Where is the "Middle" of Higher Education?

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Abstract

Our educational system is designed to provide age-appropriate learning from kindergarten through graduate school recognizing the human brain development cycle from birth to age twenty five. Age-appropriate education is critical at a young age, but as a student matures specific goals of attainment begin to blur with the recognition that some students are more gifted, while others have unique interests and stimuli. Traditionally, in the design of educational space, these lines have been clearly defined, "K-12 architecture" and "Higher-Education architecture" ignoring this blended learning that occurs as students mature. Recently, recognizing this diversity of thought, progressive secondary educators are demanding more specialized and integrated learning models including STEAM/STEM facilities and Career Technical Education (CTE) programs allowing students to grow and focus more quickly. Concurrently, post-secondary educators are also aligning their programs to reflect closely real world workplace and industry environments, which is a shift away from traditional liberal arts classroom spaces. As the price of a four-year university degree becomes cost prohibitive for larger segments of American high school graduates, there is increased awareness and understanding of alternatives to career and salary achievement at lower price points. Fueling the growth is a distinct movement towards post-secondary middle skill jobs, traditionally overlooked by high-school graduates but becoming more desirable in recognition that these skills provide readily available, high-paying jobs upon graduation. These in-demand career opportunities with lower financial barriers are fueling a new design and educational paradigm for secondary schools, universities, and industry alike in the MIDDLE of higher education.

Introduction

In architecture—and specifically in our firm—we have segmented our business into various areas of expertise depending upon project type and complexity. For some projects, the segregation is appropriate due to the complexity of the product type. For example, hospitals require healthcare planning expertise and laboratories require a clear understanding of laboratory research environments. In other areas of the business, the distinction in providing expertise blurs to become an encumbrance to our innovation in the design process. Buildings for learning is one area where this segmentation in expertise stifles the cross pollination of ideas between traditional/formal and non-traditional/informal education.

Design for learning is typically distinguished between K-12 (primary and secondary) and higher education, with increased areas of design specialization occurring in higher education. As an example, nursing schools require more customization in the design of space to better suit teaching methods, such as a simulation laboratory and hands-on training. Both K-12 and higher education learning models are seeing an increase in design customization focused on the student learning environment and particular specializations. K-12 education is seeing an increased need for specialty STEM/STEAM and CTE education environments that start to feel more like university buildings. Higher education design varies in typologies from the ubiquitous general classroom to the highly specialized teaching and research laboratory. Similarly, medical education requires unique environments that are different from trade, technology, and simulation spaces.

The role of education is also evolving to include new education models beyond the traditional primary, secondary, and post-secondary college or university, and thus educational spaces need to evolve to support these new learning paradigms. This becomes especially acute as the growth of the traditional post-secondary education becomes cost prohibitive and non-effective for specific work force development, forcing students to consider more alternative and personalized education models to achieve their desired career and salary.

The Secondary School Overlap

Before focusing on the future of "The middle of higher education," it is important to note the impact of secondary Career Technical Education (CTE) and its role in the education continuum. In total, there are about 15.1 million high-school[1] students enrolled across the nation with approximately 9.6%[2] of credits earned in high school going towards career and technical education. Unfortunately, this percentage is trending down from ten years earlier when 13.2% of high-school students had achieved one CTE credit. With more students choosing to forgo a clear "education to career" pathway, today's students are searching for an alternative approach. Most CTE courses occur at dedicated high schools or as part of community college credit programs allowing for increased flexibility. The facilities, both secondary and post-secondary, offer the equipment, technology, and space to support the much more focused hands-on-learning of these directed career paths. The enrollment between secondary schools and technical colleges allows for students to earn college credit towards college degrees[3] increasing their flexibility. CTE degrees add opportunity to students' resumes by combining technical skills with collaboration, critical thinking, entrepreneurial, and problem solving skills to enhance each student's marketability. CTE students also have the opportunity to participate in paid internships at interested local businesses, which can jump-start an individual's career. With the downward trend of CTE in secondary education, it is clear that students are looking for less specialization upon high-school graduation and more flexibility to pursue their interests in a post-secondary environment.

Higher Education Challenges

By the numbers, the metrics on the future of traditional higher education and the impact that colleges and universities will have is unclear. Student enrollment in four-year public universities is down 0.2%, four-year for profit enrollment is down a healthy 6.8%, two-year public down 2.0%, with general university enrollment trending down 1.7%.[4] The largest market is still four-year public institutions with

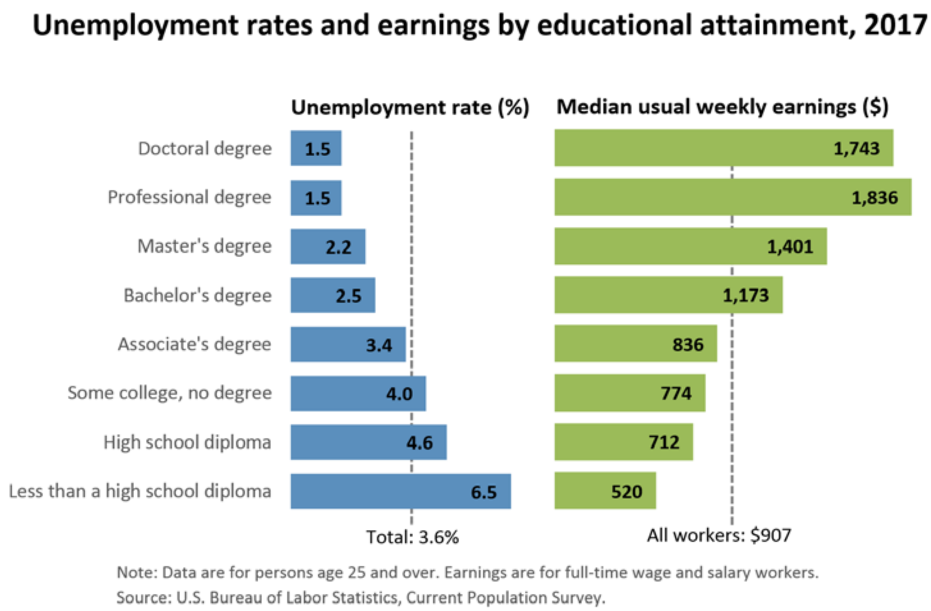
[1] National Center for Education Statistics, 2018 link
[2] National Center for Education Statistics, 2013 link
[3] Career Technical Education, https://careertech.org/cte
[4] National Student Clearing house 2018

a total of 6.7 million undergraduate students enrolled, 57% of which are women. This slight decrease in the enrollment trend could be a sign of the robust economy, reflecting the strong job market and the lack of need for potential hires to increase their value with additional education and degrees, or it could reflect other challenging trends. On average, four to five institutions of higher education close per year with peak closings correlating to the recent recessions in the economy.

One recent survey suggests that universities need to consolidate to create a more sustainable student path to higher education. In the last two academic years, the number of non-profit colleges decreased 2%, while the number of for-profit institutions reduced by an aggressive 11%. This reduction and consolidation is reflected in the merging of degree granting institutions and the elimination of programs with low job growth. As an example, a recent merger occurred between Boston University and Wheelock College, a small education and teaching degree granting institution co-located in Boston. The small college, unable to achieve enrollment and growth goals, initiated a strategic study that ultimately recommended a merger with a larger institution to prevent the school from closing. Initially, the college put out a letter of inquiry to aligned institutions proactively looking for a merger opportunity. Wheelock finally agreed to merge with Boston University to take advantage of the legacy of the institution and its programs, facilities, and students to continue its existence under the umbrella of Boston University. In addition, the strategic study recommended eliminating the bachelor in education program due to lack of interest and the trend that most students interested in teaching eventually get a master in education anyway. This merger reflects a trend in the reduction and consolidation of institutions that are focused on low earning degrees, such as teaching, and highly targeted institutions with single gender, small enrollment, small endowments, and few undergraduates.[5]

The conflicting data in higher education growth suggest the question, "Are colleges worth the money?" There is a lot of data to suggest both positive and negative outcomes from higher-education and these need to be more granular in the assessment of each individual with the understanding that the quantitative benefit of college cannot account for the qualitative experience. A recent study by economist Bryan Caplan suggests that earning a college degree is easily explained by the study skills, interest, and discipline of the student ***prior*** to arriving at college and accounts for 67% of college success.[6] The study goes on to suggest that 20% of the cost of a college degree premium reflects the actual learning and skills development while in college. The other 80% reflects all of those qualitative and intangible experiences that are specific to higher education such as participating in athletics, cultivating friendships, and developing professional networks—none of which can be assigned a dollar value. Beyond the college experience, there is still a high-salary premium post-graduation (see chart below) reflecting the simple value of a college degree in allowing employers to more easily decide which employees are better to hire based on their educational attainment.

