Policy Brief

# Training Tomorrow's AI Workforce

## The Latent Potential of Community and Technical Colleges

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## Executive Summary

It is a national security imperative to grow, sustain, and diversify U.S. artificial intelligence (AI) talent pipelines. But to date, the predominant focus of U.S. policymakers and industry continues to be on four-year degrees. Such a narrow focus is leaving talent behind and limiting opportunity, as many AI careers do not require a four-year college credential.

Community and technical colleges offer enormous potential to grow, sustain, and diversify the AI talent pipeline. They are a critical part of the U.S. postsecondary system with a student body that represents many segments of the population.

However, these institutions are not being leveraged effectively in educating and training AI talent. To understand the current landscape of AI and AI-related education at these institutions, we evaluated current program offerings and the associated number of graduates. We focused on programs where associate's degrees could be a powerful source for training and upskilling AI talent.

Our analysis found:

1. Community and technical colleges awarded few AI and AI-related degrees and certificates in 2020, with virtually none in AI-specific fields.

2. Two promising technical fields for AI-related degrees and certificates, computer and information science (CIS) and engineering technologies, saw flat or falling associate's degree attainment over the last decade.

3. Although community and technical colleges attract a highly diverse student body, in 2020, women comprised only 23 percent of graduates who earned a CIS associate's degree or certification, and 15 percent of graduates who earned an engineering technology associate's degree or certification.

4. In 2020, less than 7 percent of awards in business management administration and operations were in the subspecialties most related to AI product development and acquisition.

5. There is a small but growing number of promising industry partnerships specific to AI education and training at community and technical colleges.

These findings show that there is substantial room for improvement. This starts with building upon or modifying existing programs in AI-related fields, but also includes creating new programs with stackable certificates and industry certifications to meet the future demand for AI and AI-related competencies.

However, there are significant barriers that must be addressed for community and technical colleges to realize their full potential in training tomorrow's AI workforce. This includes the persistently uncertain funding environment; low completion rates; low female and underrepresented student participation in technical programs; faculty recruitment, development, and retention challenges; and an overload of competing priorities from system administrators and state legislatures. That these institutions often serve populations more diverse than traditional four-year institutions, with a wide range of student needs, further exacerbates these barriers.

To overcome these barriers, federal, state, and industry prioritization of AI education and workforce development is needed. Such prioritization must start at the top, with a dedicated office in the White House. It must also include additional state and federal financial support to create and elevate quality AI and AI-related programming. It also requires incentives for community and technical colleges to partner with industry to design AI and AI-related programs where employers recognize the resulting credentials and use them to hire AI talent.

To help community and technical colleges realize their potential, we propose:

1. The National Artificial Intelligence Initiative Office within the White House Office of Science and Technology Policy, in coordination with the Office of the First Lady, establish a strategic line of effort related to community and technical colleges.

2. Congress establish a federal joint Department of Labor and National Science Foundation grant program for industry-institution partnerships in

AI and AI-related degree and nondegree programs, including high school dual enrollment programs.

3. Congress enact federal tax credits for companies that form industry partnerships with community and technical colleges related to AI and AI-related programs.

4. Congress fund the National Institute of Standards and Technology, or other federal entity if appropriate, to conduct multi-stakeholder collaboration to develop a framework of technical and nontechnical AI work roles and competencies, updated regularly.

5. U.S. states facilitate articulation agreements between public two-year and four-year institutions for transfer and reverse transfer for AI and AI-related programs.

Creating AI and AI-related programs as a series of stackable credentials—nondegree certificates that demonstrate a skill or competency—will transform how community and technical colleges prepare tomorrow's AI workforce. First, it will promote lifelong learning by facilitating acquisition of new skills at any time. Second, it will enable agility in program offerings in a rapidly changing skills landscape. Third, it will encourage the mixing and matching of credentials for the unique blend of skills and competencies that matches an individual's interests, aptitude, and employment marketability. This would provide accessible and affordable education and training options not readily available elsewhere in our education system. Institutions could design programs using promising practices and lessons learned from states offering stackable credentials in other fields, such as in Ohio.

We have a vision where community and technical colleges become a core part of educating and training AI talent in the United States. They will reach underrepresented and nontraditional college populations, and provide new avenues of access and opportunity to a key segment of tomorrow's high-wage jobs. However, they cannot do this alone. Working with federal, state, and industry partners, we believe it is possible for community and technical colleges to create a truly viable alternative pathway for AI careers.

# Table of Contents


Executive Summary ... 1
Introduction ... 5
Domestic AI Education and Workforce Policy Goals ... 7
  AI Occupations and Educational Attainment ... 7
  Linking College Majors and Degrees to AI Occupations ... 9
The Promise of Community and Technical Colleges ... 11
  Diverse Demographics ... 11
  Flexibility and Affordability ... 12
  Career and Technical Education (CTE) ... 12
  Stackable Credentials ... 13
Challenges Faced by Community and Technical Colleges ... 15
  Uncertain Funding Environment ... 15
  Diverse Student Needs ... 16
  Competing Priority Overload ... 16
  Lackluster Career and Technical Education Outcomes ... 17
  Low STEM Completion Rates ... 17
  STEM Faculty Recruitment and Retention ... 18
The Latent Potential: Current AI Education and Training ... 19
  Computer and Information Science (CIS) ... 19
  Engineering Technologies ... 22
  Business Administration Management and Operations ... 23
  More Latent Potential: Degree Attainment Over Time ... 24
Realizing the Latent Potential ... 26
  Understanding Low AI-Related Attainment ... 26
  Advancements in College Completion ... 28
  Advancements in AI-Related Industry Partnerships ... 29
Policy Recommendations ... 33
  Federal Call to Action ... 34
  State Call to Action ... 36
  A Vision for the Future of Higher Education ... 37
Conclusion ... 40
Authors ... 41
Acknowledgments ... 41
Appendix A: Methodologies ... 42
Appendix B: Top States Awarding AI-Related Credentials ... 44
Appendix C: Top Institutions for CIS Graduates ... 47
Appendix D: Highlighted Partnership Details ... 49
Endnotes ... 57

## Introduction

Having a globally competitive AI and AI-ready workforce is essential to future U.S. national security and economic competitiveness. However, having the world's leading AI workforce is not assured. To stay ahead, the United States must think bigger and more proactively in addressing the challenges posed by its existing policies while leveraging the opportunities inherent in its education system. This research targets that need by proposing new ways to realize the latent potential of community and technical colleges in educating tomorrow's AI workforce.

Community and technical colleges function as a critical part of the U.S. workforce development system. These institutions serve over ten million credit and noncredit students per year[1] and offer a wide range of education programs. Degree programs typically span two years but also include four-year programs in select states. Nondegree award programs can range from a few weeks to a few years.[2]

The majority of community and technical colleges are public institutions, administered at the state level, with the remaining being either private or nonprofit institutions.[3] They award two-year college degrees, known as associate's degrees, in a range of technical and nontechnical fields. They may also offer nondegree postsecondary vocational awards, such as certificates,[4] and, in 24 states, are allowed to confer bachelor's degrees in select fields such as nursing.[5] Public community colleges are open-access, meaning they must admit everyone who wishes to enroll, with few exceptions.

Over one million associate's degrees and almost 1.2 million sub-baccalaureate certificates were awarded in the 2019–2020 academic year.[6] Of these, nine hundred thousand associate's degrees and nearly seven hundred thousand certificates were awarded by the nation's roughly 1,700 community and technical colleges. The remaining degrees and certificates were awarded by primarily four-year institutions.[7] Appendix A explains this distinction.

In 2020, over 60 percent of associate degrees and 54 percent of nondegree certificates were awarded to females.[8] Despite this, only a small share study

STEM-designated fields. In 2020, almost six out of 10 associate's degrees were awarded in just two fields: liberal arts and sciences, general studies, and humanities; and health and related professions.

Each state has a different system design. In some states, such as California, community and technical colleges are coordinated by an independent state board but governed by locally elected boards. Other states do not have local governing boards and are governed by a state board (e.g., Colorado and Indiana). There are a myriad of other combinations—local boards can be elected, appointed, or not exist at all, and state-level structures vary just as widely in authority and organizational makeup.[9]

This paper seeks to understand how community and technical colleges can achieve their potential as educators of AI talent. For our analysis, we used educational attainment data from the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS). For each of the industry partnerships highlighted in detail, we spoke with company representatives to understand motivation, program design, implementation, and early outcome indicators.

Our report is broken down into several parts. First, we define the AI workforce and policy goals, motivate the fields of study of interest, and explain our focus on associate's degrees and certificates. Second, we summarize the promise of community and technical colleges in career and technical education, along with the historical challenges that these institutions face. Third, we provide data on AI and AI-related educational attainment at these institutions. Fourth, we offer potential reasons for low award attainment, discuss recent advancements in postsecondary completion, and highlight promising practices from several industry-institution AI-related partnerships. Finally, we conclude with recommendations for policymakers and a vision for realizing the full promise of community and technical colleges in educating and training tomorrow's AI workforce.

## Domestic AI Education and Workforce Policy Goals

AI now permeates nearly every industry across the U.S. economy, with demand for AI talent projected to grow rapidly in the coming years.[10] While this offers enormous potential for economic growth and national security, the current pace of AI development will only continue with a sufficient workforce. The United States must sustain, diversify, and grow its AI talent pipeline to remain competitive. This includes not just top-tier technical talent, but also a sufficient supply of AI-literate talent across the entire workforce.

Previous CSET research identified three policy goals:[11]

1. Increase the supply of domestic AI doctorates.
2. Sustain and diversify technical talent pipelines.
3. Facilitate general AI literacy through K-12 education.

This paper addresses the second of these goals. The U.S. must leverage all parts of the education system—especially those that provide access to more diverse talent—if it is to sufficiently sustain and diversify its AI workforce. We believe a critical source of currently untapped potential in this effort is community and technical colleges. These institutions serve traditionally underrepresented populations and offer a stepping stone to both well-paying careers that do not require a four-year degree, and careers that do.

### *AI Occupations and Educational Attainment*

Previous CSET research defined the AI workforce as “the set of occupations that include people who are qualified to work in AI or on an AI development team, or have the requisite knowledge, skills, and abilities (KSAs) such that they could work on an AI product or application with minor training.”[12] We count entire occupations, because we are interested in the total pool of possible AI talent. There are 54 occupations that constitute the “AI workforce,” comprising about 14 million workers in 2019, about 9 percent of total U.S. employment.

We distinguish AI workers through four occupational categories, two technical and two nontechnical:

(1) Technical Team 1: occupations that are or could be actively working in AI, are needed to provide technical inputs into AI applications, or could laterally move into an AI development role. (Examples: computer scientist, software developer, network and database administrator.)

(2) Technical Team 2: occupations that have the related KSAs to perform technical roles on an AI team, either as is or with some minimal additional training. (Examples: electrical engineer, web developer, IT support.)

(3) Product Team: occupations that complement AI technical occupations in product development. (Examples: product managers, legal compliance officers.)

(4) Commercial Team: occupations that provide support for the scaling, marketing, or acquisition of AI at the organizational level. (Examples: sales engineers, purchasing agents.)

**Educational Attainment and Field of Study of the AI Workforce**

- While a large share of the AI workforce has at least a bachelor's degree, particularly in technical occupations, a sizable share does not. Technical Teams 1 and 2 occupations had the lowest share of workers with less than a bachelor's degree, with 28 and 24 percent respectively. Product Team occupations had the most at 44 percent, and Commercial Team occupations split the difference with 34 percent.
- Previous CSET analysis also estimated the top fields of study for the AI workforce by each category. Almost half of all workers within Technical Team occupations pursued majors within computer and information sciences or engineering. The most common field of study for Product and Commercial Team occupations was business, which also made the top five fields for the Technical Team occupations.[13]

### *Linking College Majors and Degrees to AI Occupations*

Two considerations must be made regarding the transition from AI-related credentials to AI occupations.[14] First is the appropriate fields of study (majors) needed for AI occupations. Second is the type of degree or nondegree award needed to effectively compete for and succeed in AI careers.

Regarding fields of study, the link from college major to occupation is not linear. As mappings from the U.S. Census Bureau show, many people move in and out of occupations—including STEM occupations—having a range of college majors.[15] For example, estimates show 18 percent of science and engineering workers do not have a science or engineering degree.[16] That said, the data suggests a much stronger correlation between degree and occupation in STEM, as well as certain non-STEM fields such as business.

This paper leverages the stronger correlation between STEM and business degrees to careers as it relates to key AI occupations. It considers this association as a starting point for measuring current talent pipelines and for designing new AI-specific programs. It assumes these fields of study are more likely to prepare graduates for key AI jobs, given the range of computer-related and business-related occupations included in the AI workforce categories above.

Regarding degree type, at the heart of this paper is an argument that community and technical colleges, if harnessed and equipped, could prepare tomorrow's AI workers as a viable alternative to four-year degrees. This begs the question of how many AI jobs now and going forward—including technical jobs—will require a four-year degree. That is a challenging question to answer. The debate around the broader four-year degree push remains an active point of discussion among economists, particularly in the "digital revolution" of the last decade. Here we look to the facts: Over 60 percent of the U.S. workforce does not have a four-year degree. One-third of the AI workforce does not have a four-year degree.[17] That means not all jobs, even in AI, require one.[18] More importantly, it means the ideal of everyone getting a four-year degree is unrealistic. Instead, such a limiting mindset leaves valuable talent behind.

The question becomes whether the tasks and skills involved in new and growing occupations, particularly in AI, actually necessitate a four-year college education. We argue that given the size of the AI workforce without one, the answer is not always. Alternatively, it is worth asking if "degree inflation"* is also behind the high share in AI-related job postings "requiring" a four-year degree.[19] Likely, it is a combination that is mutually reinforcing.

Regarding the increasing "requirement" for a four-year degree, we believe the issue is twofold: (1) the inability of the U.S. K-12 education to equitably equip youth with core skills (academic and nonacademic), and (2) the lack of employer-accepted alternatives to obtain such skills, in addition to the technical and nontechnical skills needed for AI jobs, outside of a four-year degree (the purpose of this report). We further believe some "degree inflation" is enabled by the sharp increase in people obtaining four-year degrees over time.[20] Indeed, statistics show more people are going to graduate school as a way to stand out to employers as the bachelor's market becomes more saturated.[21] The consequences of this ripple throughout the economy: for example, it is graduate-level student debt that drives the majority of new and outstanding federal student loans.[22]

Taken together, this suggests a starting point for leveraging community and technical colleges is to prepare talent for AI occupations that are less likely to require a four-year degree and/or fields of study that have a strong correlation to AI careers. This leads us to focus on computer and information sciences (CIS), select engineering technologies, and select types of business operations, which is the focus of the analysis in this report.

