Report of the

SCCS

STATE COMMITTEE ON COMPUTER SCIENCE

IN PARTNERSHIP WITH THE **OHIO DEPARTMENT OF EDUCATION** AND **OHIO DEPARTMENT OF HIGHER EDUCATION**

Making  a National Leader in Computer Science Education

Table of Contents

SCCS
STATE COMMITTEE ON COMPUTER SCIENCE
IN PARTNERSHIP WITH THE OHIO DEPARTMENT OF EDUCATION AND OHIO DEPARTMENT OF HIGHER EDUCATION
Making Ohio a National Leader in Computer Science Education

To:	Governor Mike DeWine Lt. Governor Jon Husted Chancellor Randy Gardner, Ohio Department of Higher Education Interim Superintendent Stephanie Siddens, Ohio Department of Education
From:	The State Committee on Computer Science Senior Vice Chancellor Mike Duffey, Chair Education Specialist John Wiseman, Vice Chair Ohio STEM Learning Network Director Kelly Gaier Evans, Facilitator
Date:	August 30, 2022
Subject:	Report of the State Committee on Computer Science (SCCS)

On behalf of the State Committee on Computer Science, as established in HB 110 of the 134th General Assembly, we respectfully submit the attached report as required by law.

The committee believes that, if implemented, these recommendations would put Ohio well on its way to become a national leader in computer science education and workforce pipeline.

Thank you for the honor of serving the State of Ohio in this capacity.

Mike Duffey, Chair
Ohio Dept. of Higher Education

Autum Barry
Project Lead the Way

Lisa Chambers
TechCorps

Kristi Clouse
JobsOhio

Tim Conley
Bloom Vernon Schools

Tonjia Coverdale
Nationwide

Mike Eilerman
Tri-Star Career Compact

Courtney Falato
JP Morgan Chase

Katie Hendrickson
Code.org

John Wiseman, Vice Chair
Ohio Dept. of Education

Debbie Jackson
Cleveland State University

Chelsey Cook Kohn
Cleveland Metropolitan School District

Tsavo Knott
Pieces.app

David Landreman
Olive

Jong Kwan Lee
Bowling Green State University

Doug McCullough
Color Coded Labs

Rebekah Michael
University of Cincinnati, Ohio Cyber Range Institute

Patricia Murakami
Dayton Regional STEM School

Lisa Nolan
Air Force Research Lab

Tom Newman
Cincinnati State Technical and Community College

Tasha Penwell
CSTA and Hocking College

Paula Naa Quartey
Student, KIPP Columbus

Paul Sivilotti
The Ohio State University

Kelli Shrewsberry
Teaching & Learning Collaborative

Bryan Stewart
Warren/Montgomery ESC

Brent Wise
Mariemont City Schools

Executive Summary

In the wake of Intel's $20 billion commitment, Ohioans are expressing surging interest in computer science (CS) education. Far beyond this investment, Ohioans recognize the ***economic opportunity*** that computer science provides students across all 88 counties.

To attract employers, Ohio will need to adapt its educational system, both PreK-12 and post-secondary, to produce a workforce pipeline that is both larger and qualitatively superior to competitors. With **historic increases to STEM education funding** during the DeWine-Husted administration, progress is happening, but Ohio must do more to compete and win.

At the post-secondary level, **Ohio ranks 33rd in the percentage of college graduates who major in CS**. And Ohio ranks just 34th in the growth rate of CS degrees. Ohio needs to rank in the top 10 states nationally for CS degree production and growth rate.

According to the National Academies of Sciences, Engineering, and Medicine, over the past four decades, the **number of computing jobs grew twice as fast as the production of bachelor's degrees**. Computer science is the only major discipline in which the projected number of job openings exceeds the rate of bachelor's degree production.

In formal surveys this year, **88% of Ohio parents indicate they want their children to have access to CS classes and two-thirds (66%) felt CS was just as important as English, math, science and other core subjects**. 23% of Ohio parents felt it was more important.

When HB 110 created the State Committee on Computer Science, we wanted to create a report with clear recommendations that could help **make Ohio a national leader in computer science education and workforce pipeline**. We believe this report achieves that goal.

If Ohio starts with industry, invests at least 1% of its educational funding, provides all students one credit in CS by the end of the decade, expands university CS degree programs and gives opportunities to all Ohio students to learn CS, then we will be the leading state nationally.

The committee believes that, if implemented, these recommendations would put Ohio well on its way to become a national leader in computer science education and workforce pipeline.

Thank you for reading this report. We look forward to the coming months of discussion in Ohio on which recommendations may be implemented to make this vision a reality.

Sincerely,

The State Committee on Computer Science

The reasons are clear: ***Ohioans want high-paying jobs that will continue to grow into the future***.

CS jobs offer median salaries **48%** higher than Ohio's median household income of $58,116 and are growing quickly, with 4.8 times more jobs than qualified applicants.

According to the Bureau of Labor Statistics, from 2014 to 2024, computing occupations **will grow nearly twice as fast as the labor market at an expected growth of 12.5%**. JobsOhio estimates computing occupation in Ohio grew 14% from 2015-2021.

In secondary education, **Ohio ranks 31st in the percentage of high schools offering CS courses**. We need to rank among the top 10 states nationally.

Report - Recommendation Highlights

RECOMMENDATION 1

Create an Office of Computer Science Education (OCSE)

Ohio should establish an office to lead state efforts to expand computer science (CS) at the Pre-K-12, postsecondary and adult workforce levels.

RECOMMENDATION 2

"One for CS" State of Ohio 1% Funding Investment in CS

Ohio should dedicate 1% of state educational funding (approximately $94 million per year in 2022) to computer science education. This will make Ohio a national leader in CS funding.

RECOMMENDATION 3

One Credit in CS as a Graduation Requirement by 2030

Ohio should require one credit in computer science for all high school graduates by the end of the decade, joining the five states that already have a CS requirement for all students.

RECOMMENDATION 4

Create Ohio's CS Promise – Guaranteed Access for Students

Ohio should offer students the opportunity to take at least one CS class per year. If providing this requires the student to receive instruction outside the home district, the state should cover the cost of these classes as this would be a small, high aptitude segment of students.

RECOMMENDATION 5

Establish an "Ohio CS Council" for Afterschool/ Summer Programs

Ohio should support existing CS summer and afterschool programs, typically run by nonprofit organizations across the state. The Ohio CS Council would provide competitive grant funding to extend CS programming to all 88 counties.

RECOMMENDATION 6

Expand Teacher Licensure and Professional Development

Ohio has a shortage of CS teachers. To address this shortage, Ohio should fund grants to cover upskilling teachers and grade band licensure into K-5, 4-9 and 7-12 like other subjects.

RECOMMENDATION 7

Start with Industry When Identifying CS Education Goals

Ohio should ask employers what skills are needed, using formal research tools and then align educational programs to better address these cutting-edge workforce needs.

RECOMMENDATION 8

Provide Individual District Playbook and Grants

Ohio should provide districts with resources to implement CS education. These can include lesson plans, high quality instructional materials, online modules and hands-on staff support.

RECOMMENDATION 9

Launch a "CS for Ohio" Marketing Campaign

Ohio should create a public service awareness campaign for CS education and workforce to inform Ohio families and students of the opportunities in this growth sector.

RECOMMENDATION 10

Provide CS Career Path Tools and Examples

Ohio should develop an online career path exploration tool that explains which classes to take to pursue a career in computer science.

Ohio's Case for Computer Science Education

Education is Key to Equality and Opportunity

Every Ohioan deserves the chance to succeed, get a good-paying job, raise a family comfortably and be secure in their future. Every Ohio student should have the opportunity to live up to their maximum potential. Computer science (CS) is one exciting pathway for students to achieve these objectives.

Education is the key to equality and opportunity. Computer science (CS) is one exciting pathway.

Since the Dewine-Husted administration took office, funding for STEM programs has increased by historic amounts. For example, Ohio's STEM scholarship program Choose Ohio First has witnessed a 73% appropriation increase since 2019. And TechCred has supported over 20,000 short term technology related credentials. But Ohio must do more to compete and win.

Ohio employer demand for CS talent is **nearly 4.8 times** current supply in Ohio. The average salary is 48% above Ohio's median.

Demand for CS Talent Exceeds Supply in Ohio

Every day, Ohio employers are working to fill openings in computer science (CS) – from data analytics to cloud computing, cybersecurity, Internet of Things, artificial intelligence, programming, networking and beyond.

From 2015 to 2021, the number of jobs in CS in Ohio grew 14%, ranking 24th nationally in CS occupational job growth over this period. The highest ranked state was Utah with 39% growth.[1]

According to JobsOhio, Ohio employer demand for CS talent is nearly 4.8 times the current supply in Ohio. JobsOhio estimates this gap could widen by approximately 11,000 jobs per year. In a recent Bureau of Labor Statistics report, the mean earning potential for CS occupations is $85,970, or 48% above Ohio's median household income of $58,116.[2]

The United States is Ceding High-Paying Jobs

The shortage of domestic CS talent nationally has produced demand for foreign workers.[3] The National Academy of Sciences, Engineering, and Medicine reports the share of foreign workers who work as computer scientists is well above other STEM occupations.[4]

In some cases, U.S. companies hire computer engineers and programmers directly, establishing a presence in India, China, Ukraine and other areas where CS talent is plentiful.

The share of foreign workers working as computer scientists in the U.S. rose from **10.6%** in 1994 to **26.8%** by 2015.

In other cases, companies hire talent visiting the United States through H-1B visas. In both cases, the jobs are not filled by U.S citizens. Approximately two-thirds of all H-1B visas in the United States are for computer-related occupations.

Approximately two thirds of all H-1B visas in the United States are for computer-related occupations.

While engineering had, on average, 15.6% of its workforce as foreign workers, computer science's percentage of foreign workforce grew from 10.6% in 1994 to 26.8% in 2015.[5] Non-US workers with college degrees typically access the United States through the H-1B visa program.

According to the National Academies of Science, Engineering, and Medicine, "the number of computing jobs far exceeds the number of computer science graduates being produced … employment in computer occupations in and beyond the technology sector grew by nearly a factor of 20 between 1975 and 2015… In particular, expertise in cybersecurity, data science, and machine learning are in high demand."[6]

Ohio ranks in the bottom half of states in the percentage of high schools offering foundational CS.

Solving Ohio's CS workforce gap will require increasing our state's educational pipeline from K-12 to postsecondary degrees while also upskilling Ohio's existing adult workforce. However, CS talent production in Ohio lags other states in both K12 education and post-secondary output.

Ohio K-12 Student Access to CS Lags National Average

In K-12, Ohio ranks in the bottom half of states in the percentage of high schools offering foundational CS courses.

For baseline measurement, utilizing the national K-12 Framework "foundational CS" definition, roughly 50% of Ohio high schools offer at least one course in CS as of 2019-2020, an increase from 42% in 2018-2019.

Despite this progress, Ohio currently ranks 31st in the percentage of high schools offering CS curriculum and courses. Leading states, including Arkansas and South Carolina, report that 92% of high schools offer CS. Other high-ranking states include Maryland and Rhode Island.

When compared with neighboring states, Ohio's access rate (~50%) is significantly below Indiana (~74%), W. Virginia (~76%) and Pennsylvania (~63%).

Among Ohio's high schools offering CS, the most significant number (185, 67%) are in suburban areas of the state, while access is lower in urban areas (76, 34%), small towns (69, 50%) and rural areas (159, 48%).

In 2020, just **3.6%** of Ohio high school students enrolled in foundational CS vs. **4.7%** nationally

Access Is Different Than Participation

Whether a course is offered or not, high school access differs from student participation. For an accurate picture of CS participation in Ohio, actual enrollment defines engagement.

In 2020, just 3.6% of Ohio high school students enrolled in a foundational CS course (18,762 out of 515,436 students).

This compares unfavorably to the national average of 4.7% of U.S. high school students enrolled in foundational CS in the 37 states that maintain this level of detail in enrollment data.[7]

Cultural Stereotypes Inhibit CS Growth

A significant and growing body of research indicates that cultural stereotypes, including the myth that "STEM disciplines are for boys," remain common in grade school and contribute to female under participation. This is not an Ohio-specific challenge but should inform Ohio's approach to increasing its CS pipeline.

Female students are underrepresented in K-12 and post-secondary computer science.

Nationally, female students are underrepresented (30.7%) in K-12 CS versus their actual representation among all students (48.9%). This mismatch also persists later in life, where only 25.1% of those working in CS were women compared to 49.6% of all bachelor's degrees examined in a study.[8]

Ohio College Degree Output in CS

If Ohio wishes to attract and retain employers, it will need to increase its pipeline output of college graduates with CS degrees.

At the postsecondary level, Ohio ranks in the bottom half of states in the percentage of college degrees and growth rate for college graduates majoring in CS.[9]

Ohio ranks **33rd** out of 50 states in the percentage of college degrees produced that are computer science as of 2020.

In 2020, the percentage of graduates at Ohio colleges and universities majoring in CS ranked 33rd out of 50 states at 3.6%.[10] Ohio's output compares unfavorably to surrounding states including Kentucky (10.7%), Pennsylvania (5.9%), W. Virginia (4.6%), Illinois (4.72%), Indiana (5.2%) and Michigan (4.8%).

A related figure, Ohio's growth rate for CS degrees, ranks slightly lower (34th) at 19.2% over the five years from 2015-to 2020. By comparison, Kentucky grew its total

Ohio ranks **34th** out of 50 states in the growth rate for college degrees that are computer science as of 2020.

CS graduates by 359.1% over the same period to lead the nation in CS degree growth. West Virginia lagged Ohio slightly with 18.1% growth and Michigan stood at 24.9%, more than five percent ahead of Ohio.

As previously referenced, the National Academies' study also found that between 1975 and 2015, the growth in the number of computing jobs far exceeded the number of graduates – nearly twice as fast as the production of bachelor's degrees.[11]

When Surveyed, Ohio Parents Overwhelmingly Support CS Education

In June 2022, Ohio Excels completed a poll of 600 Ohio parents with children in public schools with a margin of error of +/- 4.6%.

Eighty-eight percent (88%) of respondents indicated they would be interested in their child having access to computer science courses. Two-thirds (66%) felt opportunities to learn computer science were "just as important" as Ohio's existing educational requirements including English language arts, math, science, social studies, physical education and health.

Twenty-three percent (23%) of poll respondents went further, responding that computer science is "more important" than Ohio's traditional core subjects.[12] Surprisingly, for "more important," a higher percentage (24%) of respondents from rural areas agreed than in suburban (21%).

For additional context, a 2021 Gallup/Amazon poll of 4,116 students in grades 5-12 indicated that 62% of students would like to learn about CS, but only 49% have taken a class.[13]

States and Cities are Prioritizing CS Education

Twenty-seven states require all high schools to offer CS. Ohio is not among them.

Five states require all students to take a CS course for graduation: Arkansas, Nebraska, Nevada, Tennessee and South Carolina.[14] As of June 2022, Rhode Island is also working to add CS to its state graduation requirement. Mississippi has a "computer science"[15] graduation requirement that may be satisfied with a CS, technology, or engineering course (not just CS).[16]

Some metropolitan school districts, including Chicago and New York City, now require CS to be offered to their students.

Among peers states such as Indiana, Michigan, Pennsylvania and others in the Midwest, all states with higher CS job growth have professional development funding for teachers.[17] In many cases, these same states already have statewide CS education plans.

The United States Does Not Federally Prioritize CS Education

Globally, CS courses are mandatory for students in 44 countries, including the United Kingdom, Ireland, China, Russia, Australia, part of Canada, Sweden, Finland, Italy and Japan.[18]

More than half (27) of all states require all high schools to offer CS. Ohio is not among them.

Currently, only 51% of high schools in the United States offer CS. As referenced in Appendix D, the United States federal government has considered a number of CS education programs but few if any have been enacted in recent years and no significant federal funding exists.

CS is mandatory for students in 44 countries including the United Kingdom, Ireland, China, Russia, Australia and others.

States like Ohio Are Left to Prioritize CS Education

Within the past five years, Ohio's legislature enacted permissive law (HB 170-132GA) for K-12 credit flexibility, but its effects seem modest and participation rates still lag leading states.

Without dedicated state funding and increased parity for CS with traditional core subjects established in the early 1900s before computer science existed, Ohio is unlikely to take a leadership position nationally in computer science education and workforce pipeline.

Ohio's strong preference for local control in education through 600+ locally elected boards also means the state will need to provide strong incentives for local schools to increase Ohio's talent output.

Ohio, like all states, is thrust into a global competition for job growth.

Employers Validate Ohio is a Great Place to do Business

Ohio, like all states, is thrust into a global competition for job growth. Employers and investors competitively evaluate Ohio's ability to provide a steady pipeline of high school and college-educated graduates with a level of CS skills needed to create disruptive, fast-growth companies.

For some of the highest-paying jobs in the tech sector, such as research and development (R&D), employers are choosing areas collocated with high-intensity research institutions.

Technology industry sector momentum in Ohio is strong. On Jan. 21, 2022, Intel Corporation selected New Albany, Ohio, for what is expected to be the most advanced semiconductor manufacturing center in the world. This $20 billion initial investment is expected to create

3,000 permanent jobs with an average salary of $135,000 per year.

This builds upon additional recent successes as Ohio increased in rank from fifth to fourth nationally for the Prosperity Cup by Site Selection Magazine. The Prosperity Cup is awarded to the most competitive states in economic development.

Intel selected Ohio for what is expected to be the most advanced semiconductor manufacturing center in the world.

Foundational CS vs. Computer Literacy

While the committee's recommendations focus on computer science skills including computational thinking, logic and intermediate-to-advanced labor market skills, the committee recognizes Ohio should also support allied prerequisite skills sometimes described as "basic computer literacy."

Examples include keyboarding, operating systems, touchpads, word processing and the Internet. Ohio schools should address these basic expectations for a global society, not just for CS-focused students.

Yet these skills are *not enough* to differentiate Ohioans competitively. Ohio competing to win will require at least some familiarity with computational thinking and a significantly more robust pipeline of students choosing these careers as their specialty.

The Ohio Computer Science Plan represents a vision in which all **Ohio students are prepared to be both users and creators** in a world increasingly propelled by technology.

The Ohio Computer Science Plan outlined in this report represents a vision in which all Ohio students are prepared to be both users and creators in a world increasingly propelled by technology. In several sections of this report, readers may notice the phrase "foundational computer science" referenced.

Foundational computer science focuses on logical reasoning, computational "if-then" thinking and practical application in building marketable products from software apps to robotic automation and customer data analytics.

These are not basic computer literacy skills but learned, applied skills that differentiate Ohio's workforce from other states in attracting high-wage job growth. When all Ohio students have access to foundational computer science, industry and postsecondary institutions will be able to attract more students into these fields and career pathways for computer science and technology while also meeting other sectors' growing appetite for CS skills.

Defining Computer Science

The Ohio Revised Code defines "computer science" in Section 3301.012[19] as "'computer science' means logical reasoning, computing systems, networks and the internet, data and analysis, algorithms and programming, impacts of computing, and structured problem-solving skills applicable in many contexts from science and engineering to the humanities and business."

Ohio's K-12 computer science and information technology courses cover both foundational (computational thinking) and advanced computer science offerings including workforce knowledge and skills.