[5] "..the type of college that's most in danger of closing", P. Jacobs, link
[6] "Is College Worth it?" Steven Pearlstein author link



UNEMPLOYMENT RATE BY LEVEL OF EDUCATION, 2017

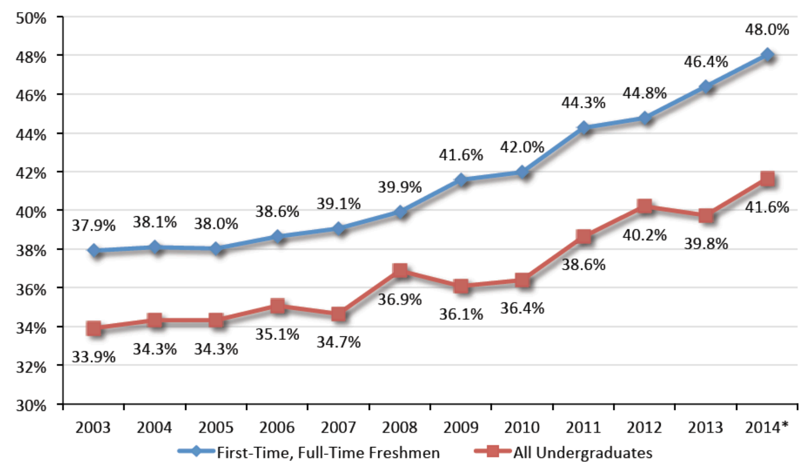
As a response to the increasing expense, there are also lower-cost alternatives to achieving a bachelor's degree that increase the total value of college tuition. A common tuition reduction strategy includes starting with CTE or advanced placement courses in high school to lighten the economic load of full-cost university credits by gaining credits prior to arriving at college. Although there is a decrease in students participating in CTE courses, there is an increase in the number of students taking advanced placement credits, thereby reducing the number of hours required for earning a bachelor's degree. Other alternatives to the full cost of a four-year program might include starting at a community college and transferring to a four-year college, taking advantage of summer classes, and pursuing degree programs that allow students to complete classwork in less time. Of the 120 credit hours usually required for a degree, students can save an average of $11,400[7] by achieving 60 credit hours at a community college first. In states such as Virginia, California, Pennsylvania, and Illinois—that number is closer to $19,000 in savings. Attending college through the summer can have repercussions on training and internship experiences of a student but it can also help a student tailor their education experience to match more closely the specific degree and training they would like to achieve. All of these strategies to lighten the financial burden of college reveal another growing movement in higher education towards curriculum personalization, which allows students to tailor their curriculum to maximize its value and economic return.

Another response to the cost pressure on students is the broad implementation of tuition discounting in higher education. The cost of tuition—which at one point was paid in full and never questioned—is now highly discounted at most colleges and universities so that institutions can attract the students they

[7] https://studentloanhero.com/featured/community-college-cost-study-10-states/

want, while still achieving the enrollment goals they require. The pace of tuition discounting at private colleges has continued to grow for the past 15 years to a current average rate of 48%. This suggests that, even with the 40% increase in the cost of private colleges[8] over the last 20 years, universities understand that the value of their product might still need to be incentivized in order to attract the top students.

Figure 1. Average Tuition Discount Rate by Student Category[4]



Source: NACUBO Tuition Discounting Survey, 2003 to 2014.
*Preliminary estimate.

TUITION RATE DISCOUNT, 2003-2014

The surge in international students has allowed this discounting for preferred domestic students to continue to occur at the expense of international students paying full fare but there are indicators that this decade-long trend is coming to an end. Over the past 10 years, the number of international students has doubled in the United States from approximately 583,000 (2006-07) to 1,079,000 (2016-17) with the latest figures showing a decrease in students since 2014. This is a reflection of several trends including the increase of degree programs in English outside the United States, a decrease in the number of scholarships given by foreign governments for their students to train abroad, and geopolitical issues due to students obtaining the necessary documentation under the current administration.[9] The decrease in international students is more acute at smaller private universities than larger public institutions.

[8] How much more expensive it is for you to go to college than your parents, Emmie Martin, link
[9] “Six things to Know about international students in the U.S., K Ross, link

AVERAGE PUBLISHED TUITION AND FEE PRICE, INSTITUTIONAL GRANT AID, AND NET TUITION RATE IN CURRENT DOLLARS PER FIRST-TIME, FULL-TIME FRESHMAN

	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18*	Percentage Change from 2008-09 to 2017-18
Published Tuition & Fee Price	$26,075	$26,980	$28,629	$29,586	$31,319	$32,246	$33,297	$34,469	$35,710	$37,040	**42.1%**
Avg. Inst. Grant Aid	$10,586	$11,249	$12,182	$13,078	$14,366	$15,165	$15,643	$16,714	$17,503	$18,798	**77.6%**
Net Tuition Rate	$15,561	$15,808	$16,664	$16,618	$17,182	$17,365	$18,004	$17,698	$18,508	$18,488	**18.8%**

Source: NACUBO Tuition Discounting Study, 2017. Data are as of the fall of each academic year.
*Preliminary estimate.

AVERAGE TUITION RATES PUBLISHED VERSUS PAID – 2008-2018

Another methodology to reduce the economic burden of higher education is the new payment strategy of income sharing. The basic income share agreement (ISA) allows the student to borrow from the university or a group of investors affiliated with the university to help pay for the cost of college. The student then agrees to repay the loan by sharing a portion of their income once they are working. There are challenges to the agreements reflecting the types of students and the type of degrees they are pursuing including the requirement that their future jobs will provide the income necessary to repay the loan. Purdue University instituted their "Back as a Boiler" ISA, which is funded through the university endowment. This allows flexibility not available through private loans,[10] which is gaining student interest over traditional debt financing strategies. The ISA programs and their apparent similarity to apprentice funding models, which will be discussed below, indicates that more flexibility is needed to deal with higher education costs in the future.

As higher education institutions look for ways to get the necessary income to operate, two trends are emerging. Public flagship institutions are turning to donors for fundraising and endowments to maintain enrollment and modernize facilities. Alternatively, smaller and regional institutions are focusing on growth and cost reduction strategies, while looking at refining their educational model by establishing deeper relationships with local workforces as they become the most critical educator in their respective regions. Both flagship and regional higher education institutions are also allowing students to personalize their degree programs, while providing unique payment and funding models to reduce costs. Many of the new educational strategies utilized by universities and students alike are already present in the apprentice and vocational educational models, which suggests these hubs for middle education will become more critical to the workforce. Alternative education partnerships will continue to flourish for future high school graduates opening up the market for North America's much needed middle skills.

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[10] "Alternatives to Student Loans", A. Lanza, link

Middle skills jobs

There is no doubt that personal success in the workplace is reflected in the statistics that the demand for jobs requiring a post-secondary degree has increased from 28% to 65% from 1973 to 2018. The increased need suggests students cannot afford to forgo a higher education degree. At the same time, universities should continue to make post-secondary education more accessible and targeted to each student. There is also a clear understanding that the "higher" one goes up the educational ladder, the more wage growth and lower future unemployment is expected, which is supported by the statistic that a master's degree candidate earns 17% more than their bachelor counterparts. However, there is also a trend that more education, such as a doctorate degree, does not necessarily increase wage achievement and might not be worth its quantitative value. Consider the wage growth potential in the ability to enter the job market more quickly, with less debt, while gaining valuable hands-on experience, earning a pay check and fine-tuning career goals.

Valparaiso University Law School is an example of how additional education and the resulting debt can decrease wage achievement and career growth. Since 2008, the demand for lawyers has continued to increase at a slower rate than the number of students graduating from law school. Recognizing that there will always be demand for students from top-tier law schools, wider availability of general legal help online made it more difficult for lower and mid-tier graduates to establish a legal career. Valparaiso, a mid-tier school, did not initially recognize that their law degree was not providing enough opportunities for well-paying jobs for their recent graduates, especially those who were buried under significant education debt. Ignoring the loan cost pressures on their graduates, the law school altered and lowered their admission standards to keep enrollment at their current levels. Less qualified students were admitted with lower LSAT scores and subsequently worked their way through the JD degree program. Upon graduation, these students were then required to pay back their large student debt. When time came to pass the bar exam and find a job to repay the debt, these graduates discovered that they could not achieve either. Recognizing the pressure on their graduates to repay loans, the university ultimately discovered there was a direct correlation between the student scores on the LSAT and their ability to pass the bar exam.[11] Valparaiso University Law School—after witnessing their alumni struggling with student debt, unable to find jobs, and caught in a failing cycle of test achievement—decided to decrease enrollment, reduce faculty, and more recently close the school. Following their counterparts, several other law schools have curtailed or eliminated their programs in response to the decreasing market for law degrees, which only punctuates how quickly desired careers can become less so and how more education does not necessarily get one to a higher station in life.

