

Lighting the Path

From Community College to Computing Careers



Association for
Computing Machinery

Advancing Computing as a Science & Profession





Lighting the Path: From Community College to Computing Careers

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Executive Summary

Traditional four-year degree programs are increasingly struggling to fill the computer science jobs in the U.S. workforce, and alternative pathways are urgently needed to prepare more students for careers in computing. The demand for graduates is high, yet many students (especially those from groups typically underrepresented in STEM fields) are often hindered from successfully finding or following a pathway to a computing degree. One critically important computer science (CS) workforce pathway begins with matriculation at a community college (CC)¹ followed by a transfer to a four-year institution for completion of a degree. Navigating this pathway, however, can be difficult, due to several challenges:

1. Inadequate partnerships among two-year and four-year institutions;
2. Absence of state-level leadership and policy around articulation and transfer pathways;
3. Lack of a defined academic pathway from two-year to four-year programs, recognizing credit and content equivalencies; and
4. Impeded physical or cultural access creating barriers to enrollment or retention

Attention to easing student entry into computing at CCs, and subsequent seamless transfer to four-year institutions would go a long way to diversifying the workforce in computer science, while addressing workforce demands. Policy makers and educators throughout the U.S. support students' aspirations by adopting promising and best practices that establish new pathways through computer science postsecondary institutions.

The ACM Education Policy Committee, in partnership with other organizations, advocates for increasing the availability and quality of computer science (CS) education as well as for providing all students with flexible pathways through postsecondary education and into the workforce. However, too little is currently understood about the role that CCs could play in building the computer science workforce pipeline.

This report is an initial step in filling that gap through gathering and reporting on information on the computing workforce landscape, the role of community colleges in educating a diversity of students in CS, and how CCs and four-year institutions can work together to create the pathways that will supply the professionals for our country's computer science workforce needs.

In this report, we feature five successful case studies that illustrate promising practices for the authentic inclusion of CCs in the CS educational pathway. These include:

1. Developing Articulation and Transfer Agreements and Policies
2. Fostering Cross-Institution Faculty/Administration Dialog and Partnerships
3. Providing Incoming Transfer Student Information, Faculty Contact and Personalized Support
4. Employing a Student Cohort-Based Model
5. Centralizing a Job Market Focus





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The CS Workforce Landscape

With the flourishing of the knowledge-based economy and the prevalence of the technology- and data-enabled workforce, the focus on creating educational pathways in preparation for entering computing occupations has become critical. Workforce projections suggest that the growth in STEM (Science, Technology, Engineering, and Math) occupations will continue to outpace all other occupations, with computing jobs particularly strong in growth and in remuneration. Nearly half a million new jobs created through 2024 will be computing jobs,² with an expected 13.1% growth in computer and mathematical occupations compared to 6.5% growth across all occupations by 2024.³ To meet these needs, college CS programs are under pressure to produce more graduates.

Not only are there tremendous opportunities for full time employment in computing fields, these occupations pay extremely well; the lowest paying computing occupations which are shown to require associate's degree or equivalent level of education at entry have a median salary of almost \$68,000, compared to a median annual wage for all occupations of \$37,040.⁴ Given that associate degree earners make up roughly 10% of those employed in these computing fields, while bachelor's degree earners make up roughly 43% of those employed in these computing fields, it is important to focus on the issue of two-year to four-year vertical transfer in computing fields.⁵

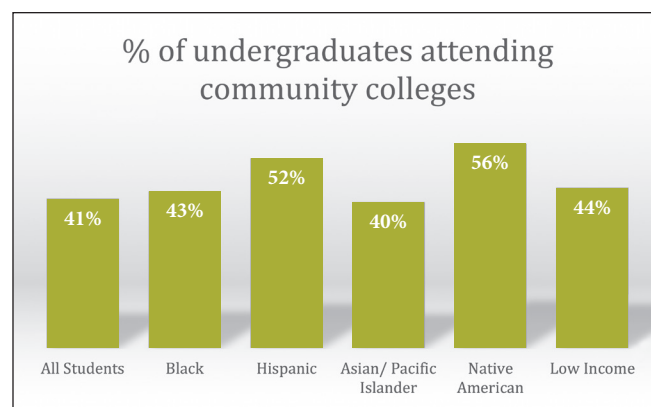
The shortage of the CS workforce is exacerbated by the fact that there are demographic groups perennially underrepresented in the field. Entire sections of the population are underrepresented in computing fields, including women, Blacks, Hispanics, Native Americans, first generation college students, low socioeconomic status students, post-traditional—older or working—students, students with disabilities, and others. Increasing representation of these groups in CS education pathways is critical to meeting the CS workforce needs.

Community Colleges and Transfer Pathways

As open-access and lower-cost institutions, CCs serve students with a wide range of academic and socioeconomic backgrounds. These institutions were originally established to build a local workforce through job credentialing, but today CCs attract not only students with immediate job goals, but also students who wish to transfer to a four-year institution and earn a bachelor's degree.

Attention to easing student entry into computing at CCs, and subsequent seamless transfer to four-year institutions would go a long way to diversifying the workforce in computer science, while addressing workforce demands.

Community College Enrollment Community colleges play a vital role in preparing a large and diverse population of postsecondary students, including large proportions of students traditionally underrepresented in computing. In 2015, the American Association of Community Colleges reported that community colleges were serving 41% of all undergraduates in the United States, and the majority of students from many racial and ethnic minority groups,⁶ as shown in the figure below.⁷



The diversity among community college attendees extends beyond race and socioeconomic status. Students span a broad range of ages, bring with them myriad experiences, manage numerous non-academic obligations, and have many different reasons for attending a two-year institution.⁸ As states and cities increase efforts to offer free community college to their recent high school graduates, GED/HSED earners, and out of school adults, the demographics of community college students will continue to evolve.⁹ Together, these data show that community colleges play a critical role in educating historically underrepresented groups, and elucidate why community colleges need to be a focus when discussing potential mechanisms to broaden participation in STEM and computing fields.

Completion and Transfer to Four-Year Programs The ratios by race of students completing associate degrees and pre-baccalaureate certificates reflect the racial diversity of students at CCs, but this does not hold true at the bachelor's degree level. In the 2014-15 school year, community college enrollees were 22% Hispanic and 14% Black.¹⁰ That year, Hispanic students earned roughly 13% of associate degrees awarded, while Black students earned about 16%.¹¹ However, when looking specifically at CS associate degrees, Black and Hispanic students represented less than 10% each.¹²

Though the data on students transferring from CC's to 4-year colleges is not complete, recent reports indicate that only 22% of transfer students across all disciplines are from the bottom two socioeconomic status (SES) quintiles, indicating that while community colleges tend to serve a student population comprised of students from low SES backgrounds, the majority of students who go on to four-year schools are more economically advantaged than their community college peers. In CS programs this is expected to be exacerbated, especially given the sparse numbers of students pursuing transfer into computing programs. Clearly community colleges are serving minority and low SES students at a high rate, yet those students are not transferring to four-year programs at similarly high rates.

When comparing computing to other STEM fields, about 1.4% of transfer students who entered community college in 2007 eventually earned a four-year CS degree, compared to 21.2% earning another four-year STEM degree. A factor contributing to this gap is that the majority of CS programs at community colleges fall into the "technician" category—designed for certification, not vertical transfer to four-year colleges the way other "science and engineering" STEM programs are designed.

The Community College Research Center studied the pathways of 3,290 CC students who earned bachelor's degrees in Computer Science. CCRC found that their individual experiences traversed more than 1,200 distinct pathways from community colleges to four-year universities to obtain a CS degree, and only 1% of these students adhered to the traditional two-year + two-year full time transfer path to bachelor's completion.¹³ It is understandable why transfer from two-year to four-year schools in pursuit of a CS degree was characterized in this study as "complex and challenging" when we realize that few transfer students (19%) land at four-year institutions with strong representation of transfer students in their CS departments.

Current estimates indicate that there are 10,000 IT and cybersecurity professionals needed in the government alone, with the private sector indicating a much larger need in its technology and data enabled workforce. It is clear that our education and employment sectors must support a plethora of onramps into the many current and future CS and technology occupations.¹⁴ While there is great potential for community colleges to broaden participation in vertical transfer and four-year CS degree completion, this potential is not yet being realized.¹⁵

Clearly community colleges are serving minority and low socioeconomic status (SES) students at a high rate, yet those students are not transferring to four-year programs at similarly high rates.