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* By "degree inflation" we mean the inflation of degree requirements for jobs whose associated tasks and skills are not commensurate with a higher level of education. The U.S. Federal Reserve Bank of New York studies this in detail, for example, tracking recent graduate underemployment.

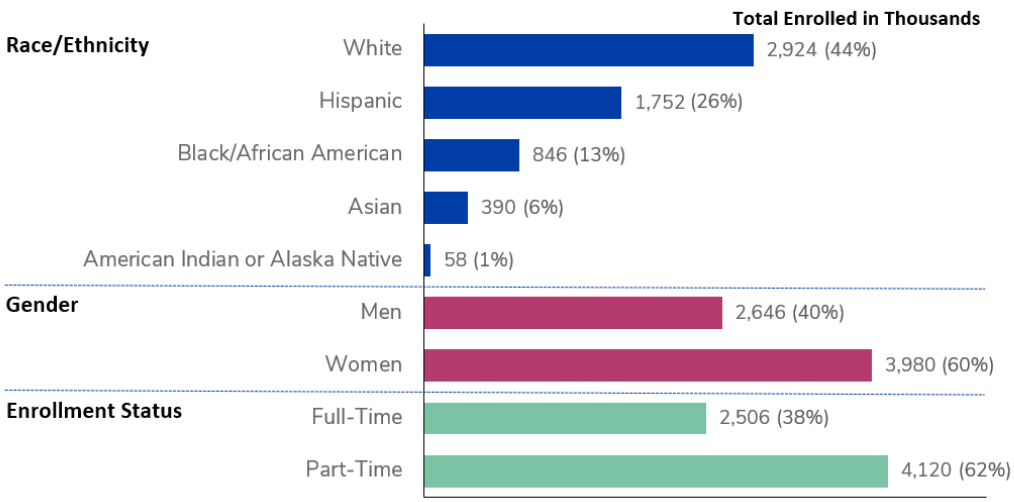
## The Promise of Community and Technical Colleges

Community and technical colleges offer enormous potential to grow and diversify AI talent. Several factors make them such a powerful asset, including their ability to reach students who are traditionally underrepresented at four-year institutions, lower tuition costs, full- and part-time offerings, and a proven track record of career and technical training. They also serve as a gateway for students to obtain higher education who are not interested in or able to pursue a traditional four-year degree or who intend to transfer into a four-year degree program.

### *Diverse Demographics*

One of the greatest strengths of community and technical colleges is the demographic diversity of the learners they serve. This is a key advantage of these institutions, as previous CSET research has shown that these populations are underrepresented in many occupations considered part of the AI workforce.[23] Figure 1 provides the demographic composition of students enrolled in community and technical colleges in the fall of 2020.

Figure 1. Community and Technical College Student Population, Fall 2020




*Note that race/ethnicity data shown here does not include the categories two or more races, race/ethnicity unknown, and nonresident alien. Total for credit student enrollment in community and technical colleges in fall 2020 was 6,625,612.

Source: NCES/IPEDS; CSET calculations.

Figure 1 shows just how diverse the student population is at community and technical colleges. Black/African American, Hispanic, and Asian students made up over 45 percent of enrolled students in 2020. Part-time students also made up over 62 percent of enrolled students, compared to only 19 percent of undergraduates who are part-time at primarily baccalaureate institutions. These institutions also serve a disproportionate number of adult learners over age 25.[24]

### *Flexibility and Affordability*

Many community and technical colleges—namely public institutions—must admit everyone with few exceptions. Private not-for-profit and for-profit two-year institutions are also generally less exclusionary than most four-year institutions. They provide both full- and part-time programs, which enables flexibility for the many other time commitments placed on adult learners.

Moreover, public two-year institutions are relatively inexpensive. They are especially affordable when compared to four-year colleges and universities. For the 2018–2019 school year, average total tuition, fees, room and board rates charged for full-time undergraduate students was only $11,389 for two-year institutions, while four-year institutions averaged $28,123.[25] For those that wish to transfer into a four-year degree program, community and technical colleges offer the option to accrue credits at a fraction of the price, often at locations close to their home, that can then be put toward a four-year degree.[26]

There are many reasons students might prefer community and technical colleges. For example, an individual might have a full-time job, be a family caretaker or have dependents, or lack the financial resources to pay for an expensive four-year degree. Community and technical colleges offer solutions to many of those issues, as they are geographically distributed across states.

### *Career and Technical Education (CTE)*

In addition to traditional degree programs, community and technical colleges provide a range of career and technical education programs.[27] These programs can lead to workforce development-focused credentials, including applied associate degrees, certificates, industry-recognized certifications, and credit or noncredit courses that serve as training for specific employers.[28] Many two-year institutions offer specific career and technical education (CTE) pathways, which can begin as early as middle school,[29] and teach career field-specific skills and competencies. Such programs can offer a critical avenue to middle skill jobs that do not require a bachelor's degree.[30] One example is Forsyth Technical Community College, which offers a CTE pathway that prepares participants for Cisco's certified network associate certification exam.[31] Other training programs in sectors such as manufacturing lead to standardized certifications endorsed by national industry associations.

Federal programs like the Trade Adjustment Assistance Community College and Career Training and the National Science Foundation Advanced Technical Education program encourage the development of career pathways at two-year institutions through grants. Best when developed with significant input from local employers, more effective CTE programs provide job search assistance and have work-based learning opportunities such as internships.[32]

***Stackable Credentials***

Stackable credentials are incremental awards that allow individuals to demonstrate competency in a certain skill or ability. They are designed to facilitate employability, and progressive credentials are able to be "stacked" in pursuit of more advanced credentials. Individuals can pursue additional credentials at their discretion, resulting in more flexibility in their education and training process. For example, a student might earn a skills certificate in machining, and then return at their own pace and apply those credits to an associate's degree in advanced manufacturing. This amplifies the already accessible nature of community colleges for first-time-in-college (FTIC) students, part-time learners, or adults looking to upskill or reskill.

Some states are leading the way on these programs. Ohio has a coordinated state-wide effort to implement stackable credentials through legislative initiatives. The state has grown the amount of short-term certificate programs in health care by 146 percent, and in manufacturing and engineering technology by 171 percent. As certificates earned increased, so too did the number of stacked credentials and subsequent degrees earned, with accompanying gains in earnings with each credential. While not the only type of institution providing these programs, community colleges did account for about 87 percent of first-time certificates.[33]

Other states have also worked with their community college systems to develop stackable credential pathways. This includes 17 states that have allocated funding to that purpose, and 10 states that have made stacking options a requirement.[34] For states integrating industry certifications into their stackable credential pathways, it is critical to ensure those credentials are high quality and marketable to potential employers. Given the proliferation of certifications, particularly in AI and related competencies that have no accreditation or quality standards to measure against, this is essential but difficult. Three states, Florida, Kansas, and Louisiana, have made strides in verifying and endorsing specific credentials through business and industry buy-in, cross-institutional review process, and differentiation of credentials by rigor and industry demand.[35]

## Challenges Faced by Community and Technical Colleges

Great promise comes with great challenges for community and technical colleges, particularly as it relates to preparing tomorrow's AI workforce. Yet there are long-standing reasons for why their potential has been notoriously under-realized. Some of these challenges are more general on an institutional or system level, and apply equally to AI-related programs. Others are more specific to CTE and STEM programs, and also affect technical AI-related programs.

The greatest challenge for AI-specific programs is that few appear to exist.[36] The challenge is therefore how to repurpose or modify existing and related programs, and thoughtfully create new programs. Adding to this is the need to effectively market those programs to serve a diverse student population, ensure that students complete these programs, and find themselves gainfully employed in AI careers.

Effectively training tomorrow's AI workforce will require working through many of the general and CTE or STEM-specific challenges outlined in this section. Together, these challenges create a complex operating environment that cannot be quickly or easily resolved, but affect these institutions' ability to offer AI-related programs that best serve their student population.

***Uncertain Funding Environment***

Perhaps the greatest challenge affecting community and technical colleges is their uncertain funding environment. Public institutions in particular suffer from continued underfunding. Nationally, figures from the State Higher Education Executive Officers Association show state funding levels remain 6 percent and 15 percent below 2008 and 2001 levels.[37] Over 2008–2018, state funding fell in 41 states, with 19 states cutting per student expenditures by over 20 percent (inflation-adjusted).[38] As a result, reliance on tuition revenue, through private sources and federal student aid, has steadily increased.

Recent years of declining enrollment accelerated by the COVID-19 pandemic have only exacerbated funding challenges.[39] State funding—one primary source of funding for community and technical colleges—is driven in part by enrollment numbers. The fewer students enrolled, the less funding an institution receives.[40] Community and technical colleges have been hit particularly hard by the pandemic, with freshman enrollments down 10 percent in fall 2020, and an additional 3 percent in fall 2021.[41] When combined with new costs like remote learning support, testing and contact tracing requirements, and social distance measures, the COVID-19 pandemic has strained already insufficient community and technical college funds.

Another consequence of traditional funding streams has been limited fluidity between adult education, CTE, and degree-bearing programs. This is because of legal, administrative, and other restrictions associated with multisource funding streams, such as differences in general education requirements, historically siloing these programs. Many adult education programs, for example, are funded through Department of Labor grants (e.g., Perkins and the Workforce Innovation and Opportunity Act) while traditional degree programs are funded as noted above. The requirements associated with these streams are quite different.

***Diverse Student Needs***

The diverse population of students served by community and technical colleges also have a range of needs. Additional needs of the community and technical college student populations include English as a second language (ESL) support, learning disability support, specialized tutoring, mental health counseling, food pantries and shelters, child care, and transportation, among other needs. As a result, many community colleges have invested in wraparound supports to provide such resources, although limitations on available funding and counseling support remain a challenge.

***Competing Priority Overload***

Balancing many competing priorities is a challenge all community and technical colleges face. While providing many educational and noneducational services is a great strength and allows them to serve communities in a wide variety of ways, attempting to fulfill too many missions can sap efficiency across each and strain limited fiscal resources.

Because of financial constraints, community and technical colleges must choose how to spend their limited funds. The competing priorities of various stakeholders like system administrators, faculty, state legislators, and industry associations complicate this due to the pressure they can exert on institutions. For example, some legislative priorities may focus on reforming developmental education while others emphasize general completion. Institutional priorities may also include piloting new courses or industry partnerships, staffing courses, providing student supports, technology modernization, and departmental reorganizations. However, the need to diversify and grow the AI workforce, in both technical and nontechnical fields, could be an opportunity to provide renewed investment in these institutions.

***Lackluster Career and Technical Education Outcomes***

What is a success above is also a challenge: while evaluations of CTE programs are promising when designed and implemented well, many programs face key barriers in funding and execution which limit success. These barriers affect program quality, which in turn negatively affects completion rates and student outcomes.[42] In terms of funding, the traditionally separate funding stream for CTE programs can pose limits on the ability for institutions to compete for qualified faculty and invest in appropriate equipment and facilities. In terms of execution, in many cases there is a mismatch in incentives for institutions and local area employers to work in close partnership on program design, work-based learning opportunities, and eventual hiring. When these partnerships do not exist, exist in name only, or exist with the wrong employers due to resource constraints in building relationships with the right employers, institutions work independently to create program content which may not reflect local area needs.[43] If built-in industry certifications are not high quality or marketable to employers, this presents yet another challenge.

***Low STEM Completion Rates***

Retention and completion rates of two-year colleges are persistently low, particularly in STEM fields. For all fields, the completion rate of obtaining a credential at two-year institutions within three years of enrollment was 33 percent.[44] For STEM, a 2016 study showed completion rates for any STEM credential within six years of initial community college enrollment was just 21 percent.[45]

STEM-related transfer rates and completion rates from two-year to four-year programs are also notoriously low.[46] One 2019 study estimated just 6 percent of community college students who transferred to a four-year school and received a bachelor's degree were in STEM-related fields.[47]

Many factors contribute to low completion rates in STEM fields. Among the more significant ones are high rates of placement into noncredit developmental education, insufficient academic and career advising services, and student needs in and beyond the classroom.

For example, over 60 percent of students entering community college are deemed not college ready.[48] Of these students, significantly more are deemed not college ready in mathematics.[49] Worse, just 20 percent of students referred to developmental mathematics make it through the sequence to complete the gateway course.[50] As a result, more states are consolidating or removing their developmental education programs.[51] For students who are more likely to truly need developmental support, that poses a different risk.

***STEM Faculty Recruitment and Retention***

Community and technical colleges face persistent difficulty in attracting qualified instructors, particularly in technical fields such as computer science.[52] Low salaries for community college instructors juxtaposed against the high wage rate of private sector jobs in these fields creates a difficult dynamic. Further, many community colleges do not have strong IT support capabilities or physical infrastructure necessary for technical courses, making the task of attracting suitably qualified candidates even more difficult.[53]

## The Latent Potential: Current AI Education and Training

Relatively few degree and nondegree awards at U.S. community and technical colleges are in AI or AI-related fields. Given the current and projected need for AI-related technical and nontechnical skills,[54] this suggests that there is untapped potential for these institutions to leverage. We believe elevating and modifying current offerings is an important step, and that first requires understanding the current attainment landscape.

We intentionally focus on programs where associate's degrees and certificates could be a powerful source for training and upskilling AI talent. We selected fields of study for analysis based on: (1) our technical and nontechnical AI occupation list as previously defined by CSET[55] and (2) occupations less likely to require a bachelor's degree or higher, programs for which these institutions are well-suited. As discussed earlier, this focused our analysis on computer and information science (CIS), selected engineering technologies, and selected business operations fields of study.

We analyze degree and nondegree certificate awards based on the Classification of Instructional Programs (CIP), an official taxonomy of fields of study. All institutions annually report completions data to the U.S. Department of Education using this taxonomy. More information about our methodology is provided in Appendix A.