Complementing the challenges of the high end of higher education leads to a discussion about careers in demand and in particular the bulk of all future jobs which are termed "middle-skill careers." These are the jobs that require more than a high school diploma and *potentially* less than a four-year bachelor's degree. This category of education, skills, and ultimately jobs includes about 35-50% of all new job openings beyond 2020. Middle-skill jobs typically include clerical, sales, construction, installation, repair, production, and transportation. Middle-skill jobs reflect a broad range of education trajectories

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[11] "An expensive law degree and no place to use it", N. Scheiber, link

including on-the-job training, vocational training, bachelor, and professional degrees. In addition, *Campus Technology Online* states that the growing demand for middle-skill jobs will be one of the top three trends that will directly affect small regional and community colleges by 2021.[12] To train and educate for these middle-skill jobs, the bulk of all candidates get on-the-job training and/or related work experience. Almost one third of all middle-skill jobs are serviced through short-term, on-the-job training, such as a line cook at a fast food restaurant, but these jobs usually have the lowest wage potential. For all middle-skill jobs, the bulk of education is sourced through a minimum of high school education (46%), but a significant number of these jobs skills are satisfied through partial-college (28%) and bachelor's degrees (26%).[13] The middle-skill jobs that require some or full college degrees are also the jobs that are growing much more quickly than those that just require a high school education. The surprising number in educational attainment is the demand for partial-college educated workers at 28%, which is as high as the demand for college degreed workers indicating that there are opportunities for those who decide to forgo a full bachelor's degree and start their career more quickly. If one-quarter of the workforce requires only a partial college education, we need to tailor our educational system to satisfy the career needs in the underserved *middle* of higher education.

The graphic below illustrates the actual and projected supply of workers by educational attainment and illustrates the need to supply a broad workforce of partial and full college graduates:

	Percent of Workers			Change in Percent	
	1980	2000	2020	1980-2000	2000-2020
Less than High School Diploma	21.7%	10.1%	8.6%	-11.5%	-1.5%
High School Diploma	39.4%	31.9%	29.3%	-7.6%	-2.6%
Some College	17.3%	27.7%	28.4%	10.5%	0.7%
BA or Higher	21.7%	30.3%	33.6%	8.6%	3.4%
Total	100.0%	100.0%	100.0%	0.0%	0.0%

Sources: U.S. Bureau of Labor Statistics, *Occupational Projections and Training Data*, 2006, Aspen Institute, Grow Faster Together. Or Grow Slowly Apart, 2003.

BUREAU OF LABOR STATISTICS, OCCUPATIONAL TRAINING DATA

Middle skills demand

To achieve this growth in middle-skill jobs in the vocational, associate, and bachelor's degree markets, schools need to adapt to provide skills to the most needed professions both effectively and efficiently. In a study specific to manufacturing by the National Association of Manufacturers, 90% of respondents indicated a moderate to severe shortage of qualified skilled production employees, a result that did not

[12] "Top 3 Trends to Impact Community Colleges by 2021", R. Kelly, link
[13] "America's Forgotten Middle-Skill Jobs", H. Holzer, R. Lerman, link

vary significantly after controlling for company size, industry segment, or region. Specifically, middle-skill jobs are defined within these categories and subcategories outlined below:[14]

Computers	Construction	Health Care	Installation, Maintenance and Repair
Support Specialists	Carpenters	Dental Hygienist	Aircraft Mechanic
Specialists, Other	Electricians	Licensed Practical Nurse	Auto Mechanic
	Painters	Medical Lab Technician	Bus/Truck Mechanic
	Operating Engineers	Physical Therapy Assistant	Heating/AC installer
	Plumbers	Radiology Technician	Heavy Equipment Mechanic
		Respiratory Therapist	Industrial Machinery
		Surgical Technologist	

Middle-skill job growth reflects the greatest opportunity for specialized technical colleges, apprentice schools, and vocational facilities to respond to enrollment growth including careers in computers, construction, healthcare, and installation-maintenance-repair. The bulk of the jobs are in construction (37%) and in installation-maintenance-repair (37%), with carpenters and industrial machinery demanding the most employees, 33% of the jobs. The highest growth areas with these middle-skill categories from 2004-14 are generally in the healthcare field including a 44% jump in the need for dental hygienists and physical therapists. The other middle-skill areas that are unlikely to benefit through specialized post-secondary facilities include transportation and insurance related careers reflecting the importance that colleges focus on building future facilities in advanced manufacturing, healthcare, and trades to educate a new generation of students.

Advanced Manufacturing

To further define the growth in demand of middle-skill jobs and the facilities designed to educate them, it is valuable to define what is advanced manufacturing in the context of middle-skill job growth and the specific curriculum and facilities that will satisfy this growth. Historically, manufacturing was defined in two categories: traditional and advanced. Traditional manufacturing was defined as hard product industries such as automotive, steel, and industrial machinery, while advanced was defined as manufacturing process technologies. Traditional was Detroit and advanced was Silicon Valley.[15] This definition, however, has quickly become obsolete as companies recognized the advancements in manufacturing that have come to the "traditional" industries and the rapid overlap between technology, automation, and design. Thus in today's nomenclature, every type of manufacturing can be considered ***advanced manufacturing***. The common definition today of advanced manufacturing involves the use of technology to improve products and/or processes, with the new relevant technology being described as advanced, innovative, or cutting edge. Most parties agree that an appropriate advanced manufacturing

[14] "America's Forgotten Middle-Skill Jobs", H. Holzer, R. Lerman, link
[15] "Traditional Industrial vs. Advanced Manufacturing", J. Schuetz link

definition is dynamic and should be treated as more of a benchmark as the "frontier" is constantly changing.

The other aspect of advanced manufacturing that is valuable in the discussion of the middle of higher education is the shortfall in workers to fill these jobs. The reason why advanced manufacturing is important to the economy is the potential increase in wages that will exceed standard growth rates providing for a future middle class. Many manufacturers have recognized that the supply of *skilled trade* workers is decreasing. Skilled trades include what was originally eleven categories, the three largest being electrical technicians, machine maintenance, and welders.[16] Demand for skilled trade workers and the decrease in their supply reflects an age discrepancy, where fewer people are entering these fields to learn the skills needed and a higher percentage of workers ages 55 and older are retiring.[17] According to a 2015 study, 58.8% of advanced manufacturing jobs will go unfilled due to a shortage of well-qualified workers.[18]

One normal of the new advanced manufacturing is the entire sector has become a lot more efficient through automation, which requires fewer workers but requires workers with more education and skills. The manufacturing jobs that originally were filled by high school graduates have been replaced by automation or offshoring and the careers that are available in the United States now require employees with a minimum post-secondary education. The latest data show a steady growth in manufacturing jobs from the 2008 recession to current levels of approximately 12.7m jobs nationally.[19] Most of the growth in manufacturing jobs has been in the oil and gas, aerospace, computer, and software design industries, which generally reflect industries that cannot be automated as easily.

The five top future careers in advanced manufacturing, according to ASME.org, include medical device design and manufacturing, sustainability manufacturing, control sensors development, welding engineering, and supply chain strategy. The markets with the highest number of advanced manufacturing jobs are New York, Los Angeles, and the Washington Metropolitan region with the Washington, San Francisco, and Seattle metropolitan regions having grown most rapidly in the last 30 years. Specifically, the Washington D.C. region has grown the number of jobs in this sector by 235%.