CASE STUDIES

While the challenges are many, the opportunities for success are great. Our research into the problems and solutions is articulated through five case studies:

- 1. New Jersey:** Kean University and local community colleges: Internal investigation found that Kean University had no relationships with community colleges, but building new partnerships shows great success.
- 2. Kentucky:** Bluegrass Community & Technical College and Kentucky Universities: State policy and a statewide oversight panel guides the integration of two-year and four-year schools.
- 3. California:** California State University, Monterey Bay and Hartnell Community College: A focus on supporting transfer students with a combination of financial aid, learning cohorts, internships and job matching increases successful program completion.
- 4. Oregon:** Western Oregon University (WOU) and two community colleges; Academic challenges are addressed through better two-year/four-year articulation, cutting costs for schools and improving student outcomes.
- 5. Hawaii:** University of Hawaii and Leeward Community College: Addressing geographic challenges and school proximity leads to a dramatic increase in transfer students.

The case studies examine the complex issues that educational institutions face, in order to grow the CS workforce via an increase in successful transfer pathways. Each also shows demonstrated success, through changes at the state, institution, and departmental level.

New Jersey: Kean and Local Community Colleges

Context

By 2008, the overall Computer Science Department enrollment at Kean University was down, due in part to the decline in transfer students. To increase CS and IT major enrollment, transfer enrollment was studied, as transfer students had traditionally made up half of all CS and IT major graduates, and it was found that

transfer numbers had declined to near zero due to no interaction with community colleges. When this was discovered, Kean began a partnership with New Jersey Community Colleges (Ocean, Middlesex, Essex, Bergen, Brookdale, Union County, and Raritan Valley) to facilitate student transfers. This initiative focused on three promising practices in transfer pathways.¹⁶

- Articulation and transfer agreement between community college(s) and baccalaureate institution.
- Faculty and student dialog and interaction opportunities before student transfer.
- Student retention at baccalaureate institution through a dedicated immigration course and personalized study plan.

Description of Initiative

1. Articulation and Transfer Agreement Between Community College(s) and Baccalaureate Institution.

The state-wide website in support of transferring¹⁷ is backed up with detailed articulation agreements and program equivalencies developed by Kean and a specific CC.

2. Faculty and Student Dialog and Interaction Opportunities Before Student Transfer.

a. Reciprocal visits

For the CS and IT programs (CS/IT), CC faculty are invited to attend annual Advisory Board Meetings at Kean, and Kean faculty attend the Advisory Board meetings at partner CCs. These reciprocal visits allow faculty to provide input on programs and proposed changes and to heighten awareness of program impacts on transfer students.

b. Directed mailings

Directed mailings to CC faculty from the four-year program promote opportunities for CC students. These mailings are designed to be forwarded to students, and a variety of information, as noted here.

- Scholarship opportunities for CS and IT students at Kean that are shared with the CCs.
- An invitation to HackKean, the annual Hackathon, which is open to CC students. This allows visiting CC students to see the campus, participate in the Hackathon, and—in 2016—to win a team prize!
- Four Open House events a year that are marketed to include CC students.
- Specific student outcomes, including post-graduation professional placements, internships, and scholarships.

3. Student Retention at Baccalaureate Institution Through a Dedicated Immigration Course and Personalized Study Plan.

a. Immigration course for transfer students

At Kean, in addition to a university-wide Transfer Transition course (GE 3000, required for all transfer students, 1 credit) the department offers CPS 1010 Intro to Computing at Kean (1 credit). This immigration course is required for all incoming CS/

IT transfers who receive credit for CS0 or CS1 and must take CS1 or Data Structures at Kean. CPS 1010 is taught by a full-time faculty member, and transfer students are given this faculty member as a 'point of contact' during their first semester at Kean. The Linux/Unix skills taught in CS0/CS1 are given as a series of lab assignments, and the students are given local knowledge on systems, department activities and expectations which students who took CS0 and CS1 at Kean already have. Once this course was implemented, it was found that transfer student success in Kean's programs increased. If students encounter problems, they can speak to their CPS 1010 professor or their faculty adviser.

b. Personalized study plan for every transfer student

Beginning in 2014, a 'Study Plan' outlining coursework needed for graduation has been prepared for every CS/IT transfer student, showing the courses needed to complete the four-year degree. This considers all the transferred credit; Kean courses are placed in the correct semesters and summer course recommendations are provided. Students find these plans to be very helpful in showing them how to complete their degree; they are updated each semester during faculty advising appointments. The study plans are initially developed during the CS/IT transfer student's first visit to campus, prior to registering for classes, during a 1-on-1 visit with the Department Chair. This process offers an experienced point-of-contact to the new student, as well as an opportunity to ask questions and learn how the future semesters will be handled, after the assignment of faculty advisor

Measures of and Indications of Success of Initiative

Kean University CS and IT majors often have internships or professional jobs after graduation. The location in the NY/NJ metro area leads to 100% employment within 6 months after graduation for students who are seeking jobs.

1. Data on Increased Transfers

Transfer numbers in 2008 had declined to near 0, due to no interaction with community colleges. Since then, Kean's numbers have recovered dramatically. The program is 50% transfer, as measured by the students who persist to graduation. Additionally, numbers measured from 2012-2017 have increased by 50% for transfer student enrollment in the seven community colleges which have been the focus of our effort.

Transfer student count (Fall) from top 10 institutions	2012	2013	2014	2015	2016	2017
Computer science	14	13	18	18	22	21
Information Technology	9	4	16	10	13	13
TOTAL CS/IT	23	17	34	28	35	34

2. Data On Student Transfer By Race

Underrepresented students have also increased for some groups. Kean is now designated as an HSI (2016), as are several of the community colleges that were the focus this transfer effort.

Transfer student count (Fall) from all institutions by race/ethnicity: CS	2012	2013	2014	2015	2016	2017
Asian	3	5	4	5	8	10
Black	8	5	8	7	14	4
Hispanic	3	9	7	4	2	6
Multi	0	0	1	2	0	1
Not reported	5	1	6	2	1	3
White	2	6	4	5	7	9
TOTAL	21	26	30	25	32	33

Transfer student count (Fall) from all institutions by race/ethnicity: TOTAL CS/IT	2012	2013	2014	2015	2016	2017
Asian	5	6	6	9	8	15
Black	10	7	12	15	24	8
Hispanic	7	11	10	6	7	8
Multi	0	0	1	2	0	2
Not reported	8	2	8	3	1	6
White	3	7	11	8	10	15

Transfer student count (Fall) from all institutions by race/ethnicity: IT	2012	2013	2014	2015	2016	2017
Asian	2	1	2	4	0	5
Black	2	2	4	8	10	4
Hispanic	4	2	3	2	5	2
Multi	0	0	0	0	0	1
Not reported	3	1	2	1	0	3
White	1	1	7	3	3	6
TOTAL	12	7	18	18	18	21

3. Results of Collaboration

a. Expansion of programming languages

There has been an expansion of the programming languages taught at the CCs, which has increased the number of four-year programs into which the students could smoothly transfer. C++ used to be the only language taught in the CCs, which was primarily in support of transfer to regional engineering programs; now Java and Python are also taught in support of transfer to a broader range of CS and IT four-year programs.

Transfer numbers in 2008 had declined to near 0, due to no interaction with community colleges. Since then, Kean's numbers have recovered dramatically. The program is 50% transfer, as measured by the students who persist to graduation.

b. Flexibility in science requirements

The requirement of two semesters of Physics as the 'only' lab science in the CC curriculum for transfer to the engineering program has been expanded to also include an option of two semesters of other lab sciences (e.g., Biology, Chemistry). This has increased the flexibility for CC students both while at their CC and upon transfer. Many four-year programs will accept 2-semester of any lab science, not only Physics.

c. Visibility of community college programs at baccalaureate institution

Through increased collaboration, four-year schools have early visibility of CC programs (e.g., Cybersecurity, Game Design, Networking) and can prepare transfer evaluations for those programs, letting CC faculty (and students) know which four-year degrees programs will align well with the CC program.

4. Future Goals Of The Initiative

Future goals of the program include joint-admissions agreements, which are now in place with Union County College and Middlesex County College, with other schools to follow. This supports early identification of the students interested in CS and IT degrees and encourages seamless transfer from the two-year degree program to the four-year degree program. Additionally, several community colleges have started ACM chapters, but report they do not have enough students for activities such as Hackathons, Cyber events or guest speakers. Therefore, Kean's ACM and ACM-W are working to include community college ACM chapters in programming planning to increase outreach and sense of community.