Although we focus on 2020 data, we do consider historic trends in these fields as it provides important insight. Interestingly, while some fields of study increased notably over the last decade, the fields of study explored here have all either remained relatively constant or declined.

### *Computer and Information Science (CIS)*

A small share of associate's degrees at community and technical colleges are awarded in CIS. In 2020, CIS comprised just 29,000 out of just over 937,000 total associate's degrees awarded at community and technical colleges, or 3 percent.[56] Similarly, CIS nondegree awards comprised 37,000, or about 5 percent of all nondegree awards.[57] These awards were predominantly in general CIS and IT systems networking.

Overall, more CIS certificates than degrees were awarded in 2020, demonstrating the importance of both types of awards for AI-related programs. The gap was largest in systems networking, general CIS, and IT management. Only in two fields, information science and computer science, were more degrees than certificates awarded. Table 1 shows the distribution of CIS degree and nondegree awards by sub-specialty.

Table 1: Computer and Information Science, 2020

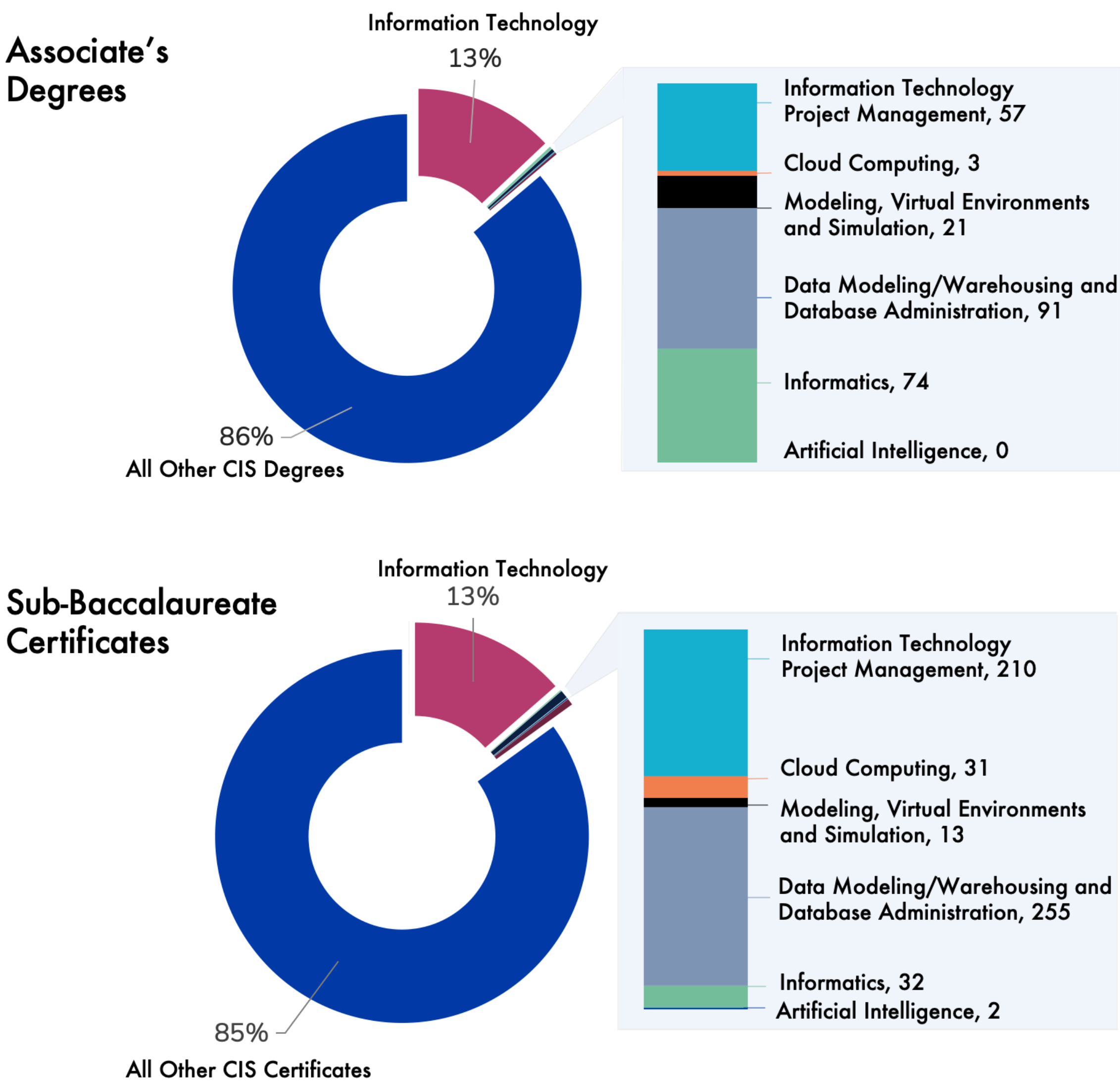
| Field of Study | Associate's Degrees | Sub-Baccalaureate Certificates |
|---|---|---|
| CIS, General | 8,324 | 12,331 |
| Computer/Information Technology Management and Administration | 6,203 | 8,503 |
| Computer Programming | 3,559 | 4,111 |
| Computer Systems Networking and Telecommunications | 3,370 | 5,910 |
| Computer Science | 3,120 | 146 |
| Computer Software and Media Applications | 1,980 | 2,999 |
| Data Processing | 865 | 1,004 |
| Information Science | 746 | 403 |
| Data Entry/Microcomputer Applications | 185 | 420 |
| CIS, All Other | 179 | 426 |
| Computer Systems Analysis | 93 | 321 |
| Total | 28,624 | 36,574 |
| Share of Total Awards, 2020 | 3.1% | 5.2% |

Note: Across all U.S. degree-granting institutions, there were 32,000 total CIS associate's degrees awarded, or 3 percent of all associate's degrees, in 2020. There were also about forty thousand CIS certificates awarded, about 5 percent of all such awards. An additional 6,059 sub-baccalaureate certificates were awarded in CIS in 2020 by nondegree granting institutions.

Source: NCES/IPEDS; CSET calculations.

Although the 2020 CIP codes include new subfields within CIS specific to AI—such as AI, cloud computing, and data warehousing—very few degrees or certificates were awarded.[58] Figure 2 shows the number of awards as a share of total CIS awards for these subfields. Our analysis also revealed that few community and technical colleges conferred AI-specific degrees and awards, similar to our investigation of institutions offering AI-specific programs.[59]

Figure 2: Few Credentials Were Awarded in AI-Related Subfields in 2020




Source: NCES/IPEDS; CSET calculations.

***Engineering Technologies***

We next analyzed a selected set of degrees and nondegree certificates in engineering technologies that closely relate to occupations identified as part of the AI workforce.

Similar to CIS, the data shows that few degrees and certificates were awarded in these specialties in 2020. Also similar to CIS, more certificates were awarded than degrees, with the exception of general engineering technicians and nanotechnology. The composition of awards is provided in Table 2.

Table 2: Selected Engineering Technologies, 2020

| Field of Study | Associate's Degrees | Sub-Baccalaureate Certificates |
|---|---|---|
| Electromechanical Technologies | 3,875 | 5,255 |
| Industrial Production Technologies | 3,327 | 5,453 |
| Drafting/Design Engineering Technologies | 2,998 | 5,465 |
| Electrical/Electronic Engineering Technologies | 2,736 | 3,855 |
| Mechanical Engineering Technologies | 1,453 | 1,505 |
| Engineering Technologies, General | 1,209 | 945 |
| Computer Engineering Technologies | 1,095 | 1,152 |
| Nanotechnology | 16 | 8 |
| Total of Selected Categories | 16,709 | 23,638 |
| Total Engineering Technologies | 21,083 | 29,766 |
| Share of All Awards, 2020 | 1.8% | 3.4% |

Source: NCES/IPEDS; CSET calculations.

We also analyzed the top-awarding states for these degree and nondegree certificates. Those results are presented in Appendix B. We note that Texas was the top-awarding state for both types of awards in 2020.

Additionally, we analyzed a related field of study that closely corresponds with another AI occupation, electrical/electronics maintenance and repair technicians.[60] We found a similar pattern of very few awards being conferred. Likely due to the nature of this field, almost four times more certificates were awarded than degrees. Just 1,612 associate's degrees were awarded, compared to 4,172 sub-baccalaureate certificates. The top state awarding sub-baccalaureate certificates was Georgia, while the top state for associate's degrees was California.

### *Business Administration Management and Operations*

Within the broader field of business administration management and operations, several subfields are directly applicable to key roles on an AI product team. This includes procurement and acquisition, supply chain management, and product management. Moreover, it is not obvious that training for such roles should require a four-year college degree.[61] As such, we also considered associate's degrees and nondegree certificates in these fields.

Table 3 shows the composition of awards for all business administration management and operations, and the selected subfields. We find very few awards were designated in the key fields of interest. Instead, the overwhelming majority of business degrees were awarded in general business operations and management.

Table 3: Business Administration Management and Operations, 2020

| Field of Study | Associate's Degrees | Sub-Baccalaureate Certificates |
|---|---|---|
| Business Management, General | 48,352 | 31,084 |
| Logistics Materials and Supply Chain Management | 670 | 1,291 |
| Operations Management | 222 | 3,536 |
| Procurement/Acquisitions and Contracts Management | 37 | 66 |
| Project Management | 36 | 171 |
| Science/Technology Management | 3 | 0 |
| Research and Development Management | 0 | 1 |
| Research Administration | 0 | 0 |
| Risk Management | 0 | 0 |
| Total of Selected Categories | 49,320 | 36,149 |
| Total Business Administration Management and Operations | 51,634 | 40,213 |
| Share of All Awards | 5.3% | 5.2% |

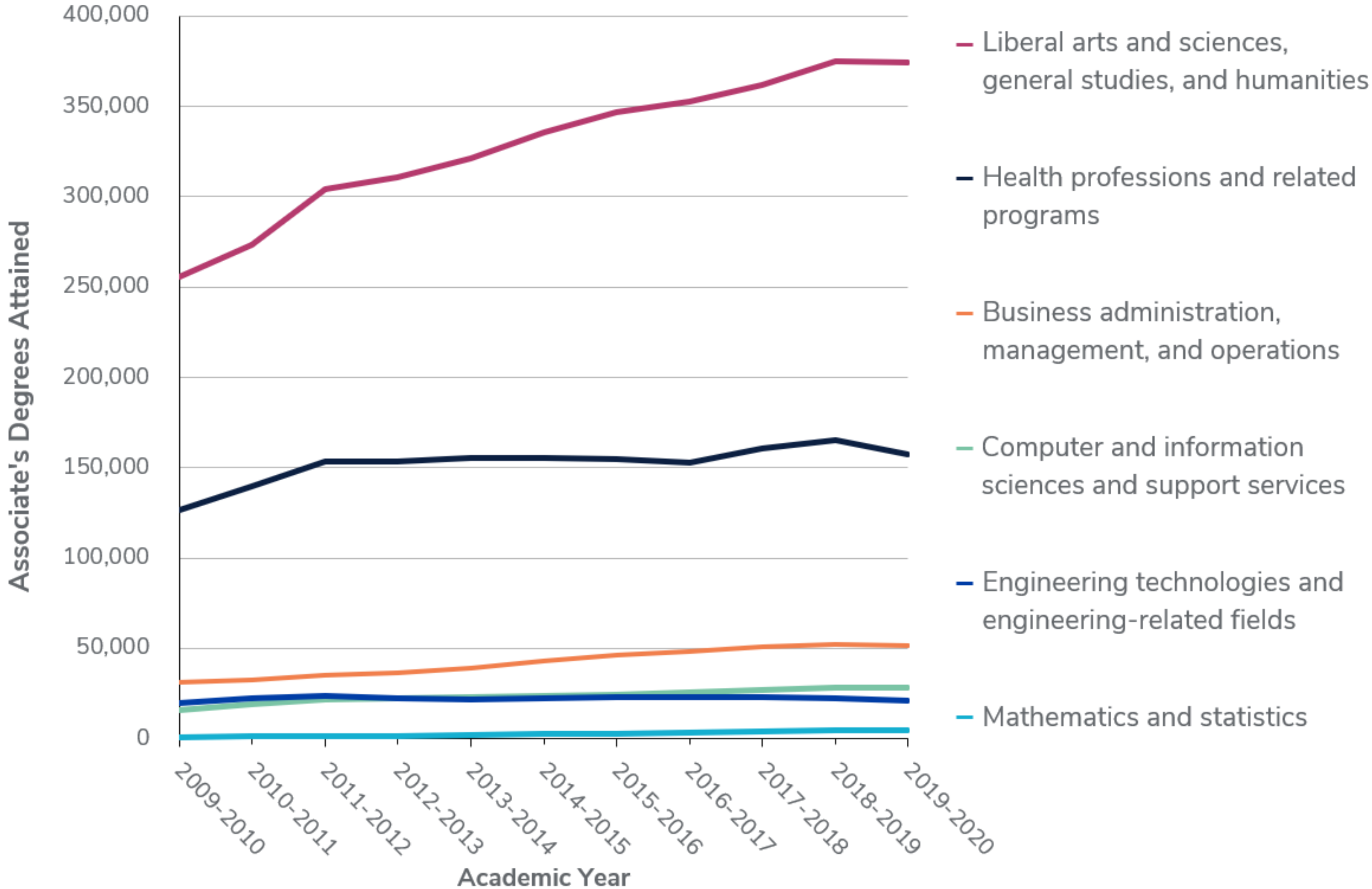
Source: NCES/IPEDS; CSET calculations.

We also considered the top-awarding states, with the results in Appendix B. We note here that a large concentration of awards, consisting of over half of associate's degrees and 60 percent of all certificates, are awarded in the top five states.

***More Latent Potential: Degree Attainment Over Time***

Credentials in these fields could prove incredibly valuable as a gateway into AI careers. However, historical data from the U.S. Department of Education shows associate's degree attainment across our fields of study of interest have either changed little or fallen in the last decade. For example, fields like CIS have consistently remained around current levels.[62] In contrast, even though total associate's degrees have remained flat since 2012, fields such as liberal arts and sciences, general studies, and humanities saw large gains.[63]

Figure 3: Liberal Arts Dominate Associate's Degrees




Source: NCES/IPEDS; CSET calculations.