The lack of clarity in the skills needed for each advanced manufacturing career further complicates the barriers to entry in understanding the necessary education, apprenticeship, and on-the-job training required. This educational puzzle is compounded by the transitional void that occurs between educating the students for today's industry and providing them the right skills to allow industry to benefit from that education curriculum in the future. The chart below addresses the percent of manufacturing workforce by education level indicating that 70% of the workforce in advanced manufacturing benefits more from an associates or apprentice degree versus a bachelor's degree with a general trend in gaining

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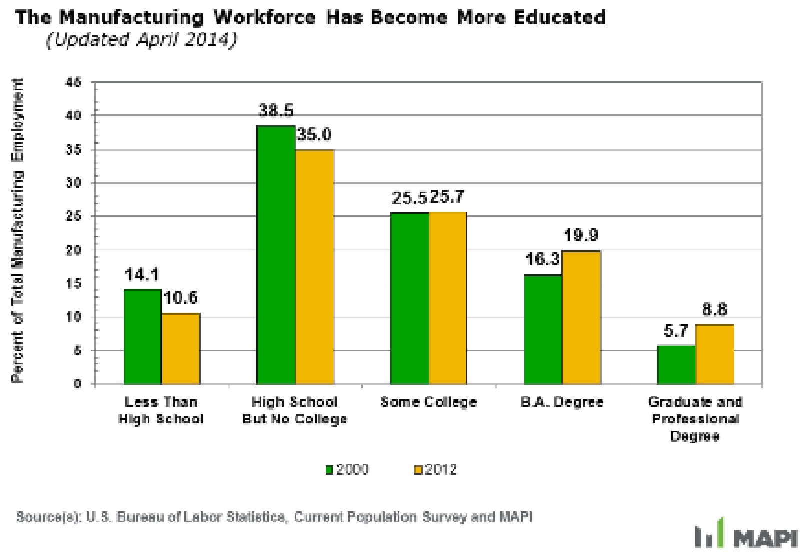
[16] "Skilled Trades Gap Analysis Report" Virginia Manufacturers Assoc, link
[17] "Skilled Trades shortages loom..", J. Wright, link
[18] The skills gap in US manufacturing, Manufacturing Institute and Deloitte. link
[19] Bureau of Labor Statistics, link

more targeted education.[20] Thus, these middle-skill degree academies must also provide a pathway for students which allows for credits and on-the-job training to be translated into future bachelor's degrees.



BUREAU OF LABOR STATISTICS, MANUFACTURING LABOR EDUCATION LEVELS (2000 VS. 2012)

The balance between on-the-job training versus in the classroom education also plays a critical part in the design of advanced manufacturing education programs. The hands-on nature of the manufacturing sector indicates a stronger linkage between classroom theory and workshop practice than with other sectors. It's clear in the advanced manufacturing industry that education is wherever learning takes place, including on the factory floor.[21] As we define the types of education spaces that need to support this particular education process there needs to be a diversity of both formal and informal spaces. Workspaces need to be more suited to educational models and educational spaces need to be more reflective of the actual work environment. If the work environment is advanced manufacturing, the educational space needs to function like a manufacturing environment. This merging of environments suggests the reemergence of the "traditional" apprentice academy.

The Role of an Apprentice Academy

An apprenticeship is defined as a combination of on-the-job training and related classroom instruction under the supervision of a trade professional in which each student-worker learns the practical and theoretical aspects of a highly skilled occupation. This implies that this combination of education and practical experience occurs in the same location with the same qualified group of instructors and professionals. Apprenticeships are typically led by employers, associations, and labor-management organizations, and the cost of the apprenticeship is borne almost entirely on the sponsor. Apprenticeships typically include 2,000 hours of on-the-job training and a minimum of 144 hours of classroom-based instruction each year.[22] The goal of apprenticeships is to provide a government-issued

[20] Manufacturing Institute, link
[21] Practical Experience vs. Formal Study? E. Hilgart, link
[22] Apprentice Report, 2018 report

certificate that serves as a nationally recognized portable credential. This portability provides opportunity for students, but results in challenges for employers as well as for the growth of apprenticeships.

Historically in the United States, organized labor has paid for the on-the-job training and classroom instruction required for apprenticeships from union labor dues. This apprentice structure worked because labor and the unions provided training to high school graduates specifically to get into the manufacturing industry. As jobs in the apprenticeship industry began to require more education, training, and experience, workers were forced to depend less on the union for training and education and were instead responsible for paying their own way. The educational pathway of forgoing apprenticeships for traditional college education was exacerbated by the decline in support from industry and the re-alignment of an at-payer system that put the funding of education back onto the employee rather than the employer or union. This shift exacerbated the movement away from organized labor. The increased portability of credentials has discouraged employers from investing in training and credentialing because their well-trained employees will always be a flight risk. In their prime, unions helped mitigate the risk to employers for apprenticeships but by 2020, 65% of jobs will require more training and education than employers and unions will provide, thereby making the education and its costs solely the responsibility of the individual student.

Countering this apprenticeship decline in the United States, other countries have had recent success in the increasing role of apprentice academies contributing to their labor force. In particular, political leaders in the United Kingdom have embraced apprenticeships as an important tool for boosting worker skills recovering from a period of steep decline in apprenticeships in the 1970s and 1980s. In 1993, the Conservative government launched “Modern Apprenticeships,” a program that aimed to boost worker skills through the creation of 150,000 new apprentices each year. The Labor government later expanded the range of qualifications that could be classified as apprenticeships, leading the way for increases in the number of apprentices in nontraditional sectors such as health care, business, and retail. As a percentage of population, the United States has 1 apprentice for every 14 in the United Kingdom revealing how government, education, and industry are needed to fuel the support.

Reflecting on the future role of apprenticeships in the American economy, the Apprenticeship Report lists several criteria that businesses and governments must satisfy in the United States to foster the development of these programs. One challenge to businesses is that they are usually set up to produce instead of educate, which requires a paradigm shift in their business model, staffing, and return on investment. Secondly, the employees in the apprenticeship industries need to be geared to educate and share knowledge with new apprentices. Industry needs to recognize and maximize the business case in the value of apprentice programs directly correlated to future increased productivity. One Swiss study found that employers earn about $1.08 back for every $1.00 they spend on apprentice programs.[23] Lastly, employers need to guarantee—with certain qualifications—that upon completion of their apprenticeship, there will be a job opportunity available for the apprentice.

For government and credentialing institutions, there are various challenges that need to be addressed for the economy to benefit from an expanded apprenticeship program. Appropriate messaging to dispel some of the misconceptions of these programs is one key to success. It is critical to articulate that these programs are not for lower performing students, not strictly for manual occupations, nor are they

[23] Training for Success, B. Olinsky and S. Ayers, report

exclusive to male dominated professions. Currently 6% of apprentice program participants are women. Governments also have to set up a clear methodology for accreditation across all training fields and allow students to get credit for classroom skills and on-the-job training. Governments need to encourage completion of apprentice programs. The current 39% rate of completion is much lower than college graduation rates. Lastly, governments need to provide tax incentives for manufacturers that participate in this valuable economic process.

The success of an apprentice program will optimize several key aspects in the recruitment, training, employment, and delivery of an accreditation process in these growing career fields. In some cases, businesses must adjust their physical space to better account for the educational needs of their employees or alternatively establish linkages between community and technical colleges with apprenticeship programs to maximize each student's potential for success.

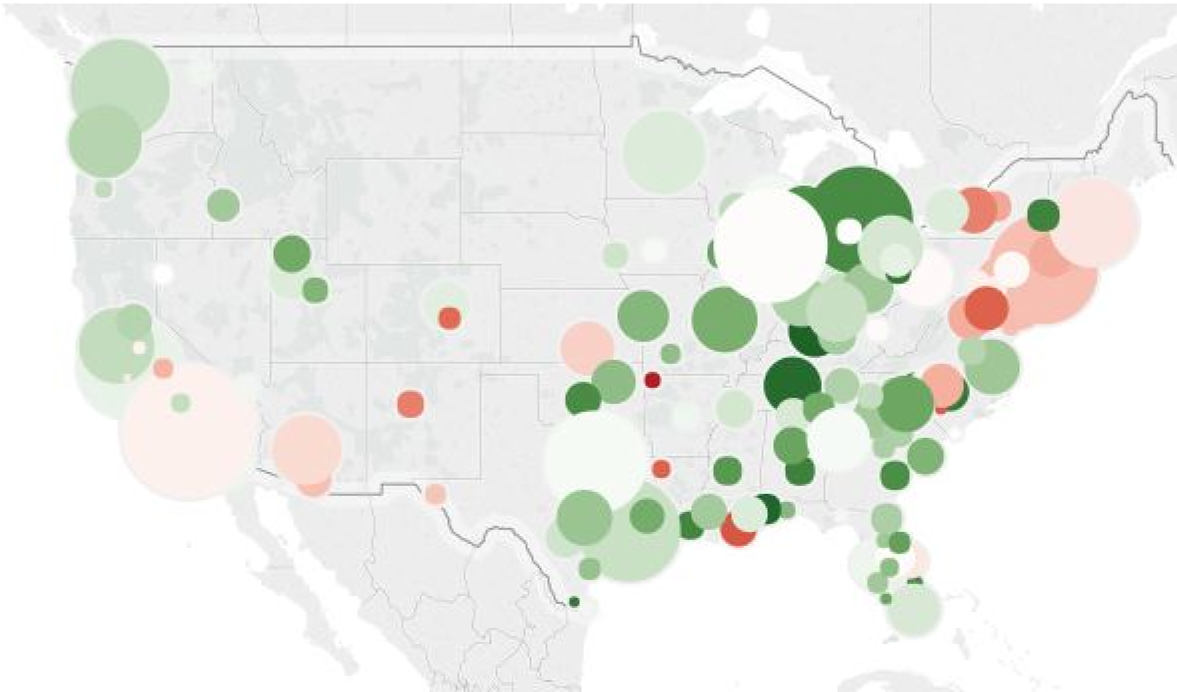
Apprentice Academies – Geographic Considerations