The K-12 Computer Science Framework adopted by the National Science Foundation (NSF), Computer Science Teachers Association (CSTA), Code.org, the National Math + Science Initiative (NMSI) and the Association for Computing Machinery (ACM), as used in the annual "State of CS" reports define computer science as *"the study of computers and algorithmic processes, including their principles, their hardware and software designs, their implementation, and their impact on society."*[20]

These two definitions are substantively similar, but it is important to realize that the nationally published State of CS report only counts courses in "foundational computer science" that must include application of learned concepts through programming (minimum 20 hours per course).

This differs from Ohio's Education Management Information System (EMIS) which codes computer science according to tables established by the Ohio Department of Education. This statewide data collection system is Ohio's authoritative source of information on Ohio primary and secondary education demographic information, time, attendance, course information, financial data and test results.

In some cases, courses defined as computer science by EMIS may not match the K-12 CS Framework definition. When in doubt, please consult the Ohio Department of Education.

Some in the computing industry use the term "information technology" or "IT" to refer to a branch of skills and content knowledge in computer science. IT typically refers to maintaining and troubleshooting the computers of an organization, ensuring networks, systems and security are optimized. Working in IT often requires knowledge of computer science principles, whereas "foundational computer science" is design oriented, including the creation of applications and other tasks typically conceptualized as computational thinking and/or programming.

The committee wishes to recognize the thoughtful comments of Dr. Hazem Said from the University of Cincinnati, who noted in public comments that computer science may also be considered more broadly as "computing" rather than just "computer science." In higher

education and industry, computer science is one of many disciplines of computing.

Dr. Said noted that federal programs use the term “computer science” more broadly and that national discussions also often use “computer science”, but he wished to clarify to the committee computing encompasses technologies such as programming, networking and web development that often do not align to post-secondary “computer science” majors.

While the committee uses “computer science” throughout the report, we thank Dr. Said for these thoughtful comments and express our intent that “computer science” be interpreted to include computing, with the customary caveats regarding foundational vs. computer literacy.

Committee Origin and Background

The State Committee on Computer Science (SCCS) was established in HB 110 of the 134th General Assembly, which required the State Superintendent of Public Instruction at the Ohio Department of Education, in consultation with the Chancellor of the Ohio Department of Higher Education, to appoint committee members.

The committee was comprised of 26 individuals representing a broad cross-section of Ohio, from K-12 teachers and administrators to postsecondary faculty, JobsOhio, large employers, fast-growing startups, military research and computer science advocacy organizations.

The committee included one K-12 student and a recent college graduate-turned-entrepreneur. Geographically, members traveled from Athens, Celina, Cincinnati, Cleveland, and Columbus, among communities representing the full breadth of Ohio's geography and schools.

The committee's recommendations were designed to make Ohio a national leader in computer science education and workforce pipeline. HB 110 identified several specific topics for the committee to address as later itemized in this report. Specific charges are flagged within recommendation using color-coded letter and number markers referencing the statute.

Meetings were publicly noticed, streamed on the Ohio Channel and hosted at the Center of Science and Industry (COSI) in Columbus. The committee first convened on Nov. 17, 2021 and met a total of 10 times through Aug. 30, 2022.

The committee's effort was a continuation of previous policy changes that began in 2017. Ohio educators continue to voice strong support and enthusiasm for advancing CS in Ohio. As Ohio endeavors to be the most innovative and entrepreneurial state in the Midwest, increasing access to computer science education remains a priority for this administration.

In mid-July 2022, Governor DeWine joined governors from all 50 states in committing to expand computer science education for students by increasing the number of high schools offering computer science, allocating funding to CS education, creating pathways to postsecondary success and providing equitable access to computer science for all students.

This commitment by all 50 governors followed a letter from hundreds of executives ranging from Bill Gates to Jeff Bezos, calling on governors from all 50 states to prioritize computer science education. The agreement is known as the 'Compact to Expand K-12 Computer Science Education" and was facilitated by Code.org and the National Governors' Association.

State Committee on Computer Science
Membership Roster

SCCS

STATE COMMITTEE ON COMPUTER SCIENCE

IN PARTNERSHIP WITH THE OHIO DEPARTMENT OF EDUCATION AND OHIO DEPARTMENT OF HIGHER EDUCATION

Making Ohio a National Leader in Computer Science Education

PreK-12

John Wiseman,
Vice Chair
Ohio Dept. of Education

Tim Conley
Bloom Vernon Schools

Chelsey Cook Kohn
Cleveland Metropolitan School District

Mike Eilerman
Tri-Star Career Center

Patricia Murakami
Dayton Regional STEM School

Paula Naa Quartey
Student, KIPP Columbus

Bryan Stewart
Warren/Montgomery ESC

Brent Wise
Mariemont Schools

Post-Secondary

Mike Duffey,
Chair
Ohio Dept. of Higher Education

Debbie Jackson
Cleveland State University

Tsavo Knott
Pieces.app

Jong Kwan Lee
Bowling Green State University

Rebekah Michael
University of Cincinnati

Tom Newman
Cincinnati State

Tasha Penwell
CSTA and Hocking College

Paul Sivilotti
The Ohio State University

Nonprofit

Autum Barry
Project Lead the Way

Lisa Chambers
TechCorps

Kristi Clouse
JobsOhio

Katie Hendrickson
Code.org

Kelli Shrewsberry
Teaching & Learning Collaborative

Business

Tonjia Coverdale
Nationwide

Courtney Falato
JP Morgan Chase

David Landreman
Olive

Doug McCullough
Color Coded Labs

Federal

Lisa Nolan
Air Force Research Lab

Ohio's School Funding System and its Role in CS

The scale of Ohio's existing K-12 funding system is enormous – over $23 billion per year in combined resources between local levies, federal funding, state formula and other state funding according to U.S Census data on school finance itemized by state for FY 2020.[21]

Yet while state spending on education is the most cited figure on Capitol Square, it amounts to less than half of the $23 billion. According to Ohio's Legislative Service Commission[22], state-only spending on K-12 education in FY 2020 was $11.2 billion from general funds, special funds and lottery profits, meaning the other $11.8 billion in spending was raised and spent from other sources – primarily local district levies and, to a lesser extent, federal funds.

Ohio will spend approximately $9.4 billion in FY 2023 specifically on the school funding formula, with zero dollars specifically dedicated toward CS education. Please note the committee recognizes that some Ohio districts *do* spend available state funding on computer science – the funds simply are not dedicated for that purpose specifically.

If, in a future operating budget, Ohio dedicated an amount equivalent to just 1% of direct state K-12 education spending toward computer science as part of its regular biennial budgetary funding increases, it could provide $94 million annually for expansion of computer science while remaining a relatively small percentage of Ohio's total school funding effort.

Total state spending in Ohio on education grew by 5.6% or $534.7 million in the first year of the biennium and 2%, or $203.8 million, in the second. This totals to an increase of $738.5 million in education or about 7.8 times as much as the "1% for CS" recommendation in this report. All of these increases occurred within the most recent single two-year period.

Ohio's CS Teacher Shortage

The consensus of the state planning committee is that there is a clear shortage of qualified CS teachers in Ohio, and this workforce bottleneck is exacerbating schools' decision to not offer computer science courses.

As referenced in Recommendation 3, "One Course in CS as a Graduation Requirement by 2030", Ohio's teacher pipeline also reflects that district hiring practices are fundamentally driven by state mandates.

When determining how many full-time equivalent teachers it would take to fully staff Ohio districts for computer science, the committee benchmarked against Ohio's current staffing level of health teachers as an existing half-credit course requirement for graduation.

Ohio currently reports ~4,600 full-time equivalents (FTEs) in districts as health teachers but only 1,080 FTEs for computer science. This is the estimated gap that needs closing.

The committee identified this "factor chain" as contributing to Ohio's CS teacher bottleneck:

- CS is not required for graduation or state tested.
- It is well known that school administrators are motivated to hire teachers to meet state graduation and testing standards.
- Without a state graduation requirement, school districts are not likely to be motivated to hire CS teachers.
- Preservice teachers recognize the absence of CS job openings in local districts and therefore do not pursue CS educational endorsements or CS-focused careers.
- Colleges and universities observe lower preservice teacher demand for CS as students pursue available jobs in state-tested fields such as math, science, language arts, etc.
- Ohio's only CS teaching licensure program (Wright State University) closed in January 2021 due to insufficient enrollment. (Note: other paths still exist to teach CS)
- Widespread CS adoption depends on legislative actions by the Ohio General Assembly.
- Pay scales for teachers in Ohio are insufficient to compete with the private sector.
- Expectations are low; it is common for Ohio schools to not offer CS courses to students.
- If teachers wish to pursue professional development to qualify to teach CS, no funding currently exists to fund that learning, and no district salary enhancement is offered.
- The state does not provide funding to incentivize districts to offer CS generally.
- If a teacher seeks and receives a CS endorsement, he/she currently becomes qualified to teach K-12, not just the grade band taught today, and therefore could be forced into a new grade by a school administrator. This discourages endorsement adoption rates.
- If grade bands were adopted, this chilling effect could possibly be eliminated.

For these reasons, the committee believes that without a uniform high school graduation requirement or strong positive financial incentive for districts, CS is unlikely to grow quickly enough to meet Ohio workforce expectations.

House Bill 110 – Recent Statutory Law Changes

Ohio House Bill 110, passed in July 2021, included several new provisions for K-12 computer science education. The law:

1. Requires the Ohio Department of Education to update the Ohio Learning Standards and Model Curriculum within one-year of the effective date of HB 110 (Ohio Revised Code 3301.079(A)(4).

2. Requires that no later than 30 days after the effective date of this legislation, the Department, in consultation with the chancellor of higher education, shall establish a committee to develop a state plan for computer science education not later than one year after the effective date of the legislation (Sept. 30, 2022) for the purposes of primary and secondary education (Ohio Revised Code 3301.23(A)).

3. Requires the state plan for computer science include a requirement that the Department collect any data regarding computer science courses offered by school districts and school buildings operated by school districts, including the names of the courses and whether the courses were developed using the standards and model and post the collected data on its website (Ohio Revised Code 3301.23(D)(1)).

4. Beginning with the 2022-2023 academic year, requires state universities to recognize the successful completion of a course in advanced computer science in high school, as described in the standards adopted pursuant to division (A)(4) of section 3301.079 of the Ohio Revised Code, as a unit for admission to the university.

Report – Recommendations Summary

The Computer Science State Planning Committee developed the following recommendations to expand computer science education in Ohio.

1. Create an Office of Computer Science Education (OCSE)
2. "One for CS" State of Ohio 1% funding investment specific to CS
3. Establish CS as an Ohio Graduation Requirement by 2030.
4. Ohio's "CS Promise" to Students
5. The "Ohio CS Council" beyond school
6. Teacher Licensure and Professional Development
7. Start with Industry When Identifying CS Education Goals
8. Individual District Support, Playbook, Stipends and Grants
9. "CS for Ohio" marketing campaign
10. CS career path tools and examples

Report Key – HB 110 Charges and Related Recommendations

The following color-coded markers are utilized in the report as shorthand to indicate which charges from HB 110 statutory language each specific recommendation addresses.

- B1 Best practices and challenges
- B2 Demographic data
- B3 Benchmark data for teachers
- B4 Best practices for public-private partnerships
- B5 Graduation requirement
- B6 Work-based learning pilot
- B7 Any other topic determined appropriate
- D1 Challenges that prevent school districts from offering computer science
- D2 Requirement that ODE collect data regarding computer science, including alignment with standards
- D3 Requirement that committee determine the best ways to compile data
- D4 Any findings the committee determines appropriate

RECOMMENDATION 1:
Create an Office of Computer Science Education (OCSE)

HB 110 Charges Addressed: B1 B2 B4 B7 D1 D2 D3 D4

Ohio should establish an Office of Computer Science Education (OCSE) dedicated to expanding computer science (CS) at the K-12, postsecondary and adult workforce levels that includes staffing at the Governor's Office, the Ohio Department of Education, the Ohio Department of Higher Education and allied workforce agencies.

ACTUALIZATION

The Office of Computer Science Education (OCSE), acting as a policy team, would be charged with driving Ohio K-12, postsecondary and workforce policy for CS, advising the governor's policy team, benchmarking against other states, advising on funding to prioritize CS, supporting teacher pipeline, overseeing implementation of all recommendations which the governor and legislature choose to implement in a budget and supporting local districts.

The OCSE, in collaboration with ODE and ODHE, also would be charged with establishing Ohio's ongoing operational plans for CS education, producing periodic reports to the governor and legislature, overseeing the state's CS budget and ensuring fair and equitable access to CS education across Ohio's 88 counties.

To the extent regional educational and industry leaders may be asked to form advisory panels, the OCSE should coordinate efforts with regional educational service centers, chambers, CIO roundtables, sector partnerships and other industry groups.

STRUCTURE

An executive director or equivalent position should lead the OCSE. Additional teams of staff for program implementation should be established within the Ohio Department of Education, Ohio Department of Higher Education and related workforce agencies.

Executive Director
The first step in establishing the OCSE is hiring a knowledgeable, charismatic, outgoing, ambitious and passionate executive director to lead the office. The executive director should have prior experience in K-12, higher education, computer science, the technology industry and workforce programs. This position should report directly to the governor and work closely with the governor's policy director to establish CS policy goals for Ohio. Finally, the executive director would serve as a liaison and CS thought leader on behalf of the governor's office with the various agencies, with local education agencies (such as school districts) and should have a small internal team within the governor's office to support his or her work.

RECOMMENDATION 1: Create an Office of Computer Science Education (OCSE)

Ohio Department of Education

The Ohio Department of Education currently has 1.5 full-time program specialists in the area of computer science. The committee considers this too small for future needs. With the implementation of this plan, a director-level manager and a program administrator would be necessary. In addition, a specialist/consultant that works directly with school districts to implement CS expansion programs could be stationed in each region. The Department will need staff whose duties include traveling to districts and working with school officials and parents, and who would help implement CS plans in districts that opt in to participate.

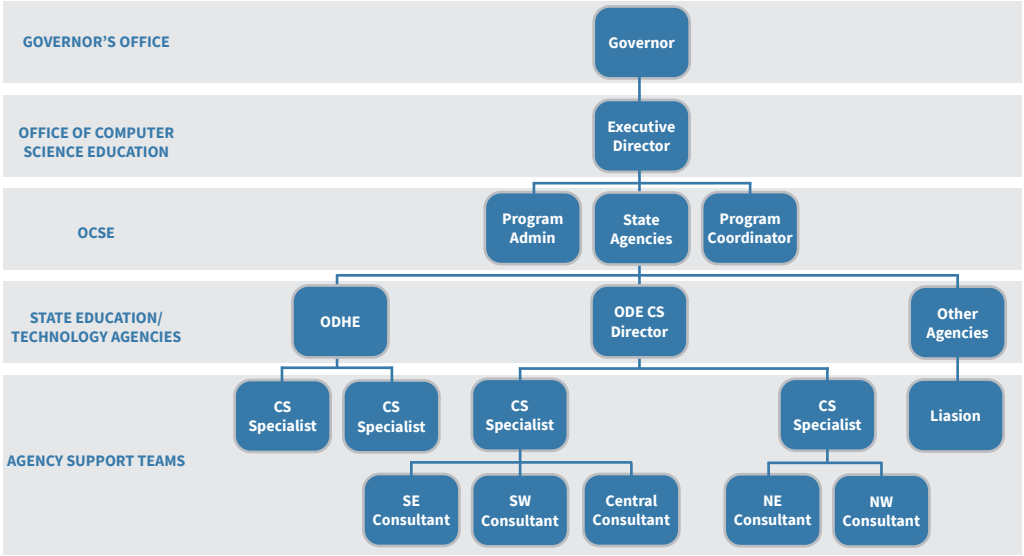
Ohio Department of Higher Education

A small team may be necessary at the Ohio Department of Higher Education to support the expansion of CS degree enrollment (associate, bachelor's, master's and doctorate) and CS teacher preparation (preservice teachers) at the postsecondary level, including working with universities and colleges to establish programs and staffing, coordinate workforce goals established by the OCSE and to help align postsecondary admissions. This would likely entail fewer than five full-time equivalent staff.

Related Workforce Agencies

Policy work should include related workforce agencies, including those who serve adults through programs such as TechCred. A small team may be necessary to help coordinate work through the Governor's Office of Workforce Transformation and allied workforce agencies (ODJFS, Development, Workforce Investment Boards, Business Advisory Councils, etc.) to focus on CS expansion. To the extent possible, the OCSE should ensure coordination with regional workforce boards already formed across the state.

Sample Diagram – Office of Computer Science Education (OCSE)



RECOMMENDATION 1: Create an Office of Computer Science Education (OCSE)

TIMELINE

2022 *Create Office of Computer Science Education (OCSE)*
OCSE connects with allied state agencies to collaborate

2023 *State legislature appropriates 1% for CS funding (includes funding OCSE)*
Hiring the Executive Director and core team
Determine staffing, begin hiring at ODE and ODHE agencies
Engage with stakeholders and implement recommendations

MEASUREMENT

The effectiveness of the OCSE should be measured by the overall metrics tracked by the state, including the number of districts offering CS, number of students participating in CS, student-level outcomes in postsecondary and workforce, equitable representation in CS access surveys of Ohio employers and overall ability to move Ohio toward CS as a key strategic priority.

For more information, please see the Data Collection and Reporting Requirement section.

REQUIREMENTS FOR SUCCESS

The OCSE can exist and succeed only if a state budget CS funding stream is secured. Full implementation of the OCSE is possible only through the support and collaborative work of agencies and stakeholders.

POTENTIAL IMPACT

The Ohio Department of Education currently only has 1.5 FTE employees working on computer science for K-12, and 1 FTE employee for Career Technical Education (information technology which falls under the state definition of CS). ODHE has zero FTEs dedicated to CS, but several vice chancellors and other staff have contributed time to the committee process. To implement the state computer science plan effectively, additional staff will be needed in early years to coordinate funding the state may appropriate to eliminate CS enrollment bottlenecks at state colleges and universities. In sum, the Office of Computer Science Education will facilitate:

- Critical policy development and implementation oversight on a permanent basis
- Effective use of resources through the regional specialists/consultants
- Efficient use of professional development resources
- Additional points of contact available to districts and teachers
- Increased staff solely focused on computer science education to facilitate depth of knowledge and responsiveness to constituencies regarding changes in legislation, rules and curriculum, and help districts keep up with the rapid changes in computer science

RECOMMENDATION 1: Create an Office of Computer Science Education (OCSE)

- Increased CS access for all districts by having staff available onsite to support districts
- Increased awareness of Computer Science
- Increased collaboration between agencies, industry, higher education, nonprofit partners and K-12 schools
- Increased collaboration between agencies, industry, higher education, nonprofit partners and K-12 schools

RECOMMENDATION 2:
"One for CS" – State of Ohio 1% Funding Investment

HB 110 Charges Addressed: B1 B2 B3 B4 B6 B7 D1 D2 D3 D4

Ohio should dedicate funding equal to at least 1% of the state's K-12 school funding formula to the cause of expanding CS education in the state. Generally speaking, these funds would be utilized to achieve the recommendations in this report. See Appendix A: Budget for "One for CS" 1% Funding Investment for a draft potential budget model for first-year implementation.