Institutional and Financial Support Necessary for Success

Interpersonal faculty connections between the community college programs and universities provide a foundation of success, supported by strong faculty advising both at the 'sending' school and the 'receiving' program. Personal faculty encouragement to 'look-up' specific four-year faculty once a community college student arrives on the four-year campus helps the student transfer with intent

and purpose. Institutional support for transfer students and the availability of scholarships for transfer students are also important.

Many students attend community college because they are lower cost institutions. Kean University offers financial aid to students enrolled in degree programs, and many of the CC transfers are on financial aid and therefore want to be full-time (12 credit hours/semester). Kean University is very affordable, and offers a good location, small classes (less than 20 per section) and dedicated teaching faculty. Graduating students most often cite cost, location, and class size as reasons to attend.

Advice for Implementation

University faculty should reach out to community college faculty and travel to CCs to participate in advisory board meetings and provide talks. Transfer students are persistent in degree completion and often have a dedication and focus which allows them to excel in both coursework and undergraduate research, and benefits all. Receiving four-year degree programs should work to make a connection with incoming transfer students from two-year programs as quickly as possible, through special intake activities, experiences, or invitations.

Possible Challenges

This program takes advantage of an urban region; New Jersey has 19 public community colleges and the majority are located within 1 hour of Kean's north-central New Jersey campus. Through focused recruiting, schools most likely to send students to Kean's programs were identified, and efforts concentrated on those programs. A four-year program with fewer neighboring community colleges might have to use Skype or Google Hangouts to reach the CC faculty, rather than driving to visit in person, which could work for more rural or less densely populated locations. Interpersonal relationships between faculty can be built regardless of geographical co-location. Many faculty work closely with collaborators they rarely, if ever, meet in person.

Kentucky: Bluegrass Community and Technical College and Kentucky Universities

Context

The Kentucky Postsecondary Improvement Act, enacted in 1997, separated community and technical colleges in the state from university governance while at the same time providing a framework to support improved transfer pathways for Kentucky's postsecondary students. This included:

- easing transfer from two-year to four-year institution in Kentucky and
- the creation of Kentucky's Council on Postsecondary Education (CPE) which provides direction to institutions related to articulation and transfer agreements.

Description of Initiative

1. Updated Kentucky Statutes

The Kentucky Postsecondary Improvement Act of 1997 precipitated an amended statute¹⁸ that granted all CCs in the Kentucky Community and Technical College system the right to offer all lower division academic courses offered for credit by any of the four-year baccalaureate public universities in the state. In addition, the statute guaranteed that receiving institutions would accept these lower division academic courses at the CCs for transfer credit.

Additionally, in 2012, an updated Council on Postsecondary Education General Education Policy¹⁹ stated that the Council would collaborate with public universities and community and technical colleges to facilitate the development and implementation of a statewide agreement for alignment of associate degrees to programs so that transfer students with an associate degree would be guaranteed to meet general education requirements for the bachelor's degree.²⁰

2. Bluegrass Community and Technical College (BCTC) Transfer Pathways

With the amendments to the Kentucky statutes mentioned above, BCTC can

- develop and offer Associate in Science (A.S.) and Associate in Arts (A.A.) degrees which guarantee that students completing these degrees will fulfill all general education requirements at all Kentucky four-year college and universities; and
- teach all lower-division courses (the first two-year courses) offered at Kentucky four-year colleges and universities.

To this end, BCTC offers an A.S. degree with a focus area in Computer Science which includes several University of Kentucky (UK) computer science courses. These courses are adopted by BCTC and taught by BCTC faculty. Since they are UK courses, students completing the A.S. with a focus area in CS have a true seamless transfer to University of Kentucky (UK). The students are deemed "general education certified," meaning they have completed all general education courses required by UK (or any other Kentucky four-year college or university) and the computer science courses are accepted for transfer because they are UK courses. Since many other Kentucky four-year colleges and universities accept UK computer science courses, students may also easily transfer to other Kentucky schools to continue studies in computer science. This seamless transfer pathway has been in effect since 2012.

In the last few years, BCTC has also adopted several informatics courses from Northern

Kentucky University (NKU) resulting in a slow but steady increase in transfer students to NKU. Again, the general education courses are fulfilled at BCTC and the informatics courses are accepted since they are truly NKU courses.

3. Effectively Adopting and Teaching a University Course at a Community College

When adopting courses from another institution, frequent and meaningful dialog must take place. Bluegrass Community and Technical College (BCTC) faculty have developed a close relationship with the University of Kentucky (UK) and Northern Kentucky University (NKU) faculty to develop strong computing transfer pathways by:

- adopting multiple UK computer science courses and multiple NKU informatics courses to be taught at BCTC;
- working closely with UK and NKU faculty to insure course content is consistent and that approved course changes at the university level are communicated to and consistently implemented at BCTC; and
- inviting university faculty to serve on community college advisory boards—faculty from UK and NKU serve on BCTC’s advisory board (for all degrees offered by the Computer & Information Technologies (CIT) program).

Measures of and Indications of Success

The BCTC Computer and Information Technologies (A.A.S. in CIT) and Computer Science (A.S. with a focus area in CS) programs are popular majors. Throughout the history of these two degrees, recruiting new students has not been an issue. Nonetheless, to build a stronger computing pathway from high school to two- and four-year colleges in Kentucky, a concentrated effort began in 2015 for CIT faculty to work more closely with dual credit high school students.

Funded by corporate grants, the *BCTC Informatics Academy (IA)* was established in the fall of 2015. The Informatics Academy offers the following opportunities to high school junior and seniors.

- Enroll in a series of four dual credit computing courses taught by BCTC faculty.
 - a. Introduction to Databases—taken in the fall of the junior year
 - b. Computational Thinking—taken in the spring of the junior year
 - c. Java Programming I—taken in the fall of the senior year
 - d. Java Programming II—taken in the spring of the senior year
- Earn an *Informatics Programming Certificate* upon successful completion of the courses above and high school graduation.
- Attend at least one computing conference during the junior year and one during the senior year.

- Participate in a Computer Science Speaker Series (four speakers per year).
- Engage in group projects outside of the classroom to learn different aspects of computing (3D printing, mobile programming, drone technology, motion-capture applications, etc.).

Using the Kentucky Dual Credit Scholarship Program and grant funding, all four courses are free for the Informatics Academy students. Using gracious donations from textbook publishers, there are no charges for the course textbooks and the cost of transportation to all Informatics Academy events are covered by Academy funds. Consequently, the courses and activities are free to the students and high schools.

The Informatics Academy was organized during the 2015-2016 academic year. Twenty students from one high school enrolled in the 2016-2017 year and 25-30 students from two high schools participated in the 2017-2018 year. Surveys indicate these students have wide-ranging interests in the computing field. A few students are merely inquisitive, some are interested in how technology impacts non-computer science majors, and others are strong candidates to persist in computer science studies. Approximately 20% of the those starting the first year, completed the Informatics Programming certificate.

Many of the high schools in the BCTC service area do not employ computer science teachers and do not offer Advanced Placement Computer Science (AP CS) exams. The Informatics Academy courses help students prepare for and sit for the AP CS Principles and AP CS A exams as well as learn more advanced college-level computing concepts. The professors teaching the Informatics Academy courses offer exam preparation sessions for those interested in taking the AP CS exams. This has been an attractive added benefit to local high schools.

While the Informatics Academy has only offered courses for two years, approximately 20-25% of the Informatics Academy students have enrolled in or will enroll (fall 2018) in computer science programs at the college-level. Of those successfully completing all four courses, 100% are continuing studies in the computing field. Some will attend BCTC and some will attend four-year institutions. BCTC views this as a very positive impact on CIT and CS recruitment and developing stronger pathways for high school students in the BCTC service area. We believe this model is easily replicable.

BCTC has a unique Transfer Center which provides BCTC office space for advisors from many of the four-year colleges (regional and research institutions) in Kentucky. BCTC students do not have to travel to the four-year institutions to learn more about transfer requirements and scholarships. They simply make an appointment with a four-year advisor located on our campus.

BCTC graduates have several attractive tuition support opportunities to continue their studies at four-year colleges. BCTC has transfer programs with Eastern Kentucky

University, Western Kentucky University, Bellevue University, Morehead State University, the University of Kentucky, Kentucky State University and others. A few examples are provided here. CIT and CS students at BCTC are eligible for the following agreements.

- University of Kentucky (UK)**—An agreement, known as the BCTCblue+ program, was established in 2008 to streamline the transfer process from BCTC to UK. This dual enrollment agreement allows students to take classes at both schools simultaneously. BCTCblue+ is a dual enrollment partnership between Bluegrass Community and Technical College and the University of Kentucky. The program is designed for BCTC students who intend to complete an Associate in Arts or Science degree (AA or AS) and then transfer to UK.