## Realizing the Latent Potential

Understanding why AI-related attainment is so low, particularly in CIS and engineering technologies, is important to elevate these fields and pathways into AI careers. Here, we first provide several possible explanations that likely all contribute, in addition to the challenges noted earlier. We then discuss recent advancements in community and technical college education and highlight promising industry partnerships that could provide a promising roadmap for elevating and creating AI programs.

### *Understanding Low AI-Related Attainment*

Several factors likely contribute to low levels of award attainment in CIS and engineering technologies. One is the same gender challenges that affect many STEM fields.[64] While more women earned associate's degrees in 2020, degree attainment in CIS and engineering technology fields is predominately male. In 2020, only about 23 percent of all CIS associate's degrees and certificates and 15 percent of engineering technologies awards from community and technical colleges went to females.[65] That means that while these institutions are serving more diverse student populations, gender diversity is less reflected in these fields.

Limited levels of college readiness for more technical fields may be another barrier as noted in the challenges section above. For example, prerequisites and course requirements associated with many CIS programs could present a limitation for students, particularly those who are not college ready.[66] At Northern Virginia Community College (NVCC, commonly referred to as NOVA), for example, students are recommended to have 4 units of high school mathematics, as preparation for the required calculus and computer science.[67] Although NVCC was the top-awarding CIS associate's degree program in 2020, just 22 percent were women. That suggests that even at the largest programs more needs to be done in terms of academic and non-academic support to increase representation. This could partially explain the large growth in nontechnical fields of study over the last decade.

The continuing focus on four-year degree attainment for STEM-oriented fields further limits potential students from pursuing these fields.[68] Much discussion about the promise and purpose of community and technical colleges is focused on the transferability to four-year credentials when the reality is that transfer success rates for STEM fields is low. In addition to many students not being adequately prepared for core math and English courses, the lack of clear or any articulation agreements between institutions is a key limiting factor.[69]

Other factors relate back to the broader challenges facing community and technical colleges as noted in the challenges section. This includes availability of faculty to teach these courses and the traditional siloing of CTE programs from degree programs, limiting educational attainment. It also includes constraints in the availability of structured, regular, and tailored career and academic advising.

Ultimately, getting more students to pursue AI-related degrees and certificates is complex. It involves individual, social, and environmental factors, many of which are outside the control of community and technical colleges.[70] For example, student preferences, aptitude, influence networks, and financial standing all factor into career and educational decision making.[71]

However, we believe there is far more that community and technical colleges can do. To start, AI workforce training cannot happen without AI-specific programs or courses. As a new and emerging field of study, we also note the need for quality curricula and standards for certificates and certifications that relate to the many technical and nontechnical AI workforce roles, and that train students on the associated competencies. Here we point to the effectiveness of the National Initiative for Cybersecurity Education (NICE) framework, as it defined cybersecurity work roles and competencies to promote the creation of standardized education and training materials, and is regularly updated.[72]

Designing AI-specific courses and programs will also need to take the above challenges into consideration, particularly for more technical courses. That is, to fully realize the potential of such programs, they must be inclusively designed and marketed to encourage greater representation and high completion rates.

### *Advancements in College Completion*

As community and technical colleges elevate and create AI and related programming, incorporating other advancements in college completion can enhance the potential success of these programs. These advancements have a demonstrated track record of improving completion rates and job placement. We consider these advancements because many of the general issues that affect completion rates would apply equally to AI programs.

The Guided Pathways model encourages student completion by coupling predefined “meta majors” with intensive advising and job coaching.[73] These “pathways” or “meta majors” are designed by institutions to direct students into a career field but broad enough to enable multiple career options within the given field.[74] Rather than the traditional approach to offer a wide selection of courses that can overwhelm students, guided pathways are limited in number, simplifying the process. The core feature is structured programs with clear course roadmaps that lead to designated credentials. These credentials may be stackable toward degrees by design, careers, or further education. Students are guided both in the initial selection of a pathway and advised as they progress. This comprehensive redesign of programs and support services addresses many issues associated with low completion rates.

Approximately four hundred community colleges are involved in Guided Pathways reform efforts, including 16 state-wide initiatives.[75] Rigorous evaluation of these programs is underway, and early results are promising.[76] The guided pathways model could therefore offer insight in designing AI-specific programs.

Another recent development is the adoption of the corequisite model as a replacement for traditional remediation approaches. Using corequisites, which could range from a separate course, to a lab or office hours, students not academically prepared for a course are provided additional academic support. Much of the recent advancement has been centered around developmental education, helping students successfully complete gateway college-level courses sooner.[77] While longer-term benefits are less clear, providing corequisite support for more challenging AI-specific courses could also help students successfully complete those courses.

Other advancements concern "holistic" student advising as an upfront intervention and early alerts for drop-off in student performance during enrollment. The practice of holistic advising emphasizes the entirety of a student's experience, in course placement and in providing other support for at-risk students.[78] The implementation of early alert systems by some community colleges enables rapid response to at-risk behaviors, prompting intervention from institutional faculty and staff.

The final advancement we note is the less common, but no less important, practice of continuous improvement. Here institutions use data collection and analysis to continuously assess the cause of poor performance and then systematically test different solutions.[79] This approach emphasizes the knowledge of frontline educators on how to fix problems, focuses on processes, and requires iteration and dissemination of effective practices. As new AI programs roll out across community colleges, their success will depend significantly on appropriate evaluation and iteration of these programs, and sharing best practices.

***Advancements in AI-Related Industry Partnerships***

Industry partnerships to create new courses and pathway programs have promising outcomes for students. For example, Indian River State College in Florida has developed partnerships with Florida Power & Light for their electronic engineering and nuclear technology programs. Also, Boeing partnered with Mesa Community College beginning in 2019 to develop a boot camp to train electrical technicians,[80] and LaGuardia Community College worked with healthcare groups Mount Sinai Health System and Weill Cornell Medicine to create a medical billing program.[81] Partnerships like this allow for experiential learning opportunities and internships, and help ensure that programs are teaching the competencies desired by employers.

Partnerships for AI and AI-related fields are beginning to gain exciting momentum, especially as more employers are realizing the potential of community and technical colleges to meet their workforce needs. In just the last two years, announcements on promising industry-led partnerships to train AI and AI-related talent have come from companies like Amazon, Google, Intel, and Microsoft. Another planned program at Miami Dade College leverages a grant from the National Science Foundation.[82]

Here we highlight two examples that have a number of promising features: the Intel AI for Workforce Program and Amazon Web Services (AWS) Academy.[83] We also highlight a job placement organization, Hack.Diversity, that effectively places Black and Hispanic students in AI and AI-related jobs from community colleges. While still under piloting and evaluation, these efforts could offer insight for the design of new AI programs. We spoke with representatives from these organizations about each program to learn more, and provide program details in Appendix D.

### Intel AI for Workforce Program and AWS Academy

The Intel and AWS Academy programs share a number of features that mirror best practices for program design regardless of field. These include:

- **They provide instructional materials to community colleges to teach industry-relevant skills**. Intel provided 225 hours of AI educational content spread across four modules. AWS Academy provides access to free AWS "ready to teach" cloud computing curriculum for educators, along with the ability for educators to create an AWS Learner Lab that allows students to work directly with select AWS Services.[84]
- **They support faculty and administrators in the integration of the materials into existing curricula or new programs.** Intel provides four pre-packaged courses—64 hours each and designed to be completed in a semester—of teacher education, and the option to become a certified Intel AI trainer. AWS Academy offers complimentary AWS professional training for educators to assist them in becoming accredited instructors.
- **They contain stackable credentials that lead to a degree.** Intel developed an AI associate degree program and some programs grant stackable

credentials upon module completion.[85] AWS Academy certification pathways all start with a foundational cloud course and certification that can be built upon to obtain additional AWS certifications. AWS certification programs offered in collaboration with educational institutions vary by region, but all embed microcredentials into the coursework that lead to an industry certification, a certificate, and/or a degree.[86] In Los Angeles, courses culminate in an AWS certificate. In Northern Virginia, they have developed a two-year associate's degree program with an embedded certificate that can lead into a four-year program at partner universities.

- **They collaborate with stakeholders including state and local government, and school administrators and faculty.** Intel, in its Arizona partnerships, worked closely with the Maricopa County Community College District and the Arizona Commerce Authority. In its initial southern California partnership, AWS worked with 19 community colleges and the Strong Workforce Program, as well as local tech companies to align curriculum with in demand skills.

In January 2022, Intel announced a new expansion of their program, naming it the AI Incubator Network, which will provide experiential learning to students at participating community colleges.[87] This program was formed in collaboration with the American Association of Community Colleges and Dell, and seeks to design and build AI labs at 10 community colleges to increase access to AI equipment, tools and resources, and to inform future AI programming.

Just as both programs share many of the same strengths, they also share challenges. Given that they are still new, neither program has strong evidence of positive labor market outcomes for participants. They also lack robust outcome data-tracking methods. This gap makes it difficult to ascertain the efficacy of the program in increasing graduate employment and wage outcomes.

### Hack.Diversity

Hack.Diversity is a nonprofit that is promoting alternative pathways to AI and AI-related jobs for Black and Hispanic students.[88] It partners directly with a variety of nontraditional pathways into tech, including community colleges, vocational programs, professional learning programs, boot camps, and self-learners to select one cohort of fellows each year. Most importantly, it has a track record of placing talent from community colleges into engineering and data jobs.

The program creates partnerships with two- and four-year universities, including every community college in the greater Boston area, and companies which have job openings in applicable technology fields.[89] The universities and companies form each end of an internship-to-employment pipeline, with Hack.Diversity assisting the transition through a cohort-based mentoring and guidance program for participants.

From 2017–2021, over 80 percent of fellows seeking full-time employment received offers.[90] Over its five program cycles to-date, they have bridged more than 250 Black and Hispanic professionals into first jobs as software engineers, data analysts, and IT professionals. In 2022, the program's sixth cycle, Hack.Diversity will support the success of 130 fellows across 32 employer partners.

### Other Partnerships

The Intel and AWS efforts are not the only AI-related industry partnerships. Another recently launched campaign from Microsoft seeks to harness community colleges to help address the need for more cybersecurity talent. They are providing free curricula and certification training, training faculty at 150 schools, and funding scholarships.[91] Another example is Google, which is expanding its Grow with Google community college partnership to include free access to its career certificate programs for all community colleges, and CTE high schools, for college credit.[92] These career certificates are available in IT, data analytics, project management, and UX design and are featured on the Coursera online learning platform. They are offered in both credit and noncredit courses, depending on the school.

## Policy Recommendations

There is great potential for community and technical colleges to be a mainstream educator of tomorrow's AI workforce. However, the reality is that this potential cannot be realized without additional support. These institutions are operating in a challenging environment that limits the ability to create new programs. Moreover, to fully realize this potential also requires employers accepting degree and stackable nondegree credentials as a pathway into AI jobs.

Our analysis shows that community and technical colleges have both a dearth in available programming specific to AI and AI-adjacent fields, and in the number of students completing AI and AI-related degrees. There are many reasons for this, including the historical challenges faced by institutions and the challenges associated with low attainment in AI and AI-related fields as detailed earlier. There is also the challenge of market value for nondegree awards, even though many exist and are more attainable for more people.

The implication is two-fold: (1) states, institutions, and industry must work together to create AI-specific degree and nondegree credentials accepted by employers, and (2) institutions, in collaboration with employers, must prioritize programmatic, advising, and early outreach changes that encourage more students and more diverse groups of students to pursue and complete credentials in AI-related fields.

Community and technical colleges need not start from scratch to advance these goals. They can and should leverage advancements and best practices in college completion and industry-institution partnerships. Moreover, our recommendations have applicability for STEM and the wider science and technology workforce which creates additional opportunity to learn from experiences in those programs. While our focus is on AI and AI-related programs, we acknowledge the applicability of the policies needed to other related fields given the common barriers that must be addressed.

These recommendations are designed to encourage more students of all backgrounds to pursue and attain AI and AI-related credentials. This will require realigning incentives while providing resources to facilitate these changes. We propose two sets of recommendations, at the federal level and for states. We do this because of the inherent design of the U.S. education system.[93] For community colleges, the majority of funding and oversight happens at the state and local level,[94] while course or program student learning objectives and curricula design happen at the institutional level. At the federal level, some oversight happens through the administration of federal financial student aid and review of institutional accreditation agencies. Other federal support is provided through designated grants to states, institutions, and researchers.[95] It is also at the federal level that a clear signal can be made for prioritization in AI education and workforce development.

***Federal Call to Action***

1. **The National Artificial Intelligence Initiative Office within the Office of Science and Technology Policy (OSTP), in coordination with the Office of the First Lady, should establish a strategic priority related to community and technical colleges.**

We propose OSTP, in coordination with the Office of the First Lady,[96] advance the role of community and technical colleges in educating and training AI workers by: (1) hosting an annual AI-specific community and technical college education conference, (2) creating an annual award for an outstanding institution, and (3) hosting a central repository of postsecondary AI program evaluations.

2. **Congress should establish a federal joint Department of Labor and National Science Foundation grant program for industry-institution partnerships in AI and AI-related degree and nondegree programs, including high school dual enrollment programs.**

Grants would provide institutions with the resources needed to design, evaluate, and test new programs, in close partnership with local industry. They would be designed to facilitate cross-enrollment between academic, CTE, and adult education programs, or bridge these programs through guided pathways as appropriate. If it is a CTE program, it would include an industry-accepted certification and a work-based learning component such as an internship.[97]

These grants would also include professional development funding for administrator, advisor, and faculty AI education, and funding for data infrastructure to collect and report program outcomes.

3. **Congress should enact federal tax credits for industry partnerships with community and technical colleges related to AI and AI-related programs.**

The examples of Intel and Amazon provide case studies for how companies are working with community and technical colleges to advance education and training for tomorrow's AI workforce. The incentive for such partnerships should be codified with a tax credit. The credit would extend to any companies engaged in the design, development, and deployment of safe AI who partners with one or more community and technical colleges in the development of curricula, faculty training and mentorship, degree and industry-accepted nondegree credentials, and apprenticeships.