When studying the geographic location of an apprentice academy, it is important to consider the jurisdictions that have a culture of apprentice programs and businesses willing to invest to support their success. One third of all state governments have committed to a robust investment in the growth of apprenticeship programs. These states include Connecticut, Virginia, West Virginia, Indiana, Iowa, Missouri, Wisconsin, Minnesota, Arkansas, North and South Dakota, Nebraska, Oregon, Washington, Alaska, and Hawaii. However robust the government investment is in the apprentice program, it is important to note that success of the program is also dependent on interested industry and educational institutions. Some of the states have a robust investment in apprentice programs but do not currently have the advanced manufacturing forcing student graduates to move out of state.

Since 2011, the American advanced manufacturing industry has experienced employee growth in 23 out of the 35 manufacturing categories. The two top-growing manufacturing categories are railroad stock manufacturing and motor vehicle manufacturing, which traditionally were concentrated in certain geographic areas. The industries with the most job growth do not reflect the most wage growth, nor do they reflect the volatility of the employment within the industry. Motor vehicle manufacturing is notoriously susceptible to broader economic downturns, where consumer staples and healthcare technology might be more recession-proof. Beyond these economic variables, some careers are just woefully under employed reflecting strong demand in apprentice academies for the foreseeable future. These future industries are focused around technology including robotics, wearables, drones, and genomics. To support these industries, middle skill careers that could benefit from future growth and investment include machinery, industrial manufacturing, computer equipment manufacturing, pharma, and medical manufacturing.[24]

Geographically, the region of the United States that has benefitted the most from the growth in advanced manufacturing since 2008 is the middle of the country. The map below shows an encouraging amount of job growth in advanced manufacturing industries, especially in the middle southern states of Alabama, Tennessee, and Kentucky.

[24] "Advanced Manufacturing pinpointing growing hubs", L. Pizzo, link



CENTERS OF ADVANCED MANUFACTURING, GROWTH AND DECLINE 2011-2015

Decline is especially evident in Baltimore, Maryland (18% decline since 2011) and Rochester, New York (14% decline). Baltimore has lost nearly all of its iron and steel mills and alloy manufacturing jobs, of which there were over 2,000 jobs in 2011. Similarly, Rochester lost nearly 3,000 jobs in its other chemical product and preparation industry mostly from the wind-down of Kodak and related industries.[25] Generally from 2011-2015, the Northeast was trending down with Boston down 2.8%, NY region down 7.1%, and Baltimore down 17.5%. The Midwest is trending up and specifically showing strong growth in Michigan due to automobile and automobile part manufacturing. Growth has been level elsewhere in the Midwest with the exception of Louisville, which has also shown strong growth due to automobile manufacturing. Elsewhere, there is consistent growth in the Southeast, strong growth from tidewater, North Carolina, Tennessee, and the Texas Gulf coast. On the west coast, southern California and Arizona have seen a drop, while northern California, Oregon, and Washington have witnessed growth. Attracting skilled workers in the Northwest is a challenge due to the high housing prices.[26] As noted, Oregon and Washington State recognized the shortfall in qualified candidates by investing in apprenticeship growth. One critical observation on the location of advanced manufacturing and apprentice academies is that clearly the larger, expensive cities will continue to lose jobs to lower cost, rural, well-connected centers of manufacturing with fewer governmental controls.

Apprentice Academies – Organization Strategies

A key aspect of the success of an apprentice academy and its curriculum is a strong linkage between the individual course of study and a broader business and educational framework. In its simplest terms,

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[25] "America's Advanced Industries", M. Muro et al., 2015 link

[26] "Where Manufacturing is thriving in the U.S.", J. Kotkin, 2017, link

academies are more successful if they have a connection to an established college or trade school, have a strong relationship with an existing manufacturing entity, or have a connection to the local workforce. An established college or trade school connection provides the most stability towards the success of the program. This allows students to be exposed to a specialized academic program within the broader support of a college curriculum and infrastructure. The broader connection to the curriculum provides the ability to create a more well-rounded student who is able to fine tune their education and career goals as they move though the apprenticeship process. The broader infrastructure of a campus provides the academy the support facilities to supplement student engagement through either research (libraries), food and beverage (dining halls), and recreation and wellness (fitness and lockers). This broader connection might also help to reduce the high dropout rates in current apprenticeship programs.

An alternate strategy for establishing an apprentice academy program is interest and motivation coming directly from the manufacturing and business sectors. This could include a business that recognizes the value in the training of their own employees in markets that are underserved by nearby schools. The apprenticeship approach could focus on intensive engagement on a factory floor including hands-on experiences with educational and executional aspects. This approach needs to consider the organization of the manufacturing and apprentice environment that allows for both efficient production and for training and education. This might include separate production lines that include an educational zone, educational “overlooks,” and visual connections between classroom spaces and production spaces. Critical to this apprenticeship success is understanding the need to have specialized employees who are highly-skilled, able to train and educate new students, and produce product on the manufacturing floor.

Success in academies also results from local governments and educational entities recognizing un-met needs in these middle-skill jobs and providing incentives to support these programs. Governmental strategies that support apprenticeships recognize the symmetry and overlap between multiple educational institutions, industry, and employees and work to unite disparate entities into one governing body. As an example, The Southwest Virginia Alliance for Manufacturing is one such entity that brings manufacturers and government institutions together with potential employees located on the campus of a regional community college. Successful government strategies that recognize the skills in the local workforce, the demand for the jobs, and the portability of their education to other markets are more likely to succeed.

Apprentice Academies – Design Considerations

The design considerations of each academy depend on the broader goals of the educational program, its local partnerships, and the existing infrastructure. As noted, the curriculum strategy of the academy highly influences its layout and organization, whether it is broad or specialized, part of a college or part of manufacturing, and the types of apprenticeship degrees provided. Specialized learning environments are required for advanced manufacturing, healthcare, energy, and technology apprenticeships, where less specialized environments are needed for finance, transportation, and hospitality, with the exception of food service training. Construction and telecommunication apprenticeship schools require dedicated training and education spaces, but cannot be combined with manufacturing locations as these apprenticeships serve highly itinerant industries.

Correlation between Research, Manufacturing, and Academies

The correlation in recognizing the convergence of education, research, and manufacturing and the impetus for this paper began because of Commonwealth Center for Advanced Manufacturing (CCAM). A research and collaboration for manufacturing and education, CCAM merged several unique program typologies together into a subscription-based facility. The 63,000-SF CCAM facility uses an innovative consortium of private industry, government, and university partners to allow for translational research to occur between education and advanced manufacturing. Completed in 2012, CCAM is located next to the Rolls-Royce rotatives (aircraft engine machining) plant at the Crosspointe manufacturing campus south of Richmond, Virginia. The facility works in tandem with researchers at various institutions including UVA, Virginia Tech, and Virginia State University.[27]

COMMONWEALTH CENTER FOR ADVANCED MANUFACTURING, PRINCE GEORGE COUNTY, VIRGINIA

Recognizing the need to support various areas of research on the same manufacturing campus, Virginia Commonwealth University subsequently commissioned the planning and design for an additional research facility that would focus on advanced logistics systems to support the needs of both university and industry in Virginia, especially at the port of Virginia, the seventh largest in the United States. Commonwealth Center for Advanced Logistics Systems (CCALS) is designed to accommodate 40,000 square feet of training, education, laboratory, visualization, and high-bay space for the research on the logistics systems, similar to the subscription service provided by CCAM, in its own purpose built facility.[28] Considering the need to develop a workforce component on the campus, CCAM leadership encouraged the opportunity to provide a dedicated apprentice academy that could support the needs of the manufacturing campus, its constituents, and the surrounding community. Ultimately, the new academy

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[27] Perkins+Will Research Journal Vol 06.01, 2014, link

[28] Commonwealth Center for Advanced Logistics Systems, https://www.ccals.com/

was funded through a series of state and economic grants to program and provide a concept study for the CCAM Advanced Manufacturing Apprentice Academy at Crosspointe.