Students enrolled in this program are eligible to take up to 12 credit hours (or four courses) of pre-major and major coursework at UK while pursuing an AA or AS degree at BCTC. BCTCblue+ students pay the BCTC tuition rate for the allotted 12 credit hours of UK courses.

- University of the Cumberlands (UC)**—BCTC CIT graduates could earn a BS in Information Sciences at the University of the Cumberlands in 12 months. Upon successful completion of the Associate of Applied Science degree in Computer Information Technology, coursework will be applied towards the requirements of the Bachelor in Science degree in Information Technology Sciences from the School of Computer and Information Sciences at UC. Areas of concentration include Cybersecurity, Infrastructure/Networking, Management, and Software Engineering.

- Kentucky State University (KSU)**—BLINKS Scholarship: BCTC students who have applied and been approved for BLINKS will have an opportunity to utilize mentoring, study strategies, and other resources to help them be successful at BCTC and to graduate with an A.A. or A.S. After which with a GPA of 2.8 or above they will be awarded full tuition to KSU for their undergraduate degree.

The purpose of the BLINKS Scholarship is to increase the graduation rate of community college students, to increase the number of community college students who transfer to Historically Black Colleges and Universities (HBCUs), to encourage greater collaboration among community colleges and HBCUs, to increase the enrollment of selected HBCUs, and to increase the graduation rate of students at HBCUs.

KSU also has a dual enrollment agreement, called the BCTC Green and Gold program, which is designed for students who plan to complete an associate degree from BCTC and then transfer to

KSU to pursue a bachelor's degree. Students who enroll in the BCTC Green and Gold program will be eligible to take classes at a reduced tuition rate at KSU while enrolled at BCTC, and when they successfully complete the associate degree (BCTC students must have a 2.0 GPA to graduate), the students will be guaranteed admission to KSU upon application by the appropriate deadline.

- Morehead State University (MSU)**—A joint enrollment and reverse transfer agreement, called Eagle Express, will provide academic advising and admissions counseling for bachelor's degree seeking students, from the beginning of their college careers at BCTC to the point where they are ready to transition to MSU. Students participating in the program will have the benefit of advising from both schools, unofficial transcript review, and free transcript exchange. In addition, there is no application fee to enter this program.

Data on Increased Transfer

	2014-2015	2015-2016	2016-2017
Computer Science (AS CS)	18	17	23
Computer & Information Technologies-Programming (AAS CIT Programming Track)	16	16	17
Computer & Information Technologies-Networking (AAS CIT Networking Track)	12	19	14
Computer & Information Technologies-All other tracks (AAS CIT-Other Tracks) Not related to CAE2Y Application	7	6	7
TOTAL Graduates	53	58	61

CIT Program - Graduation Percentages by Reported Gender:

Year	Female	Male
2010	17%	83%
2011	15%	85%
2012	18%	82%
2013	19%	81%
2014	15%	85%
2015	16%	84%
2016	18%	83%
2017	19%	81%

As you can see in the table, Graduation Percentages by Reported Gender, over the last seven years the graduation percentage has stayed between 15-19% female. We had an overall dip in enrollment and graduation numbers in 2014 which may help explain the dip in female graduation rate that year.

CIT Program - Graduation Percentages by Reported Race:

Year	American Indian	Asian	Black	Hispanic/Latino	Non-Specified	2+ Races	White
2010	0%	8%	4%	4%	0%	8%	75%
2011	0%	5%	8%	5%	0%	8%	75%
2012	0%	6%	9%	3%	0%	0%	82%
2013	0%	4%	0%	0%	7%	4%	85%
2014	4%	0%	8%	0%	0%	8%	81%
2015	0%	3%	10%	0%	0%	3%	84%
2016	0%	3%	8%	5%	3%	5%	78%
2017	0%	0%	5%	0%	5%	5%	86%

The numbers in the table, Graduation Percentages by Reported Race, the graduation rates fluctuated a bit. Many of these values are single digit counts; a small change can influence the percentage quite a bit.

Institutional and Financial Support Necessary for Success

As mentioned previously, success in the BCTC Computer Science and Informatics transfer pathways rests solely on strong relationships between the university and community college faculty. This group of faculty members have worked together for many years, with the university faculty serving on the BCTC CIT advisory board.

However, much credit is given to Kentucky policymakers. BCTC transfer pathways were easily and seamlessly implemented due to the changes in Kentucky statues and a recognition by lawmakers of the importance of improved transfer agreements.

Other Advice for Implementation

While it may not be possible to implement statewide policies, community colleges and universities should entertain conversations about community colleges teaching lower division university courses. Confidence and trust build between two-year and four-year faculty through routine in-depth conversations about curricula. This “course adoption” model can help ensure transfer students are prepared for upper level courses easing the transition from a community college to a university setting. With many universities seeing dramatic increases in computer science majors today, local community colleges teaching lower division courses may help during times of high enrollment at the universities and be an added benefit of the course adoption model.

Possible Challenges to Scalability

The Kentucky transfer pathway model is predicated on policy changes at the state level which may not easily be replicated in certain areas or states.

California:

California State University, Monterey Bay and Hartnell Community College

Context

In 2012, Hartnell Community College and California State University Monterey Bay (CSUMB) Computer Science facul-

ty members began a partnership to improve transfer rates, reduce degree completion time, and address the diversity problem in the technology industry. Working across both community colleges and four-year institutions was imperative to lowering program costs. In addition, both schools are Hispanic serving institutions with Hartnell College having a 69% Hispanic/Latinx student population and CSUMB a 41% Hispanic/Latinx student population. This project created a model that contains the following elements:

- three-year clear pathway between a community college and a California State University (CSU);
- cohort-based program; and
- student support focused on financial aid, academic success, internship and job obtainment support, and facilitation of registration, course enrollment, transfer, and application for graduation with a bachelor’s degree.

Description of Initiative

1. Development and Implementation of a 3-Year Pathway (“Csin3”)

The three-year pathway was developed to meet all transfer and graduation requirements for CSUMB’s bachelor’s degree and Hartnell CC’s associate degree requirements. The students complete roughly half of the total bachelor degree units at Hartnell CC, and their upper division course work at CSUMB. Starting at the CC reduces the cost for the student, helps with capacity concerns at both institutions, and in turn makes the pathway accessible to first generation (FG), low-income (LI), and underrepresented minority (URM) students. Every semester, the institutions ensure that the courses in the pathway are available in the schedule of courses and reserve seats for the students going through the pathway.

2. Collaboration Between CSU Monterey Bay and Hartnell College Faculty Members

Communication between the faculty partners is key. Every week, the faculty members meet and discuss program needs, next steps, upcoming opportunities, and program progress. They also maintain an open dialogue and monthly meetings with institutional leadership. These meetings facilitate timely help in addressing challenges that may arise and are beyond what a faculty member can quickly fix.

3. Cohort Recruitment

Recruitment begins in late August at the local high schools. Our program assistant visits math and technology related high school courses to present information about our cohort programs. In addition, our assistant collects contact information from interested students. Some approaches that have helped in the recruitment process include working closely with high school counselors/advisors and bringing current cohort students who are alumni from that high school to the presentations. The school usually receives about 45 completed applications and conditionally accepts

about 40 students. Conditional acceptance depends on their personal statement and group interview. In these elements, the school is looking for grit, a willingness to work hard, and commitment to this intense program. Since this is a three-year program, students must be calculus-ready for their first semester. Students in the area don't always meet placement exam levels and prerequisites for starting calculus in the fall, so they are required to go through a math preparation workshop on Saturdays during the spring semester prior to their first fall semester. Through these workshops they begin building cohort culture and the school is able to see which students are truly committed to the work ethic required to be successful in the program. It is important to note that admittance is not based on GPA, but on a willingness to work hard. By the end of the math preparation workshops, there is usually end a cohort average of around 32 students.

4. Implementation of Cohort and Cohort Culture

To implement the cohort model, the same group of students are guaranteed to be in the same courses throughout the pathway. This is accomplished by working with department deans or chairs so that they can staff and offer course requests from the pathway. Then 30 to 36 seats are reserved for cohort students. This way, there is the opportunity for traditional students to join the class as well, which maximizes use of the classrooms.