4. **Congress should fund the National Institute of Standards and Technology (NIST), or other federal entity if appropriate, to conduct multi-stakeholder collaboration to develop a framework of technical and nontechnical AI work roles and competencies, updated regularly.**

These definitions can be used by educational providers to design AI-related curricula, and by third-party independent accreditation agencies or industry associations to develop industry-accepted AI certifications standards.

We do not call for a replication of NICE, but instead call for a high-level framework that defines technical and nontechnical AI work roles and competencies.[98] It should be updated regularly, ideally used to create consistent, quality, accessible education and training materials similar to NICE.

We believe this framework is essential to advancing AI education and workforce training in the United States, but the private sector lacks both the momentum and a clear independent AI-specific professional standards-setting organization to fulfill this role. However, we acknowledge NICE was a one-time commitment and not typical of NIST's mission. Yet NICE has been very successful in terms of facilitating standardized and accessible education and training materials, including certifications.[99] Moreover, NIST is a qualified, credible agency for creating such a framework for AI. We could not think of a better federal agency to take on this role, but welcome alternatives as appropriate.

Alternatively, Congress could provide funding for NIST to facilitate the convening of stakeholders, and oversee a grant or contract to a third-party neutral authority or national industry association to develop the framework. If industry stakeholders see sufficient value, the convening organization could charge membership fees to sustain the process past the sunset of federal funds.

***State Call to Action***

5. **States should facilitate articulation agreements between public two-year institutions and four-year institutions for transfer and reverse transfer for AI and AI-related courses.**

All states should encourage articulation agreements between two-year and four-year public institutions for AI and AI-related fields. We note such agreements may ultimately be broader than AI-related coursework, but given the challenges with such agreements propose to focus on AI. We also note this may require two-year and four-year colleges to better align courses for credit determination, and that this is a positive. Some institutions may need funding and technical support to create these arrangements, and further recommend states provide that support as needed. Finally, we note the increasing trend for two-year colleges to award bachelor’s degrees, and for four-year colleges to award associate’s degrees. This is not mutually exclusive but instead promotes greater coordination and collaboration between the two systems.

Finally, we note a proposal commonly cited but one we do not include here. That is, a state-level tuition or financial aid forgiveness program for students attaining AI and AI-related degrees and nondegree awards. We acknowledge 34 states currently offer some form of free community college, many also called “promise” programs.[100] These programs pay remaining costs of tuition and materials after federal and other aid has been applied, including Pell Grants. Some states, like Florida, target STEM majors, while others do not.[101]

We do not propose a tuition or aid reimbursement program because of the complexity required to effectively incentivize students to pursue and complete AI and AI-related degrees. Research evaluating these programs suggests mixed effectiveness, where some students benefit more than others, raising questions of equity and fairness.[102] The findings also suggest benefits are on higher enrollment over completion.[103] At some level, students taking on some of the financial risk for their own human capital investment helps motivate completion. Moreover, it is not clear the extent to which financial hardship is a driving factor in choosing these fields of study.

***A Vision for the Future of Higher Education***

We have a vision for a higher education system that could start with AI and AI-related programs at community and technical colleges. It builds off of the work of proponents of stackable credentials, taking their ideas one step further. Instead of creating more stackable credential programs alongside existing degrees, our vision is to completely redefine college degrees as packages of stackable credentials. It breaks apart the monopoly of college degrees in higher education and replaces them with competency-based credentials that mix and match and progressively stack.

This requires a fundamental shift in how colleges think about degrees, and the knowledge, skills, and abilities associated with them. It will mean decomposing fields of study into core competencies, and eventually changing the notion of a degree entirely. The goal is to create opportunities for all students to earn credentials that have proven market value, promote lifelong learning, and acknowledge that jobs and the skills needed are rapidly evolving. It should never be the case that life is a financial struggle just because someone does not fit the mold of a traditional college graduate.

Community and technical colleges can lead the way by using AI and AI-related programs as a new opportunity, spurred by these recommendations. These programs should include many entry and exit points, and be based on accumulating several industry-recognized nondegree awards for identified critical competencies. These credentials should be both marketable as standalone awards and have a clear guided pathway to earning two-year, four-year, and graduate-level degree equivalents. Programs could be technical and nontechnical to account for the many roles and responsibilities involved in the design, development, and deployment of AI.

Programs should be built using best practices highlighted in this report. This includes promising and evidence-based best practices like guided pathways, corequisites, mentoring, and access to other wraparound supports. This also includes experiential learning and collaboration with industry, and continuous improvement. Most importantly, they should design, iterate, evaluate, and then scale what works. They should publish data on enrollment, completion, and job placements, and share lessons learned.

Now is the right time for programs to move in this direction. First, the current environment creates an urgent need to overcome institutional inertia that has kept the status quo degree structure in place. There is a concerning rise in working-age adults without college degrees, particularly men, who are out of the labor force.[104] Youth are falling behind other countries in a host of important educational measures, and the COVID-19 pandemic has had a worrisome effect on youth education with impacts that may well reverberate for decades to come.[105] Everyone will increasingly need to routinely retrain or upskill to remain employable; lifelong learning is a reality for workforce competitiveness. Yet as it stands, we are in the Wild West of certifications, courses, and other online learning vendors, with little data on which provide meaningful returns on investment.

Second, stackable credentials programs now have the longevity needed to accommodate rigorous program evaluations. Findings from initial efforts are very promising in terms of degree attainment and future earnings premiums, as mentioned earlier in this report. Moreover, these findings also point to demonstrable best practices regarding program features and design elements.

Third, it will encourage the mixing and matching of credentials for the unique blend of skills and competencies that matches an individual's interests, aptitude, and employment marketability. This would provide educational and skills development options not readily available elsewhere in our education system, not only benefiting a broad and diverse range of Americans, but also greatly enhancing the labor pool for employers.

The risk of not acting is to choose stagnation over innovation in the higher education sector. A system of continuous learning structured around stackable credentials can help to meet the workforce needs of the future, bringing in those left out of the current education system to create opportunity for everyone. Workers on the sidelines of the labor force could leverage the many new onramps to education to reskill or upskill affordably. More broadly, if the higher education sector does not innovate to meet industry needs, industry may eventually decide to create and offer their own content without collaboration. This could make industry both the educator and employer, awarding more power and market share in a critical economic sector that should remain open and accessible to all Americans.

## Conclusion

Community and technical colleges have enormous potential to educate and train tomorrow's AI workforce. These are generally low-cost institutions, enable flexible enrollment, and serve a high percentage of underrepresented students and nontraditional learners. Further, although much of the discussion surrounding community and technical colleges focuses on transfer to four-year programs, many programs provide career and technical education designed to meet the needs of local labor markets.

However, while there is much latent potential within states' community and technical college systems, their emergence as a pathway to AI careers is not guaranteed. Our analysis finds relatively few AI and AI-related degrees and nondegree awards are currently awarded by community and technical colleges, and the entire system faces longstanding and entrenched challenges.

Fortunately, recent developments offer a path forward. Advancements in community and technical college education at innovative institutions have increased completion rates and placement into field-related jobs. The rise of stackable microcredentials and certifications for identified critical competencies also offers an exciting opportunity for designing programs in emerging fields as skill demands rapidly evolve. And more industry partnerships are working to create programs and course offerings in AI and AI-related fields.

Our analysis provides the baseline from which these programs can evolve, expand, and elevate to become viable alternative pathways into AI careers. We propose several ways that community and technical colleges could build their AI and AI-related programming in a way that works with industry to recognize the associated credentials. It includes both a federal and state calls to action.

Ultimately, we have a vision to reimagine degree programs entirely. It builds on the ongoing momentum in stackable credentials to make higher education credentialing entirely competency-based.

## Authors

Diana Gehlhaus is a research fellow at CSET, where Luke Koslosky is a research analyst.

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## Appendix A: Methodologies

This appendix will discuss two methodologies. First, the sample set included in this analysis relative to all institutions awarding associate's degrees and sub-baccalaureate certifications. Second, the approach to assessing AI and AI-related associate's degree and sub-baccalaureate certifications.

***Institutions Included in Analysis***

There are many ways of parsing data from the National Center for Education Statistics' (NCES) IPEDS, especially when choosing which institutions to include within queries. The focus of this paper is accredited institutions that primarily provide associate's degrees and sub-baccalaureate credentials, regardless of their specific sector designation. Because some two-year institutions offer baccalaureate degrees, they are classified within IPEDS as public four-year institutions. This means searching only for two-year institutions leaves out a substantial number of relevant schools.[106]

Thus the criteria used when selecting institutions for analysis was:

- Currently in the IPEDS universe
- Open to the public
- A participant in federal financial aid programs
- U.S. only
- Degree-granting, not primarily baccalaureate or above
- Degree-granting, associate's and certificates

These selection criteria include two-year institutions mentioned above that provide some baccalaureate degrees. It also includes a small number of four-year institutions that primarily offer associate's degrees, like Miami Dade College, but we deemed the inclusion of all associate degree granting institutions worth that addition.

### *Evaluating AI and AI-related Awards*

We assessed degree and nondegree certificate awards across selected fields of interest to understand how much community and technical colleges are currently educating and training students for AI jobs. We consider fields of study (i.e., major) since that is how colleges define and report annual completions to the U.S. Department of Education.[107] Our analysis is based on the 2020 Classification of Instructional Programs (CIP).[108]

We include all two-year as well as "not primarily" four-year U.S. degree granting institutions, noting associate's degrees and sub-baccalaureate nondegree awards can be conferred by any sector.[109] For example, about 3,400 of all CIS associate's degrees were awarded by primarily four-year institutions in 2020. This is due to differences in the design of each state's public higher education system.[110] Our analysis focuses primarily on 2020 attainment data because it is the most recent year in a rapidly evolving field and allows us to use the newest CIP codes. For example, the 2020 CIP includes several new AI-related fields of study, such as "cloud computing," and "human-centered technology design" in addition to existing fields such as "artificial intelligence" and "data warehousing."

We intentionally focus on programs where associate's degrees could be a powerful source for training and upskilling AI talent. We selected fields of interest based on: (1) our technical and nontechnical AI occupation list as previously defined by CSET[111] and (2) occupations less likely to require a bachelor's degree or higher. We believe the selected programs are relevant for preparing talent for AI careers that these institutions are well-suited for.

For completeness, we also considered mathematics, data science, and engineering awards. However, our analysis showed that these are examples of AI-related fields that have a high share of talent with at least a four-year degree. In 2020, very few associate's degrees were awarded in mathematics and engineering with only a handful awarded in applied mathematics, statistics, applied statistics, data science, and data analytics. Just 4,800 degrees were awarded in mathematics in 2020, and 6,300 degrees were awarded across all types of engineering. Moreover, of the 4,800 associate's degrees awarded in mathematics, over 80 percent—or 3,900—were awarded in California.

## Appendix B: Top States Awarding AI-Related Credentials

Table B1 shows the top five states awarding CIS degrees and nondegree awards at community and technical colleges, along with the total share of those respective CIS awards. Notably, almost half of all CIS sub-baccalaureate certificates were awarded in the top five states. Moreover, top-awarding states are not simply those with the largest populations. Kentucky leads in CIS certificates, with North Carolina also ranking in the top five.

Table B1. Top 5 States for CIS Degrees and Certificates, 2020

| Associate's Degrees | | | Sub-Baccalaureate Certificates | | |
|---|---|---|---|---|---|
| **Rank** | **State** | **Total** | **Rank** | **State** | **Total** |
| 1 | California | 3,081 | 1 | Kentucky | 3,891 |
| 2 | Texas | 2,416 | 2 | California | 3,531 |
| 3 | New York | 2,095 | 3 | Texas | 3,489 |
| 4 | Florida | 1,745 | 4 | North Carolina | 3,293 |
| 5 | Virginia | 1,679 | 5 | Florida | 2,838 |
| Top 5 Total | | 11,016 | Top 5 Total | | 17,042 |
| Share CIS Degrees | | 38.5% | Share CIS Certificates | | 46.6% |

Source: NCES/IPEDS; CSET calculations.

Table B2 shows the top five states awarding selected engineering technician degrees and certificates in 2020. Texas ranks first for both awards, and, similar to computer and information science, North Carolina appears in the top five for certificates. Interestingly, states like Louisiana are also in the top five, suggesting that their community and technical colleges must have specific programs actively targeting these specialties.

Table B2. Selected Engineering Technicians, Top 5 States, 2020

| Associate's Degrees | | | Sub-Baccalaureate Certificates | | |
|---|---|---|---|---|---|
| **Rank** | **State** | **Total** | **Rank** | **State** | **Total** |
| 1 | Texas | 1,688 | 1 | Texas | 2,237 |
| 2 | Ohio | 1,146 | 2 | North Carolina | 1,571 |
| 3 | Louisiana | 840 | 3 | Louisiana | 1,560 |
| 4 | California | 807 | 4 | Washington | 1,462 |
| 5 | North Carolina | 720 | 5 | Ohio | 1,285 |
| Total | | 5,201 | Total | | 8,115 |
| Share, Total Selected Technicians | | 31.1% | Share, Total Selected Technicians | | 34.3% |

Source: NCES/IPEDS; CSET calculations.

Table B3 presents the top five states for business administration management and operations awards. Here we can see over half of all associate's degrees and over 60 percent of all certificates are awarded in just the top five states. California leads in associate's degrees, with nearly 36 percent of total degrees granted. Florida has a similar proportion of nondegree awards granted, with nearly 37 percent of the total.

Table B3. Business Administration Management and Operations, Top 5 States

| Associate's Degrees | | | Sub-Baccalaureate Certificates | | |
|---|---|---|---|---|---|
| Rank | State | Total | Rank | State | Total |
| 1 | California | 17,734 | 1 | Florida | 13,327 |
| 2 | New York | 5,092 | 2 | Texas | 3,949 |
| 3 | Texas | 2,937 | 3 | North Carolina | 3,348 |
| 4 | Ohio | 1,984 | 4 | Indiana | 2,472 |
| 5 | New Jersey | 1,922 | 5 | Kentucky | 2,434 |
| Total | | 29,669 | Total | | 25,530 |
| Share, Total Business Administration Management and Operations | | 57.5% | Share, Total Business Administration Management and Operations | | 63.5% |

Source: NCES/IPEDS; CSET calculations.