COMMONWEALTH CENTER FOR ADVANCED LOGISTICS SYSTEM, PRINCE GEORGE COUNTY, VIRGINIA
(WITH CCAM IN THE BACKGROUND)

Case Study 1: Advanced Manufacturing Apprentice Academy, Prince George County, VA.

The Advanced Manufacturing Apprentice Academy (AAMA) was originally conceived on the Crosspointe campus adjacent to CCAM as a stand-alone building at the main entry to the site. Although designed for the specific education of new apprentices, the AAMA is also part of a larger research and manufacturing masterplan. The purpose-built academy program is designed to support apprentice development in advanced manufacturing on the Crosspointe campus but also throughout the local region and thus visibility and access to the new facility was an important consideration.

The mission of the AAMA is to deliver qualified workers with industry certified skills and credentials for advanced manufacturing jobs. Over the past decade, advanced manufacturing has dramatically changed the face of the industry making manufacturing attractive once again for higher-cost production environments such as Virginia. The Commonwealth of Virginia recognized that investing tax-dollars in this type of workforce training to support manufacturing recruitment and grow this beneficial to the state and its manufacturers. The introduction of advanced materials, production capabilities, and disruptive innovation in automation, robotics, and fully integrated production systems directly impacted the demand for skilled workers and the apprentice curriculum provided by AMAA including credentials in middle-skill occupations such as machining, welding, and mechatronics. In 2017, Virginia alone required 8,000 qualified workers in advanced manufacturing to support the existing industry. The academy will supply apprentices with the skills that emulate real-world environments and curricula that align with industry needs.[29]

ADVANCED MANUFACTURING APPRENTICE ACADEMY, PRINCE GEORGE COUNTY, VIRGINIA

Curriculum Considerations

To begin, the AAMA will focus on three core apprenticeship tracks that are directly beneficial to the adjacent CCAM and Rolls Royce Rotatives Factory. Although direct employment in manufacturing in Virginia has reduced 21 percent from 2006-2011, contribution to the state's gross domestic product has increase 19 percent in the same time period. While manufacturing economics are reducing the number of jobs in Virginia, the skills required in lean manufacturing and flexible manufacturing processes has increased the demand for schools to support this specialized curriculum.[30] The three initial apprenticeship programs provided at AAMA will be Machining, Mechatronics, and Welding. This focused curriculum aligns to standards defined by the National Institute of Metalworking Skills (NIMS) for machinists, the America Welding Society for welders, and the NIMS and Siemens Mechatronics Systems Certification Program for industrial maintenance mechanics allowing the certification to be transferable. As the program and partnerships develop, the curriculum will evolve into new credentialing and local industry partnerships.

Organizational Considerations

Creating a collaborative environment of learning and maker spaces, the AMAA will provide a new state-of-the-art learning facility. This apprentice academy approach is different from other academy models in that it is not located on an educational campus; it is part of an industrial and research campus. This provides benefits in the alignment of the curriculum to manufacturer needs, but causes challenges due

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[29] CCAM Announces Federal And State Funds To Build Apprentice Academy, 2018, link
[30] Manufacturing in Virginia, Trailblazers. 2012

to the lack of educational infrastructure. The initial design proposed a two-story building of approximately 57,000 square feet to accommodate the curriculum primarily for advanced manufacturing. The overall planning of the building is organized in a compact building configuration, allowing the students to visualize and engage with all three curriculum environments. The north-south zone includes learning and event rooms, while the east-west zone accommodates administration and support services. The main entrance, lobby, and exhibit area are located at the intersection of the two program zones. The maker spaces (high-bay shops and welding) form the remainder of the facility, which benefits from good interior visual connections and high visibility from the main entry space and from the surrounding community. The plan establishes a direct view from the lobby into the high-bay shop areas to immediately reinforce the purpose and mission of the building to any student, faculty, or visitor.

ADVANCED MANUFACTURING APPRENTICE ACADEMY, FLOOR PLANS

The functional building program is organized into four general areas with targeted learning environments tailored to student needs. The program provides both high-bay, hands-on maker spaces along with small targeted classroom environments. The learning and maker spaces are directly adjacent to each other. To support manufacturing trends, the space program also provides a hands-on welding shop along with related support spaces. The program is designed to support 200 apprentices per year with 50% of students in machining, 28% in welding, and the remaining in mechatronics. The academy is designed to offer two educational sessions (morning and afternoon) allowing scheduling flexibility to employer partners. This scheduling block considers the changeover, storage, and administration criteria that need to occur with this operational strategy.

Growth Considerations

One consideration that is important to the design is how to recruit new students, industry partners, and feeder schools to participate in the program. Being a stand-alone facility does not allow the academy to benefit from adjacent educational buildings and so it must rely on providing both information and physical space to bring perspective students to the facility. Initially, the intent of the facility was to attract students from the surrounding school districts and create partnerships with southern Virginia Community Colleges. Due to the initial startup operational hurdles, the AAMA decided to reduce the size of their initial building to 36,000 SF and integrate it as an addition to the existing CCAM building to reduce overhead and leverage existing infrastructure already present on the campus. The reduced scope provides the high-bay and classroom space along with welding and support spaces. The reduced footprint eliminates some classrooms, lunch and event rooms, vertical circulation, and site development costs. The addition uses existing spaces already present inside CCAM, while providing its own unique entry for apprentice education. The reduced floor plan will allow the program to ramp up enrollment gradually until a larger facility is required.

ADVANCED MANUFACTURING APPRENTICE ACADEMY - ADDITION ON THE NORTH SIDE OF THE EXISTING CCAM

Case Study 2: Kawartha Trades and Technology School

Interview with Maxine Mann, Dean of the School, Tour and discussion 2016, updated in 2018

KAWARTHA TRADES AND TECHNOLOGY SCHOOL, PETERBOROUGH, ONTARIO, CANADA

The new Kawartha Trades and Technology Centre building, which opened in 2014, showcases education in the trades at Fleming College in Peterborough, Ontario, Canada. Since the opening of the new building, the program has generated a measurable increase in enrollment trade related certificates and diplomas because of the excitement surrounding the new facility. As part of the case study, we visited the facility in 2016 and subsequently followed up via telephone more recently on the successes and challenges of the building and its curriculum. Maxine Mann, Dean of the school, shared various observations on what is working in the facility and some of the keys to success for this type of school in the future.

Reinforcing comments on the tour, the design of the facility and the "wow" factor of the 5-year-old facility continues to be an attractor for current, new, and future students. Creating, maintaining, and refining the curriculum continues to be an important part in distinguishing the program from the surrounding competition. Integral to the school's current success is being part of the larger framework of Fleming College, which allows students to explore a wider range of diploma and degree options based on their interests. This exploration has reinforced the idea of personalized curriculum. The facility is currently at maximum occupancy due primarily to the success of the programs and there is currently a proposal to add Saturday classes, a move that would be unprecedented in trades and technology schools. One key limitation of the facility manifested through its use and curriculum is the now codified inability to put "trades" and "technology" in the same building, which is discussed further in the "curriculum considerations" section below. Beyond the success of the curriculum and facility, Fleming College must also constantly adjust their curriculum, growth, and graduation numbers in collaboration with the provincial funding body, the Ministry of Training, College and Universities. The program's success has resulted in high demand for the programs from international students including strong interest in learning about the program and the successes from international delegations. As the facility moves into its fifth year of operation, its future is bright. [31]

Curriculum Considerations

Reflecting on the original project program design brief, recently Kawartha's leadership team has recognized that trades and technology programs cannot successfully work together in the same space. Fortunately, the building is not suffering from underutilization due to the growth of the trades programs and the ability to move technology elsewhere on campus. The primary reasons that the technology programs cannot co-exist is the vibration, infiltration, and noise control differences between the two diverse programs. Additionally the openness, access to daylight, and visibility aggravates environmental issues that cannot be easily controlled in spaces that require an immense amount of technology and engineering integration. This valuable observation goes contrary to the current thinking in higher-education of combining various types of facilities and programs into single buildings. It is clear from this model that certain types of education programs do not like to co-exist.

