Community Colleges Perspectives: From Challenges to Considerations in Computer Science Curriculum

Christian Servin, Elizabeth K. Hawthorne, Lori Postner, Cara Tang, Cindy S. Tucker

Abstract  Community and Technical Colleges are two-year college institutions in the US that have been at the intersection of many educational initiatives and partnerships, such as K-12, four-year colleges, and workforce/industry partnerships. Community Colleges are notable for their diversity and heterogeneous student population, but also for the workforce’s influence to disseminate specific curriculum requirements. Therefore, community colleges offer a large variety of computing programs, including Computer Science degrees, notably Associate in Science (AS) and Arts (AA) (a.k.a. academic transfer degrees). Ideally, these transfer degrees align learning outcomes, objectives, and competencies to the ACM/IEEE curricular guidelines, mainly to create two-year programs that align curricula and ease transferability to Computer Science programs at four-year colleges. Due to the nature

Christian Servin
Information Technology Systems and Computer Science, El Paso Community College, 919 Hunter Dr., El Paso, TX 79915, USA, e-mail: cservin1@epcc.edu

Elizabeth K. Hawthorne
Rider University, Lawrenceville, NJ 08648, USA, e-mail: ehawthorne@gmail.com

Lori Postner
Dept. of Mathematics, Computer Science and Info. Technology, Nassau Community College, Garden City, NY 11530, USA, e-mail: lori.postner@ncc.edu

Cara Tang
Computer Information Systems, Portland Community College, Portland, OR 97217, USA, e-mail: cara.tang@pcc.edu

Cindy S. Tucker
Computer and Information Technologies, Bluegrass Community and Technical College, Lexington, KY 40508, USA, e-mail: cindy.tucker@kctcs.edu
of these degrees, Computer Science programs at the lower-division undergraduate level face curriculum challenges and emerging opportunities while adopting curricular guideline recommendations. Some of these include the number of transfer hours, the scope of topics in computer science, and the most recent ABET accreditation efforts for two-year programs in computing. This discussion aims to identify and recognize additional significant challenges that Computer Science programs in community colleges face, particularly while adopting curricular guidelines recommendations, such as CS2023. Moreover, the discussion on this matter will influence the recognition of curricular guidelines and considerations for two-year programs in Computer Science. Compilation of community colleges’ viewpoints and feedback during this conversation will be considered part of the curricular practices “Community Colleges Perspectives: From Challenges to Considerations in Curricula” document, featured in the new version of the CS2023: ACM/IEEE-CS/AAAI Computer Science Curricula.

1 Introduction

Community colleges are typically two-year institutions that offer a variety of academic and vocational programs to students at an affordable cost [5, 6]. Some of the common characteristics of community colleges:

- **Open enrollment**: Community colleges generally have an open enrollment policy, meaning that anyone who meets the basic admission requirements can enroll in classes. This makes community colleges accessible to a wide range of students, including recent high school graduates or current high school partnerships, adult learners, and working professionals.
- **Affordable tuition**: Community colleges are generally much more affordable than four-year colleges and universities, making them a popular choice for students who want to save money on tuition and other expenses.
- **Career-focused programs**: Many community colleges offer Career and Technical Education (CTE) programs that are designed to prepare students for specific careers, such as nursing, law enforcement, or information technology. These programs often include hands-on training and internships that give students practical experience in their chosen field.
- **Small class sizes**: Community colleges tend to have smaller class sizes than larger universities, which can provide students with more “one-to-one” personalized attention from their instructors and a greater sense of community on campus.
- **Transfer agreements**: Many community colleges have transfer agreements with four-year colleges and universities, which can make it easier for students to transfer their credits and continue their education at a higher level by having memorandum of understanding (MOU).
- **Diverse student body**: Community colleges often attract a diverse student body, including students from different socioeconomic backgrounds, racial and ethnic groups, and age ranges. Community Colleges are known for their diverse het-
erogeneous student population, such as high school students, transfer and experienced students with many years of experience from the workforce or military, and first-generation students. Community colleges focus on the support the socio-economically disadvantaged and first-generation attending college communities who face challenges in many aspects, including degree completion [3]

- **Flexible scheduling:** Community colleges often offer flexible scheduling options, such as evening and weekend classes, online courses, and hybrid formats, which can be particularly helpful for students who are working or have other commitments.