## Appendix C: Top Institutions for CIS Graduates

Tables C1 and C2 show the top producing community and technical colleges for sub-baccalaureate CIS awards. Table C1 lists the top 10 institutions for CIS associate's degree awards in 2020 while Table C2 shows the top 10 institutions for CIS certificates.

Two institutions are a top 10 producer for both degrees and certificates: Ivy Tech Community College in Indiana and Valencia College in Florida. Ivy Tech, ranked high on both lists, offers programs spanning IT, software development, database management, cybersecurity, and cloud computing. Notably, for-profit colleges are also among the top awardees for both lists.

Table C1. Top 10 institutions awarding CIS Associate's Degrees, 2020

| Rank | Institution | State | Total |
|---|---|---|---|
| 1 | Northern Virginia Community College | VA | 925 |
| 2 | Ivy Tech Community College | IN | 435 |
| 3 | ECPI University | VA | 381 |
| 4 | CUNY Borough of Manhattan Community College | NY | 323 |
| 5 | Montgomery College | MD | 276 |
| 6 | Dallas College | TX | 272 |
| 7 | Austin Community College District | TX | 269 |
| 8 | CUNY LaGuardia Community College | NY | 243 |
| 9 | Gwinnett Technical College | GA | 204 |
| 10 | Valencia College | FL | 202 |
| Total | | | 3,530 |
| Total Share of CIS Degrees | | | 12.3% |

Note: This includes U.S. degree-granting institutions not designated as primarily baccalaureate or above.

Source: NCES/IPEDS; CSET calculations.

Table C2. Top 10 institutions awarding CIS Certificates, 2020

| Rank | Institution | State | Total |
|---|---|---|---|
| 1 | MyComputerCareer-Columbus | OH | 1,820 |
| 2 | Dallas College | TX | 948 |
| 3 | Ivy Tech Community College | IN | 912 |
| 4 | Jefferson Community & Technical College | KY | 877 |
| 5 | Wake Technical Community College | NC | 863 |
| 6 | Valencia College | FL | 709 |
| 7 | Bluegrass Community & Technical College | KY | 580 |
| 8 | Salt Lake Community College | UT | 500 |
| 9 | College of Southern Nevada | NV | 478 |
| 10 | Edmonds College | WA | 442 |
| Total | | | 8,129 |
| Total Share of CIS Certificates | | | 22.2% |

Note: This includes U.S. degree-granting institutions not designated as primarily baccalaureate or above.

Source: NCES/IPEDS; CSET calculations.

## Appendix D: Highlighted Partnership Details

We are seeing a recent increase in promising industry-led partnerships with community colleges to train AI and AI-related talent. While still recent and under piloting and evaluation, they could offer tremendous insight for how other programs might be designed and implemented. We highlight several along with notable features of each program. Information was provided by program representatives and CSET compilation based on publicly available documents.

***Intel AI for Workforce Program***

Intel commenced an AI associate degree program in June 2020 in partnership with the Maricopa County Community College District (MCCCD) and the Arizona Commerce Authority (ACA). In August 2021 it announced a broad expansion of this effort, in partnership with Dell Technologies, entitled the Intel AI for Workforce Program. This expansion will serve eight hundred thousand students across 31 schools in 18 states.

### Support Provided

Intel provides 225 hours of AI educational content spread across four modules. It also includes over 250 hours of teacher education, spread across four pre-packaged modules,[112] to assist in building out a curriculum from the material, which Intel guides faculty through. Over 80 professors have completed this training and are certified as Intel AI trainers. Intel also offers technical advisors to assist faculty upon request, and has built a peer support network for faculty as they build curricula from the provided materials.

### Program Design and Content

The content ranges from introductory material—basic AI literacy, including no code courses—to courses on AI/ML applications like computer vision and natural language processing. The final modules introduce projects featuring real world examples found in industries like manufacturing and healthcare, so that graduates of the course have tangible experience to showcase to employers. Faculty at participating universities developed their own curricula using these materials as the backbone, with support from Intel upon request, based on their institutions' structure and needs. Importantly, no prior technical computer experience is needed for students.

### Program Outcomes

The majority of community college partners are setting up the program as part of an associate of applied science or associate of science degree path with accompanying transfer agreements to nearby four-year universities for graduates. The latter examples would indicate that those community college partners do not see the program as sufficient for graduates seeking to enter a technical field. Another common approach is to grant stackable credentials or certifications upon completion of the Intel coursework, but this process is not standardized across the program.

### Collaboration Across Stakeholders

The Intel team emphasized collaboration with community college administrators and faculty, and with state and local agencies. They focused on ensuring that the educators and institutions had the tools and knowledge that they needed to effectively leverage the materials Intel provided to them. Soliciting feedback from faculty and administrators also helped Intel identify the gaps in their program design and deliverables. Open communication cemented buy-in from the educators tasked with implementing the curriculum, many of whom have become advocates and advisors to the new programs standing up across the country. Outreach to the ACA also secured a state grant to build out physical infrastructure for the program.

As the program expanded to other states, conversations with the National Governors Association helped to garner similar government interest in new locations. Many of the community colleges, including those from MCCCD, already had an interest in increasing their capacity for AI education, creating mutual interest from all sides. During the expansion, Dell Technologies also was added to the partnership. They provide input on how best to configure AI labs for part-time or full-time remote learning, and help community colleges procure some of the technology needed to build out on campus AI labs.

### Challenges

There are several challenges for program administrators as they implement microcredentials for coursework completion. There is no industry standard for certifications recognized by employers as a substitute for a four-year degree, and the use of stacking microcredentials is a relatively novel approach. Outside of transferring to a four-year university, program administrators remain uncertain how students apply what they learn to demonstrate aptitude to potential employers. Intel has been engaging with professional associations on the subject, but face difficulties due to the number of different associations and time to action across groups. Program officials indicated that there were some MCCCD students that would be hired into a summer internship program, with potential to transition to a full-time role post-internship.

Another area requiring additional refinement is the measurement of program outcomes. The program measures learning outcomes for enrolled students, and provides assessments for teachers to offer feedback on the course itself. However, there is limited collection of student outcome data besides information on student projects. This gap makes it difficult to ascertain the efficacy of the program in increasing graduate employment and wage outcomes. It is worth noting that the Intel team was fully aware of these challenges, and stressed the importance of beginning the building process even without all questions answered and challenges addressed.

#### *AWS Academy*

Amazon Web Services (AWS) Academy—formerly part of AWS Educate—is partnering with community colleges in Arizona, California, Connecticut, Georgia, Indiana, Louisiana, Texas, Utah, and Virginia to offer cloud computing associate degrees and certifications.[113] AWS originally began forming these partnerships in 2018 through AWS Educate, but has since shifted functionality for institutions to AWS Academy with accompanying changes in support provided to community colleges. Under AWS Educate, the creation and design of the program varied slightly by location, but it retained many consistent features across each. AWS Educate designed their models to scale, so that institutions could adopt the programs with relative ease. Their first partnership, the

California Cloud Workforce Project (CA Cloud), is an illustrative example of their program structure. Starting in Los Angeles, CA Cloud offers coursework at 19 community colleges. It was launched in fall of 2018 after a 2017 pilot program at Santa Monica College and is supported by over $200 million in annual investments from California's Strong Workforce Program.[114] [115]

This section will describe the AWS Educate programs as they were designed, and provide an overview of the services now provided under AWS Academy.

### Support Provided

In partnerships prior to AWS Academy, students received access to AWS Educate for free, which included instructional content for their classes, microcredentials—known as badges—in interest areas (e.g. Alexa, gaming, and Internet of Things), and access to AWS Educate Jobs Board. Educators also gained access to AWS services including virtual classrooms and tools to help teach students. Using these resources, community college faculty created their own curricula with technical support and assistance provided by AWS and other LA-based tech companies. The program also shared curricula developed by these community colleges with new partners as a reference point for their own curricula creation.

AWS Academy provides access to free AWS "ready to teach" cloud computing curricula for educators, along with the ability for educators to create an AWS Learner Lab that allows students to work directly with select AWS Services.

### Program Design and Content

The curriculum for CA Cloud was created by community college faculty with technical support and assistance provided by AWS and other LA-based tech companies. It was designed as an entry-level program, consisted of four core courses, and required 18 units for completion. These core courses were chosen to align to critical competencies required by employers. Each community college also formed agreements with high schools to offer concurrent enrollment in the certificate program. As of fall 2020, 3,555 students had enrolled in cloud computing courses.

AWS Academy courses are organized into certification pathways. Each start with a foundational cloud course and certification that can be built upon to obtain additional AWS certifications. The pathways that contain additional stackable certifications are cloud developing, architecting, operations, and machine learning.

### Program Outcomes

The programs within CA Cloud—and other locations—feature stackable microcredentials for each of the core classes, and culminate in a certificate from AWS upon completion of an exam. A partnership in Northern Virginia Community College (NOVA) and George Mason University (GMU) offers a slightly different approach. They developed a coordinated two- and four-year cloud computing degree program. Credits from NOVA's two-year degree are stackable with GMU's cloud computing degree program, and GMU is also able to grant credits to students with certain industry certifications. Within the two-year A.A.S degree in cloud computing is a one-year stackable career study certificate. Furthermore, within the Virginia Community College system, if one community college does not offer a course, a student may attend other schools' courses virtually and split tuition across institutions. The degree program was designed by both schools' faculty with support from AWS Educate.

As was previously mentioned, innovative partnerships with educators make little difference if there is no demand from employers for graduates. The AWS Educate representatives acknowledged this, noting an effort internally to hire more community college graduates.

### Collaboration Across Stakeholders

Coordinating shared curricula across a consortium of 19 community colleges, receiving support from state and local agencies, and forming partnerships with Los Angeles technology employers required significant buy-in and commitment from all stakeholders. It is unclear how large of a role AWS Educate played in this process. Other organizations like the Career Ladders Project, Los Angeles Economic Development Corporation, the Los Angeles County Office of Education, and the Center for a Competitive Workforce (CCW)[116] were also involved in fostering collaboration and providing support. Together with the Los Angeles Economic Development Corporation, CCW convened a regional advisory board with industry participation.

### Challenges

Similar to Intel's program, it is difficult to measure program outcomes for educators and participants. They track the number of institutions that launch the program, how many faculty are trained on AWS, and the number of students that enroll but struggle to track education and employment outcomes for students. Community and technical colleges struggle to track these metrics under the best of circumstances, often for reasons outside of their control. AWS Educate is attempting to find means of incentivizing self-reporting from program graduates. The job board provides an option to share success after interviews and provides additional resources upon completion of this submission. Despite this approach, this remains an ongoing challenge and will make it difficult to evaluate the impact of the program.

Another impediment is a shortage of instructors with cloud experience to teach these courses. While AWS works with teachers to accredit them through the content they offer, there is a base level of competence required to teach classes. Furthermore, if an instructor does take the time to upskill, they become potentially eligible for jobs in private industry that pay significantly more than the salary of a community college professor. This problem is not unique to community colleges—four-year universities face similar challenges.

#### *Hack.Diversity*

Hack.Diversity is an example of a non-profit group that is promoting alternative pathways to tech jobs, including AI and AI-related jobs, in a different way. It partners directly with a variety of nontraditional pathways into tech, including community colleges, vocational programs, professional learning programs, boot camps, and self-learners to select one cohort of fellows each year. Most importantly, it has a track record of placing talent from community colleges into engineering and data jobs.

Hack.Diversity launched its first program cycle in 2017 in Boston, MA, with a cohort of 16 fellows—early-career Black and Hispanic professionals in tech from undervalued education pathways. It featured six host companies as employer partners hiring for internship-to-retention opportunities. To date, they have bridged more than 250 Black and Hispanic professionals into first jobs as software engineers, data analysts, and IT professionals.

Its main goal is to increase the representation of Black and Hispanic professionals in tech through shifting organization behavior to successfully hire, retain, and elevate the contributions of Black and Hispanic early-career candidates. In order to bridge the gap between education and employment, Hack.Diversity creates partnerships with two- and four-year universities, including every community college in the greater Boston area, and companies which have job openings in applicable technology fields.[117] The universities and companies form each end of an internship-to-employment pipeline. Hack.Diversity assists transition through this pipeline using a cohort-based mentoring and guidance program for participants. The program does not focus on introductory courses, and applicants must possess a base level of around 18 months of exposure and literacy in their chosen field. After selection into the program, each cohort of fellows engage in nine months of technical project work, professional development, one-to-one mentorship from an industry professional, community building around identity and belonging, and network expansion. The last three months of the nine-month fellowship is placement into a paid internship-to-retention opportunity with an employer partner.

Program milestones include technical project completion, internship matching, internship completion, and permanent conversion offers. Hack. Diversity seeks to flip the power dynamic experience for fellows. Rather than applicants sending out large amounts of applications with little promise for a response, the program curates a pool of employers who then pitch their company during the interview. This emphasizes the responsibility that employers have to cultivate a climate of belonging for early-career Black and Hispanic candidates.

After matching their fellows into internships, the program works closely with fellows' employers and managers to maximize implementation of racial equity, diversity, inclusion practices, meeting of internship goals, and receiving continuing employment offers post-internship. It provides recommendations to companies and fellows to develop milestones for the internship, set high expectations, convey constructive feedback. It also collects experiential data from fellows to inform companies' workplace culture and management practices, especially how those processes align with stated values of diversity and inclusion. Hack.Diversity will work with companies to address any noted issues, a process that is expected and encouraged from the outset of the partnership. Importantly, they retain the right to end partnerships with companies if they are not deemed to be taking necessary steps to improve identified problematic practices.

When interns begin at their host company, there is an agreement that should they perform at a level that meets or exceeds predetermined expectations, the company will offer them continuing employment at the end of the internship. Between 2017–2021, on average, over 80 percent of fellows seeking employment post-internship receive offers.[118] However, permanent employment is not the required end state of all program participants. Hack.Diversity provides career guidance for fellows whether they are seeking continued education, additional certifications, or different employment options.

There were some noted challenges when placing interns from two-year institutions in host companies. First, there is a stigma, sometimes not explicitly stated, associated with hiring talent from community colleges. This can manifest as hesitancy to accept an intern or offer a paid role, or as inflexible job requirements that demand a four-year degree. Second, interns with associate degrees may receive lower salary offers independent of their performance of competence. Hack.Diversity works with their fellows to mitigate these issues, and requires progress from companies to remove barriers to pay and opportunity that do not relate directly to fellows' actual performance. While Hack.Diversity is currently a Boston-based effort, its next five-year plan includes expansion to other geographical areas, given its success locally and regionally. This success in placing underrepresented Black and Hispanic students from community colleges and other nontraditional institutions of higher education into tech industry jobs hints at the importance of the services it provides.