The cohort culture is composed of the following

- A growth-mindset
The idea that hard work and determination will help you in accomplishing your goals and academic successes.
- Strong network with peers
Build from each other's network, learn from each other (study groups) and shared responsibility of the cohort's success.
- Supportive environment
 - Healthy competition among cohort peers to challenge each other to learn more and work harder.
 - Peer-to-peer tutoring.
 - Encouragement of each other.
- Professionalism
A cohort culture is fostered through weekly Friday workshops during the semester called "Friday Cohort Enrichment." In these workshops students are taught how to study, manage time, network, etc. One of the team members with a computer science background is responsible for delivering these workshops and creating content.

5. Implementation of Student Support Services

Support services are provided throughout the CSin3 pathway, including the following.

- **Admissions and Records student support**
One program staff member works with counselors

and the registrar's office to register students for courses. What each student sees is that s/he has a schedule of courses already set for him/her on his/her student portal, and each student is responsible for making sure any remaining fees are paid after his/her financial aid comes in. Seats in the courses are reserved which ensures timely completion of the pathway. This process happens at both partnering institutions every semester for the first year and a half. Students take one course each semester at CSU.

CSin3 staff provide workshops in collaboration with Admissions and Records to complete transfer paperwork and walk cohort students through the transfer process. Then one of the staff team members follows up with the transfer office to make sure all CSin3 students successfully transferred. From a student's point of view, s/he fills out the forms and continues taking courses. Students are unaware of the behind-the-scenes work, and the process is invisible to the student. Because of this support, roadblocks concerning navigating the various processes at the two institutions are not an issue or concern for the students.

The two institutions also work with the program to offer a financial aid workshop. At this workshop, students have experts available to answer their questions about filling out the FAFSA (Free Application for Federal Student Aid) and to learn how financial aid works. These experts are employees from the respective institutions. Most of our students qualify for financial aid and the community college's Board of Governor's (BOG) waiver. The BOG waiver covers enrollment fees for California residents at the community college level, which makes it possible for most of our students to enroll in courses for free while at the community college. In addition to federal financial student aid, our cohort students are eligible for a financial need-based scholarship of up to a total of \$14,000 for the three years. Previously, the scholarship was funded for up to \$30,000 by a generous foundation, the Matsui Foundation. Without financial support, our collaborative three-year program between a CSU and community college has tuition and fees costs of just under \$14,000 total for the three years. The financial aid and scholarship support help our students pay for tuition and fees and help them focus on academics and attendance to the enrichment activities, without having to get a job to cover these educational expenses.

Finally, staff work with admissions and records on CSUMB's side when the students are ready to graduate with their bachelor's degree, to verify that each student has met the requirements for graduation. Mostly this applies to students who have transferred AP units and any prior community college coursework. If there are any issues with a student's graduation status, the student is informed of what s/he needs to do. Normal issues include the necessity for students to send transcripts or AP exam scores to the CSU.

- **Academic support**

Students accepted into the program have demonstrated a willingness and motivation to work hard. We measure some of this grit through pre-college math preparation sessions that form incoming students into a cohort. The students are asked to participate in a 10-week face-to-face Saturday four-hour math problem solving session through Khan Academy. The program provides tutors, a high school math instructor and a CC math instructor. In addition to the four hours on the ten Saturdays, students are asked to do about 8 hours a week extra at Khan Academy. Staff monitor time spent during the week and the students' progress through a set of goals. The goals consist of math topics in pre-algebra, algebra, geometry, and pre-calculus. Students who meet the requirements receive credit for one of the calculus prerequisites at Hartnell College. Providing this support makes the pathway accessible to students in our community.

In addition, the program hires tutors for the courses they undertake. If a student in the cohort needs one-on-one tutoring sessions, that resource is made available and mandatory for that student in their first year. The hope is that this helps students learn good habits for ensuring their academic success. The Peer-Led Team Learning model (PLTL) has also been implemented by hiring older cohort students to be the PLTL leaders. This serves two purposes: 1) deeper understanding of material for the students leading the PLTL sessions and those participating; 2) mentoring relationships between the PLTL leader and the students in the session; and 3) some added financial support for the student PLTL leaders.

- **Internship and full-time job preparation support**

Students in their second year are asked to participate in an internship. Resources and support for obtaining an internship are provided, but ultimately it is up to the student to earn that internship. The following are provided on an almost weekly basis for the students.

- Mock interview practice (delivered by industry professionals)
- Resume writing and review
- Interview prep (practice programming problems)
- Industry presentations (which discuss opportunities and requirements for students interested in applying)
- On-campus interviews by industry partners

- **Facebook in Residence Program**

A Facebook engineer spends a semester at CSUMB and students can interact and work with this engineer on projects and internship preparation. We were fortunate to have Facebook approach us about this program they had launched.

Measure of and Indications of Success of Initiative

Key results demonstrated by the cohort model include the following.

- **Significant increase in the capacity of CS program**— While CSUMB is one of the smallest campuses in a 23-campus CSU system that serves almost 500,000 students, we produced 6.3% of all CS graduates from the entire CSU system in Spring 2017.

CSin3 cohort program at Hartnell Community College resulted in significantly improved completion rates.

- **Significant demographic shift in CSUMB CS graduates**— Prior to launching CS cohort programs in 2013, CSUMB produced 2.9% of all Hispanic CSU CS graduates from across the CSUs and 3.3% of all female CSU CS graduates. As of 2017, CSUMB produced 10% of all Hispanic CSU CS graduates and 7.7% of female CSU CS graduates. The total number of computing related degrees awarded from 2013 to 2017 increased from 1,160 to 1,928 across CSUs. During the 2013 and 2017 increase in computing degrees awarded, CSUMB's share in graduates including women and Hispanics also increased as depicted in the ratios above.
- **One hundred thirty-one students completed summer internships in 2015, 2016, and 2017.** Organizations with these internships included Adobe, All State, Amazon, Apple, Atlassian, Bank of America, Cisco, Code2040, Driscoll, eBay, Facebook, Google, Intuit, NASA Ames, Nationwide, New Relic, Salesforce, Uber, VMware, WorkDay, Zen Desk and Zynga.
- **Thirty-six out of forty-six participants (78%) had a job within two months of graduation.** Hiring organizations include Apple, BlackRock, CIG, Driscoll, Dolby, iFoodDecisions, HeavyConnect, HumRRO, JP Morgan Chase, Kibo, Liberty Mutual, Lyft, Panafold, RedTeal, Salesforce, SSCS, NBC Universal, Uber, and Verizon.
- **CSin3 cohort program at Hartnell Community College resulted in improved completion rates.** Associate degree completion in 1.5 years and transfer rates for the three CSin3 cohorts are: 27 out of 32 (84%) of first cohort, 28 out of 32 (88%) of second cohort and 31 out of 38 (82%) of third cohort. In comparison, the community colleges' 6-year completion rate is 39%.

Institutional and Financial Support Necessary for Success

Necessary for success of this program are strong and supportive collaborations between faculty from the CSU and CC institutions. Institutional support of changes or additions to procedures that would allow for cohort seat reservation in specific courses, cohort registration in courses, cohort transfer, and cohort application for graduation are also key.

In addition, there also needs to be an institutional commitment to scheduling courses on the pathway at given times and days of the week. The institutions need to be willing to work together to make these processes function mutually and dependent on one another. For some of these processes and paperwork, it is helpful to have two additional staff members who perform a variety of administrative support services (dependent on support already offered by the institutions).

Most importantly, building this program from the ground up was not possible without the scholarship support provided by the Matsui Foundation. They funded scholarships of up to \$30,000 total for each student, for the first five cohorts which helped to garner student interests and initial engagement, as well as visibility across the state. Our team is currently working on ideas to make the model possible for more colleges that may not have access to generous donors like the Matsui family.

Future Work

Our work on this project is not complete, we are still working on replication of the model at other institutions. When this aspect of the project is implemented, we hope to have a clearer picture of the requirements for 1) necessary and critical institutional and financial support and 2) fundamental implementation requirements.

Oregon: Western Oregon University (WOU) and Two Community Colleges:

WOU and Chemeketa Community College

Problem Addressed

Community college graduates face credit transfer issues with a two-year Associates of Applied Science degree (AAS). The AAS is considered a “terminal degree,” thus not easily articulated to a university without loss of credits, or with credits that count as electives and not specifically towards completion of a bachelor’s degree. Historically, there has been no direct transfer pathway for students who complete a two-year AAS degree to complete a four-year bachelor degree with only two additional years of study at a comprehensive university. The curricular and degree requirement challenges are threefold:

1. the technical knowledge and skills covered in the AAS program are ramified throughout the upper and lower division coursework at the university;
2. general education curricula are concentrated in lower division coursework during the first two years of university study but is deemphasized in the two-year technical degree; and
3. bachelor-degree programs require a minimum number of upper division credits which can only be earned after transfer.