From the programs currently offered, 2 and 4 semester (8-16 month program) certificate has been the most popular due to national career retirements and the growing demand in manufacturing, oil exploration, and extraction. In Canada, welding continues to be the fifth highest in-demand profession for 2017[32]. Nationally, industrial electricians and pipe fitters are in strong demand, which makes many of the primary degree programs provided at Kawartha popular for future careers. Another important aspect of a successful program is creating thoughtful and sustainable relationships with outside partners including manufacturers and suppliers. As a response, Fleming College has created and maintained a strong partnership with Siemens AG (German industrial manufacturing company) to provide the latest technology to support their education program including providing equipment to support their Electrician Apprentice, Electrical Technician, Instrumentation, and Controls programs. Due to this successful partnership, Siemens has moved all of their training to the Fleming College campus for all North America. Clearly, the success of these advanced technical and trades programs relies on a strong partnership between business and education and benefit from the ability to share technology, training, and space challenges.

Organizational Considerations

The design and organization of the building continues to contribute to the success of the Centre. The ability to visualize the trades program immediately upon entering the building and see the two-story high-bay construction trades laboratory provides perspective students a glimpse into the curriculum opportunities. This visibility between discussion and implementation reflects the importance of providing both teaching/lecture spaces with the hands-on laboratories within the same building and, depending on the acoustics, within the same classroom. This sharing of teaching and hands-on areas works well in certain programs but not in others such as welding and carpentry shops where sound level

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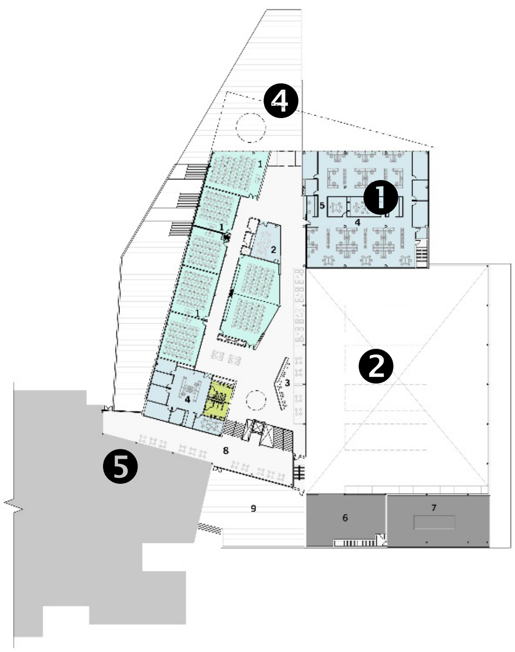
[31] Kawartha Trades and Technology Centre, https://flemingcollege.ca/about-fleming/
[32] "17 careers in Demand in Canada", link

and impact noises take away from lecture-style discussions. In the welding studios, as well as welding booths, there are additional needs for communal forging and cutting areas for added flexibility. Similar to other educational projects, flexibility in classroom layouts allows the adaptability of curriculum to student needs so a reduction in the amount of fixed furniture is essential. Kawartha's location as part of a campus allows the students to participate in both "dirty" shops and "clean" classrooms without providing dedicated locker facilities because dormitories and recreational buildings are nearby to support the students. Trades schools that do not benefit from the nearby student and residence life adjacencies might require additional support spaces to buttress the welding and building trades programs if students are expected to go between trade and technology laboratories and classrooms. Lastly, it is always important to provide adequate space for storage of materials, storage of equipment, and areas for bulk recycling, which are often spaces that get eliminated in an effort to reduce construction cost.



Main Floor

1. classroom
2. meeting room
3. lounge
4. administrative
5. reception
6. storage mezzanine
7. rooftop mechanical
8. campus link
9. terrace

Lower Floor

1. learning factory
2. masonry area
3. presentation room
4. gas/ oil/ HVAC shop
5. welding/ machine shop
6. sunken courtyard
7. office area
8. lower lobby
9. storage
10. mechanical/ electrical
11. shipping/ receiving

Kawartha Trades and Technology Centre, Floor Plans

❶ Former Administration area, converted to classroom space.
❷ The triple height trades "Kube" benefits from visibility but suffers from flexibility.
❸ The welding shop suffers from its own success and would benefit from increased size and visibility.
❹ The site topography allows public access from the upper level and service/material access from lower.
❺ The building is thoughtfully connected to the rest of the college buildings and campus.

Growth Considerations

Due to a change in the office space needs, the administration area was downsized and located elsewhere. The leftover was then converted to additional general classrooms that can support the trade school. (❶) The building trades program and the building plan could have benefitted more from a separation between the trade types and eliminated fixed equipment where appropriate. The visually impactful trade "Kube," a 3-story trades and training classroom located within the high-bay space, serves as a unique teaching environment but is challenged by its lack of flexibility. (❷) The welding space, although highly successful, suffered from its success and was immediately undersized. To resolve the welding shortfalls, an expanded welding area would include additional downdraft tables, an overhead crane with increased clearance, and an expanded exhaust/filtration room. The welding shop was unfortunately programmed in one of the least visible areas of the building and could have been acoustically separated but visually connected to the main circulation spine of the building. (❸) Other consideration for growth of the program include automation, which allows students to learn about how to manage and program automation and virtual reality (VR) and augmented reality (AR) programs that can supplement the hands-on experiences currently offered as part of the curriculum.

The Future

Looking beyond the Kawartha building and Fleming College, there are some interesting trends in education specific to Canada. There is a growing demand for students to come to Kawartha *after* completing their three or four year bachelor's degree due to employers' interest in hiring graduates with both theoretical degree knowledge and practical hands-on expertise. The lower cost of in-province tuition might encourage additional certificates and diplomas paid for by the Canadian government, which would not be available to students from the United States. Alternatively, the apprenticeship programs in Canada attract international students including those from the United States due to the higher level of expertise in these certificate programs. Currently, there is a strong enrollment by international students in Canada due to the marketability of a North American degree and the immigration blockade into the United States, but overall, this demand in North America might soften as more international programs come on-line. One observation made was there is strong interest from emerging economies in building domestic trade schools to supplement the skills need that wasn't present five or ten years ago. Recently, an Indian delegation visited Kawartha to study the curriculum as a response to the shortfall of trades in India due to neglect in providing their own trades schools. Lastly is the need to make trades and technology more desirable to women in the workforce. Women in trades enrollment has quadrupled from 3 to 12% at Fleming but, unfortunately enrollment in technology has been stagnant at 6%, which reflects a lost opportunity and should be a critical part in shaping the future.

Case Study 3: Advanced Manufacturing Training Centre, Catcliffe UK

Interview with Nikki Jones, Director AMRC Training Center, September 2018/December 2018

ADVANCED MANUFACTURING TRAINING CENTRE, CATCLIFFE, UK

The University of Sheffield's Advanced Manufacturing and Research Centre (AMRC) was established in 2001 in partnership with Boeing and has since expanded to include more than 100 manufacturers and supply chain partners. In 2010-11 the manufacturers in the Sheffield region recognized that there was a shortfall of highly skilled and qualified advanced manufacturing apprentices and the University's AMRC responded to this by opening its doors to a purposely built training centre of apprentices. The Centre was funded, designed and built with a combination of university, regional government and European Union grants and began their advanced and degree apprenticeship programs in 2014.

Apprentice programs have a strong history of support in the United Kingdom and more recently, has seen significant reform to the funding methodology and standards. . Many of the current individuals in positions of leadership at manufacturing companies in the UK got their start in apprentice programs and thus highly value the role of the AMRC in providing the future workforce. The relationship between the companies, the government, and the training centre is integral to the success of the programs. Apprenticeships are strictly regulated by the British government—similar to the German, Switzerland and Canadian system—but largely depend on the system of levies imposed on manufacturers to support the workforce education and growth. Recently refined by the government, large manufacturers with revenues above £3 million are required to pay a 0.5% levy into a central apprentice fund. The payments are translated into vouchers that are used to fund the educational training programs. Conversely, smaller companies pay 10% of their training costs directly to the provider with the government paying the remaining 90%. The UK government provides 100% of the funding for the training of 16-18 year-olds if a company has fewer than 50 employees. All of the companies have 24 months to convert the vouchers into training for employees. Students in apprenticeship programs benefit from all costs being paid by manufacturers and the government, unless the student has already participated in other formal apprentice or university training prior to joining the program.