## Endnotes

[1] American Association of Community Colleges, “Fast Facts 2022,” 2022, https://www.aacc.nche.edu/research-trends/fast-facts/.

[2] They may also be credit-bearing or noncredit. See for more: Iris Palmer, “An Explainer: Non-degree vs Non-credit programs,” *New America*, March 24, 2021, https://www.newamerica.org/education-policy/edcentral/an-explainer-non-degree-vs-non-credit-programs/.

[3] U.S. Department of Education, “Community College Facts at a Glance,” accessed January 25, 2022, https://www2.ed.gov/about/offices/list/ovae/pi/cclo/ccfacts.html.

[4] There are many thousands of different programs that result in degrees, licenses, certifications, certificates, badges, microcredentials and other forms of credentials. In this report, the terms “awards” and “credentials” are used to capture all types. For a breakdown of the differences between credentials, see: Janet Forte, “Understanding Certifications,” *Workcred*, December 10, 2020, https://blog.ansi.org/workcred/understanding-certifications/#gref.

[5] See Ivy Love, Debra Bragg, and Tim Harmon, “Mapping the Community College Baccalaureate,” *New America*, November 2021, https://www.newamerica.org/education-policy/briefs/mapping-the-community-college-baccalaureate/; Sara Weissman, “Two-Year Institutions, Four-Year Degrees,” *Inside Higher Ed*, May 7, 2021, https://www.insidehighered.com/news/2021/05/07/arizona-allows-community-colleges-offer-bachelors-degrees.

[6] Across all U.S. degree-granting institutions. About three hundred thousand sub-baccalaureate certificates were also awarded at nondegree institutions in 2020, bringing total certificate awards to almost 1.5 million. Degree totals come from the National Center for Education Statistics, “Integrated Postsecondary Education Data System, Fall 2010 through Fall 2020, Completions component,” U.S. Department of Education, August 2021, https://nces.ed.gov/programs/digest/d21/tables/dt21_321.10.asp. Certificate totals are CSET calculations using IPEDS data.

[7] See Appendix A for further elaboration on the sectoral composition of associate’s degree and sub-baccalaureate certificate awards.

[8] Increasing to about 57 percent for all sub-baccalaureate certifications. We note that this is analogous for bachelor’s degrees; females earned 58 percent of all bachelor's degrees in 2020.

[9] Aims McGuinness, "Community College Systems Across the 50 States," National Center for Higher Education and Management Systems, January 28, 2014, https://www.leg.state.nv.us/interim/77th2013/committee/studies/commcolleges/other/28-january-2014/agendaitemvi,nationalcenterforhighereducationmcguinness.pdf?rewrote=1.

[10] Previous CSET research found that the demand for AI workers is projected to grow two times faster than the national average over 2019–2029. See for more: Diana Gehlhaus and Ilya Rahkovsky, "U.S. AI Workforce: Labor Market Dynamics" (Center for Security and Emerging Technology, April 2021), https://cset.georgetown.edu/publication/u-s-ai-workforce/.

[11] Diana Gehlhaus, Luke Koslosky, Kayla Goode, and Claire Perkins, "U.S. AI Workforce: Policy Recommendations" (Center for Security and Emerging Technology, October 2021), https://cset.georgetown.edu/publication/u-s-ai-workforce-policy-recommendations/.

[12] Diana Gehlhaus and Santiago Mutis, "The U.S. AI Workforce: Understanding the Supply of AI Talent" (Center for Security and Emerging Technology, January 2021), https://cset.georgetown.edu/publication/the-u-s-ai-workforce/.

[13] For a full breakdown of educational attainment and top fields of study by category, see: Gehlhaus and Mutis, "The U.S. AI Workforce: Understanding the Supply of AI Talent."

[14] This paper does not cover general issues related to education-workforce transitions, which is its own body of literature.

[15] Even in STEM occupations, workers come from a range of undergraduate disciplines within STEM fields and non-STEM fields. See U.S. Census Bureau, "Where do college graduates work?," July 10, 2014, accessed March 13, 2022, https://www.census.gov/dataviz/visualizations/stem/stem-html/.

[16] Amy Burke, U.S. *S&E Workforce: Relationship between Education and Occupation* (Washington, DC: National Science Foundation, September 26, 2019), https://ncses.nsf.gov/pubs/nsb20198/u-s-s-e-workforce-relationship-between-education-and-occupation#educational-background-of-workers-in-s-e-occupations.

[17] Gehlhaus and Mutis, "The U.S. AI Workforce: Understanding the Supply of AI Talent."

[18] Interestingly, economists often decompose occupations into competencies and tasks, and consider one's ability to perform those tasks in terms of knowledge, skills, and abilities. Yet much of the workforce preparedness discussion is focused on degrees, not competency-based education (CBE). This paper also pushes against the emphasis on four-year degrees with its vision for the future of higher education.

[19] Autumn Toney and Melissa Flagg, "U.S. Demand for AI-Related Talent" (Center for Security and Emerging Technology, August 2020), https://cset.georgetown.edu/publication/u-s-demand-for-ai-related-talent/

[20] National Center for Education Statistics, "2021 Digest of Education Statistics," U.S. Department of Education, Table 322.10, accessed March 13, 2022, https://nces.ed.gov/programs/digest/d21/tables/dt21_322.10.asp?current=yes.

[21] National Center for Education Statistics, "2021 Digest of Education Statistics."

[22] Abigail Johnson Hess, "Only 25% of those with student loans went to graduate school—but they owe around 50% of all student debt," *CNBC*, July 16, 2021, https://www.cnbc.com/2021/07/16/graduate-students-owe-around-50percent-of-all-student-debt.html.

[23] Gehlhaus and Mutis, "The U.S. AI Workforce: Understanding the Supply of AI Talent."

[24] For comparison, we estimate using IPEDS data that 81 percent of undergraduate students at institutions that are primarily baccalaureate or above were full time in 2020, and only 18 percent were above the age of 25.

[25] National Center for Education Statistics, "Fast Facts: Tuition costs of colleges and universities," U.S. Department of Education, 2021, https://nces.ed.gov/fastfacts/display.asp?id=76.

[26] In practice, this process can be complex. We discuss associated challenges in a subsequent section.

[27] In addition to programs that bridge the two through structuring credentials within a defined set of "meta majors," or "guided pathways." We discuss this more in detail in a subsequent section.

[28] We note the difference between college-awarded certificates, industry-awarded certifications, and government-awarded occupational licenses. See for more: http://www.workcred.org/.

[29] "Middle School CTE Programs," District of Columbia Public Schools, https://dcpscte.org/overview/cte-middle-school-programming/.

[30] Anthony P. Carnevale, Jeff Strohl, and Neil Ridley, "Good Jobs That Pay without a BA: A State-by-State Analysis" (Georgetown University Center on Education and the Workforce, 2017), https://goodjobsdata.org/wp-content/uploads/Good-Jobs-States.pdf.

[31] See for more: "Information Technology-Network Management Cisco Certified Network Associate Certificate (C25590P4)," College & Career Promise: Forsyth Tech, accessed March 13,

2022, https://www.forsythtech.edu/files/credit-programs/technical-career-path/2018/Information%20Technology-Network%20Management%20Cisco%20Certified%20Network%20Associate.pdf

[32] Catherine Imperatore and Alisha Hyslop, “2018 ACTE Quality CTE Program of Study Framework” (Association for Career & Technical Education, October 2018), https://www.acteonline.org/wp-content/uploads/2019/01/HighQualityCTEFramework2018.pdf.

[33] For more information on Ohio’s stackable credential efforts, see Lindsay Daugherty, Drew M. Anderson, Jenna W. Kramer, and Robert Bozick, “Building Ohio's Workforce Through Stackable Credentials” (RAND Corporation, 2021), https://www.rand.org/pubs/research_briefs/RBA207-1.html.

[34] Katharine Meyer and Ben Castleman, “Stackable credentials can open doors to new career opportunities,” *Brookings*, February 2, 2021, https://www.brookings.edu/blog/brown-center-chalkboard/2021/02/02/stackable-credentials-can-open-doors-to-new-career-opportunities/.

[35] “Credentials of Value” (Advance CTE, October 2016), https://cte.careertech.org/sites/default/files/files/resources/Credentials_of_Value_2016_0.pdf.

[36] No comprehensive data is publicly available. To assess this, CSET reviewed two samples of institutions: (1) the current program offerings at the largest 25 community and technical colleges by 2019–2020 enrollment, and (2) the 25 largest by computer and information science (CIS) associate’s degrees conferred in 2020. Between the two samples, we found just two had AI-specific programs; a degree at Houston Community College and a certificate at Mt. San Antonio. Three additional schools have announced plans for future AI programs, such as Miami Dade College. We also show in the next section very few degrees are currently awarded in AI and AI-adjacent fields, as reported to the U.S. Department of Education, even though AI-specific fields are part of the formal U.S. government field of study taxonomy. It could be the case that institutions do not delineate sub-specialties such as AI when reporting completions data, but there is limited information available on institutional approaches to reporting. We note that Houston Community College, the only college in our sample with an AI degree program, did report those awards within the AI sub-specialty. We therefore make the assumption that if institutions had AI-specific programs then they would report that data in the AI-specific subfields that fall under computer and information sciences (CIS). Since they do not, it is more likely that they do not exist.

[37] “New Report Finds Despite Eight Years of Increases in State Support, Public Colleges Entered the 2020 Recession with Historically Low Funding,” State Higher Education Executive Officers Association, May 26, 2021, https://sheeo.org/new-report-finds-despite-eight-years-of-increases-in-state-support-public-colleges-entered-the-2020-recession-with-historically-low-funding/.

[38] Michael Mitchell, Michael Leachman, and Matt Saenz, "State Higher Education Funding Cuts Have Pushed Costs to Students, Worsened Inequality" (Center on Budget and Policy Priorities, October 2019), https://www.cbpp.org/research/state-budget-and-tax/state-higher-education-funding-cuts-have-pushed-costs-to-students.

[39] For the historic trend in enrollment, see John Fink, "Undergraduate Enrollment Trends by Sector," Tableau Public, accessed March 6, 2022, https://public.tableau.com/app/profile/john.fink/viz/UndergraduateEnrollmentTrendsbySector/Summary.

[40] Emma Whitford, "State Funding Hit Lands on 2-year Colleges," *Inside Higher Ed*, March 23, 2021, https://www.insidehighered.com/news/2021/03/23/state-funding-two-year-colleges-declined-year-while-four-year-colleges-saw-small-dip.

[41] "Current Term Enrollment Estimates," National Student Clearinghouse, January 13, 2022, https://nscresearchcenter.org/current-term-enrollment-estimates/.

[42] Ann Huff Stevens, "What Works in Career and Technical Education (CTE)? A Review of Evidence and Suggested Policy Directions" (Aspen Institute, 2019), https://www.aspeninstitute.org/wp-content/uploads/2019/01/1.2-Pgs-40-54-What-Works-in-Career-and-Technical-Education.pdf.

[43] Diane Auer Jones, "The Path Less Taken: Barriers to Providing Career and Technical Education at Community Colleges" (American Enterprise Institute, November 2017), https://www.aei.org/wp-content/uploads/2017/11/The-Path-Less-Taken.pdf.

[44] Although the rate is higher at private for-profit and non-profit two-year institutions. The data is for initial enrollment in the fall of 2016. See: National Center for Education Statistics, "Undergraduate Retention and Graduation Rates," U.S. Department of Education, May 2021, https://nces.ed.gov/programs/coe/indicator/ctr.

[45] Typical completion rates are estimated to 150 percent of enrollment time, or three years for two-year programs. This study considered six years to include those transferring to four-year programs, where 150 percent time is six years. See Table 2-12 in Shirley Malcom and Michael Feder, eds., *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways* (Washington, DC: National Academies Press, May 2016), https://www.ncbi.nlm.nih.gov/books/NBK368175/.

[46] Many students also transfer institutions multiple times. See for more, "Community College Transfer" (Community College Research Center, July 2021), https://ccrc.tc.columbia.edu/media/k2/attachments/community-college-transfer.pdf.

[47] James Jacobs and Jennifer Worth, "The Evolving Mission of Workforce Development in the Community College" (Community College Research Center, March 2019), https://ccrc.tc.columbia.edu/media/k2/attachments/EvolvingMissionWorkforceDevelopment.pdf.

[48] Each institution follows its own process for determining student "college readiness," usually through the administration of a one-time college placement exam. While many institutions use the test exclusively, an increasing trend is to pair the results with "holistic advising" that considers more than just test scores for more accurate placement. See "Developmental Educations FAQs," Center for the Analysis of Postsecondary Readiness, https://postsecondaryreadiness.org/developmental-education-faqs/.

[49] We note some students are college-ready, but do not test well and are placed erroneously in developmental courses. Other students testing into developmental courses are likely not academically prepared for gateway mathematics courses, although to varying degrees. Those testing near the "cut-off" score may be more likely to succeed in college-level courses with additional support, while those testing well below the cut-off may not. Inconsistent and de-personalized advising can also complicate placement.

[50] Thomas Bailey, Dong Wook Jeong, and Sung-Woo Cho, "Referral, Enrollment, and Completion in Developmental Education Sequences in Community Colleges" (Community College Research Center, April 2010), https://ccrc.tc.columbia.edu/publications/referral-enrollment-completion-developmental-education.html.

[51] Katherine Mangan, "The End of the Remedial Course," *The Chronicle of Higher Education*, February 17, 2019: https://www.chronicle.com/article/to-help-students-colleges-are-dropping-remedial-courses-will-that-backfire/

[52] Adams Nager and Robert D. Atkinson, "The Case for Improving U.S. Computer Science Education" (Information Technology & Innovation Foundation, May 2016), https://www2.itif.org/2016-computer-science-education.pdf#page=20. To further help address this issue, in our report "U.S. AI Workforce: Policy Recommendations," we propose Congress fund the National Science Foundation to award grants for upskilling existing faculty and industry professionals to teach AI and AI-related courses. See for more, Gehlhaus, Koslosky, Goode, and Perkins, "U.S. AI Workforce: Policy Recommendations."