This "1% for CS" funding stream should consist of recurring permanent funding in the state operating budget to be utilized by the Office of Computer Science Education, the Ohio Department of Education, the Ohio Department of Higher Education and the proposed Ohio CS Council (described in Recommendation 5), and in local school districts throughout the state.

If this policy were in place for 2022, the funding target would be approximately $94 million annually based on the state's $9.4 billion funding formula appropriation. As state appropriations change over time, this 1% for CS goal should be considered the floor for funding as many districts have zero resources to actualize CS programming effectively without this resource.

The State of Ohio currently does not dedicate any state or federal funding to computer science education as a K-12 school funding formula component. Ohio also does not provide non-formula supplemental funding for computer science separate from limited STEM funding.

To a limited extent, the state funds STEM education in K-12, at the postsecondary level through state share of instruction funding weights and STEM-focused programs such as the Choose Ohio First scholarship. Ohio also funds technology-focused short-term credentials through workforce upskilling programs like TechCred. These funds generally are not targeted toward computer science.

OHIO'S SCHOOL FUNDING SYSTEM AND ITS ROLE IN CS

The scale of Ohio's existing K-12 funding system is enormous – over $23 billion per year in combined resources between local levies, federal funding, state formula and other state funding according to U.S Census data on school finance itemized by state for FY 2020.

Yet while state spending on education is the most cited figure on Capitol Square, it amounts to just a fraction of the $23 billion. According to Ohio's Legislative Service Commission, state of Ohio spending on K-12 education in FY 2020 was $11.2 billion from general funds, special funds and lottery profits, meaning the other $11.8 billion in spending was raised and spent from other sources, mostly local district levies and to a lesser extent, federal funds.

RECOMMENDATION 2: "One for CS" – State of Ohio 1% Funding Investment

Ohio will spend approximately $9.4 billion in FY 2023 on the school funding formula alone with zero dollars specifically dedicated toward CS education. However, the committee recognizes that some Ohio districts do spend a portion of available state funding on computer science. The funds simply are not dedicated for that purpose specifically.

If, in a future operating budget, Ohio dedicated just 1% of direct state K-12 education spending toward computer science as part of its regular biennial budgetary funding increases, it could provide $94 million annually for expansion of computer science while remaining a relatively small percentage of Ohio's total school funding effort.

Total state spending in Ohio on education grew by 5.6% or $534.7 million in the first year of the biennium and 2%, or $203.8 million, in the second year. This amounts to an increase of $738.5 million in education or about 7.8 times as much funding as the "1% for CS" proposal recommended in this report.

ACTUALIZATION

As part of the biennial state operating budget appropriations process, the governor's office and legislature should propose and appropriate funding equal to 1% of the proposed school funding formula, dedicated specifically to computer science.

Funds should be supplemental to existing funding but may be sourced from planned increases in K-12 budget funding overall. Ideally, these funds should be in addition to the increased amount necessary to complete the phase-in of the Fair School Funding Plan.

Final determination for utilization of funds should be determined by the Office of Computer Science Education in consultation with the governor, legislature, Ohio Department of Education, Ohio Department of Higher Education and related workforce agencies.

Please see *Appendix A: Budget for "One for CS" 1%* Funding Investment for a draft potential budget model for first-year implementation. Future year budget models should change based on needs identified by stakeholders.

TIMELINE

Appropriation of this funding is a necessary step toward establishing an Office of Computer Science Education and implementation of all recommendations that include the expenditure of state funds, which includes nearly every recommendation. As a result, the legislature's appropriation of funding should be among the first steps taken in the first year.

MEASUREMENT

The Office of Computer Science Education should be charged with tracking the effective use of all funds appropriated, evaluating metrics of success including:

RECOMMENDATION 2: "One for CS" – State of Ohio 1% Funding Investment

- The number of districts expanding programs to offer computer science
- The number of students participating in computer science course(s)
- Measures of persistence and success for students who take multiple CS courses
- Enrollment and degree completion outcomes at postsecondary institutions
- The number and quality of after-school, summer and public-private partnerships established through the CS Council grants
- The number of teachers who become qualified to teach CS in Ohio and how Ohio's professional development program (Teach CS) is positively impacting this goal
- Any Ohio marketing program for CS and its effectiveness
- Workforce outcomes related to the appropriations
- Overall ability to move Ohio toward CS as a strategic priority

The OCSE should explore longitudinal research, including postgraduation outcomes such as percentage of students who matriculate into college-level CS coursework or enter a CS-related career field, together with wage outcomes. These figures should be reported on a regular cadence, possibly every two years.

REQUIREMENTS FOR SUCCESS

To provide 1% for CS funding, Ohio will need to incrementally increase state education funding by this amount to avoid supplanting existing K-12 and higher education funding. State educational funding generally cannot be appropriated outside the biennial operating budget process that begins in odd-numbered years. This funding is prerequisite for implementing most of the recommendations in this report. As a result, nearly all other recommendations connect to, and depend upon, resolution of this recommendation.

POTENTIAL IMPACT

1% for CS recommendation is predicated on the belief that it is incredibly difficult to move enormous K-12 and postsecondary educational systems toward positive workforce change without noticeable resources. In this context, the committee believes that 1% of the state funding formula is a reasonable initial commitment by the state as permanent recurring operating funding.

At the same time, this committee believes, given current understanding of resources in other states, this investment would likely be considered a watershed nationally among all 50 states in terms of the commitment it demonstrates to CS expansion. This 1% for CS education investment would put Ohio on the map, making Ohio a top 5 leader among states dedicating resources to CS education.

RECOMMENDATION 3:
Establish CS as an Ohio Graduation Requirement by 2030

HB 110 Charges Addressed: B3 B5 B7 D1 D2 D3 D4

The committee recommends that all Ohio high school students who graduate in 2030 or later should complete one credit of high school level computer science.

The committee received public comments asking that this requirement occur earlier than 2030 and sympathizes with this sense of urgency but does not feel this would be practicable. The committee also received a comment from the Ohio Association of School Business Officials (OASBO) suggesting that all high schools be required to offer CS, but not require students to take it for graduation. The committee believes this would not reach students that otherwise would never choose on their own but who may nevertheless discover a passion for CS.

The committee recognizes that the most challenging barriers for CS expansion, including the shortage of teachers, may be impossible to remedy without a graduation requirement, as high schools hiring practices tend to closely follow state requirements. In the absence of a high school graduation requirement, the committee believes Ohio is unlikely to reach near-universal offering of computer science to students who wish to take these courses.

A single-credit high school computer science course requirement would ensure students in all 88 counties in the state of Ohio have at least one meaningful experience with computer science before graduating from high school. This is similar to the rationale behind the lab science course requirement (e.g., biology, chemistry) that students must take but may not pursue later in life.

The committee believes that, philosophically, Ohio should aim to provide parity for CS with other currently *required* subjects, including English language arts, social studies, history, math, science, physical education, health and financial literacy.

As context, five states currently require CS for graduation: Arkansas, Nebraska, Nevada, Tennessee and South Carolina.[23] As of June 2022, Rhode Island also is working to add CS to state graduation requirements.[24] Mississippi has a "computer science"[25] graduation requirement that may be satisfied with a CS, technology or engineering course (not just CS).[26]

With unanimous support from the K-12 members of the committee, we recommend Ohio adopt a one-credit high school CS graduation requirement by the year 2030. This would remain substantially below Ohio's traditional four credits required in English and math and less than Ohio's traditional three credits required in lab sciences and social studies.

This eight-year phase-in will allow districts in Ohio to plan for this substantive change with plenty of time to upskill teachers, plan curriculum and build a community of support.

RECOMMENDATION 3: Establish CS as an Ohio Graduation Requirement by 2030

Note: Ohio is launching a Strengthening Ohio High School Mathematics Pathways Initiative this fall to be implemented in the 2022-2023 school year. This initiative addresses new guidance around what courses can be considered Algebra 2 equivalent, including some computer science courses. The committee recognizes the benefits for Ohio students of the math pathways initiative and computational thinking skills it supports.

ACTUALIZATION

Computer Science Graduation Requirement

Ohio should enact a statewide high school graduation requirement that includes one credit in computer science (CS), effective for the graduating class of 2030. The Ohio Department of Education should publish a list of EMIS course codes that will satisfy this requirement. Qualifying courses include foundational computer science courses such as AP Computer Science A, IB Computer Science, Programming, Database Applications, Cyber Security, Computer and Mobile Applications, Interactive Application Development, among many others. They may also include related disciplines such as human-computer interaction, user experience (UX), data science, and discrete math/computer science. To the extent a subject such as discrete math may be utilized, it should include computer science content.

The list would not include computer literacy courses, keyboarding or word processing.

For a complete list of courses that the committee recommends, please see *Appendix B: Supplemental Information, EMIS Codes for Graduation Requirement*

Ohio schools should supplement the 2030 high school requirement by expanding grade-level integrated instruction in grades K-5 and stand-alone CS courses in grades 6-8. The committee recommends schools utilize curriculum aligned to existing state standards for computer science education at each grade level.

If implemented with fidelity, this plan helps ensure all children in Ohio will experience CS to some extent in each grade from kindergarten through eighth grade as well as at through at least one stand-alone high school course by 2030.

The committee believes this recommendation would significantly broaden Ohio student participation in computing, dramatically increasing rural and urban students' access to potential future careers while maintaining a flexible approach to choosing curriculum and pathways.

A focus for all grades should include using evidence-based programs or researching and evaluating new programs to scale effective initiatives across Ohio.

RECOMMENDATION 3: Establish CS as an Ohio Graduation Requirement by 2030

Related Ohio Computer Science Licensure Revisions

Please see *Recommendation 6: Expand Teacher Licensure and Professional Development* for additional detail on increasing Ohio's number of teachers qualified to teach CS through professional development, licensure grade banding and other incentives.

Related School Report Card Indicators

Teachers are not the only individuals that the state needs to incentivize to achieve success. Administrators determine priorities for buildings and districts and must make choices about where to invest organizational time and resources.

To incentivize school districts generally to scale CS hiring on a timely basis to meet the 2030 goal, the state should publish new report card indicators.

These flags would not be graded on the state report card but would indicate which districts are "on track" to have sufficient qualified teachers and/or which schools have participating students.

School districts should receive a *Computer Science Teacher Indicator* on the State Report Card if they satisfy either of the following criteria:

The district's number of qualified CS FTEs rose 20% or more vs. the prior year, or
The district has already met the date-specific benchmark for CS FTEs

The committee also recommends the Ohio Department of Education consider adding a *Computer Science Access Indicator* that would report CS course enrollment participation for all groups of students who enroll in CS courses in grades 6-8 and 9-12.

TIMELINE

2022 *Create Office of Computer Science Education (OCSE) and staff agencies.*

2023 *OCSE publishes "Ohio Computer Science Report" facts and figures.*
ODE appropriates funding for professional development and stipends.
ODE establishes Computer Science Teacher Indicator(s) on State Report Card

2024 *ODE adds grade banding to CS licenses*
ODE updates licensure dictionary for CS/CTE licensure crossover

2025 *Districts begin to offer integrated CS and/or stand-alone courses*

2026 *ODE provides a grade 7-8 indicator for CS offerings on the State Report Card*
ODE provides Computer Science Access Indicator on State Report Card

2027 *Districts begin to teach stand-alone CS courses as required in grades 6-8. First HS freshman cohort required to have one credit of CS credit for graduation*

2028 *ODE provides a grade K-6 indicator for CS offerings on the State Report Card*

2030 *All HS graduates starting this year are required to complete one credit of computer science education in approved EMIS course codes for graduation.*

MEASUREMENT

Key measurements related to this recommendation include counting the number of qualified CS teachers in Ohio before and after implementation of this recommendation, the number of students before and after who are enrolled in foundational CS courses and the percentage of Ohio high school students who completed at least one qualifying CS course before graduating.

From a more holistic perspective, the Office of Computer Science Education should attempt to measure the extent to which every Ohio student has experienced a positive, quality CS learning experience in each of the three major grade bands before graduating from high school.

Lastly, Ohio should explore longitudinal research into post-graduation outcomes such as the percentage of percentage of students before and after this policy who matriculate into college-level CS coursework or enter a CS-related career field, together with wage outcomes.

REQUIREMENTS FOR SUCCESS

**Co-Dependent Recommendation:* The committee does not support the implementation of this high school graduation requirement without the implementation of Recommendation 6 (Teacher Licensure and Professional Development).

POTENTIAL IMPACT

Ohio's ability to meet future CS talent workforce pipeline needs depends on the recruitment of students from across the state. Ohio will need greater engagement in CS from student populations in rural Appalachia, East Cleveland, Celina, Cincinnati and all areas in between.

And for each of those students to have the opportunity and choice to decide their career path, they need to first experience at least one introductory computer science course.

By implementing this policy, Ohio will likely become the seventh state nationally to implement a CS graduation requirement for high school. And in doing so, Ohio will continue to position itself as the best location for technology-related job growth and investment.

RECOMMENDATION 4:
Create Ohio's CS Promise to Students

HB 110 Charges Addressed: B1 B2 B3 B4 B7 D1 D2 D4

While most of the recommendations in this report focus on expanding access to at least one foundational CS course to all Ohio students, this recommendation addresses the opposite dilemma – how to support Ohio's most passionate students who are committed to learning across multiple CS courses, often along a sequentially more rigorous path that leads to more advanced and specialized topics.

To guarantee that all Ohio students who wish to take CS courses may do so at least once per academic grade level, the committee recommends that the state create an "Ohio CS Promise."

This program would provide students with a guaranteed opportunity to take CS courses even when their local school district cannot offer the course. In providing these courses, the state would fully cover the expense so local districts do not bear the financial burden.

Courses could be taken through various arrangements. One exciting possibility could be a world-class online catalog of courses provided by a partnership of Ohio universities, K12 schools and nonprofits. This could be akin to a state-sponsored online CS campus.

Additionally, regional partnerships could be formed by local districts with visiting CS teachers, at a local college, neighboring school district, Educational Service Center (ESC), nonprofit or another remote modality similar to College Credit Plus.

ACTUALIZATION

An example of a typical CS Promise student could include a student who takes an Intro to Computer Science course in seventh grade, sparking her interest in additional CS courses. That summer, she participates in a robotics club sponsored by her school district and decides she wants to keep taking CS classes all the way into high school.

Under current law, the student has no right to continue her CS studies if the courses she wishes to take (artificial intelligence/machine learning and mobile application development, for example) are not offered by her local district and school.

Under CS Promise, this student would have a statutory right under Ohio law to continue taking CS classes at a minimum of one course per year per grade through 12th grade. She could take artificial intelligence at a community college and mobile application development through a class arranged by her district with a visiting teacher from a coding nonprofit.

RECOMMENDATION 4: Create Ohio's CS Promise to Students

Accordingly, upwards of six CS courses could be taken before graduation at no cost to the student or the local district. All costs would be proposed paid from the 1% for CS education funding. The Ohio Department of Education would establish business rules to govern approved providers, transportation and other programmatic details.

TIMELINE

2022-23 *Develop Ohio's CS Promise business rules within 6-12 months following the creation of the OCSE*

2023 *Begin awards of CS Promise funding for 2023-2024 academic year*

MEASUREMENT

As with other measures tracked by OCSE, participation numbers in Ohio CS Promise should be included in periodic reports. These could include the following:

- The number of students enrolled in CS Promise courses and specific classes taken
- The amount of funding necessary to fund these courses statewide and growth rate
- The cost-effectiveness and educational impact of various modalities and providers
- The number of sequential courses students take on average, median, etc.
- Student outcomes such as credits earned, and longitudinal outcomes such as matriculation to college, persistence in CS, careers, etc.
- Evaluation of administrative/operational experience to streamline the program

REQUIREMENTS FOR SUCCESS

This recommendation is dependent upon the following other recommendations:

- Recommendation 1: Creation of an Office of Computer Science Education (OCSE)
- Recommendation 2 "One for CS" - State of Ohio 1% funding investment specific to CS

POTENTIAL IMPACT

School districts want to provide students with a variety of CS course options but cannot afford to hire dedicated teachers for every possible pathway (programming, networking, AI, app development, database development, cybersecurity, etc.) Ohio's CS Promise offers a solution at no cost to local districts (an attractive benefit compared to College Credit Plus).

Once students "catch the bug" for CS, they will want to take multiple courses across various grade levels, potentially in more rigorous sequences. It is important that the State of Ohio

have a program in place that can allow these students to continue learning and eliminate unnecessary roadblocks to taking another course in sequence.

Ohio's CS Promise gives our best and brightest CS students the ability to live up to their maximum potential. These students exemplify our strongest and most committed talent and Ohio employers' future workforce.

RECOMMENDATION 5:
Establish an "Ohio CS Council" for Afterschool/Summer Programs

HB 110 Charges Addressed: B1 B4 B6 B7 D1 D2 D3 D4

For many students, their first positive, life-changing experience with computer science will occur not in a school classroom, but with friends at an afterschool club, summer camp or other extracurricular enrichment activity. Ohio has a robust ecosystem of nonprofits already focused on CS, robotics, coding boot camps, application development, etc. Rather than reinvent the wheel, Ohio should help fund these programs across all 88 counties utilizing a model already proven effective for funding nonprofit arts organizations – the Ohio Arts Council. This recommendation conceptually extends the arts council grant funding model into a new "Ohio CS Council" that focuses specifically on creating CS experiences for Ohio youth.

Imagine an afterschool program in Athens, Ohio that connects middle school students with the Ohio Cyber Range Institute regional center at Ohio University for a cyber "capture-the-flag" hacking event utilizing virtualized machines. Imagine a summer camp for students in Lima, Ohio that teaches them how develop a mobile game to play with friends. Imagine students in Cleveland participating in the RITE / Greater Cleveland Partnership "Discover IT Information Scramble" to learn about career opportunities.

The committee recommends funding the CS council at $20 million per year to be competitively awarded across the entire state with a focus on geographic reach, inspiring students who historically have had fewer opportunities to participate in these kinds of programs.

ACTUALIZATION

Because Ohio already has many nonprofit organizations fundraising for the majority of their own programming, an Ohio CS Council grant can help extend programming to new students at fraction of the cost if the state had to provide the same opportunities directly.

The council should include a governing board of approximately 13 CS-focused community and workforce leaders around Ohio who would be responsible for approval of funding requests. The awards process could include tiers for large, medium and smaller CS organizations.

One of the most positive aspects of these organizations is that they often feature charismatic, engaged technology leaders and volunteers who make CS fun and engaging. This is especially vital to engage students historically underrepresented in CS nationally, including girls, minority students, low-income households and students from rural Ohio communities where no one in their immediate family or community has had this experience.

In addition to public funding, the Ohio CS Council could be structured to accept private donations from individuals, corporations and foundations with aligned interests.

RECOMMENDATION 5: Establish an "Ohio CS Council" for Afterschool/Summer Programs

TIMELINE

2023 *Legislature appropriates the 1% for CS funding level*
Legislature authorizes the creation of the Ohio CS Council in state law
OCSE and Ohio CS Council work to begin first awards cycle in Fall 2023/Spring 2024

MEASUREMENT

The Ohio CS Council should develop metrics for measuring successful computer science education programs, review and score grant applications and fund programs that align with those goals. The council would take the additional step of assessing the efficacy of funded programs and report to the state on best practices to ensure our CS dollars are being used wisely and for the benefit of our students, employers, state and economy at large.

