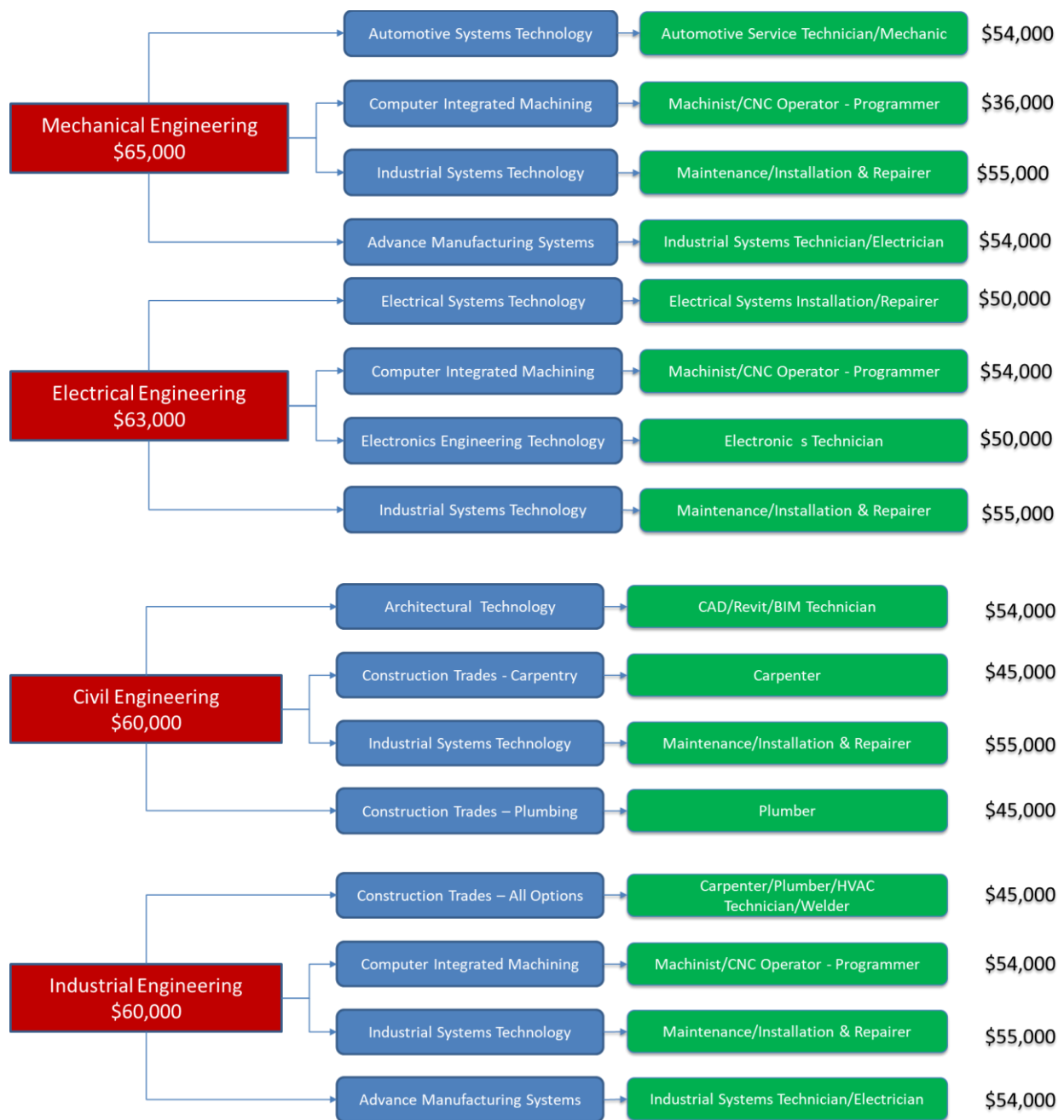


Figure 10: Career Paths in Construction Trades - Plumbing

Salary Analysis

This section presents a comparison of traditional engineering salaries to those of the applied engineering and skilled trades (see Figure 11). It should be noted that while the traditional engineering salaries look slightly higher than those for applied engineering, the latter affords a wider range of career fields and more opportunity to eventually have your own business, as opposed to those who continue along the traditional route of being part of the “system” and working for large firms where advancement is sometimes hard to achieve.