Part of the complication of the government-directed program is the need for the AMRC training centre administration to actively reach out to manufacturers with trade events so that they are able to understand and participate in the benefits of the program. Through manufacturer events, AMRC has been able to fine tune their curriculum to the needs of their constituents including industry events to discuss needs and the benefits of the payment systems while adapting the curriculum to better correspond to manufacturing needs. The centre focuses on students ages 16-18, which makes up 85% of their student population. Most of the students come from the Sheffield region, 30% of which hail from disadvantaged UK post codes.

Curriculum Considerations

The AMRC apprenticeship program, based on the UK standards, is a graduated level of apprentice programs that begin post-secondary education with the GCSE (General Certificate of Secondary Education) at intermediate (level 2) and progress to higher level of apprenticeships (levels 4/5/6/7). AMRC currently has 700 enrolled in levels 3-6 with 121 new students to the program for 2018. In addition to the strict controls by the government on the number of apprentices, the centre closely regulates their individual programs to guarantee that each student has dedicated access to an individualized training and equipment environment. AMRC's current curriculum is focused on certificates in Mechanical Machining, Electrical Technology, Fabrication and Welding, and Technology Support programs such as Mechatronics. Unlike other case study programs, fabrication and welding have seen a drop in growth while mechanical machining has been consistently popular and technology support programs are becoming highly desirable. Most of this desire is coming directly from manufacturers. AMRC is consistently refining their technology programs to match the market by including more design and programming, including CNC and robotics, with CAD being an important part of preparing apprentices for more automation in the future.

Organizational Considerations

The training centre—conceived in 2010 and completed in 2014—was originally imagined as a simple classroom block with an attached high-bay training space. The double-loaded, light colored classroom block supported the classroom work while the "dark" colored high-bay supported the hands-on work. Similar to Kawartha School, there is access from the exterior to the building from multiple levels, allowing students to arrive on the second level of the classroom block. The second level contains the 270-seat refectory space and workshop gallery that looks down into the high-bay space. Visibility between the two blocks has been limitedly successful and would have benefitted from additional windows. The 1530 square meter (16,100 SF) high-bay workshop is organized for flexibility to adapt and adjust equipment based on curriculum needs. The lower entry level of the classroom block is connected to the workshop floor and contains specialty classrooms for robotics, welding, and instrumentation. The upper levels of the classroom blocks are tightly packed with classrooms of varying sizes and support areas with administrative and instructor offices on the same floor as the refectory. The AMRC experimented with different strategies in providing instructors including using external teachers on contract and sharing instructors with the university but ultimately settled on managing the instructors, curriculum, and training themselves. AMRC instructors typically come from the industry and although they are well versed in their specialty, special effort has been implemented to provide educational training in addition to advanced manufacturing training to make the instructors more effective. This includes providing practical teaching courses, assessor, and coaching programs.

Growth Considerations

The current AMRC training centre has reached its current operational and physical capacity. When the project was originally imagined, a master plan was not developed for the campus in an effort to open the facility as quickly as possible. The success of the growth of the programs and the lack of clear master plan has stifled campus synergies by preventing future growth. The original training centre was conceived to include an additional classroom bar to the southwest of the current building while doubling the high-bay space to the southeast of the current workshop. Land ownership, topography, and parking have prevented this growth from happening. As a result, AMRC focused on creating a new facility one kilometer away at the AMRC business park for research and advanced training called Factory 2050. Although not specifically a training center, Factory 2050, is a bridge between training, research, and manufacturing and was modelled on solving the translational issues between research and manufacturing.

The Future

Fourth Industrial Revolution will guide the future of apprenticeship careers in the United Kingdom and throughout the world. The fourth industrial revolution includes exponential advances in robotics, automation, virtual and augmented reality to solve increasingly complex physical, digital and biological challenges more quickly than ever before.[33] This integration is the foundation for the Factory 2050 at the AMRC manufacturing park where lines between research, manufacturing, and training will begin to blur. Apprentice programs of the future will understand that the automation in advanced manufacturing will create an ever-evolving cycle of job growth, refinement, and ultimately destruction created by this revolution. To support the pipeline of future students, there needs to be continued effort to educate secondary school graduates in the value of apprentice manufacturing programs while also focusing the diversity of the programs to include more women in advanced manufacturing. Currently, women represent just 6% of advanced manufacturing jobs. To increase female interest, AMRC has begun to focus on younger generations including a program entitled “primary engineering” which focuses on primary schools and specifically on STEM at age 14 to encourage young women to go into engineering careers. The success of AMRC will continue to be dependent on its manufacturer partnerships, government affairs, and its relationship with Sheffield University. The AMRC-Sheffield University partnership has been good by providing many research and innovation opportunities with its member manufacturers. AMRC has also encouraged its member institution researchers to teach upper level 4 and 5 apprentice courses and thus promote the pollination of ideas between education and manufacturing. AMRC training centre benefits from being part of a larger framework of established university programs, interested manufacturers and motivated students poised to adapt to future manufacturing growth.

[33] The Fourth Industrial Revolution, World Economic Forum, link

Conclusions

The future of higher education will reflect the increased role of middle-skills education, personalized curriculum, and student-directed training. Trends in career technical education indicate a decreased interest in committing to a career path before completing a high school degree thereby discouraging early career specialization. Universities, parents, and students recognize that providing a longer timeline to focus on a career post high-school graduation might be more advantageous. Tuition cost pressures and consolidation of colleges and universities will continue to increase, forcing future students to make different economic decisions to achieve individual career goals. Alternative educational strategies might be more desirable than the traditional college education model. These alternative career pathways will include more high-quality vocational and technical training and will rely on more internships and apprenticeships to balance costs with interests and flexibility. With the discounting of college and alternative education models increasing, metrics indicate that curriculum personalization will become central to each student's learning objectives, goals, and degree. This will make the middle-skills job market more desirable as students explore overlooked markets to allow individual education personalization to occur.

New education pathways that solve the high cost and time-to-market issues to which traditional four-year degrees are prone, while also resolving specific shortages in the labor market will be more desirable as students expect more value from their educator. New industry-education partnerships will provide unique qualifications for consideration that allow students to take their education as far as they desire with increased degree and qualification portability. Regional universities will feel particular pressure to find unique partnerships with business and manufacturing to provide degrees and career paths targeted to their unique and local workforce. These relationships will form symbiotic educator-critical employer apprenticeship models especially geared towards lower-cost manufacturing sectors. The blending of industry and education might occur as part of a production and apprenticeship schedule or may more closely resemble Fleming College and its integration of multiple degrees, traditional college education, and specific industry training programs. Higher education might find a preferred model in bringing advanced industry on to campus to help share the economic load, providing a workforce pipeline, and aligning curriculum to industry needs.

The easier model for industry might be to provide educational infrastructure at manufacturing sites similar to the AAMA project, which is close to research and manufacturing hubs. This model provides a more robust marriage between education and industry but allows for less flexibility on the part of the student. Fewer curriculum options are possible than with a traditional college apprenticeship program because the programs are aligned to the specific manufacturing need in the geographic region. Careful consideration and coordination need to be given between the needs of the availability of jobs with the local industry, the flexibility of the apprenticeship, and the requirement that the certifications achieved be transferrable to other companies including the alignment between skills desired and skills conferred.

Key to the design of the middle-skills education spaces is adaptability and flexibility that allow changes to the various learning typologies and the tractability to react to growth industries. Specialized spaces need to include traditional dirty and clean spaces, or at a minimum the ability for students to adapt to the clean environment of a classroom and the dirty environment of a manufacturing floor or trades laboratory. Specialized rooms typically require higher ceilings and high-bay spaces, flexibility in the connection of technology, ease of access for large equipment, and active noise and vibration considerations. Organizing spaces for traditional lecture-style curriculum to visually align to hands-on production space is especially important in order to allow students to visualize the learning process. The spaces should also include the ability for new models of curriculum personalization through peer-to-peer learning, maker spaces, and collaborative teaching models.

Lastly, the jurisdictional bodies need to participate actively in the educational framework so that industry and education partnerships can succeed simultaneously. Government, either local or federal, needs to be involved. The federal government needs to provide the framework for incentives to industry, as well as degree portability and information to perspective students. Local governments need to understand their individual markets, the necessity for skilled workers, and their industry growth potentials as well as how to bring industry and education together through the creation of programs and physical spaces. Government monetary incentives to both industry and students will provide the necessary encouragement to offset increased training costs to businesses, while encouraging an increased number of students to participate. This re-alignment and incentivization will help broaden access to education and resolve the shortage of students in advanced manufacturing education programs. The alignment between industry and education will result in robust growth and newfound learning opportunities in the middle of higher education.