REQUIREMENTS FOR SUCCESS

This recommendation dependent upon the "1% for CS" funding appropriation. The $20 million annually should be sourced from the recommended $94 million funding allocation.

POTENTIAL IMPACT

There is no question that some of the best learning occurs outside the classroom, whether those experiences are summer camps, sports or afterschool clubs. Like many states, Ohio already has several nonprofit organizations and public-private partnerships working to offer CS to students across Ohio.

However, we are still not reaching nearly enough students as demonstrated by our state's below-average participation in CS courses and college degrees.

With this recommendation, we are providing a huge boost to the kinds of activities that promote lifelong interest and make students passionate about a CS career. This, in turn, results in a larger educational and workforce pipeline to support job attraction and retention in the state.

RECOMMENDATION 6:
Expand Teacher Licensure and Professional Development

HB 110 Charges Addressed: B1 B3 B4 B5 B7 D1 D2 D3 D4

To teach more CS courses, Ohio will need more CS teachers. This is, unfortunately, an expensive and time-consuming proposition for most teachers with no additional expected wage compensation under salary schedules commonly negotiated in nearly every Ohio district.

One effective and important way to help ease this bottleneck would be for the state to pay all costs associated with the professional development of CS teachers and to provide modest stipends for teachers who commit their personal time toward this endeavor. This could be similar to university fellowships in which graduate students learn and earn a modest stipend. While the state may not be able to afford training for all teachers simultaneously, it could address statewide needs with several years of funding and a phase-in approach.

To the extent possible, the state should explore access to federal funds such as Workforce Innovation and Opportunity Act (WIOA), Pell and other resources to support these teachers, including through registered apprenticeships.

In addition to reducing out-of-pocket costs for CS teacher training, Ohio needs to expand its teacher licensure from K-12 (all grades) to add more specialized grade bands in PK-5, 4-9 and 7-12 like other core subjects. This could help reduce the cost and burden of the various endorsement programs. It would also address concerns that a K-12 license could result in some teachers being reassigned to a different grade level than the one they currently teach.

Finally, the committee recommends the State of Ohio explore the U.S. Department of Education's recent announcement that teaching qualifies as an apprenticeship-eligible profession. Teachers in Ohio should be able to earn while they learn.

ACTUALIZATION

Part A: "Teach CS Grants" and Related Stipends

A common pathway to produce a CS teacher in Ohio today would be to encourage an existing licensed math or science teacher, for example, to pursue a "supplemental license" or university program "endorsement" as an "add on" to an existing teaching license.

Current law for supplemental licenses requires an employer-based request, a passing grade on an assessment exam and a two-year mentorship. Upon passing the exam, teachers can teach CS immediately while the mentorship continues.

RECOMMENDATION 6: Expand Teacher Licensure and Professional Development

Endorsement programs exist in several Ohio colleges but may require up to 15 college credits and a total cost of ~$7,500. To compete this pathway, the prospective CS teacher would need to pay for college out of pocket, often receive no reimbursement, take two classes per semester for a year and, ultimately, not receive a salary increase or guaranteed job (because CS courses are not required for graduation and therefore the positions generally do not yet exist).

The committee recognizes the completely unworkable nature of this dynamic. Therefore, the committee is recommending that the state create "Teach CS" grants that pick up 100% of the cost of professional development, such as the example endorsement program, and provide a $2,000 stipend for five years to Ohio teachers willing to make this commitment.

Using the number of qualified health teachers in Ohio (a half-credit graduation requirement comparable to the proposed single credit CS graduation requirement) as a benchmark, Ohio schools would need an estimated total of 4,500 qualified CS teachers by 2030. Ohio currently reports ~4,600 full-time equivalents (FTEs) in districts as health teachers but only 1,080 FTEs for computer science. This is the gap that needs closing.

The committee believes that in the absence of salary increases for CS teachers across the state, the most cost-effective means to produce sufficient CS teachers is to offer to pay for the professional development plus a stipend for a period of several years. Direct costs examples include college-level courses, course materials, continuing education and examination fees.

In considering funding incentives for professional development, the state should also explore incentives to post-secondary education programs that encourage the development of expanded options for teachers to qualify to teach CS, whether by adding additional university programs or new endorsement programs that are grade banded, requiring less time and expense.

The "Teach CS" grant program should fund coursework, materials and exams as determined by the Ohio Department of Education, including but not limited to:

1. Supplemental License – a mentorship-based pathway for existing teachers
2. Endorsement (University Program) - a coursework-based path for existing teachers
3. Alternative Resident Educator License – for industry experts and other non-teachers
4. Continuing education – professional development for existing teachers, including PreK-12 teachers who are generalists and those seeking advanced content knowledge.

While numerous programs exist to support teachers to offer CS, such as Code.org, Microsoft TEALS and others, the committee notes that completion of teacher preparation through these programs would not satisfy Ohio's legal requirements for credentialing without, in nearly all cases, passing the Ohio exam among other requirements. However, such programs may benefit teachers holistically in their approach to offering courses to students.

For more information, please see Appendix E: Summary of pathways to teaching computer science & licensure

Part B: Ohio Computer Science Licensure Revisions

As referenced in the introduction to this recommendation, the committee believes Ohio should, in addition to the existing CS licensure from K-12 (all grades), add licensure grade bands for K-5, 4-9 and 7-12, respectively.

Ohio's current absence of grade banding for CS requires teachers to be familiar with content most would never teach – such as an elementary school teacher being required to learn content knowledge for high school courses. This adds to unnecessary time and expense for licensure endorsements and related licensure qualification pathways.

Grade banding should also help eliminate a "chilling effect" raised by teachers that they could be relocated to different grades than they currently teach (e.g., from elementary to middle or high school) when the teacher seeks and receives a full K-12 license or endorsement.

Part C: Registered Apprenticeship for CS Teachers

In November 2021, the U.S. Department of Labor, Employment and Training Administration, Office of Apprenticeship issued a bulletin announcing the K-12 teaching occupation as a newly apprenticeship-eligible profession.[27] In making the announcement, the department touts the ability of preservice teachers to "earn and learn" at the same time.

To increase access to computer science instruction in our K-12 schools, the committee recommends Ohio consider adopting an apprenticeship model of alternative licensure where anyone with a computer science bachelor's degree could be placed with a highly qualified mentor teacher as an apprentice to work together immediately to provide instruction in computer science and computational thinking to Ohio students.

Currently the alternative license includes 12 credit hours of instruction taking upwards of 16 weeks to complete prior to earning a license before the prospective educator can then lead a classroom. The apprenticeship model offers an "earn and learn" model for those already holding the content knowledge, paired with a high-quality teacher to provide guidance on instructional pedagogy and classroom management.

Other states such as Tennessee have been quick to adopt a registered apprenticeship program for teachers. Before Ohio can implement a program, however, legislative changes may be needed. For example, Ohio Ethics Commission Advisory Opinion No. 2011-05 on supplemental compensation may prohibit stipends for teacher mentors. More importantly, ORC 3319.088(D) states that students preparing to become licensed teachers shall not be compensated. https://codes.ohio.gov/ohio-revised-code/section-3319.088

RECOMMENDATION 6: Expand Teacher Licensure and Professional Development

TIMELINE

Part A: "Teach CS Grants" and Related Stipends

2023 *Legislature authorizes 1% for CS funding appropriation*
ODE establishes business rules for Teach CS grants and stipends, begins awards

Ohio's "Teach CS" teacher pipeline program should be developed in the 6-12 months following the creation of the Office of Computer Science Education and begin funding professional development as soon as possible. After several years, perhaps sometime after 2030, if Ohio has achieved stability in its teacher pipeline for CS, then these programs can be re-evaluated.

Part B: Ohio Computer Science Licensure Revisions

2024 *ODE revises CS licensure pathways to reflect grade bands PK-5, 4-9 and 7-12*
ODE updates licensure dictionary to allow CS and CTE IT license to crossover

Creating new licenses and developing the programs will take approximately 3-6 years. The state will take about one year to create the licenses and develop program standards. Once the state creates the program standards, it will take universities 1-2 years to develop the programs and obtain required approvals at the university and state levels. For preservice teachers, these will be four-year programs; for currently licensed teachers, they could be 1–2-year programs.

By March 1, 2024, the state should publish revised CS teacher licensure pathways to reflect the grade bands that exist in core subject areas such as math or science, including:

- For the Primary (PK-5) license: Integrate CS standards into the generalist curriculum so future elementary teachers are prepared to teach CS in PK-5 grades.
- For the Middle Childhood (4-9) license: Add CS as a curriculum area for both initial licensure and endorsement to teach CS in these middle grades, 4-9.
- For the Adolescence to Young Adults (7-12) license: Add CS as a teaching field for both initial licensure and endorsement to teach CS in middle to high school grades, 7-12.

In doing so, the state should update the licensure dictionary to allow CS and CTE IT licenses to teach EMIS code-designed courses within both Table 16 (Computer Science) and Table 29 (Career Technical Education – Information Technology). CS and CTE licensed teachers should be able to teach both CS and CTE courses by August 2024. Without this CS/CTE crossover revision, Ohio will limit the ability of each school to offer career pathways for students to pursue CS and IT careers.

Additionally, the committee is recommending the legislature create a new 40-hour license for industry professionals to teach computer science. This would add a specific CS version to a license path that already exists. It would require an amendment to ORC Section 3319.301.

In addition to these licensure changes, the committee recommends retaining the existing provision/waiver for teachers to teach CS with professional development and approval by the district. The OCSE should re-evaluate this waiver every three to four years and make a recommendation to the legislature.

For more information, please see *Appendix E: Summary of pathways to teaching computer science & licensure*

Part C: Registered Apprenticeship for CS Teachers

2023 *OCSE should convene discussions with ODHE, ODE, JFS on teacher apprenticeship*

Upon creation of the Office of Computer Science Education, the executive director should convene discussions with the Ohio Department of Higher Education, the Ohio Department of Jobs & Family Services and the Ohio Department of Education about the possibility of registered apprenticeships for computer science teachers or all teaching specialties.

While these discussions occur, the legislature should at the next regular operating budget remove permanent statutory law that may prohibit apprenticeship programs in Ohio, instead allowing the Ohio Department of Higher Education to administer and oversee any future registered apprenticeship program by rule. This would allow regulatory flexibility to explore this option.

MEASUREMENT

The goal of this recommendation is to increase the number of qualified CS teachers in Ohio. Accordingly, the Ohio Department of Education and Office of Computer Science Education should track various metrics associated with this recommendation, including but not limited to:

- The number of teachers participating in Teach CS grants
- The number of CS qualification credentials received
- The number of Teach CS grant recipients who are now teaching CS
- Persistence levels in teaching CS one, three and five years later
- Benchmarking Ohio against its teacher qualification goals for 2030

There will be a delay in some reporting measures until the licenses have been created and postsecondary institutions are enrolling and completing preservice teachers.

RECOMMENDATION 6: Expand Teacher Licensure and Professional Development

REQUIREMENTS FOR SUCCESS

This recommendation's success is dependent on the "1% for CS" funding as a revenue source for the Teach CS grants and stipends. Ohio has no current professional development funding stream. Limited funds that existed two years ago were swept during the COVID pandemic.

POTENTIAL IMPACT

Supporting educators with professional development is a common theme among states working to expand computer science education. The need for this funding is often among the earliest agreed-upon recommendations and enjoys broad consensus.

If Ohio agrees to fully fund "Teach CS" grants and stipends, our state should quickly become a national leader and model program for other states.

SPECIAL THANKS

In 2021, Ohio passed HB 110 requiring teacher preparation programs to include instruction in computer science. This applies not just to CS teachers but to all prospective teachers as foundational knowledge in their college programs. To address this requirement, a panel of computer science and education faculty from Ohio's institutions of higher education convened and developed the series of modules, which are housed and made available for free at Miami University online.

The committee wishes to express its gratitude to Todd Edwards, Sherril Sellers, James Kiper and Dean Jason Lane at Miami University, Barry Wittman from Otterbein University, and Melissa Goodall from Wright State University for their wonderful work developing and presenting a series of online modules for preservice teachers to learn principles of computer science as required by HB 110, enacted in 2021. The committee is confident that this first-class resource will help familiarize future Ohio teachers with critical computer science concepts such as patterns and decomposition and help to integrate CS theory as a tool for all Ohio teachers.

As context for the importance of this work, according to researchers Laurie Campbell and Samantha Heller, in a survey of preservice elementary teachers in the U.S., only 10% responded they understood the concept of computational thinking.[28] Similarly, a Google/Gallup poll found that 75% of teachers incorrectly consider "creating documents or presentations" to be a topic that students would learn in a CS course rather than computer literacy.[29] For all these reasons, the committee believes extending the opportunity to future Ohio teachers to learn what computer science means is a positive step for well-rounded teachers.

RECOMMENDATION 7:
Start with Industry when Identifying CS Education Goals

HB 110 Charges Addressed: B1 B4 B6 B7 D2 D3 D4

From our initial meeting in November 2021, the committee agreed that our overarching goal would be to help make Ohio a national leader in CS education and workforce pipeline. Implicit in this mission is a recognition of the sometimes-elusive goal that K12 and postsecondary education be aligned to workforce skills relevant for economic competition in the 21st century.

The committee believes Ohio should start with industry when identifying CS education goals. This will require frequent communication and outreach through the Office of Computer Science Education with Ohio employers, technology leaders and beyond. The OCSE should facilitate and promote opportunities for the industry to work closely with K-12 and higher education.

While the committee does feel that workforce alignment should be a key priority, the committee also recognizes non-workforce reasons for computer science education, as highlighted by the Ohio Council of Teachers of Mathematics (OCTM).

OCTM noted in its public comments that Ohio's Learning Standards for Computer Science are written with the premise that we are preparing student to live in a world where computers affect their lives in many profound ways, and that there are other reasons to teach computer science, such as solving real world problems using concepts derived from computer science.

ACTUALIZATION

The Office of Computer Science Education (OCSE) should lead specific efforts designed to bridge the gap between industry and Ohio K-16 institutions through initiatives including:

- Industry Insights Survey – a periodic survey of workforce skills trends in CS
- Hosting biennial CS conferences in Ohio to bring together industry, K-12 and higher education to share relevant skills and best practices. Highlights could include:
    - » Keynote from industry thought leader(s)
    - » Present results from employer surveys on in-demand skills/insights
    - » Breakouts relevant to stakeholders (K-12, higher education, industry)
    - » Industry training sessions for teachers
    - » Secondary and postsecondary sessions on best practices
    - » Updates on Ohio policy and law changes, funding, etc.
- Webinar(s) to connect industry, K-12, higher education, parents, students and other interested stakeholders on a semi-frequent basis

RECOMMENDATION 7:Start with Industry when Identifying CS Education Goals

- Creating a living database of skills and curriculum resources managed by the Office of CS Industry Participation:
  - » Engagement Increase: Incentivizing industry (e.g., double TechCred dollars) to partner with schools, colleges and universities, by serving on advisory boards, coteaching, mentoring, guest lecturing, etc.
  - » Fast Response: Creating a mechanism for private industry to help school districts and out-of-school providers be cutting edge and help take the burden off the district for afterschool programs. Industry partners could help with curriculum, teachers, compensation, software, equipment, etc.

TIMELINE

2022 *OCSE should engage the industry following a 1% funding appropriation*
2023 *OCSE administers first Ohio employer CS skills survey*

The Office of Computer Science Education and allied agencies should aim to engage industry immediately upon the creation of the office and appropriation funding. Longer lead time projects such as employer surveys and conferences may require one or two years before sufficient planning can be completed.

MEASUREMENT

The goal of this recommendation is greater alignment with the industry. As a result, the following metrics could be useful in evaluating success:

- A net promoter score or similar instrument to measure employer sentiment toward Ohio's K12 and post-secondary educational systems in meeting workforce needs
- Focus group qualitative feedback on which specific skills are necessary and/or feedback on how Ohio's K12 and post-secondary systems are meeting workforce needs
- Evaluation of nationally available (or state held) comparative labor market data on whether Ohio seems to be meeting its workforce needs
- Published lists of industry skills recommendations and crosswalks with K-12 and postsecondary education coursework preparation
- Evidence of local school district engagement with industry for CS education
- Number of participants/attendees in the Ohio Computer Science Conference
- Quality and number of education-industry partnerships established in the state

REQUIREMENTS FOR SUCCESS

This recommendation is dependent on the creation of an Office of Computer Science Education (OCSE). It also is dependent on the 1% for CS education funding to provide resources to complete the research and administrative tasks necessary to plan events, issue reports, oversee industry surveys, etc.

RECOMMENDATION 7:Start with Industry when Identifying CS Education Goals

POTENTIAL IMPACT

By promoting frequent, direct conversation and involvement between industry hiring partners and Ohio's K12 and postsecondary educational institutions, Ohio will increase alignment between the skills taught in educational programs and those needed by the industry. This in turn can improve Ohio's economic competitiveness by signaling the value of Ohio's educational pipeline to prospective employers who may wish to choose Ohio for job growth or retention.

Events and activities that gather stakeholders from different sectors of industry and education will also help Ohio build a sense of community in computer science. Students and parents who visit these gatherings could benefit from moving beyond theoretical classroom practice into real-world applied examples grounded by industry. Lastly, engagement with students from all parts of Ohio can help increase the number of students from underrepresented communities who choose to make computer science part of their career path.

RECOMMENDATION 8:
Provide Individual District Support, Playbook, Stipends and Grants

HB 110 Charges Addressed: B1 B4 B5 B6 B7 D1 D2 D3 D4

State learning standards and model curriculum offer conventional documentation, often in the form of text-based guides identifying what content students should know and be able to do in any given subject, and model curricula for how to teach it.

While these resources are helpful, the committee recognizes that computer science is a new, different and sometimes daunting field of study for many of Ohio's administrators and teachers.

To get Ohio schools excited about CS, the committee recommends the state provide hands-on support to individual districts, a playbook for teaching CS, stipends and grants. Resources should be strictly opt-in, meaning no district would be required to engage with these resources unless that district specifically wants to participate.

For districts that do engage, however, the resources would be plentiful. Charismatic teams of experts would be available to meet with school administrators and teachers, brief school board members, engage with parents, describe the importance of CS education, help districts formulate a plan, train teachers on ways to get students excited and even co-teach a class. In delivering these resources, the Department of Education could partner with regional ESCs.

By providing these resources, Ohio will make saying "yes" to CS an easier decision for local school districts across the state, a more enjoyable experience and increase adoption. It's all about making computer science fun and accessible, not just for students, but also for schools.

ACTUALIZATION

With a target goal of one year after legislative approval of the 1% for CS education appropriation, the Ohio Department of Education would publish a notice soliciting expressions of interest by local school districts in Ohio to tap into these resources. The Department would need to decide how many districts it could serve in the first year and its prioritization process. It would then announce to districts which ones were selected for engagement in the first year.