Students who completed an AAS degree were therefore faced with three or more additional years of fulltime course work to complete a bachelor’s degree.

Chemeketa Community College offers an AAS in Computer Systems and Information Technology (CSIT), which is not a fully transferable degree. Historically, when students decided to continue their education after they graduated, their credits would transfer without fulfilling general education or program requirements at the university, so students ended up earning many more than the 180 quarter hours typically needed for a bachelor’s degree. This meant students needed three to four years after the AAS to complete their bachelor’s degree.

To provide an efficient pathway for Chemeketa Community College students in the AAS CSIT program to obtain a bachelor degree, the Computer Science and Information Systems faculty at Western Oregon University (WOU) revised their program requirements in Information Systems (IS) in conjunction with developing Applied Baccalaureate (AB) degrees. WOU opened admission to AB programs in both IS and CS during the 2014-15 academic year and implemented its revised IS course offerings and degree requirements starting with the 2016-17 academic year.

Description of Initiative

1. Applied Baccalaureate Degree

Applied Baccalaureate (AB) degree programs were created to address the second and third challenges listed above—the emphasis on lower division general education classes during the first two years of university study and the need for upper division coursework to fulfill generally accepted requirements. AB degree programs were designed specifically for “individuals with a terminal or non-transfer associate degree who wish to pursue a bachelor degree to advance in their careers, change careers or who may seek to pursue graduate education.”²¹ The AB framework provides a pathway around the lower division general education trap by defining a set of general education requirements based on upper division coursework allowing students to simultaneously satisfy upper division credit requirements and general education requirements.

The AB degree program accepts all the student’s AAS credits in fulfillment of the first two years in the bachelor degree at the university (up to a maximum of 120 quarter hours). The AAS graduate thus enters WOU as a junior. The AB degree path (CS or IS), is then completed by the student with an average of 90 more quarter credit hours. In the case of the AB in IS, this may be completed in 2 academic years.

2. Reconfigured Segmentation of the Information Systems Curriculum

To facilitate transfer pathways for students with AAS CSIT degrees, WOU’s Information Systems curriculum was completely rewritten. Based on the ACM/AIS 2010

IS program guidelines,²² core lower and upper division curricula were developed with the following lower/upper division breakdown:

Lower Division

1. Foundations of Information Systems
 - o Introduction to Information Systems
 - o Introduction to Programming
2. IT Infrastructure
 - o Operating Systems
 - o Networks
 - o Database Fundamentals

Upper Division

3. Information Management
4. Enterprise Architecture
5. IS Project Management
6. Systems Analysis and Design
7. IT Infrastructure - Systems Administration
8. IS Strategy, Management, and Acquisition

Together with a selection of lower- and upper-division electives and a capstone project, this curriculum structure is both complete and segmented to allow transfer students to move directly into upper division coursework with little duplication of technical fundamentals nor need for remediation. Students with terminal two-year degrees will have covered all the lower division coursework in some format, though the chunking of that coursework may be focused on a specific vendor’s architecture as opposed to the vendor-neutral curriculum offered by WOU.

To date, 31 students are on track to increase their employment opportunities, enrich their personal lives, and continue a path of lifelong learning by achieving the bachelor’s degree.

3. Faculty and Student Interaction Opportunities Before Student Transfer to WOU

Chemeketa students who have an interest in the AB degree at WOU meet with a Chemeketa Computer Information Systems faculty advisor to map a defined pathway. This ensures that the student is provided with accurate information as to the courses that would be most beneficial to them in the transfer process (e.g., appropriate level of math).

An AB transfer night is held annually at WOU and Chemeketa students are invited to attend alongside their instructors. This is an opportunity for students to meet with the professors, tour the facilities, and ask questions about the field, as well as learn more about the AB program. This has been a very successful event, attendance growing since its inception of 2014.

Measure of and Indications of Success of Initiative

1. Data on Increased Transfer

The number of students transferring to pursue AB degrees has increased dramatically each academic year.

Degree	14-15	15-16	16-17	17-18 (as of fall 2017)
<i>Computer Science</i>	2	4	8	12
<i>Information Systems</i>	3	5	10	17
<i>Total</i>	5	9	18*	29**

* 2 students graduated for the first time in the AB CS program.
 ** 10 students are on the path to graduation in the spring term of 2018.

2. Data on Non-Traditional Student Participation

A benefit of the AB degree is that it provides a pathway for non-traditional students to earn a bachelor’s degree. Western Oregon University’s definition of a non-traditional student is over the age of 25 or is returning to school after an extended break or has children. Chemeketa Community College consists of approximately 40% of students who are over the age of 25.

Approximately 80% of the students seeking the AB degree are non-traditional students.

AB Degree	14-15	15-16	16-17	17-18 (as of fall 2017)
<i>Non-Traditional Students</i>	4 (80%)	7 (78%)	15 (83%)	23 (79%)

Results Of Collaboration

This collaboration has provided a pathway for an AAS student to pursue a four-year degree without the limitations of course acceptance at the university. This has increased the number of students who pursue and earn a bachelor’s degree. Many of these students would never have reached this goal without this option. To date, 31 students (including two who have graduated) are on track to increase their employment opportunities, enrich their personal lives, and continue a path of lifelong learning by achieving the bachelor’s degree.

Institutional and Financial Support Necessary for Success

Frequent connections between both institutions is necessary for success. A dedicated liaison between the institutions both provides for a personal connection and ensures an understanding of the AB student needs. Faculty and staff support to develop and maintain the AB degree is crucial; alignment of academic requirements is rarely an accident. Funding is needed for events for students and time for faculty to interact to discuss the AB opportunity, as is awareness of the degree option at the advising centers in each institution.

Other Advice for Implementation

Active participation in the AB program and commitment from all parties at each institution ensures that transfer students’ interests are represented both before and after transfer. Developing relationships among faculty and staff at

both institutions is necessary. These relationships can then provide a conduit for faculty to establish a personal connection to students that bridges transition between institutions.

Possible Challenges

One challenge to success is developing an awareness of what an AB degree is, how it can benefit a student, and which students are best suited for the degree path. Challenges to implementation may come from the traditional four-year degree pathway, as the idea of an AB is relatively new, and may not be fully understood by all parties.

Western Oregon University (WOU) and Two Community Colleges:

WOU and Chemeketa Community College

Problem Addressed

In 2015, Western Oregon University (WOU) began a partnership with Clatsop Community College (CCC) to facilitate student transfers in the new statewide Associate of Science Oregon Transfer Degree in Computer Science (ASOT-CS). This initiative allows rural students an opportunity to earn the ASOT-CS degree while participating in substantial faculty and student interactions prior to transferring to WOU as a junior to complete a Bachelor of Science degree in Computer Science. This partnership also gives rural students the opportunity to complete the ASOT-CS and the Bachelor of Science degree within two and four years, respectively.

The focus was placed on the promising practices of:

- seamless transferability between Clatsop Community College and Western Oregon University;
- strong faculty and student interaction opportunities before student transfer; and
- successful student retention at the community college level.

Description of Initiative

1. Seamless Transferability

The statewide ASOT-CS degree was developed for seamless transferability and students are provided a University Program Advising Guide which specifically details BA/BS Lower Division graduation requirements and Computer Science specific requirements.

2. Faculty and Student Interaction Opportunities Before Student Transfer

WOU faculty visit CCC at least annually and at most quarterly to meet with students and CCC advisors, discuss curriculum needs and updates with CCC administration, review on-site equipment, and determine how best to utilize the shared distance education model. CCC students also visit the WOU campus annually to meet with faculty and staff, sit in CS classes and tour the campus. These reciprocal visits allow WOU faculty to provide input on the

program and to assist CCC advisors with course selection, sequencing, and overall student academic development prior to transfer.

3. Student Retention at the Community College Level

Prior to the WOU partnership, CCC had very limited computer science course offerings. Introductory courses included Fundamentals of Computing, Introduction to Computer Information Systems, and Beginning Webpage Design but these courses were not helpful to students who wanted a solid computer science core for either higher level learning or transfer. Due to this, CCC couldn't retain students and they left prior to graduation. With the WOU partnership, CCC can now offer 100- and 200-level Computer Science courses including: CS 160W, Introduction to Computer Science; CS 161, Computer Science I; CS 162, Computer Science II; CS 260 Data Structures I; and, when available, CS 271, Computer Organization or CS 272, Low-level Programming.