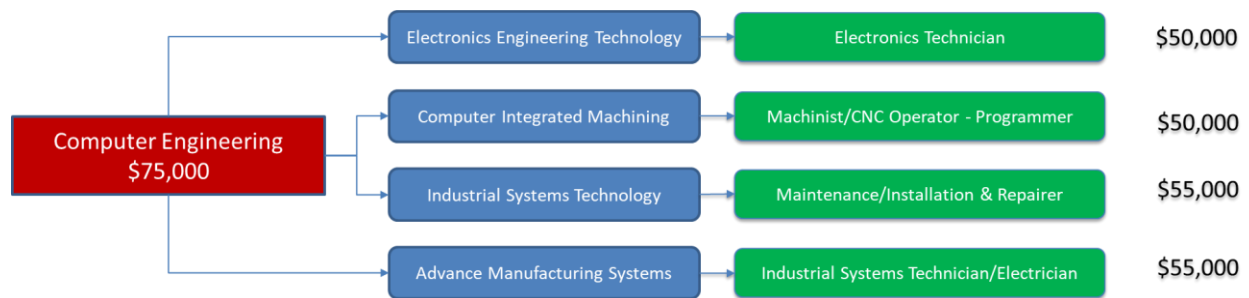


Figure 11: Comparing the traditional engineering salaries with the applied engineering and skilled trades salaries.

Recruiting and Marketing Efforts

While most community colleges which offer skilled trades are still faced with the challenge of changing the perception of the trades in order to promote them and make them more appealing to high school students, the good news is that some high schools are beginning to re-introduce skilled trades into their curriculum. They are also working with employers to make apprenticeships available to the students in their senior year if they are taking skilled trades courses. Students who are introduced to this option and the advantages it offers are more likely to pursue skilled trades at the community colleges which offer these programs. Consequently, most community colleges are doing a great job visiting the high schools and sharing skilled trades ideas as well as providing the students with skilled trades options. Recruiting personnel are currently employed by most community colleges whose main purpose is to bridge the gap between high school graduates and colleges; but in this case, promoting skilled trades is at the forefront.

Finally, community colleges and high schools are collaborating in an effort to provide summer programs for those who are interested in learning more about the skilled trades. These programs are like a mini college course, providing the students with introductory training and limited hands-on experience, and giving them a brief but realistic idea of what the skilled trades are like. By doing so, it is hoped that this effort will inspire a new generation of skilled trades workers that is sorely needed in the real-life world.

Conclusion

The building and technical skilled trades are rapidly becoming the leading edge of innovative education for young people who don't necessarily want to follow the traditional route of getting a four-year degree. Up until recently, the advantages of working in these trades, along with the many career opportunities they offer, haven't been given the attention they deserve.

As has been emphasized in this paper, the building and skilled trades offer students the deal of a lifetime – immediate employment in the field of their choice through apprenticeship programs that offer both on-the-job training and a salary while still getting an education. Employers also benefit by having on staff young, willing people who are motivated to do their best, who are

learning the latest techniques of their trade, and who can eventually become valued full-time employees. It is hoped that in the long run, this will save employers the time, money and hassle of having to advertise or search for new, qualified employees to fill an open position, as well as the time and expense of having to provide on-the-job training to new hires who aren't thoroughly experienced or qualified. Consequently, it's a win-win situation for both the employer and the students.

Finally, although not really discussed in this paper, students enrolled in skilled trades education programs further benefit from the fact that these programs are designed to give them the option of furthering their education if so desired, allowing them to go on and get a four-year degree. This is particularly the case with the technology and engineering type programs. Hopefully this paper has succeeded in connecting the dots in explaining the strong connection between the trades and engineering, and how engineering interfaces with and plays a vital role in the educational curricula.

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