Once selected, a team of CS specialists would visit with administrators at the school district, and with teachers, and discuss the district's goals with a future CS program. The team could then be asked by the district superintendent to present to the local school board, parents and other stakeholders in the district. Eventually, the district would decide whether to move forward.

RECOMMENDATION 8: Provide Individual District Support, Playbook, Stipends and Grants

At this point, the Department would outline the various supports the state can provide, ranging from playbook resources (project and work-based learning, course sequencing, how to teach CS, examples of lesson plans, etc.) to microgrants. Some resources could even include card-based learning (that does not require a computer) and other unplugged activities valuable for students in regions of the state without hardware and Internet access.

As part of this engagement, the Department could offer modest stipends for teachers and administrators who commit to work on launching a CS program. *See Recommendation 6: Expand Teacher Licensure and Professional Development*

After a period, possibly an academic semester or two, the state team engagement would finish its work and the district would hopefully continue to teach CS courses independently. The resource team from the state could be available to assist later as needed or answer questions.

The intent is that deep individual district support would be temporary but would accelerate adoption among school districts that want initial help with getting started. The state team would act as a consultant to the district with all decisions remaining local control for each community.

TIMELINE

2022-23
OCSE works with ODE to establish resource teams to travel state
ODE selects schools for initial cohort engagement
ODE teams visit with school officials to answer questions and begin planning
ODE teams approve plans and provide microgrants and stipends as needed

After an academic semester or two, the engagement would wrap up. The cycle would repeat annually with a new cohort of schools who express interest in engagement and grants.

MEASUREMENT

The goal of this recommendation is to accelerate adoption of CS plans by local school districts across the state, making CS fun and enjoyable for all stakeholders. As a result, the following metrics could be useful in evaluating success:

- The number of districts that express interest in these resources
- The number of districts that choose to launch CS programs after engagement
- The level of student engagement that follows a district launch
- Program persistence over time and longer-term outcomes for students
- Qualitative feedback from districts and teachers on the value of the resources offered

RECOMMENDATION 8: Provide Individual District Support, Playbook, Stipends and Grants

REQUIREMENTS FOR SUCCESS

This recommendation is dependent upon creating an Office of CS Education and a 1% dedicated funding stream for CS. One of the more challenging tasks will be quickly staffing the Office of CS Education with highly qualified leadership and field teams. The Executive Director within the Office of CS Education would be the most critical hire.

POTENTIAL IMPACT

It is critically important that early adopter schools have the most positive experience possible with computer science education, as they will make referrals to peer districts who are also considering adoption. If executed well, individual district support can make the process of launching a CS program truly a delight and generate excitement among parents and students.

This is the goal behind individual district support, microgrants and stipends for adoption. The state should give the team the authority to award $2,000 per teacher/administrator per year stipends and $10,000 per building stipends to incentivize opt in. Funding should be resourced from the 1% for CS funding pool of state funds. Stipends should last five years.

To be successful in launching a computer science adoption campaign among 600+ school districts, the state will need to do more than implement a graduation requirement, CS promise, offer grants, etc. Ohio should provide hands-on guidance and support that teaches districts how to properly establish a CS program (a new concept for most districts) and make the adoption process easier and positively recommended to fellow districts. This recommendation will function as an accelerant to the adoption curve in Ohio.

RECOMMENDATION 9:
Launch a "CS for Ohio" Marketing Campaign

HB 110 Charges Addressed: B1 B4 B6 B7 D1

The proposed Office of Computer Science Education should develop a world-class, statewide marketing plan designed to generate awareness and help educate parents, K-12 students, postsecondary students and Ohio's adult workforce of the many diverse and unique opportunities that exist in computer science.

RECOMMENDATION

Engage a marketing consultant to build full strategy and execution plan. The marketing plan would be designed to create awareness and educate K-12 students of the various career pathway opportunities that are available within CS.

ACTUALIZATION

Messaging/Branding

Initial development of the marketing plan should focus on creating a unique motto, branding/identity package including logo and messaging for the CS program campaign. This will provide a visual presence and recognizable theme for students over multiple years.

This process should include the development of testimonials, informational videos and other short videos that include real-world people in CS roles such as an entrepreneur, fashion designer, self-driving car engineer, cybersecurity manager, etc. Testimonials can showcase what each person's job entails and how it is CS-related. Videos may be presented in school assemblies, on social media, attached to emails, on school websites and in earned media.

Once the program is underway, photography of real Ohio students participating in CS courses can and should be woven into marketing materials for authentic reinforcement.

Website Creation

Creating an online destination for students, teachers, parents and caregivers is a critical step in a marketing plan. This should work with Recommendation 10 regarding career paths to highlight educational sequences necessary, lifestyle and labor market outcomes (salary, etc.) and generally generate excitement for the many career options that exist in computer science.

RECOMMENDATION 9: Launch a "CS for Ohio" Marketing Campaign

Collateral Materials

Marketing materials may include brochures, banners and flyers that show traditional CS jobs as well as some that most wouldn't think of being CS. Additional collateral could be geared as appropriate to certain grade bands, for example:

- Elementary (K-5): Focus on creating materials that are ACTION oriented (word search, multiplication challenges, science experiment forms) or supporting local science, technology or manufacturing fairs with promotional items to encourage participation.

- Middle (6-8): Create STEM exploration kits that encourage critical thinking and generate excitement with hand-on activities.

- High (9-12): Develop career pathway assets (interactive digital builds, brochures etc.) to help students visually see themselves within the careers – focusing on growth opportunities, "cool factor," career flexibility and salary elements to drive youth to adult interest.

Providing branded CS logo items to students in appropriate age groups would include stress balls, pencils, pens, erasers and notebooks – things that students would use in school regularly.

Social Media Strategy

Utilizing social media to engage core age groups. For example:

- Creating a video challenge specific to CS and utilizing hashtags to connect posts – this could be organized at the individual level or the classroom level as a class project.

- Paid advertising to promote views and engagement re: career paths and testimonials.

This would also need to be developed differently around parents compared to students, and a third segment is to educate faculty (teachers, counselors etc.) about the pathways.

Creating Family and Community Resources

- Create a Family and Community Campaign as part of the marketing plan to build on the importance of computer science and ways the community and families can support local initiatives.

- Create a resource page (housed on the OCSE/ODE websites) that families and communities could utilize if interested in early access to computer science.

Educator Awareness Campaign

- • Create an Educator Awareness Campaign as part of the marketing plan to build on the importance for computer science, including exemplar resources and professional development opportunities K-8 educators can utilize.

TIMELINE

Upon approval of funding, the initial build'of the campaign's brand awareness/messaging and website portion of the campaign should take approximately six months. The website should be refreshed annually. Creation and use of collateral materials and social media campaigns should be specific to various audience types.

- Elementary (K-5): Focusing on annual education (one time per year) is appropriate for this age band, with each grade level having a somewhat different focus.
- Middle (6-8): This audience should receive 4-8 promotions throughout the school year through print materials (leveraging QR codes), event campaigning or social media.
- High (9-12): This audience should receive communication every three months – with a primary focus between grades 10-12 as postsecondary schools and career paths are being considered. Promotions should be extended to focus messaging on parents and caregivers for continued encouragement.

MEASUREMENT

Success should be measured on campaign engagement, including:

- Website traffic, including yearly growth and metrics (time spent, actions and page views)
- Social media reach and engagements (shares, reactions, likes, etc.)
- School Event Participation (# of career fairs or science fair sponsorships)
- Student CS course participation

REQUIREMENTS FOR SUCCESS

This recommendation supports Recommendation 3, Establish CS as an Ohio Graduation requirement by 2030, and relies on Recommendation –, "One for CS" - State of Ohio 1% funding investment specific to CS.

A budget for the "CS for Ohio" marketing campaign depends on the desired scale of the campaign, selected channels and campaign duration. It may be practical to ask the future

Office of Computer Science Education (OCSE) to establish a budget amount and then design the campaign to fit the investment.

For optimal success, the Office of Computer Science Education (OCSE) should hire staff supporting the marketing strategy, overseeing the marketing consultant and helping to engage stakeholders, possibly even at the school or district level.

POTENTIAL IMPACT

When well executed, a successful marketing campaign can excite and inform Ohioans in a meaningful and authentic manner, helping to drive student and adult interest in CS careers.

Creating a marketing campaign can not only showcase what computer science offers Ohio students, but also help to generate the public awareness necessary for communities to self-organize and offer support locally (regular convenings, CS events, CS clubs, etc.).

The earlier these programs are featured for children, teachers and parents in the Ohio education system, the more likely they are to join other programs within the state and even move towards a CS career. Ultimately these efforts may persuade students to pursue higher education and a CS career in Ohio, helping to increase Ohio's workforce pipeline.

RECOMMENDATION 10:
Provide Career Path Tools and Examples for Students

HB 110 Charges Addressed: B1 B4 B6 B7 D1 D2 D3 D4

Recognizing that CS career paths can be complex and confusing, Ohio should develop, publish and regularly update a centralized career path exploration tool (via website) that achieves the following goal: Parents, students, teachers and counselors can visit the site to learn about CS career paths, including roles that use CS skills across industries. The site should feature role models for computer science, where possible using real Ohioans as examples/mentors.

The tool should prioritize engagement over quantity of information provided. The tool should be distributed and embedded within Ohio's K-12 education system so that continual awareness is built among all stakeholders, including within the education community at large.

ACTUALIZATION

Parents and students often perceive CS career paths as vague and complex. This unnecessary friction, along with outdated career stereotypes, obscures the excitement and energy that exists for many professionals who work in this field.

To address questions on the mind of many Ohioans: "Why computer science? What does it mean for my career? What do I need to get started? Where might this lead me?," the committee recommends the following approach:

- A team from the Office of Computer Science Education (OCSE) and ODE should research and develop a portfolio of career paths and related educational sequences.
- The team should publish an initial set of minimally viable, yet maximally impactful content through the proposed online career path tool.
- The tool should be simple enough to avoid overwhelming users but detailed enough to offer meaningful information for parents and students.

The proposed centralized website should achieve the following:

- Enable students, teachers and school counselors to learn about CS, both alone and in its allied roles across seemingly unrelated careers (science, healthcare, fashion, etc.)
- Provide step-by-step, year-by-year resources and programs on classes to take, afterschool programs offered, events such as hackathons or meetups, universities admissions requirements, degree programs and career opportunities.
- Remain continually updated, actively distributed and embedded within the K-12 education system to maintain awareness.

RECOMMENDATION 10: Provide Career Path Tools and Examples for Students

This should be a tool with an audience that is primarily parents and students, with secondary amplification/utilization by school counselors, teachers and others in career counseling.

TIMELINE

This could be launched 12-24 months after the Office of Computer Science Education is formed, as time will be needed to hire appropriate staff and develop materials.

The OCSE should work with the Governor's Office of Workforce Transformation, OhioMeans Jobs, regional workforce and business community stakeholders to research, curate, develop and build this digital guide to facilitate the navigation of a career pathway in CS.

MEASUREMENT

Success could be measured using metrics including but not limited to the following:

- Website traffic and engagement
- A net promoter score for user satisfaction (yes/no) or similar exit survey
- A survey to measure before and after parent/student perceptions of CS career paths
- A survey to measure perceptions among administrators and teachers
- Quality and depth of content
- Frequency of content updates
- Engagement among education and industry stakeholders

REQUIREMENTS FOR SUCCESS

This recommendation is dependent upon the creation of an Office of CS Education (OCSE) and a 1% for CS funding stream. Oversight and project management for surveys and industry outreach will require significant annual staff time.

This recommendation should also be coordinated directly with implementation of Recommendation 9, Launch a CS for Ohio marketing campaign. The career tool should rely heavily upon the marketing campaign to drive traffic and engagement.

POTENTIAL IMPACT

For Ohio to be successful in launching a CS adoption campaign among 600+ school districts, the state will need a method to communicate various career paths and educational sequences that support each path. Together with the "CS for Ohio" marketing campaign, this work should help share the positive outlook for careers in computer science and even unrelated fields that will increasingly rely upon the skillsets acquired through CS training.

RECOMMENDATION 10: Provide Career Path Tools and Examples for Students

To win hearts and minds of Ohio's parents and students, the state needs to answer the "why and how" questions that are often asked when a student is considering an educational focus.

One of the most effective ways to do this would be to describe the career path (lifestyle, salary expectations) and educational sequence (which skills to develop, courses to take, etc.).

These implications need to be communicated both from a global/worldly impact perspective, and an economically sound, personal, continuous and relevant, long-term ROI. This recommendation should function as an accelerant to the adoption curve in Ohio.

Data Collection and Reporting

HB 110 Charges Addressed: B2 B3 B4 B7 D2 D3 D4

This recommendation addresses legislative data requirements included in HB110, as well as suggestions for data collection and use beyond HB110 requirements.

- HB110 requires the Ohio Department of Education to collect any data regarding computer science courses offered by school districts and school buildings operated by school districts, including the names of the courses and whether the courses were developed using the standards and model curriculum adopted under division (A)(4) of section 3301.079 of the Revised Code, and post the collected data o its web site.

- The State Committee on Compute Science is also required to determine the best ways to compile data on computer science courses, teachers and undergraduate students studying computer science in universities.

RECOMMENDATIONS

The committee recommends at least two primary proposed methods of data collection.

First, data should be collected and analyzed using the existing Ohio Department of Education "Computer Science Course Enrollment." This dashboard is currently housed on data.ohio.gov and includes total state enrollment by year, by LEA school district, by county, by race and by economically disadvantaged status. This tool can be updated in the future to include data on specific courses taken, typology of course (programming, cybersecurity, AI, etc.), etc. The data source for this tool is generally EMIS (Educational Management Information System).

A second method of data capture could be to use either a survey or other existing data-collection method to capture data that is not available using EMIS, including qualitative data and information pertaining to professional development and any other data that would be useful toward making Ohio a leader in computer science education and workforce pipeline.

For more information, see the *Data Collection and Reporting Requirement* section.

Education's Education Management Information System (EMIS)

Data should continue to be collected by leveraging K-12 computer science student, course and teacher data available through the Ohio Department of Education's Education Management Information System (EMIS) using the Ohio Computer Science Course Enrollment dashboard.

Many filter-capable data points are already collected through EMIS including but not limited to enrollment data disaggregated by student demographics, reporting district, course location, district typology, subject code and course name. Student demographics include gender, race, economic disadvantage, homeless status and English Learner status.

Please note: EMIS data typically is at least one year old by the time of publication.

Data not available through EMIS

The Office of Computer Science Education (OCSE) and Department staff should work with local school districts to gather annual data not available through EMIS, including whether district CS courses are based on Ohio Learning Standards for Computer Science as required in HB 110.

The system and interface for the data collection outside of EMIS should be based on an instrument that already exists or will be designed for this specific purpose.

The same data-collection interface also could be used to gather other district data, including postsecondary and business partners, curriculum being used and any other valuable information.

Unlike EMIS reporting, this data-collection instrument ideally can and should be adjusted and edited yearly without significant barriers. The Office of Computer Science Education should work with the Ohio Department of Higher Education to gather and report postsecondary data including:

- Computer science and computer science education faculty and staff capacity in Ohio postsecondary institutions, as well as student to faculty ratios and benchmarks
- Postsecondary computer science enrollment data
- Students enrolled in computer science education teaching programs

The Office of Computer Science Education, working with the Ohio Department of Education and Ohio Department of Higher Education, will make these reports or links to these reports available on the respective webpages.

Ohio Computer Science Report

The state should publish the number of Computer Science FTEs for all publicly funded schools by Sept. 1, 2023 and update this report annually by Sept. 1.

The report should include the following:

- A district listing of CS FTEs, specifying the number of teachers teaching CS per district
- A district listing of AP Computer Science Principles and AP Computer Science A course offerings

- A district listing of CCP CS courses students are enrolled in each year
- A district listing of CTE pathway offerings, N0-N4 CTE pathways inclusive of CTAGs
- A district listing of CTE middle school IT course offerings, N0-N4 CTE pathways

State Report Card – Indicators

From 2028 to 2030, Ohio should begin reporting CS course offerings as a nongraded yes/no indicator on the state report card as follows:

- By fall 2023, ODE establishes Computer Science Teacher Indicator on the State Report Card, which districts can achieve by increasing qualified CS FTEs 20% or more in a single year or by meeting the date-specific benchmark for CS FTEs.
- By fall 2026, ODE establishes a Computer Science Access Indicator for grades 7-8, allowing districts to attest to offering CS courses for those grade
- By fall 2026, ODE provides Computer Science Access Indicator on State Report Card
- By fall 2028, ODE provides a grade K-6 indicator for CS offerings on the State Report Card

These flags would not be graded on the state report card but would indicate which districts are "on track" to have sufficient qualified teachers, which schools are offering CS courses and which sub-groups of students within the school district are participating in CS courses. When evaluated against the statewide CS teacher goal for 2030, individual district staffing should meet the following benchmarks, as reported on the State Report Card:

- By fall 2029, 90% …of target goal CS teacher hiring complete
- By fall 2028, 80%
- By fall 2027, 70%,
- By fall 2026, 60%
- By fall 2025, 50%

Other Data Collection

Analyzing existing data (Ohio Means Jobs, JobsOhio, etc.) from CS, Information Technology and other connected industries will inform state and district stakeholders about workforce needs of local and statewide employers.

The OCSE will continually evaluate computer science education in other states and countries for possible best practices or processes that could benefit Ohio CS education initiatives.

ACTUALIZATION

The Office of Computer Science Education, the Ohio Department of Education and the Ohio Department of Higher Education will compile a set of reports each year that will be conspicuously posted or linked on the webpages of each organization.

- Using data available through the Ohio Computer Science Data Dashboard, create and publish reports centered around students.
- Reporting will include data around specific course offerings. This data would be a combination of data reported through EMIS and the Ohio Office of Computer annual data collection.
- Reports will be centered around regional, district and teacher need.
- Reporting will include postsecondary metrics around CS and CS teacher prep programs.
- Reports will detail how many students obtain CS certifications.
- Collect data about undergraduate students in computer science programs in universities.
- The report will provide data about students who start in teacher education finish teacher education and become teachers.
- Research to see if there is postgraduation survey data that ODHE or universities administer to follow CS undergraduates into their jobs? Are they staying in Ohio? Are they obtaining masters or doctoral degrees?

TIMELINE

The Ohio Computer Science Data Dashboard is fully operational and is available to the public. A subset of these data is the source of the annual Foundational Computer Science Report published by CODE.org.

Any changes to EMIS can take between 12-24 months. Changes to licensure, subject codes and graduation requirements must go through specific process that involves multiple offices at ODE. For maximum effectiveness, once the changes are ready, district staff will need professional development to ensure that data is entered in EMIS correctly and that teachers are properly licensed. This process could take 12-18 months, depending on the specific plan for implementation.

Once the OCSE is established and the regional teams are in place, the collection of additional data not available through EMIS would require the creation of a survey instrument. The timeline for this could be between 12-18 months after regional staff are developed.

Once established, the OCSE will work with ODHE to identify, collect and analyze postsecondary program, staffing and student information. This information would become part of the reporting and will be available on the OCSE office, ODE and ODHE websites. The

timeline for this could be between 12-18 months after regional staff are developed.

For more information, see *Data Collection and Reporting Requirement* section.