### 2 Community College Environment

According to the Community College Research Center, during the 2020-2021 academic year, 33% of all undergraduates in the United States are enrolled in a two-year college. [Community College Research Center] “Community colleges are centers of educational opportunity. They are an American invention that put publicly funded higher education at close-to-home facilities, beginning nearly 100 years ago with Joliet Junior College. Since then, community colleges have been inclusive institutions that welcome all who desire to learn, regardless of wealth, heritage, or previous academic experience. The process of making higher education available to the maximum number of people continues to evolve . . . ” [4]. Community colleges routinely and uniquely provide a learning environment for

- transfer into baccalaureate programs;
- entrance into the local workforce;
- workforce development and skills training (local economic development); and
- lifelong learning for personal and professional enrichment.

Two-year colleges serve:

- dual-credit high school students,
- high school graduates proceeding directly into college,
- workers needing to upgrade skill sets or master new ones,
- immigrants seeking to become integrated into the local culture, including learning a new language,
- individuals leaving the workplace to engage college-level coursework for the first time,
- previous college students who did not perform well but are again trying to be successful,
- returning students with college degrees who have decided to pursue an alternative career path, and
- many individuals in need of ongoing training and skill updating.

This diversity is addressed in numerous ways, including targeted career counseling, remediation of basic skills, specialized course offerings, individualized instruction and attention, flexible scheduling and delivery methodologies, and a strong
emphasis on retention and successful completion. The mission of two-year college faculty is to focus their full-time attention on effective pedagogy for educating a diverse student population, as well as remaining current in their discipline and in the scholarship of teaching and learning, and fostering student success. Two-year, community, or technical colleges, as well as certain four-year colleges, award associate degrees to students completing between 60 and 66 higher education semester credits in a specific program of study. It is often the case that an associate-degree requires approximately half the college credit of a bachelor’s degree. Associate-degree programs are comprehensive, whether designed specifically to enable graduates to transfer into the upper division of a baccalaureate program or to enter into the workforce. Community colleges also offer certificate programs, intended to be fulfilled in less time than an associate degree program; such programs are often designed for targeted student audiences and focused on specific content.

2.1 Career and Transfer Programs

Typically, associate-degree computing programs fall into two categories: those designed to prepare graduates for immediate entry into career paths, usually an Associate of Applied Science (A.A.S), and those designed for transfer into baccalaureate degree programs, usually an Associate of Science (A.S.) or Associate of Arts (A.A.). Career-oriented associate-degree programs provide students with the specific knowledge, skills, and abilities necessary to proceed directly into employment in a targeted work environment [7]. The program of study may include professional development coursework as well as courses that emphasize communication skills, mathematical reasoning, and other general education requirements. In addition, many students will augment their formal studies with technical industry certifications to enhance their immediate employability. It is important to note that a career-oriented associate degree program is not intended to facilitate transfer into a baccalaureate program but rather to provide entry into a career that requires specialized post-secondary skills and an advanced level of expertise and education. Nevertheless, many students graduating from career-oriented programs later elect to further their education at the baccalaureate level. Transfer-oriented degree programs provide the academic foundation and pathway to continue a program of study at a four-year college or university. Articulation is a key consideration in associate-degree programs which are designed as transfer curricula. Articulation of courses and programs between academic institutions is a process that facilitates transfer by students from one institution to another. The goal is to enable students to transfer in as seamless a manner as possible. Efficient and effective articulation requires an accurate assessment of courses and programs as well as meaningful communication and cooperation among institutions. Both students and faculty have responsibilities and obligations for successful articulation. Ultimately, students are best served when educational institutions establish well-defined articulation agreements that actively promote transfer.
2.2 Diversity in the Computing Profession

Across the globe, there is a high demand for computing professionals and a significant shortfall in job vacancies in many locations. The growth of new and emerging roles in computing, technology, and engineering fields exceeds the rate that underrepresented groups enter these fields. Academic research continues to bear light on the pressing need to increase the diversity of students pursuing computing degrees and the numerous benefits of doing so. To help fulfill the increasing shortage of computing professionals, computing faculty should increase efforts to effectively recruit and retain a wider range of students and build and provide effective support structures so that all students can successfully graduate.