Measure of and Indications of Success of Initiative

Over the past two full program years, course participation has increased by 200%.

Course	15-16	16-17	17-18 (as of fall 2017)	Total
CS 160W	6	16	10	32
CS 161	6	7		13
CS 162	1	3		4
CS 260	NA	2		2
Total	6	18	10	

Over the past three years, degree participation has increased by 66%.

	15-16	16-17	17-18	Total
ASOT-CS	0	6	10	10

From the degree participation, 100% of ASOT-CS degree-seeking students are on track to complete the transfer degree on schedule. Transfer data will be gained after the 2018 graduation.

Results of Collaboration

1. Expansion of Program Offerings and Connections to Baccalaureate Degree

This collaboration has been more successful than originally anticipated. These successes include program availability to students in an underserved rural area as well as money saved by students and employers. This collaboration has allowed rural students of all ages and backgrounds access to computer science degrees that they would not otherwise be able to complete. In

addition, local, regional, and statewide businesses who have been unable to find employees with computer science skills, will now be able to hire these local graduates.

2. Future Goals of the Initiative

Future goals of the program include: developing a CCC Computer Science Regional Advisory Committee to assist in gaining more local employer engagement with the program; designing a two-year and four-year advising planner that connects to WOU specifically; and budgeting for more trips to WOU for our CS students to participate in WOU events.

Institutional and Financial Support Necessary for Success

Interpersonal faculty connections between CCC and WOU provide a foundation for success, supported by strong CS faculty at WOU who collaborate with the CCC Distance Education Coordinator and Workforce Dean. Personal faculty encouragement to have students connect with them when visiting the campus helps students feel they can transfer seamlessly and without concerns. Institutional support for transfer students and the availability of scholarships for transfer students are also important.

Other Advice for Implementation

As stated above, faculty-student interaction is the key to success in a distance education program. Enabling faculty to have personal connections with students leads to students' confidence in transferring to the university.

Possible Challenges

Being a smaller school with fewer resources available, CCC needed more technical assistance and help with basic equipment set up than larger schools with more financial resources and capabilities. The distance between institutions also poses challenges as not all students are able to travel individually to visit the WOU and resources limit how many times CCC employees can travel within a year to WOU.

Hawaii: University of Hawaii and Leeward Community College

Background

The University of Hawaii System is a single university public system for the state of Hawaii. The system has ten campuses; three of them are four-year universities, two of which are on the island of Oahu: The University of Hawaii at Manoa (UH Manoa—a PhD granting/research university) and the University of Hawaii West Oahu (UHWO—a bachelor's and master's university). The Island of Oahu has four community colleges; one of them is Leeward Community College, located in the west side of the island.

Since most of the ICS (Information and Computer Science) faculty are graduates of the University of Hawaii at Manoa, the tendency was to prepare students wishing to pursue a to transfer to UH Manoa. However, Leeward Community College graduates were not transferring to UH Manoa at the expected rate, despite the informal 'pathway' set up for them.

In 2015, after several years in the making, Leeward Community College and the University of Hawaii West Oahu established their first articulation agreement to allow graduates of the ICS program at Leeward Community College to transfer with junior status into the BAS-ISA (Bachelor of Applied Science-Information Security and Assurance) at UHWO.

While the transfer rate to UH Manoa has remained the same, transfers to UHWO have soared.²³ According to students, this was because of UH Manoa's location in central Oahu. The traffic on the island is terrible during rush hours and this deterred students from continuing their education at UH Manoa.

In contrast, the UHWO campus on the west side of the island is relatively close to Leeward Community College. In 2015, once the agreement was officially in place, students began transferring at a very high rate. Even students who were not originally considering transferring or continuing their education at a four-year university decided to transfer.

Given the economy of the island, often employers want to hire one employee who can wear many hats. Students graduating from UH Manoa are great programmers, analysts, and security consultants with much theory to back that up. However, graduates from UHWO are very hands-on because the program is for a bachelor of applied science. Students in this program learn diverse skills that allow them to wear many hats. They begin at Leeward Community College acquiring technical experience with much hands-on networking and security. Later, they move into the BAS at UHWO where they continue polishing their skills while learning new ones. At UHWO students learn about project management and acquire valuable business skills that are extremely useful in this small island economy.

The Leeward Community College-UH West Oahu alliance serves our student graduates and the community while helping alleviate the traffic by keeping students in the west side of the island.

Description of Initiative

Students from Leeward Community College who have graduated from the ICS (Information and Computer Science) program are eligible to transfer to UHWO with junior status. AS-ICS graduates are also eligible to have some transfer fees waived.

Unofficially, both campuses agree that the first two years of the BAS-ISA should take place at Leeward Community College and the last two at UHWO. This is clear-cut and helps save resources and increases graduate numbers counts.

If any student applies directly at UHWO for the BAS-ISA (Bachelor of Applied Sciences Information Security and

Assurance) they are sent to Leeward Community College to work on the first two years of the curriculum. Students are not taken directly as freshmen into the BAS-ISA.

Direct benefits to UHWO include that they do not have to hire instructors to teach the first two years of their program; instead, they can focus on the last two years of the program. They leave the first two years to Leeward Community College. If a student has done part of the work elsewhere, s/he is directed to Leeward CC staff to review his/her transcripts and get him/her into the CC program. Once they graduate they continue at UHWO.

Measures of and Indications of Success of Initiative

There was a negligible number of students going to UHWO before this agreement was put in place. Once it was set, transfer numbers have been:

	Program Year			
	13-14	14-15	15-16	16-17
Transfers to UH 4-yr	10	15	11	13

Note that most students in Hawaii are minorities.

Since the articulation was set into place we have received at least two requests per semester from UHWO students to enroll at Leeward Community College to earn credits and retroactively obtain their AS in ICS.

Institutional and Financial Support Necessary for Success

The institution plays an integral role in the granting of transfer credits; “UHWO accepts transfer credits only in courses completed at regionally accredited colleges or universities, with a minimum grade of ‘D’ (not D-).”²⁴ In order to be accepted meeting UH West Oahu’s degree requirements, it is imperative for transfer students to present all credits attempted with the concomitant grade. Moreover, transfer students are encouraged to apply early for Financial Aid and warned that student’s eligibility is contingent on the applicant. Another source of funding are scholarships awarded based on merit, academic performance, and/or financial

Unofficially, both campuses agree that the first two years of the BAS-ISA should take place at Leeward Community College and the last two at UHWO. This is clear-cut and helps save resources and increases graduate numbers counts.

need and contingent upon availability of funds. A transfer student should meet with a UHWO academic advisor prior to matriculation to understand the transfer credit policy, financial support, and the academic degree plan for the desired degree. As a result, the transfer student will be encouraged to learn that personal effort and time invested in a baccalaureate degree will be a worthy “return on investment.”

Other Advice for Implementation

What is making this initiative a success is a system of divide and conquer; UHWO does not teach any of the first two-year courses, and anyone who needs or wants to take those is referred to Leeward Community College. On the CC side, students are informed about the possibility of transfer through a transfer workshop that includes attendance by counselors, career specialists, and computer science club members. In these ways, the information is disseminated extensively.

Challenges to Success

It is fortunate that our state has only one public university system, “The University of Hawaii System.” This allows a very controlled environment—a kind of “island Petri dish.” Contact among all computer science instructors on all campuses is simplified since all are acquainted, and regular articulation meetings are held so that all are informed. In addition, there is (virtual) sharing of curriculum and—occasionally—equipment.

Promising Practices and Recommendations

As we see from these case studies, community colleges and their partners in various regions of the U.S. have implemented changes in policies and practices that have created easier-to-navigate and more inviting transfer pathways for a more diverse blend of students than have been traditionally served by CS programs. By centering on the student, these institutions and policymakers have made changes that relieve students from the burden of navigating complicated transfer pathways so that they can focus instead on their goals and education. These practices can shorten and straighten student pathways—even as far as making a 3-year degree possible. These institutional success stories indicate five promising practices that could be localized and implemented in other CC ecosystems to attract and retain a more diverse student body in computing, leading to a larger and more diverse CS workforce.