REQUIREMENTS FOR SUCCESS

OCSE and regional staff (Recommendation 1) must be in place to collect and analyze data from both the Computer Science Dashboard and other instruments used to collect data. To increase the value of data, changes to EMIS subject codes should be made that allow courses to be coded with higher accuracy.

POTENTIAL IMPACT

Course, student and teacher data will measure the effectiveness of CS plan implementation. The CS education reports proposed in the committee recommendations will inform Ohio of specific state, regional and local district trends to determine progress towards full implementation of the Ohio State Plan for Computer Science Education. In addition, understanding Ohio CS education trends is critical for Ohio to be nimble in adapting to changes in the CS and education environment.

Data collected will also enable the state and district staff to better understand the needs of each district based on their region, student demographic and workforce needs. This reporting structure will help Ohio leadership determine the return on investment of the state plan for computer science education.

For purposes of national benchmarking, the SCCS adopts the Computer Science Teachers Association and K-12 Computer Science Framework definition of foundational computer science to measure Ohio's CS offerings versus other states. The committee recommends reporting Ohio data on prerequisite skills such as keyboarding, computer literacy, etc. as well as specific disciplines within CS, including IT, cybersecurity, cloud and networking courses. Specific itemization of data is preferred.

Appendix A:
Budget for "One for CS" 1% Funding Commitment

The committee suggests the following possible itemized breakdown of the proposed 1% for CS appropriation (approximately $94 million in 2023). For many of the grant programs, the committee assumes that approximately 10% of districts will opt-in per year.

$94 million – 1% for CS – Overall Appropriation

- $30 million – "Ohio CS Promise" and K-12 School District Incentives – budgetary allowance to pick up the cost of Ohio CS Promise courses for students as well as grants to school districts and career technical schools that opt-in to pursue CS expansion – anticipating awards in the range of several hundred thousand dollars to the average district. Also assumes that approximately 10% of districts opt-in per year as available capacity per year.

- $23 million – Postsecondary Capacity Increases – state matching grants that challenge Ohio's colleges and universities to increase capacity for teaching students, including pre-service teachers to overcome Ohio's below average CS degree production.

- $20 million – Ohio CS Council – similar to the Ohio Arts Council, to provide grants to afterschool, summer and extracurricular programming, including nonprofits, with emphasis on extending CS to communities with underrepresented access.

- $8 million – "CS for Ohio" Marketing Campaign – a cost-effective campaign in Ohio's K-12 schools to encourage CS through social media advertising, school posters, prizes, etc.

- $5.5 million – Teach CS Grants / Professional Development – state grants pick up the cost for CS licensure/endorsement classes, testing and other professional development necessary to expand the number of qualified CS teachers statewide. Funds would be provided annually, allowing a phased-in approach to upskilling CS teachers.

- $4 million – Ohio Department of Education – staffing expense to engage schools across Ohio and provide instructional supports necessary to encourage rapid expansion of CS.

- $1.5 million – Development of Instructional Supports for K-12 School Districts – easy-to-adopt CS playbook, lesson plans, toolkits, etc. with web resources and supports for districts to pair with hands-on team support, developed by OCSE/ODE

- $1.25 million – Ohio Department of Higher Education – staffing expense to engage colleges and universities across the state and oversee/report/administer incentives

- $750,000 – Office of Computer Science – operational funding and staffing expense to oversee/report/administer overall appropriation and various funding streams, compile reports, establish data dashboards, evaluate program outcomes, etc.

Appendix B:
Supplemental Information, EMIS Codes
for **Recommendation 3:** *Establish CS as an Ohio Graduation Requirement by 2030*

In consultation with the Ohio Chapter of the Computer Science Teachers Association (CSTA), the following course codes are recommended by the committee in the following grade bands in order to satisfy the requirements stated in *Recommendation 3: Establish CS as an Ohio Graduation Requirement by 2030*

Middle School Requirement: EMIS Course Codes

- EMIS Table 16: Computer Science
  - » 290245 – Computer Science K-8
- CTE Middle School Information Technology Courses – VMs (30-60 Curriculum Hours)
  - » 145005 Information Technology
  - » 145010 Web Design
  - » 145060 Programming

High School Requirement: EMIS Course Codes

For the high school requirement, committee discussed current courses available through EMIS to help provide some insight on what types of courses meet the general intention of the HS CS requirement. The list below is the result of the committee's conversation.

The courses below are *recommended* to be qualify for graduation by 2030.

Recommended: Any one of these should satisfy the 2030 graduation requirement.

290250 Computer Science
290310 Computer Science with in-depth
290325 Specific Topics in Computer Science
299999 Other Computer Science
321600 IB Computer Science
145085 Database Applications Development
145005 Information Technology
145065 Object Oriented Programming
145060 Programming
145075 Systems Analysis and Design
145070 Visual Programming
290200 Computer Programming
146005 Cyber Security
146010 Cyber Defense
146015 Cyber Testing and Response
145020 Computer and Mobile Applications
145125 Interactive Application Development

The committee discussed courses not listed here that may, in the future, be considered as satisfying the requirement in Recommendation 3. These could include courses in data science, discrete math when paired with computer science, and others. In each of these cases, the committee recommends that the OCSE work with ODE to make a formal determination.

Not Recommended: None of these should satisfy the 2030 graduation requirement.

In general, the committee recommends against allowing computer literacy or keyboarding courses to satisfy any future CS graduation requirement.

Appendix C:
HB 110 Duties and Responsibilities

HB 110 of the 134th General Assembly created the State Committee on Computer Science through temporary law section 3301.23 as included in full below. The duties and responsibilities are outlined as described in the following statutory language, also summarized in this report as "charges" to the committee, color-coded within the report for each recommendation.

HB 110 – 134th General Assembly (Pages 703-705)
https://ohiohouse.gov/legislation/134/hb110

Sec. 3301.23. (A) Not later than thirty days after the effective date of this section, the department of education, in consultation with the chancellor of higher education, shall establish a committee to develop a state plan for computer science education for the purposes of primary and secondary education

(B) When developing the plan, the committee established under this section shall consider the following:
(1) Best practices and challenges associated with the implementation of primary and secondary computer science curriculum in this state;

(2) Demographic data for students who receive instruction in computer science;

(3) Benchmarks to create a sustainable supply of teachers certified to provide instruction in computer science;

(4) Best practices to form public and private partnerships for funding, mentoring, and internships for teachers providing instruction in computer science;

(5) Requiring all students to complete a computer science course prior to high school graduation;

(6) Establishing a work-based learning pilot program that includes high schools, universities, and local industry and permits the department and the chancellor to develop pathways to align computer science education in the state with the state's workforce needs;

(7) Any other topic determined appropriate by the committee

(C) The committee established under this section shall consist of all of the following:

(1) The superintendent of public instruction, or designee;

(2) The chancellor, or designee;

Appendix C:
HB 110 Duties and Responsibilities

(3) Representatives of computer science education stakeholders appointed by the state superintendent, in consultation with the chancellor. Computer science education stakeholders represented on the committee shall include all of the following:

(a) Career-technical education;

(b) Teachers;

(c) Institutions of higher education;

(d) Businesses;

(e) State and national computer science organizations.

(D) Within the plan, the committee established under this section shall include all of the following:

(1) An examination of the challenges that prevent school districts from offering computer science courses;

(2) A requirement that the department of education collect any data regarding computer science courses offered by school districts and school buildings operated by school districts, including the names of the courses and whether the courses were developed using the standards and model curriculum adopted under division (A)(4) of section 3301.079 of the Revised Code, and post the collected data on its web site.

(3) A requirement that the committee determine the best ways to compile data on computer science courses, teachers, and undergraduate students studying computer science in universities.

(4) Any findings the committee determines appropriate based on its consideration of the topics described in division (B) of this section.

(E) The committee shall complete the plan not later than one year after the effective date of this section and the department shall post the completed plan in a prominent location on its web site

Appendix D:
Recent CS Policy in Ohio and the United States

As recently as five years ago, the Ohio General Assembly enacted significant policy changes intended to support CS growth (HB 170, enacted in 2017). In summary, these changes allowed CS to count toward Ohio's graduation requirements in math, science and electives and required the State Board of Education to adopt academic content standards and model curriculum.

While not addressing most of the issues raised in this report, the legislation made it easier for Ohio schools to offer CS, as well as for students to choose courses that met Ohio graduation requirements. The legislation did not directly address the lack of schools offering CS in Ohio.

HB 170 made it easier for students to meet graduation requirements using CS courses but did not address larger barriers to CS access.

HB 170 also authorized CS licensure in Ohio, a CS supplemental license and authorized schools to establish CS and technology funds. This marked the first time Ohio had authorized computer science licensure for its teachers.

In the wake of this legislation, the Ohio Department of Education created and hired its first education Program Specialist Position for computer science. The department also adopted K-12 CS standards and a CS licensure exam.

In 2019, the Ohio Department of Higher Education proposed new K-12 CS endorsement programs for teachers.

In July 2019, HB 166 (the state operating budget) appropriated $1.5M for teacher preparation in CS and exams, but most funds went unspent, limited by restrictive program rules. HB 166 required that schools allow CS courses to count toward a foreign language graduation requirement if one exists locally.

HB 166 also established a two-year moratorium on teacher certification restrictions. By enacting the moratorium, the state granted schools more flexibility to source CS teachers by allowing schools to determine CS qualifications locally.

The operating budget enacted two years later, HB 110, enacted in June 2021, extended the moratorium for two additional years. The moratoriums, while offering flexibility, do not provide a stable, lasting licensure environment for teachers considering whether to seek CS qualification.

HB 110 established language requiring the creation of this committee, extended the CS teacher certification moratorium two additional years, began requiring education prep programs to

require candidates to receive instruction in CS and computational thinking and specified that each university must recognize CS toward admission.

In September 2021, the Ohio Department of Education updated EMIS codes to align courses to state CS standards.

When compared with other states across the 2021 State of CS nine (9) listed report metrics[30] for implementation, Ohio currently lacks a requirement that "all high schools offer CS curriculum." This separates Ohio from states such as Indiana, Illinois and Texas which are categorized as currently requiring all high schools to offer CS.

Nationally, 27 states require all high schools to offer CS. This increased by four states within the past year, tipping the "all high schools offer CS" policy into the majority of all 50 states today.

Of the nine policy measures evaluated in the 2021 State of CS report, Ohio currently is missing three categories:

1. A state plan for CS
2. Funding for teacher professional development and
3. A requirement that all Ohio high schools offer CS

The completion of this report is expected to satisfy the state plan requirements, namely: (1) the plan is specifically focused on computer science, (2) it includes a timeline, goals and strategies, and (3) is publicly available. The committee expects this report to meet the "state plan" criteria outlined by the State of CS report authors for 2022.

Federal Activity in Support of CS Expansion

CHIPS Act of 2022, also known as CHIPS+
In July 2022, portions of the USICA (see below) were moved to the CHIPS Act including tax credits for chipmaking plants such as the Intel fabrication facility planned for New Albany, Ohio. The new omnibus bill includes initiatives to increase computer science education and requires the Director of the Office of Science and Technology Policy to assess and make recommendations on the science, technology, engineering, mathematics and computer science workforce of the United States.

USICA/COMPETES — 2021/2022
The America COMPETES Act (passed by the U.S. House of Representatives in February 2022) and USICA (U.S. Innovation and Competition Act, passed by the U.S. Senate in June 2021) would authorize a new competitive grant program operated by the U.S. Department of

Appendix D:
HB 110 Duties and Responsibilities

Education to improve global competitiveness by expanding access to computer science and computational thinking skills for students enrolled in elementary schools and secondary schools, particularly for students facing systemic barriers.

HR 3602 – Computer Science for All Act of 2021
This legislation introduced by Rep. Barbara Lee from California was introduced in May 2021 but has not been passed out of the U.S. House of Representatives. If enacted, the legislation would continue efforts that began during prior administrations to fund a federal CS for All program.[31]

White House Directive – 2017
The White House issued a directive in 2017 to increase U.S. government support for STEM, including CS education, tasking the U.S. Dept of Education with utilizing at least $200M of grants funds each year for STEM education.[32]

CS for All - 2016
This $4 billion in federal spending program to support CS initiatives never won approval from Congress.[33]

Corporation for National and Community Service (aka AmeriCorps) - 2016
In 2016, as part of the CS for All initiative, the agency behind AmeriCorps pledged to give out up to $17 million over three years to support teacher training in computer science education.

National Science Foundation – CS Education Research - 2016
In January 2016, the National Science Foundation announced plans to direct $120 million in funding over five years to computer science education research.[34] This funding was intended to be used to research how best to teach computer science in schools that choose to adopt it.

Every Student Succeeds Act (ESSA) - 2015
When ESSA replaced the No Child Left Behind Act, the federal government shifted educational oversight to the states and highlighted computer science among the core subjects including science, technology, engineering, mathematics and writing that fall within ESSA's definition of a "well-rounded education."[35] This left it up to individual states to decide how to deploy federal funds to maximize computer science. ESSA has help lay the foundation for computer science being treated like traditional core subjects.

Appendix E:
Summary of Pathways to Teaching Computer Science & Licensure

Ohio offers three (3) common pathways for Ohioans interested in becoming legally qualified to teach computer science in grades PreK-12. Two pathways are focused on existing teachers while the third can allow industry experts (e.g. computer programmers, cybersecurity experts, network engineers, etc.) to become teachers through an alternative license.

Existing Teachers Without a Computer Science Qualification

Option A – Supplemental License[36]: This is a common pathway for existing teachers to upskill to teach CS to students. It is an employment-based path, meaning teachers must secure a commitment from the school district that wants the teacher to accept this new role. In addition to the employer request, teachers must pass the assessment exam and be mentored by another teacher for two years.

This licensure pathway is available to educators who already hold an active, standard Ohio teaching license and simply need the Computer Science (111790) endorsement. This pathway does not require college courses. Once teachers pass the exam and submit all paperwork, they can begin teaching CS immediately.

A supplemental license is among the fastest pathways to teach CS. Additional information is available on the Supplemental Endorsement webpage.

Option B – Endorsement (University Program): For teachers who lack content knowledge necessary to pass the assessment exam, this pathway offers high quality preparation through structured university courses. Typically, this path requires approximately fifteen (15) credits over a year at a ballpark cost of $7,500.

This university program leading to an endorsement pathway is available to educators who hold a standard Ohio teaching license. Upon completion, the teacher receives an endorsement just like a supplemental license. This pathway does not require mentorship or an employment-based request from a sponsoring district.

A list of Ohio Department of Higher Education (ODHE) approved CS endorsement (university programs) is available on the department's Education Program Finder webpage.

Computer Science Experts – Industry and Other Non-Teaching Professionals

Option C – Alternative Resident Educator License: For computer science industry experts and other non-teachers who wish to change careers and pursue teaching, the alternative resident educator (RE) license path can often meet their needs.

This licensure pathway is available to individuals who have not completed a traditional teacher preparation program through a college or university and do not hold a standard

Appendix E:
Summary of Pathways to Teaching Computer Science & Licensure

Ohio teaching license. Candidates still must pass the assessment exam, but they also must have a bachelor's degree or higher with a 2.5 GPA cumulative on their transcripts.

ODE must evaluate these criteria before issuing a certificate allowing the resident educator to enroll in pedagogical training requiring 4-8 weeks of self-paced college-level work.

Upon completion of this training, ODE will issue a different certificate allowing the resident educator to be hired by a school district. Upon hiring, the individual may eventually become a fully licensed teacher. All candidates who pursue this pathway must achieve four years of successful work experience before being granted a permanent teaching license.

For more information, please visit:
https://www.ohiohighered.org/educator-preparation/alternative-licensure

For examples of educational licensure checklists that have been created for applicants, please visit the Ohio Department of Education's Licensure Document Resources webpage.

Continuing Education for Existing Teachers

The pathways above contemplate legally qualifying Ohio teachers to teach computer science. Even after completing one of these pathways, some teachers may wish to continue their education in CS through more advanced courses or traditional continuing education to stay aware of current trends, changes in technology, etc. While this appendix focuses on initial credentialing, it should not be interpreted as excluding continuing education.

Appendix F:
CS Initiatives in Other States

As Ohio looks to adopt policy changes that help make it a national leader in CS education and workforce pipeline, the committee wishes to share examples from other states.

Inclusion on this list should not be interpreted as an endorsement of any other state policy, nor that the state is necessarily leading other states in CS outcomes.

To the contrary, some states making aggressive policy/resource movement into CS education may be doing so precisely because they have traditionally lagged in certain indicators.

Similarly, if a state is pursuing a particular CS education initiative, the State Committee on Computer Science may or may not also share the position that the specific strategy has been effective. When in doubt, please refer to the itemized committee report recommendations.

Alabama

Alabama adopted HB216 on May 29, 2019, comprehensive CS legislation that requires every K-12 school to offer CS by the 2022–2023 school year. The legislation authorized $2.3 million in funding, including $900,000 for professional learning. It also allows computer science to satisfy a secondary graduation requirement and a postsecondary admission requirement.

To help implement this work, the legislature required the Alabama Department of Education to create certification pathways for computer science teachers. The legislation also required the department to hire a state computer science specialist.

- Read the 2021 Alabama Computer Science Expansion Data Report
- Visit CS4Alabama, a statewide network that includes participation from the Alabama Department of Education, CSTA and Code.org
- Read the 2019 Governor's Computer Science Advisory Council Report

Arkansas

Arkansas Governor William Asa Hutchinson was elected in 2014, and re-elected in 2018, successfully campaigning in part on putting computer science in every high school in Arkansas.

Hutchinson is currently chair of the National Governors Association (NGA) and on February 2022 announced computer science education as his signature chairman's initiative. This has helped raise the visibility of computer science education among governors across all fifty states.

Appendix F:
CS Initiatives in Other States

Gov. Hutchinson's initiatives in Arkansas include:

- Creating the "Office of Computer Science" within the Arkansas Department of Education in 2015.
- Creating the Arkansas Computer Science and Technology in Public School Task Force (CSTF) in 2015.
  - » Key focuses: Increasing qualified teachers and professional development for CS teachers.
  - » Additional focus categories: K-12 pathways, postsecondary enrollment growth, credentials, industry engagement, funding and outcomes, promotion and marketing.
- Adoption of state computer science standards in 2016, with school implementation in 2017-2018.
- Creating the Arkansas Computer Science and Cyber Security Task Force (CSCTF) in 2019.
- Issuing the Arkansas Computer Science and Cyber Security Task Force Report, October 2020

Recommendations in this report included the following:

- Require all high schools to offer at least three CS courses
- Require one credit in CS for graduation
- Add CS to K-8 grades curriculum
- Require every public high school to hire a CS endorsed/certified teacher
- Help pay federal loans for CS teachers
- Legislate a separate pay scale for high school CS teachers.

*The Computer Science Education Advancement Act of 2021 (Act 414) was signed into law by Governor Hutchinson on March 23, 2021. This legislation is an extension of Act 187 of 2015, which established the requirement that every high school must make a computer science course available to students.[37]

As a result of this legislation in Arkansas, the following requirements have been established"

- Every student beginning with the 9th grade class of 2022-2023 must earn one full high school computer science credit to graduate,
- At least four computer science courses will be approved by ADE for instruction to 8th grade students (in addition to grades 9-12 students),

Appendix F:
CS Initiatives in Other States

- Digital course content aligned to state standards will be made available to schools, and
- Each high school must employ a computer science certified teacher by the 2023-2024 school year.