2.3 Enrollment and Degrees

According to an Association of Computing Machinery (ACM) Non-Doctoral Granting study, in the 2020-2021 academic year, there were over 1200 community colleges offering associate degrees in computing disciplines in the United States. With an enrollment of almost 249,000 students, approximately 18,000 associate-level computing degrees were conferred. In computer science alone, there were 5,642 degrees and an overall enrollment of 103,149 students (32% of computing degrees at two-year colleges in the U.S.). A companion ACM study [8, 9] found 50% of associate degree computer science graduates continued in higher education at the bachelor level. 59% of these students continued in computer science and another 23% explored a different computing discipline.

2.4 Authentic Industry and Academic Partnerships

Community and Technical college degrees often have standard courses, creating a space for collaboration between students with different backgrounds and interests by identifying the workforce and research solutions. Another objective is to support high school initiatives and partners to advanced programs in high schools such as dual-credit, early college high schools, and the Pathways in Technology Early College High Schools (P-TECHs). These characteristics mentioned above is what makes community colleges unique across the US.

3 From Challenges to Opportunities

Community Colleges nowadays presents both, challenges and opportunities in the educational and industry perspective. Some of these challenges have been present
for many years, including perceptions and transferability issues. However, these can present opportunities for growth and development future pathways to grow partnerships. In this section, we will explore how challenges and opportunities intersect in different aspects from the community college perspective.

3.1 Transfer-Related Issues

Community college’s Associate of Science in Computer Science transfer programs face a number of challenges. Most are designed with the intention that the student will begin their college studies at the community college, enter with the necessary prerequisite knowledge to take the courses in the program, will complete all the courses for the degree at the community college, graduate with the associate’s degree, and then transfer to a for 4-year program entering as a junior. With this model in mind, the A.S. degree comprises both general education classes and the math, science, and computer science requirements typically found in the first two years of a B.S. or B.A. degree in CS. Four-year schools typically accept a maximum of 60 credits, so A.S. degrees must balance the composition of the required courses to maximize the student’s credits when they transfer.

In reality, there are several variations of this model. Students may enter community college directly from high school but lack the math background to take the upper-level math and science requirements for the A.S. degree. This slows the student’s progress and may increase the number of credits they will take to graduate. Students may enter the community college to only stay a semester or two and then transfer to a 4-year institution without completing the degree. When this occurs, the 4-year institution will evaluate each course for transfer (as opposed to accepting the degree as a whole), often resulting in a loss of credits for the student. A student might enter a community college with credits from another college. These courses may not mirror the contents of the courses at the community college and create situations where students are either re-taking courses because they are missing key concepts or placed into courses where they don’t have the same background as the students who took the prerequisites at the community college.

There are very different models of the relationships between community colleges and public four-year institutions. For example, in some states, NY, a single community college may feed students into many different 4-year public institutions. But in other states, Washington, for example, many community colleges will typically feed into one state institution. In addition, students may choose to transfer to a private institution. Community colleges set up articulation agreements and joint admissions programs with many different institutions to ease the transfer process. But this can be difficult as there is no standardization of what is required in the first two years of a Computer Science bachelor’s degree. Some programs require only Calculus 1, others require completion of Calculus 2, while others require Calculus 3. ABET-accredited programs have specific lab science requirements, while non-ABET programs have more flexible science choices. Some schools have a 2-
semester introductory sequence, while others offer a 3-semester sequence. Designing a curriculum that gives the community college student the greatest flexibility is daunting. Either the requirements are extremely high with the intent of preparing students for the most rigorous CS program, which may place an undue burden on students who will choose other types of programs and delay or prevent graduation with an AS degree, or the requirements are not rigorous enough for articulation agreements or to allow students to transfer with junior status.

3.2 Math in Computer Science

Community colleges face several challenges when it comes to meeting the math requirements for computer science majors. One major challenge is that many students enter community college underprepared for college-level math, often due to inadequate preparation in high school or gaps in their learning. This can lead to students needing help to keep up with the material and becoming discouraged, resulting in lower retention and graduation rates. Transfer degrees, such as computer science, have additional math requirements or prerequisites once the student transfers to the four-year institution (e.g., discrete math/structures, linear algebra, calculus 3). Additionally, community colleges often have limited resources. They may need help to provide adequate support for students who need extra help with math, such as tutoring services or additional instructional materials. These challenges make it difficult for community colleges to ensure that their students are adequately prepared in math and able to succeed in their academic and career goals.