[53] "Colleges and institutions need to pick up the pace to meet AI skills demand," *EdScoop*, July, 2021, https://edscoop.com/colleges-and-institutions-need-to-pick-up-the-pace-to-meet-ai-skills-demand/.

[54] AI occupations are projected to grow two times faster than average over 2019–2029. See for more, Gehlhaus and Rahkovsky, "U.S. AI Workforce: Labor Market Dynamics."

[55] Gehlhaus and Mutis, "The U.S. AI Workforce: Understanding the Supply of AI Talent."

[56] This is less than for bachelor's degrees, where CIS comprised 4.7 percent of all awards in 2020. Still, this is a relatively small share of total degrees conferred.

[57] At degree-granting institutions.

[58] We note that other CIS-related fields classified as interdisciplinary, such as human-machine interaction and cognitive science, also had very few associate's degrees awarded.

[59] For example, the number of institutions awarding degrees in the six smallest specialties ranged from two in informatics to 35 in data modeling/warehousing and database administration. For IT, the largest sub-specialty considered, 293 institutions awarded associate's degrees in 2020.

[60] This field closely connects to electrical and electronics repairers, an occupation within the AI workforce.

[61] As noted earlier, business is among the top fields of study across the AI workforce, and 44 percent of "product team" workers, the category of nontechnical AI occupations that include program and product managers, had less than a four-year degree.

[62] National Center for Education Statistics, "Undergraduate Degree Fields," U.S. Department of Education, May 2021, https://nces.ed.gov/programs/coe/indicator/cta.

[63] Psychology and social sciences also had large gains but remain small fields.

[64] For a holistic assessment of science and engineering degree and certificate attainment, see Amy Burke, Abigail Okrent, and Katherine Hale, T*he State of U.S. Science and Engineering 2022* (Washington, DC: National Science Foundation, January 18, 2022), https://ncses.nsf.gov/pubs/nsb20221/u-s-and-global-stem-education-and-labor-force.

[65] We note that this is exactly analogous to the share of females earning bachelor's degrees in CIS, also at 21 percent in 2020.

[66] A cursory review suggests this is more of an issue for CIS than for engineering technologies and business.

[67] Northern Virginia Community College, "Computer Science," https://www.nvcc.edu/academics/areas/computer-science-engineering-math/computer-science.html#panel1. We note high school preparation is also a barrier at the bachelor's degree level, particularly where admitance into CIS programs is competitive.

[68] Burke, Okrent, and Hale, T*he State of U.S. Science and Engineering 2022*.

[69] See "Community College Transfer" (Community College Research Center, July 2021).

[70] Aptitude and preference sorting happens well before college. For many, it is too late to pursue more technical fields once a student enters college because of the prerequisites required from high school, especially for programs with a cap on the number of majors. For more on early ability sorting, see Susan Rotermund and Amy Burke, *Elementary and Secondary STEM Education* (Washington, DC: National Science Foundation, July 8, 2021), https://ncses.nsf.gov/pubs/nsb20211/post-high-school-transitions#transition-to-postsecondary-education.

[71] Gehlhaus, Koslosky, Goode, and Perkins, "U.S. AI Workforce: Policy Recommendations."

[72] NICE, as administered by NIST, is the result of a multi-stakeholder approach to developing professional definitions and standards for cybersecurity. For more on the framework, see: NIST, "NICE Framework Resource Center," https://www.nist.gov/itl/applied-cybersecurity/nice/nice-framework-resource-center. For a history of how NICE was developed, see: NIST, "History," https://www.nist.gov/itl/applied-cybersecurity/nice/nice-framework-resource-center/history.

[73] "Investing in Student Success at Community Colleges: Lessons From Research on Guided Pathways" (Community College Research Center, April 2021), https://ccrc.tc.columbia.edu/media/k2/attachments/policy-brief-guided-pathways.pdf.

[74] For example, "meta majors" could include arts, humanities, communications, construction, business, education, health sciences, STEM, social and behavioral sciences, and public safety/human services.

[75] "Investing in Student Success at Community Colleges" (Community College Research Center, April 2021).

[76]"Investing in Student Success at Community Colleges" (Community College Research Center, April 2021).

[77] Florence Xiaotao Ran and Yuxin Lin, "The Effects of Corequisite Remediation: Evidence From a Statewide Reform in Tennessee" (Community College Research Center, February 2022), https://ccrc.tc.columbia.edu/publications/effects-corequisite-remediation-tennessee.html.

[78] "Redesigning Advising and Student Support: Tools for Practitioners" (Community College Research Center, September 2017), https://ccrc.tc.columbia.edu/publications/redesigning-advising-student-support-tools-practitioners.html.

[79] "Continuous school improvement & support," Policy and Analysis for California Education, https://edpolicyinca.org/topics/continuous-school-improvement-support#expand-4.

[80] Dawn Zimmer, "MCC Partners with Boeing to train future workforce," Mesa Community College, April 26, 2019, https://www.mesacc.edu/news/press-release/mcc-partners-boeing-train-future-workforce.

[81] "Major Healthcare Providers Team up with LaGuardia Community College, Weill Cornell Medicine, & Harvard B-School Alumni to Train New Yorkers for In-Demand Medical Jobs," LaGuardia Community College, October 2017, https://www.laguardia.edu/home/news/training-nyers-for-medical-billing-jobs,-with-weill-cornell-medicine---harvard-b-school-alumni/.

[82] "Grants: Artificial Intelligence for All," Miami Dade College, accessed March 13, 2022, https://www.mdc.edu/entec/grants/ai.aspx.

[83] Since interviewing program representatives for this paper, the functionality available to institutions moved from AWS Educate to a new platform called AWS Academy. AWS Educate is now a self-paced cloud learning platform for anyone, while AWS Academy is a resource designed for education institutions. For more on AWS Academy relative to AWS Educate, see https://aws.amazon.com/training/awsacademy/faq/.

[84] AWS Academy focuses on the AWS Cloud Practitioner certification, with other courses and certifications building on top. See here for more: "AWS Academy," Amazon Web Services, https://aws.amazon.com/training/awsacademy/. We also note AWS offers multiple types and levels of certifications related to AI; see for more: "AWS Certification," Amazon Web Services, https://aws.amazon.com/certification/.

[85] For example, Estrella Mountain Community College offers an associate of applied science degree in artificial intelligence which requires 60 to 73 total credits. While working toward that degree, they offer a certificate of completion in artificial intelligence and machine learning which can be earned in 21 to 36 credit hours. For more information, see "Artificial Intelligence @ EMCC," Estrella Mountain Community College, accessed March 24, 2022, https://www.estrellamountain.edu/artificial-intelligence-aim.

[86] At the time of our interview with AWS representatives, Amazon was directly partnering with several community college systems to develop programs. It is those partnerships we discuss here.

[87] "Intel and Partners Open Applications for New AI Labs at Community Colleges," *Intel Newsroom*, January 27, 2022, https://www.intel.com/content/www/us/en/newsroom/news/intel-partners-open-applications-new-ai-labs-community-colleges.html.

[88] For a full description of these programs, see Appendix D.

[89] Hack.Diversity also accepts applicants who are not enrolled in IHEs, but who possess prerequisite technical skills through online certification programs or other nontraditional forms of education.

[90] According to discussions with a program official.

[91] Brad Smith, "America faces a cybersecurity skills crisis: Microsoft launches national campaign to help community colleges expand the cybersecurity workforce," *Microsoft*, October 2021, https://blogs.microsoft.com/blog/2021/10/28/america-faces-a-cybersecurity-skills-crisis-microsoft-launches-national-campaign-to-help-community-colleges-expand-the-cybersecurity-workforce/.

[92] Ruth Porat, "Expanding pathways into higher education and the workforce," *Google*, October 29, 2021, https://blog.google/outreach-initiatives/grow-with-google/higher-education-partnerships/.

[93] Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "Education in China and the United States: A Comparative System Overview" (Center for Security and Emerging Technology, September 2021), https://cset.georgetown.edu/publication/education-in-china-and-the-united-states/.

[94] For more on funding, see: "Public Funding of Community Colleges" (Community College Research Center, February 2022), https://ccrc.tc.columbia.edu/media/k2/attachments/public-funding-community-colleges.pdf.

[95] These grants can be part of specific legislation, as with the COVID relief package, routine programmatic as through the National Science Foundation, or directly from federal agencies to institutions and individuals for research.

[96] Due to First Lady Jill Biden's extensive experience in and advocacy for community colleges.

[97] "Measuring Secondary CTE Program Quality: Work-Based Learning" (Advance CTE, July 2019), https://cte.careertech.org/sites/default/files/files/resources/Measuring_Program_Quality_WBL_2019.pdf.

[98] And ideally, could be replicable for other emerging technologies.

[99] NIST, "Education and Training Provider Resources," accessed March 15, 2022, https://www.nist.gov/itl/applied-cybersecurity/nice/nice-framework-resource-center/education-and-training-provider.

[100] "College Promise Catalog of Local and State Programs" (College Promise, Fall 2021), https://assets.website-files.com/61ba001bb59d05538c5a4bd8/61ba001bb59d05c3355a4c6b

_College%20Promise%20Catalog%20Fall%202021_Final-min.pdf. These programs vary widely in terms of eligibility and amount of support. We also note several states are expanding their "promise" programs in light of the COVID-19 pandemic, or proposing new programs entirely. For example, Louisiana is proposing an expansion in eligibility, previously covering high school graduates with a 3.0 GPA. For more, see Greg Hilburn, "Louisiana poised to provide free community college for adults in high demand careers," *Lafayette Daily Advertiser*, January 25, 2022: https://www.theadvertiser.com/story/news/2022/01/25/louisiana-set-begin-offering-free-community-college-some-adults/9205628002/. Maine is proposing the creation of a new program that would make community college tuition free for students graduating high school between 2020–2023. For more, see Randy Billings, "Gov. Mills unveils $20 million plan for free tuition at Maine community colleges," *Portland Press Herald*, February 2022, https://www.pressherald.com/2022/02/10/gov-mills-to-unveil-20-million-plan-for-free-community-college-tuition/.

[101] Providing grants or scholarships upfront does not guarantee completion.

[102] For example, some assisted by these programs would have gone to college anyway, or potentially shifted college plans away from four-year institutions. Those in the lowest income bracket may not be eligible for non-tuition costs covered by promise programs that other students may be eligible for, due to the relationship of these programs to federal Pell Grants. See: Laura W. Perna, Jeremy Wright-Kim, and Elaine W. Leigh, "Is a College Promise Program an Effective Use of Resources? Understanding the Implications of Program Design and Resource Investments for Equity and Efficiency," *AERA Open* 6, no. 4 (October-December 2020): 1-15, https://files.eric.ed.gov/fulltext/EJ1280033.pdf; and Shanna Smith Jaggars, "A Broken 'Promise'? How College Promise Programs Can Impact High-Achieving, Middle-Income Students" (Third Way, April 2020), https://www.thirdway.org/report/a-broken-promise-how-college-promise-programs-can-impact-high-achieving-middle-income-students.

[103] Sarah Wood, "Study Finds Connection Between Public Community College Promise Programs and Enrollment Increases," *Diverse Issues in Higher Education*, October 25, 2020, https://www.diverseeducation.com/institutions/community-colleges/article/15108007/study-finds-connection-between-public-community-college-promise-programs-and-enrollment-increases.

[104] Laura D. Ullrich, "Male Labor Force Participation: Patterns and Trends," *Econ Focus*, First Quarter 2021, https://www.richmondfed.org/publications/research/econ_focus/2021/q1/district_digest.

[105] Burke, Okrent, and Hale, *The State of U.S. Science and Engineering* 2022.

[106] For an in-depth description of the matter see: John Fink and Davis Jenkins, "Shifting Sectors: How a Commonly Used Federal Datapoint Undercounts Over a Million Community College Students," *Community College Research Center*, April 30, 2020, https://ccrc.tc.columbia.edu/easyblog/shifting-sectors-community-colleges-undercounting.html.

[107] Ideally, we would be able to assess all AI or AI-related skills development or AI education courses on offer. However, until institutions move toward competency-based education, we must work with fields of study. We also considered "first major" only.

[108] All U.S. colleges and universities report their annual degree conferments according to CIP codes. More on these codes can be found here: "Browse CIP Codes," National Center for Education Statistics," https://nces.ed.gov/ipeds/cipcode/browse.aspx?y=55. Our analysis focused on the four and six-digit code level.

[109] See Appendix A for more detail. The appendices also provide totals on all sub-baccalaureate certificates across degree and nondegree granting institutions.

[110] Community and technical colleges with the authority to grant four-year degrees are classified as not primarily four-year public sector institutions and are included in this analysis.

[111] Gehlhaus and Mutis, "The U.S. AI Workforce: Understanding the Supply of AI Talent."

[112] The four modules are Intro to AI, Intro to ML, Natural Language Processing, and AI for Computer Vision.

[113] While not AI-specific, cloud computing education fits within CSET's definition of AI education.

[114] For a comprehensive overview of project structure see: "Building Careers in the Cloud: An Effective and Connected Community of Practice"(Career Ladders Project, February 2021), https://www.careerladdersproject.org/wp-content/uploads/2021/02/Cloud-Computing-Feb2021-Final1.pdf.

[115] The Strong Workforce Program was initiated in 2016 by the California state legislature to foster career technical education. It provides $248 million annually to community colleges, and measures success by how many students complete programs, transfer to four-year colleges or universities, get employed in their field, or improve their earnings. For more information, see: "Strong Workforce Program," California Community Colleges, https://www.cccco.edu/About-Us/Chancellors-Office/Divisions/Workforce-and-Economic-Development/Strong-Workforce-Program.

[116] CCW is the LA region arm of the Strong Workforce Program and leads employer engagement efforts for the community colleges involved in CA Cloud.

[117] Hack.Diversity also accepts applicants who are not enrolled in IHEs, but who possess prerequisite technical skills through online certification programs or other nontraditional forms of education.

[118] This average was impacted negatively by the COVID-19 pandemic in 2020–2021, as 69 percent of fellows seeking post-internship employment secured it as of Dec. 2021, much less than previous years.