Arkansas established "Computer Science Innovation Grants" to provide reimbursement funds for the purchase of curriculum, software licenses, nonfundamental equipment, professional development, student incentives and other approved expenses that support the state's CS and computing standards.

- According to the 2020 Task Force report and the high school enrollment report for 2020-2021 as a result of the efforts undertaken in Arkansas, the following outcomes occurred:

- The number of credentialed CS teachers who passed the Praxis and achieved a 528-certification increased from six (6) in 2014 to two-hundred seventy-four (274) in 2019.
- Students enrolled in baseline CS course from 1,104 in 2014/15 to 10,450 in 2020/21.

In 2021, Arkansas was tied with South Carolina for the largest share of high schools that teach CS (92 percent) of any U.S. state.[38] The state also received the Frank Newman Award for State Innovation from the Education Commission in 2020 for its CS education initiative.

California

In 2018, California adopted computer science standards for K-12, followed by a 2019 state strategic plan to expand CS access. Read about the California Department of Education's efforts here.

Following the release of the 2019 plan, the proportion of students attending California high schools that offered at least one computer science course jumped from 45% in 2003 to more than 79% in 2019.

In recent years, California State University and the University of California system began allowing CS to count toward admissions science requirements.

Following the release of the 2019 plan, the proportion of students attending California high schools that offered at least one computer science course jumped from 45% in 2003 to more than 79% in 2019.[39]

In recent years, California State University and the University of California system began allowing CS to count toward science-related admissions requirements.

Appendix F:
CS Initiatives in Other States

Georgia

Georgia's Department of Education describe the state's approach to CS as "undergoing a transformation from a set of high school electives to a comprehensive K-12 discipline."

Read Georgia's State Plan for Computer Science Education

Visit Georgia's department page on computer science

Visit CS4GA, a coalition of stakeholders including schools, industry, universities, philanthropy and state government working to ensure all students have access to CS education.
In 2019, Georgia Governor Brian Kemp signed Senate Bill 108 which requires all high schools to phase in computer science classes by the 2024–2025 school year. This new legislation "ensures that all students in Georgia have access to rigorous computer science courses and are prepared for the future."

Iowa

In 2020, the Iowa Legislature passed Iowa House File 2629, requiring all K-12 schools provide high-quality computer science instruction by the following dates:

- July 1, 2022 – High schools must offer at least a one-half unit computer science course.
- July 1, 2023 – Middle schools must provide computer science in seventh or eighth grade and elementary schools must provide computer science in at least one grade level.

Iowa also formed the Computer Science Work Group, consisting of leaders in K-12, higher education, business, industry and government, and published the Building on Iowa's Vision for Computer Science Education report on July 1, 2021.

Nevada

In 2019, Nevada adopted SB313, which requires all teacher candidates in the Nevada System of Higher Education to receive appropriate education and training in computer science. A Computer Science Strategic Plan was developed in 2018. The state also has funded computer science professional development since 2017.

SB 200 (2018) requires all high schools to make a computer science course available to all students by July 1, 2022 and requires all students to receive instruction in computer science before grade 6. Further, all students must earn one half-credit in computer education and technology, which must include computer science content.

Appendix F:
CS Initiatives in Other States

New Jersey

In May 2021, New Jersey Governor Phil Murphy announced three universities would receive grants from the New Jersey Department of Education to create computer science learning hubs throughout the state. This followed an October 2018 announcement of New Jersey's Computer Science for All initiative which resulted in a $2 million appropriation in the FY 2019 state budget.

The Expanding Access to Computer Science: Professional Learning Grants were awarded to Fairleigh Dickinson University, Kean University and Rutgers University in New Brunswick to create hubs that will provide high-quality professional learning for educators and resources for school districts to increase computer science opportunities for students.
New Jersey's DOE estimates that the learning hubs will lead to approximately 3,000 students receiving equitable high-quality computer science education during the grant period through Aug. 31, 2022.

The grants support the vision in Gov. Murphy's Computer Science State Plan, which details New Jersey's approach to supporting and expanding equitable access to high-quality computer science education for all K-12 students.

Pennsylvania

Pennsylvania has dedicated $56 million since 2018 to teacher training, teacher certification in computer science (CS), and support for STEM.[40] Pennsylvania has dedicated $20 million annually to the Pennsylvania Department of Education (PDE) for PAsmart, a program established to expand STEM and computer science education to learners of all ages.

PDE has awarded 438 PAsmart grants since the 2018-19 school year. In 2019-20, 63 percent of public high schools in the commonwealth offered a foundational computer science course—and 81 percent of high school students attended a school offering computer science. Since 2015, schools offering computer science programs increased by 271 percent, and there has been a 1,000 percent increase in the number of students enrolled in computer science programs.

South Carolina

In November 2021, South Carolina leaders celebrate the state's ranking in the 2021 State of Computer Science report, citing "South Carolina's emergence as a national leader in computer science education with the highest rate (21%) of students enrolled in foundational computer

science courses and 92% of high schools offering computer science coursework, tied with Arkansas for the highest percentage in the nation."[41] This is an increase from just 43% of high schools offering coursework in 2017-2018.

South Carolina was the first state to require a computer science course for high school graduation. The state adopted computer science standards in 2018. As a result of the new standards, the state updated the list of courses that they consider to be "computer science" and which count towards a required credit for high school graduation. South Carolina has funded computer science since 2017 and requires all high schools to offer computer science. The state has the largest share of student population enrolled in computer science of any state, with 21% of their high school student enrolled in a computer science course in the 2020-21 school year.

South Carolina is also approaching gender parity for enrollment in computer science, as 46% of students enrolled in computer science are female students. According to South Carolina, no obvious disparities for race or ethnicity exist for computer science classes in the state.

Virginia

In 2016, Virginia became the first state to require CS instruction when the legislature added "computer science and computational thinking, including computer coding" to the required academic standards that all districts must teach. CS in grades K-8, according to the standards, should be addressed within content areas while middle and high school classes should be stand-alone electives.[42]

The state has funded computer science professional development for teachers since 2016 and has since received support from Google to expand CS education.[43]

West Virginia

In 2019, West Virginia passed SB 267 requiring the creation of CS programs at all instructional levels in every school, the development of a CS education state plan and a grant program for professional development. The legislation has been interpreted to mandate that any student who wishes to take a CS course be able to do so, but it does not require every student to take CS courses.

The 2021 State of Computer Science report notes that West Virginia has increased high school access to foundational computer science courses over 65%, from 46% to 76% students in the past three years.[44]

Read the West Virginia Computer Science Plan

Appendix F:
CS Initiatives in Other States

Since summer 2018, the CodeWV program housed at WVU has reached 875 teachers in 52 of the state's 55 counties. As the agency partner to the West Virginia Department of Education (WVDE), West Virginia University's (WVU) Center for Excellence in STEM Education has developed a robust structure for the expansion of computer science education in the state. Sessions are free of charge and educators often participate in multiple trainings.

Appendix G:
Research and Labor Statistics - Computer Science Nationally

According to a 2018 consensus report of the National Academies of Sciences, Engineering and Medicine, "every two years the U.S. Bureau of Labor Statistics (BLS) publishes projections of employment trends for the next decade.

In the most recent projections, covering the decade from 2014 to 2024, BLS predicts the number of people employed in computing occupations will rise from 3,916,100 to 4,404,700."[45]

"The addition of nearly half a million computing jobs to the economy corresponds to a growth of 12.5 percent over the decade, compared to a projected overall job growth rate of 6.5 percent. This suggests that computing occupations are growing nearly twice as fast as the labor market as a whole."

2x

Job Growth

CS occupations are growing nearly twice the rate of the labor market overall.

According to Bureau of Labor Statistics BLS Occupational Employment and Wage Statistics (OES), the earning power of workers in CS jobs is also much higher than the median household income for Ohio. The average annual salary for "Computer and Mathematical" occupations is $85,970 for May 2021 while Ohio's average household income and per capital income are $58,116 and $32,465, respectively, for July 2021[46]. This represents a 48% wage premium for computer and mathematical occupations over Ohio's median household income.

Moving closer to this higher-wage sector would not only benefit Ohio workers but also the state economy, reducing Ohio families aggregate dependence on social support programs.

Earning power for computer and mathematical occupations[47]

Average annual salary for occupations classified as computer and mathematical occupations	$85,970
Average salary for computer and information systems managers	$142,630
Average salary for computer and information research scientists	$117,720
Average salary for computer systems analysts	$94,580
Average salary for computer user support specialists	$51,380
Median Household Income (Ohio, 2021)	$58,116
Ohio's Living Wage (MIT, one adult, one child)	$66,560

Appendix G:
Research and Labor Statistics - Computer Science Nationally

According to the National Academy of Sciences, Engineering and Medicine[48], "the centrality of computing to the national science and engineering workforce is reflected in Figure 4.6, which compares the size and anticipated growth in the computing sector to those in other science, technology, engineering, and mathematics (STEM) fields."

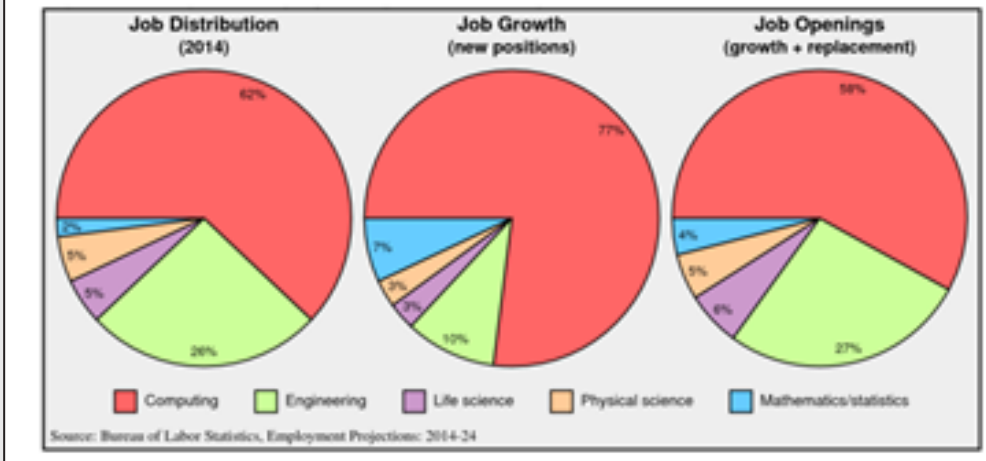
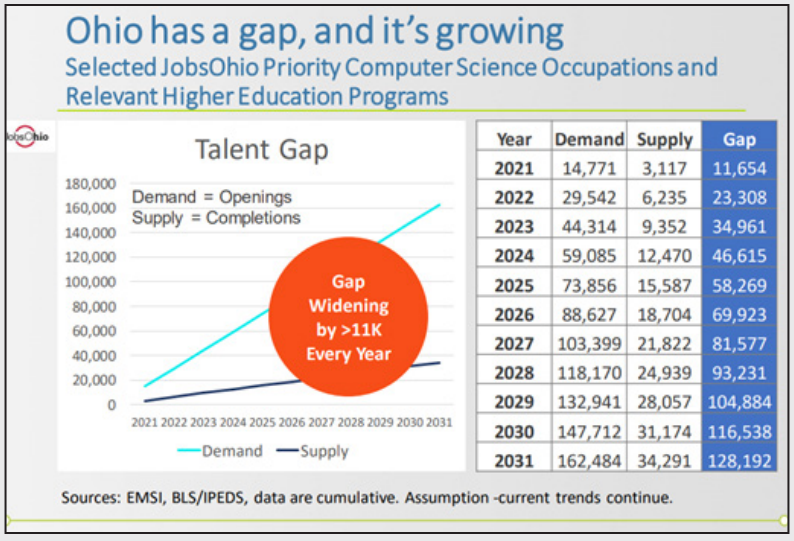


FIGURE 4.6 Projected employment growth for occupations in STEM and STEM-related fields (social sciences not included), 2014-2024. SOURCE: Data from BLS (2015), labor projections, 2014-2024.

Here in Ohio, the projected gap in CS supply versus employer demand is more acute. JobsOhio projects a talent gap that widens by approximately 11,000 jobs per year through 2031.



Year	Demand	Supply	Gap
2021	14,771	3,117	11,654
2022	29,542	6,235	23,308
2023	44,314	9,352	34,961
2024	59,085	12,470	46,615
2025	73,856	15,587	58,269
2026	88,627	18,704	69,923
2027	103,399	21,822	81,577
2028	118,170	24,939	93,231
2029	132,941	28,057	104,884
2030	147,712	31,174	116,538
2031	162,484	34,291	128,192

Appendix G:
Research and Labor Statistics - Computer Science Nationally

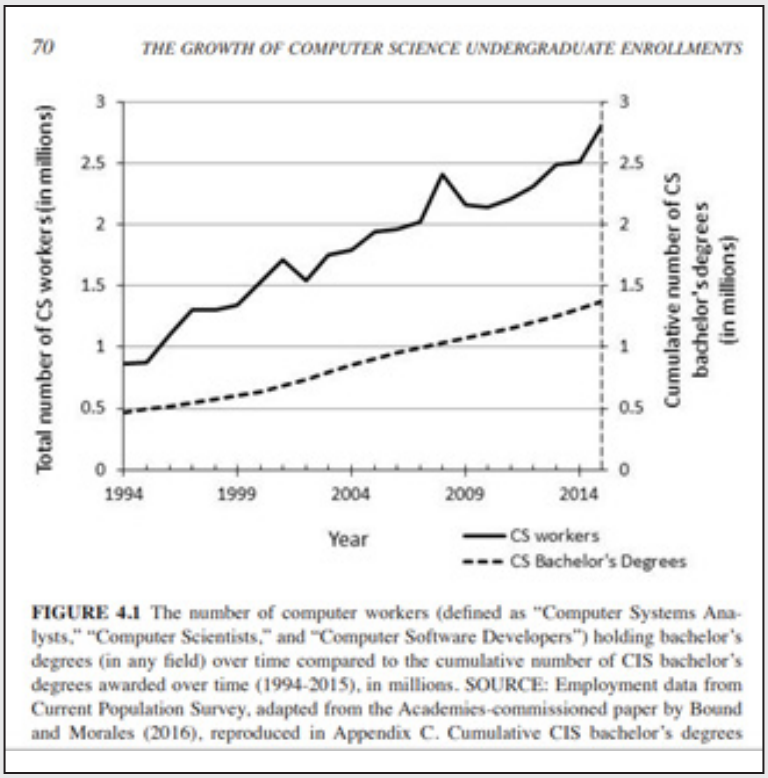


FIGURE 4.1 The number of computer workers (defined as "Computer Systems Analysts," "Computer Scientists," and "Computer Software Developers") holding bachelor's degrees (in any field) over time compared to the cumulative number of CIS bachelor's degrees awarded over time (1994-2015), in millions. SOURCE: Employment data from Current Population Survey, adapted from the Academies-commissioned paper by Bound and Morales (2016), reproduced in Appendix C. Cumulative CIS bachelor's degrees

[Note: Source is Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments (2018), https://nap.nationalacademies.org/catalog/24926/assessing-and-responding-to-the-growth-of-computer-science-undergraduate-enrollments]

Beyond the growth of the CS labor market sector itself, "analyses of job requirements show that employers now expect new hires to have significant levels of computing expertise, particularly at the high end of the labor market."

Programming skills are important for nearly half of the job openings in the highest income quartile.

"A recent estimate from Burning Glass Technologies, estimated that programming skills were important qualifications for nearly half of the job openings in the top quartile of the income distribution in 2015, as shown in Figure 4.7."[49]

Appendix G:
Research and Labor Statistics - Computer Science Nationally

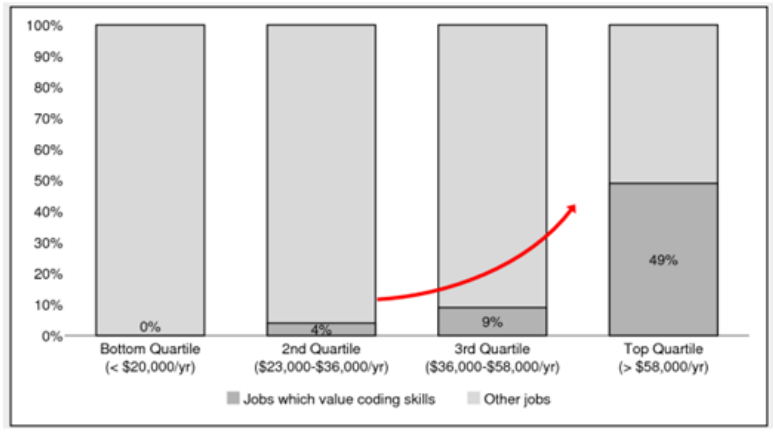


FIGURE 4.7 Percentage of 2015 job openings that value coding skills, by income level. SOURCE: Burning Glass Technologies. 2016. Beyond Point and Click: The Expanding Demand for Coding Skills. Online. Available at http://burning-glass.com/research/coding-skills/.

The National Academies' analysis raises the concern that underrepresented populations are less likely to have CS educational experience in K-12 and college, and thus end up left behind by these expected CS-related job market surges.

Projected starting salaries for bachelor's degree graduates in computer science, as published in the Winter 2022 National Association of Colleges and Employers (NACE) Salary Survey rank CS graduates as the highest average salary ($75,900), followed by engineering graduates ($73,922).[50]

The number of Americans working in CS is ***3x larger than*** the total number of bachelor's degrees in CS ever produced in the U.S.

"As of 2014 the number of people employed in computer occupations was [3.9 million] (BLS, 2015). The total number of bachelor's degrees in computer science awarded by U.S. institutions throughout the entire history of the field is only [1.3 million]."[51]

"The number of employees in computing occupations is therefore approximately three times larger than the number of bachelor's degrees in computer science ever produced in the United States."

When comparing projected job openings to degree production, the need for an increased CS pipeline becomes even more apparent (see Figure 4.8 on the next page).

Appendix G:
Research and Labor Statistics - Computer Science Nationally

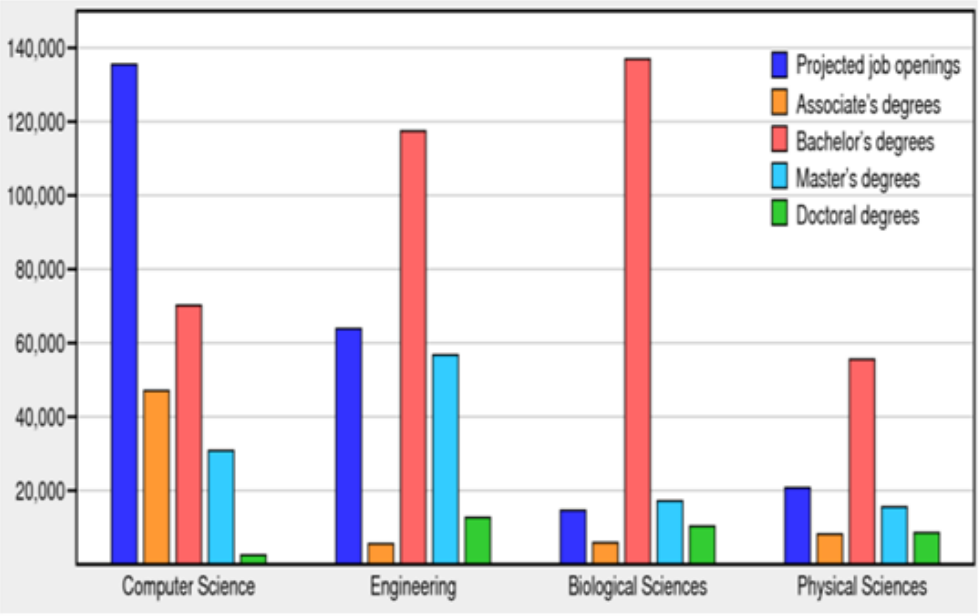


FIGURE 4.8 Projected annual job openings and current degree production in broad STEM fields. SOURCE: Data from BLS (2015) jobs projections and IPEDS completions survey.