3.3 Curricular Recommendations for Two-year Programs

The ACM CCECC (Committee for Computing Education in Community Colleges) publishes curricular guidelines for associate programs in the computing disciplines ACM recognizes, including computer science. The most recent guidelines, ACM Computer Science Curricular Guidance for Associate-Degree Transfer Programs with Infused Cybersecurity [2], also referred to as CSTransfer2017, are based on CS2013.

Additionally, the CCECC collects at their website program examples (https://ccecc.acm.org/): real programs at the associate / two-year level that map to the CSTransfer2017 guidelines. These program examples show how the ACM curricular guidelines look in practice.
3.4 ABET Accreditation

Another consideration for faculty in associate degree programs is that ABET is starting to accredit associate degree computing programs. This started with Cybersecurity programs in 2021 (ABET 2021) [1], and there are currently proposed General Criteria for Associate computing programs. Other program criteria, such as IT and CS might be coming. As associate computer science programs may have or be seeking bachelor transfer partners that are ABET accredited, pursuing ABET accreditation may be desirable to demonstrate a quality program.

3.5 US National Science Foundation

The National Science Foundation (NSF) offers community college students, faculty, and institutions several opportunities. Here are some examples:

- **Advanced Technological Education (ATE) Program**: The ATE program provides grants to community colleges and other two-year institutions to support the education and training of technicians in high-growth fields such as advanced manufacturing, biotechnology, and cybersecurity.

- **Improving Undergraduate STEM Education (IUSE) Program**: The IUSE program supports projects that enhance the quality of undergraduate STEM education and increase the number of students who pursue STEM careers. Community colleges are eligible to apply for certain funding opportunities within this program.

- **NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Program**: The S-STEM program provides scholarships to students pursuing associate or bachelor’s degrees in STEM fields at eligible institutions, including community colleges.

- **Research Experiences for Undergraduates (REU) Program**: The REU program provides summer research experiences to undergraduate students, including those at community colleges, who are interested in pursuing graduate study in STEM fields.

- **NSF INCLUDES Program**: The INCLUDES program aims to broaden participation in STEM fields by funding alliances that bring together organizations from different sectors to work towards increasing diversity and inclusivity in STEM education and careers. Community colleges can participate in INCLUDES alliances.

These are just a few examples of the opportunities that the NSF provides for community colleges. For more information, visit the NSF website or contact the NSF directly.
3.6 Towards Defining the Computing / CS Core?

The core of computer science is a set of fundamental concepts and skills essential for anyone wanting to work in the field. These core concepts include algorithms, data structures, programming languages, computer architecture, operating systems, and databases. Due to the limitation of the number of transfer credits, the CS core needed to be reduced, questioning what the most significant courses to transfer to a computer science program are.

3.7 Reverse Transferability

Reverse transferability is the process by which credits earned at a four-year institution can be transferred back to a two-year institution to award an associate degree. This allows students who transferred to a four-year institution before completing their associate degree to receive still that degree, which can be valuable for several reasons. For example, some students may have completed enough credits at a two-year institution to earn an associate degree but transferred to a four-year institution before officially applying. In these cases, reverse transferability can allow students to receive recognition for their prior work and earn a degree that may help with job prospects or further education.

Reverse transferability can also benefit students who encounter difficulties or challenges at a four-year institution and leave before completing a bachelor’s degree. An associate degree can still provide some level of credentialing and may improve job prospects. Overall, reverse transferability can be an essential tool for ensuring that students receive recognition for their academic accomplishments. It can help motivate the completion of associate degrees, which can be a valuable stepping stone toward further education and career opportunities.

3.8 Community Colleges Assist the Students Surge in Four-years Institutions

Some universities have experienced the challenge of having excessive enrollment in computer science programs. Recently, emerging multi-disciplinary programs such as CS + X or Data Science require the fundamentals of computer science as part of the prerequisites for advanced courses. Another reason is that there needs to be more faculty to teach computer science fundamentals. Therefore, students delay their registration for CS fundamentals courses, creating opportunities for regional community colleges to offer courses that address this surge.
References

1. Abet accredits 54 additional programs in 2021, including first associate cybersecurity programs, October 2021.