1. Developing Articulation and Transfer Agreements and Policies

When institutions can agree upon courses and degrees that fulfill requirements at multiple institutions, students are largely protected from having to re-take classes and/or take additional classes to graduate, which, in turn, shortens time to completion. All the case studies presented here illustrate the benefits to students of articulation and transfer agreements through the resulting increase in student pursuit of transfer and attainment. Specifically, a key seems to be that the first two years are accepted “whole” (WOU, KY, HI) rather than a few courses on a course-by-course basis. The system in Kentucky illustrates one end of the agreement continuum; by creating a statewide policy that forces all public institutions to adhere to courses that provide guaranteed academic credit no matter where taken and to accept associate’s degrees as fulfilling general education requirements, students do not get lost in a maze of equivalencies and gaps. In other states, transfer and articulation agreements assist student persistence when four-year receiving institutions are near CCs (distance—CA—or driving time—HI) and/or offer degrees aligned with workforce needs (HI, OR). State-wide websites support students navigating transfer by giving articulation and equivalency information (NJ, CA).

2. Fostering Cross-Institution Faculty/Administration Dialog and Partnerships

In the case studies described here, dialog between the faculty at both CCs and receiving institutions was key to planning and implementation of transfer and articulation agreements. This requires ongoing contact and relationships committed to by both the CC and the four-year schools to maintain the partnership; it is crucial that faculty are involved. Communication can take the form of advisory board participation (NJ, KY) or more frequent faculty contact (HI, CA, OR). Both communication and planning

support agreements by helping to ensure the consistency of course content for the same classes at different institutions, that changes to course content are communicated and implemented at all institutions, and that the early raising and fixing of anticipated program needs is implemented and next steps are planned. Regular meetings with institutional leadership at the appropriate institution(s) to facilitate timely help with challenges beyond faculty scope (CA) further help to reduce transfer barriers to students.

Perhaps the most well-publicized intervention designed to simplify and increase student transfer pathways are articulation and transfer agreements and policies involving both CC and four-year institutions.

3. Providing Incoming Transfer Student Information, Faculty Contact And Personalized Support

Receiving institutions are critical to assisting student transfer, and interventions designed to welcome transfer students increase retention. As the primary point of contact for students, faculty at both the CC and the four-year institutions are cornerstones in sending a message that students will be supported and will feel at home before, during, and after transfer. Receiving institutions can promote opportunities available to CC students by sending the information and details directly to CC faculty to be forwarded to students (NJ). Baccalaureate four-year institutions can assign faculty advisors to CC students to assure proper information, and faculty can be available to answer CC student questions during informational public events (OR). Formalized interventions to welcome and integrate transfer students are also effective and can include course(s) designed for incoming transfer students—both to familiarize students with the university department—and to introduce a faculty point of contact—as well as a personalized course plan for time at the university (NJ). Reducing student choice and narrowing the pathway can serve to streamline computing pathways, although this can require increased student support services to provide a holistic encompassing of the student transfer experience (CA). Admissions and records support staff help students register for necessary courses and notify students of any missing graduation requirements to assure that no students fall through the cracks. Information on transfer processes and paperwork as well as financial aid can be given to students at targeted workshops.

4. Employing A Student Cohort-Based Model

Retention of underrepresented students can be facilitated by creating a CS student cohort model, consisting of students completing a bachelor’s degree program with

a consistent cohort throughout, and a cohort culture that emphasizes such values as a growth mindset, supportive peer network, and professionalism (CA).

5. Centralizing Job Market Focus

Matching degrees and program content with local workforce needs can boost both student recruitment and retention as well as immediate job prospects for graduates. This can consist of s offered through a transfer pathway that meet local job opening requirements both for type of major and for applied, hands-on experience versus theoretical training (HI). In can also include job preparation support, including interview and resume support and internship contacts (CA).

Conclusion

Community colleges play a crucial role in increasing and diversifying the tech workforce. Their collaboration with 4-year universities provide students from diverse backgrounds with the opportunity to obtain a Bachelor's degree, removing barriers and opening various career opportunities. As demonstrated in these case studies, 2-to-4 year transfer pathways can increase enrollment in CS degree programs, help academic institutions meet the increasing need to provide CS courses, and develop a sustainable workforce pipeline for industry. Institutions in these states are leading the way in making community colleges an authentic and valuable step on a computing pathway.

We recommend that regions can adopt these or other policies and approaches in order to address the growing workforce needs.

- Policy makers can advocate for agreements and policies, at both the state and institution level, to ease transfer through more effective articulation agreements.
- Faculty can build relationships between academic institutions, coordinate course pathways, and provide direct student support.
- Industry can partner with these institutions to provide career readiness support, and actively recruit from these programs to diversify their workforce.
- Students can advocate for transfer agreements to their school's administration, or create their own community cohort of transfer students.

Although, the level of engagement may vary, stakeholders working in concert to create 2-to-4 year pathways can make deep impact in creating a more equitable tech workforce.

Footnotes

1. "[A] regionally accredited institution of higher education that offers the associate degree as its highest degree." Vaughan, G. B. (2006). The community college story. Amer. Assn. of Community Col. (page 1)
2. U.S. Bureau of Labor Statistics. STEM Occupations: Past, Present, and Future. <https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/pdf/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.pdf>.
3. U.S. Bureau of Labor Statistics. Occupational Employment Projections to 2024. <https://www.bls.gov/opub/mlr/2015/article/occupational-employment-projections-to-2024.htm>.
4. U.S. Bureau of Labor Statistics. Occupational Outlook Handbook. <https://www.bls.gov/ooh/computer-and-information-technology/home.htm>.
5. Given that associate degree earners make up roughly 10% of those employed in these computing fields, while bachelor's degree earners make up roughly 43% of those employed in these computing fields, it is important to focus on the issue of two-year to four-year vertical transfer in computing fields U.S. Bureau of Labor Statistics. Employment Projections. Retrieved 3/12/18 from: <https://www.bls.gov/emp/tables/educational-attainment.htm>
6. American Association of Community Colleges (AACC). (2017). "Fast Facts 2017." Retrieved 3/12/18 from: <https://www.aacc.nche.edu/research-trends/fast-facts/>.
7. National Center for Educational Statistics (IES). (2008). Retrieved 4/30/18 from: <https://nces.ed.gov/pubs2008/2008033.pdf>.
8. Lyon, L. A. & Denner, J. (2016). Student Perspectives of Community College Pathways to Computer Science Bachelor's Degrees. Mountain View, CA: Google Inc. Retrieved from <https://goo.gl/Q0wJJv>; American Association of Community Colleges (AACC). (2017). "Fast Facts 2017." Retrieved 3/12/18 from: <https://www.aacc.nche.edu/research-trends/fast-facts/>.
9. e.g. Tennessee Reconnect. <https://www.tnreconnect.gov/>; Oregon Promise. <https://oregonstudentaid.gov/oregon-promise.aspx>; Chicago Star Scholarship. <http://www.ccc.edu/Pages/StudentTools.aspx>.
10. College Board Research. "Research Brief." Retrieved 5/2/18 from <https://trends.collegeboard.org/sites/default/files/trends-in-community-colleges-research-brief.pdf>.

11. National Center for Education Statistics (NCES). Table 321.30. Retrieved 4/30/18 from: https://nces.ed.gov/programs/digest/d16/tables/dt16_321.30.asp.
12. National Center for Education Statistics (NCES). Table 322.30. Retrieved 4/30/18 from: https://nces.ed.gov/programs/digest/d16/tables/dt16_322.30.asp.
13. Jaggars, S. S., Fink, J., Fletcher, J., & Dundar, A. (2016). A Longitudinal Analysis of Community College Pathways to Computer Science Bachelor's Degrees. Mountain View, CA: Google Inc. Retrieved from <http://goo.gl/Eiz33G>.
14. CS for All Fact Sheet. <https://obamawhitehouse.archives.gov/the-press-office/2016/01/30/fact-sheet-president-obama-announces-computer-science-all-initiative-0>; ACM "Rebooting the Pathway to Success." https://pathways.acm.org/ACM_pathways_report.pdf.
15. Tang, C. (2017). COMMUNITY COLLEGE CORNER: ACM guidelines for associate-degree computer science transfer programs. ACM Inroads 8, 3 (July 2017), 20-22. [download]
16. This program was built off of the National Academies Press 2005 report Enhancing the Community College Pathway to Engineering Careers (M.S. Mattis and J. Sislin, eds).
17. www.njtransfer.org
18. Ky. Rev. Stat. Ann. 164.583
19. Ky. Rev. Stat. Ann. 164.2951
20. <http://cpe.ky.gov/policies/academicaffairs/genedtransferpolicy.pdf>
21. Western Oregon University 2017-2018 Course Catalog
22. Topi, et al., IS 2010: Curriculum Guidelines for Undergraduate Degree Programs in Information Systems, ACM/AIS, 2010.
23. <http://www.hawaii.edu/offices/cc/arpd/instructional.php?>
24. UHWO 2016-17 Catalog, p. 15.



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