As illustrated in figure 4.8, "computer science is the only major discipline in which the projected number of job openings exceeds the rate of bachelor's degree production (Freeman, 2016)."

"Second, computer science is the only STEM discipline that produces a significant number of associate degrees, which currently account for nearly one-third of computer science degrees."

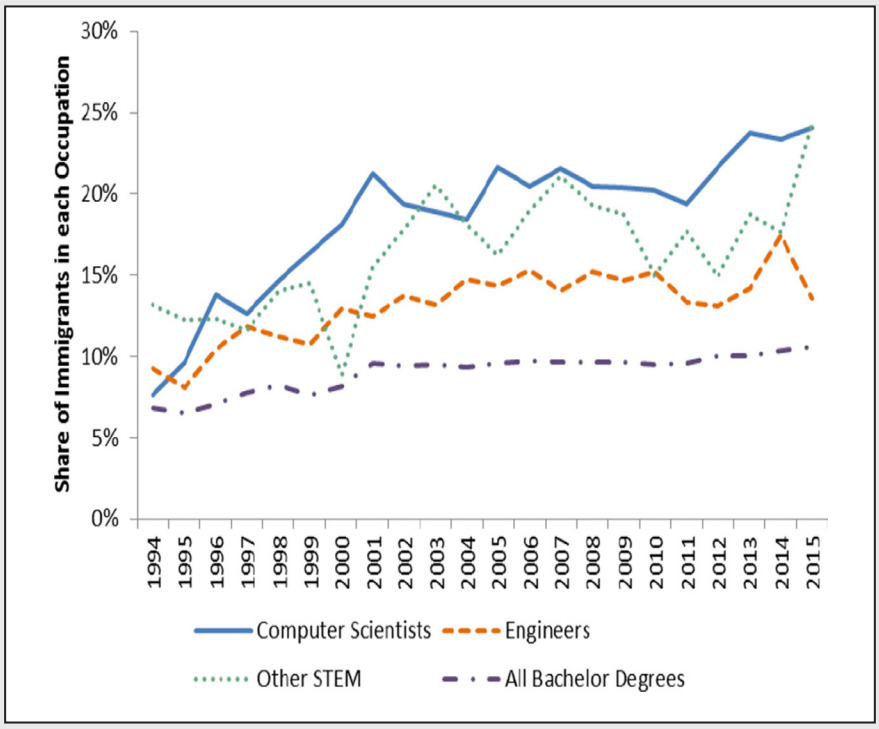
"Third, the number of doctoral degrees in computer science is proportionally smaller than it is in any other STEM field."

"Some specialties have grown dramatically in importance in recent years. Three areas are commonly highlighted as facing acute demand: cybersecurity, data science, and machine learning."

According to the National Academies consensus report, the three main sources for increases to CS workforce are new graduates, workers from other fields and foreign workers.

Appendix G:
Research and Labor Statistics - Computer Science Nationally

"As shown in Figure C.4, the foreign source is particularly significant in computer science relative to other fields. Historically, the share of foreign workers who work as computer scientists has been well above other fields such as engineering and other science, technology, engineering, and mathematics



https://www.nap.edu/read/24926/chapter/14#176

(STEM) occupations such as physics, mathematics, and biology. While engineering had, on average, 15.6 percent of its workforce as foreign workers, computer science went from 10.6 percent in 1994 to 26.8 percent in 2015. Foreign workers who have college degrees, including those with advanced degrees, generally get to the United States through the H-1B visa program…"

Appendix H:
Computer Science and Ohio's Workforce Needs

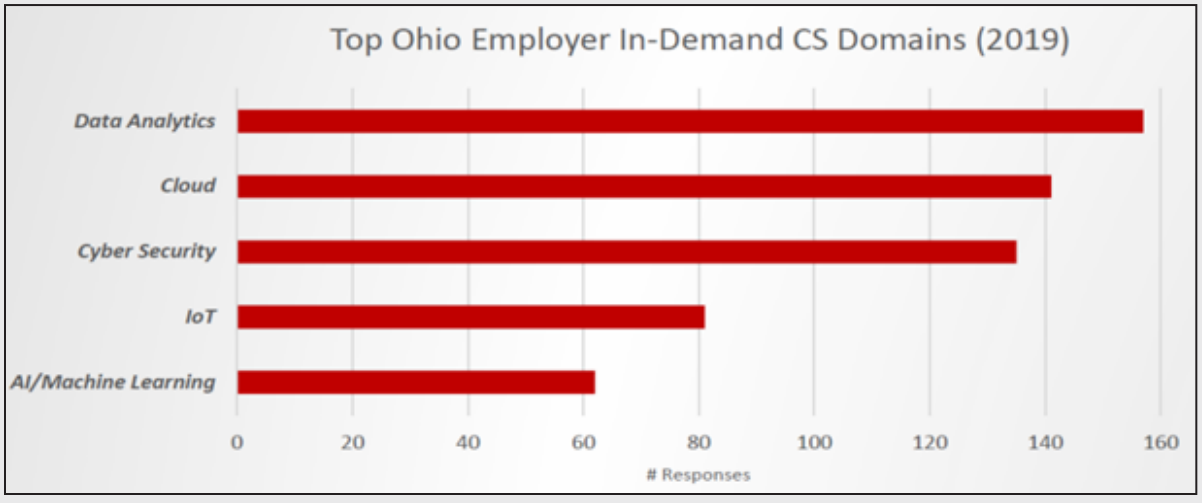
JobsOhio Presentation to the Ohio House Technology and Innovation Committee

According to the JobsOhio presentation "Ohio is the Future" presented to the Ohio House Technology and Innovation Committee on Oct. 13, 2021, Ohio is under-indexed in high-growth job sectors including information technology and healthcare and challenged by stagnant growth and shortages in STEM talent. The presentation notes Ohio's under-production of CS degrees.

In late 2019, JobsOhio held five employer focus groups on the topic of "Tech Talent." Approximately 60 companies participated in this exercise with top feedback including the need for more experiential learning such as co-op programs, real world projects and boot camps for incumbent workers. Employers are also demanding traits such as "soft skills," "passion" and "curiosity."

Among the top "tech" domains considered, Ohio employers reported "data analytics" as their top demand followed by "cloud computing," "cybersecurity, "Internet of Things" and "artificial intelligence/machine learning."

Among "tech" abilities demanded, employers' top responses were "design/architect" followed by "programming," "IT support/configuration," "business analysis" and "project management."



Additional insights include that among full-time tech roles expected to be hired, employers' top need is software developers (82% expected to hire) followed by data scientists (63%), cybersecurity (59%) and IT admin (56%). Employers surveyed were uncertain about expanding student work experiences due to the economy and pandemic but expressed a strong desire to expand internships.

Appendix I:
Perspectives of Ohio Employers – Panel Q&A

On April 20, 2022, the State Committee on Computer Science held a JobsOhio sponsored Q&A panel with five tech-oriented employer representatives as follows:

- Greg Tacchetti, former CIO of State Auto Insurance;
- Tonjia Coverdale, AVP at Nationwide;
- David Landreman, CTO at Olive;
- Jamie Timm, Chief Delivery Officer at WillowTree; and
- David Medwid, Senior Director of Talent Acquisition at Aware.

The panel discussed Ohio's sources of CS workforce talent, with panelists variously indicating they source from two-year colleges, four-year universities and boot camps like Tech Elevator.

Panelists noted demand for native mobile software development skills (Swift, Objective C, Java, Kotlin, etc.), as well as great interest in project management skills such as Agile software development methods, Scrum project management, AWS certifications, cybersecurity certifications and IT certifications.

Software engineers, among the highest paid CS occupations, were identified by the panel as qualified for employment largely based on work experience and less on certifications. In other words, certifications tend to be more important for sub-baccalaureate workforce roles.

One panelist indicated that the industry is "over-indexed" on certifications and needs "agile people" who can quickly adapt to employer needs. Most panelists indicated no certification requirements were needed for jobs as software engineers but could be required for cybersecurity and other IT roles where industry standards are more common or required.

When asked if Ohioans are prepared for the jobs employers were offering, most panelists said yes, but noted that artificial intelligence/machine learning (AIML) is difficult to source in the Midwest as most of the talent is concentrated on the West Coast. Another panelist noted that "native" mobile development skills are hard to find in Ohio.

Panelists remarked that some of the best applicants come from entrepreneurial clubs such as a Business Builders Club, Hack Ohio or other extracurricular opportunities that blend skills in entrepreneurialism with product management and computer science. When asked to describe in three words or less what their most pressing CS skills needs include, panelists responded with data science, transformation, cybersecurity, digital customer journeys and life experience.

When asked how to expand work-based learning to students, panelists said industry and educational providers need to establish closer partnerships, that educational curriculum

often lags the private sector, post-secondary curriculum updates can be tedious and suggested Ohio employers co-fund such programs if educational providers would keep them fresh.

In response to a question from an entrepreneur on the SCCS about what would produce fast-growing, high net worth companies for Ohio, panelists indicated students need more critical thinking, "space to tinker," access to real-world business problems, creating space for innovation without limiting it to a certain place, access to technology and activities outside school, finding deeply passionate people and demystifying software development.

In response to a question from an educator on the SCCS about what is needed to help employers source more talent from Ohio rather than through H-1B visas, panelists said the kinds of recommendations from this report could produce "this big structure of machinery" necessary for Ohio CS talent to blossom.

Panelists also suggested more outreach to rural Ohio and urban areas like East Cleveland would help, that the state should market CS to eliminate misconceptions, provide experiential learning and truly convince Ohioans how achievable a career in CS could be for them.

The last question received by the panel was a hypothetical that if they could speak with someone from their educational journey, whether a teacher, faculty member or fellow student, what would you tell them.

Panelists responded that more math is important, that broadly all inner-city students should be exposed to technology (not just those who take an elective), that CS recruitment should be tied to solving real-world problems that inspire students, and that young minds should be inspired with simple projects such as utilizing a Raspberry Pi to run a simple automation.

Appendix J:
Ohio Cyber Collaborative Committee (OC3) Suggestions

The State Committee on Computer Science requested comments from the Ohio Cyber Collaborative Committee on ways to expand computer science education. OC3 submitted the following suggestions, as listed in this appendix:

1. "All Ohio students must take an age-appropriate class on cyber hygiene and online safety **annually**. Propose the state develop or acquire online/remote training sessions offered twice a year at 45 minutes to one hour each that all students must take. There would be different levels of the class based on age. Any teacher can proctor the class that could be set up either at the OCRI or on an ODE web site for download and use in the classroom. (Mandated in one year)"

2. "All Ohio students **must take** a yearlong course, in either grade 8 or grade 9, that could be broken down into semester or quarterly segments that offers the following instruction: 1. Basic system administration where students would learn how to set up a home/small office style network; do basic configuration on routers, modems, and firewalls; install, update, and manage OS, programs, and browsers; learn how to back up data; and learn basic cyber-security principles. 2. A basic office suite of programs that would enable students to function in an office or school environment. 3. An introduction to IT/CS/Cyber where students would be exposed to the various types of study, jobs and basic skills of IT/CS/Cyber, the options and jobs that exist throughout the IT/CS/cyber industries and what they would need to learn to master those programs of instruction. (Mandated in three years.) This part of the course leads into item 3."

3. "All Ohio students must be **offered** a way to take a full set of IT/CS/Cyber courses while in high school. The introduction to IT/CS/Cyber class in item 2 would inform students about the options available to them and prepare them to take these courses while in high school. (Mandated in 5 years)"

4. "Ohio will develop a statewide system of definitions describing what IT/CS/Cyber is to standardize names and definitions of courses and lines of study, enabling students and employers to know exactly what was taught and what skills a student has attained. This will aid both employers and students as they look at different programs of instruction and will help make courses and certificates more portable and transferable. (Completed in two years)"

5. Ohio will coordinate and streamline teacher certifications for IT/CS/Cyber based on a "banded" system of primary, middle and high school levels of instruction. Ohio will develop ways that IT/CS/Cyber industry professionals can be certified to teach IT/CS/Cyber. As long as there is a shortage of teachers in these areas, Ohio, in conjunction with local school districts will provide stipends for teachers while in IT/CS/Cyber instructor training and will provide scholarships to help cover tuition for needed classes/certifications. (Available in one year)

Appendix K:
Summary of Feedback from Postsecondary Institutions in Ohio, Computer Science Department Chairs

In the first quarter of 2022, the Ohio Department of Higher Education initiated four convenings with computer science department chairs representing Ohio's 14 four-year public universities, nearly 50 four-year private colleges/universities and 26 two-year community colleges.

The following bullet point summaries were drawn from the feedback received and confirmed again with attendees before being recorded as final summaries.

PUBLIC FOUR-YEAR UNIVERSITIES
COMMENTS FROM CS DEPARTMENT CHAIRS

- For many IHEs, the primary limiting factor for growth in CS enrollment and degree production is the bottleneck of hiring additional faculty. Despite rapidly increasing demand from students to enter these programs, teaching faculty capacity has not been increasing sufficiently to match this demand. Additional teaching faculty would be necessary to increase enrollment and would require additional institutional funding - possibly via new funding through the State of Ohio for that purpose.

- At some IHES, there may be as many as 60-70 students in each class. *Hiring additional CS faculty will not only support recruitment but may also help with persistence/retention of students in the field*.

- Many freshman students are still in a high school mode and need additional attention to be successful in the first major courses, and this can be more difficult with large class sizes.

- One challenge for hiring teaching faculty for CS is that *industry salaries are often higher* than what universities are currently offering for teaching positions.

- In addition to faculty capacity increases, *universities will need physical facility capacity increases in the form of additional classrooms, labs, etc*. Again, this would require additional funding.

- *The preparation of high school students* for college-level CS is a concern. As demand increases, an increasing number of students may not be prepared for the nature of college-level computer science programs. This is a balancing act between courses in high school that are engaging, inspiring and open to many students, while presenting a realistic understanding of college-level work.

- The State of Ohio could help increase enrollment by establishing initiatives that increase engagement in under-represented student populations including females and minorities.

Appendix K:
Summary of Feedback from Postsecondary Institutions in Ohio, Computer Science Department Chairs

- This *mismatch* between supply and demand for CS is a global issue. Other nations are moving more aggressively to increase supply when compared to the United States.

- *Computer Science (CS) needs some rebranding beyond programming*. By approaching the discipline with a broader lens that includes solving world problems, exploring artificial intelligence and machine learning, we can possibly generate more persistence among certain student sub-groups.

- *Ohio does not currently have a Top 25 college CS program*. We have two Top 100 programs (Case and Ohio State University). Working toward having one or more Top 25 programs would have a positive effect on Ohio as a whole.

- *Universities can improve retention in CS by considering math-related barriers* such as prerequisite requirements that focus on calculus. Consider in addition to the traditional B.S. programs, a B.A. option that focuses more on discrete math and linear algebra to create more opportunity for enrollment and success among potential CS students.

- Universities should *socialize degrees and more diverse pathways that meet the needs of industry*, which can often be stringent, especially employers like the U.S. Department of Defense.

PRIVATE COLLEGES AND UNIVERSITIES
GROUP ONE OF TWO - COMMENTS FROM CS DEPARTMENT CHAIRS

- For many IHEs, the primary limiting factor for growth in CS enrollment and degree production is the bottleneck of hiring additional faculty. Despite rapidly increasing demand from students to enter these programs, teaching faculty capacity has not been increasing sufficiently to match this demand. Additional teaching faculty would be necessary to increase enrollment and would require additional institutional funding - possibly via new funding through the State of Ohio for that purpose. At least one chair suggested that college leaders may be wary of hiring if this is only a temporary demand increase, i.e., they might wait for the “wave” to pass before making more commitments to hire faculty.

- For some IHEs, some of the best students come from abroad, yet they are encountering difficulty finding jobs in the United States, i.e., not securing job interviews. While the exact cause is unclear, it could be the result of cultural and/or language barriers, VISA issues or other factors.

- Private IHEs are seeing higher student demand in two subsets of computer science: data analytics and cybersecurity.

Appendix K:
Summary of Feedback from Postsecondary Institutions in Ohio, Computer Science Department Chairs

- Private IHEs are seeing an increase in students in other majors who wish to minor in CS or related disciplines or skill sets such as data analytics, etc.

- General consensus that the pay differential required to hire CS faculty is a major barrier to meeting demand. In some institutions, particularly smaller private liberal arts colleges, the norm is for all faculty to make the same salary, which is not practical for computer science faculty where private sector salaries are substantially higher.

- Some private CS chairs would like to know if employers value interdisciplinary approach to CS where students may receive foundational skills in writing and soft skills, but a less technical approach to CS. Does this fill a need for Ohio employers is the question on some CS chairs' minds.

- Choose Ohio First grants are helpful in attracting student talent.

- Some CS chairs are approaching CS as mission oriented, helping humanity and feel that this approach attracts more students particularly at faith-based colleges where service to humanity is a priority.

- Private CS chairs suggested that the State of Ohio could help with short-term (less than two year) grants to help colleges hire faculty, potentially non-tenure track, to meet student demand with the expectation that state funding would expire, and colleges would need to become self-sufficient. One suggestion was for state grants to pick up ~50% of an FTE salary cost.

- Some CS chairs expressed a reality that CS students may leave before receiving a degree because they have been offered a job, particularly after receiving a certificate, and wonder how this interacts with metrics the state cares about such as degree attainment.

- When asked if programs are at capacity, the response was mixed. It sounded like many programs are turning away students while others are healthy but not yet turning away students. No program indicated a shortage of student demand.

- When asked if students are arriving prepared for college-level work, at least some CS chairs felt they are not ready, particularly in mathematics, and the pandemic seems to have exacerbated this issue.

- One CS chair raised a question about the difficulty of training new faculty with Ph. Ds when Ohio requires 60 hours for a Ph.D. where other states may only require 48 hours. The ability of CS majors to get high-paying jobs with a bachelor's degree is another barrier.

Appendix K:
Summary of Feedback from Postsecondary Institutions in Ohio, Computer Science Department Chairs

- In measuring student demand, at least one CS chair shared that one concern raised by leaders at colleges may be the low birthrate during the 2008-2009 recession and potential impact on student demand in 2026 and near periods.

- At least one CS chair recognized that industry entry-level jobs often want very specific skills whereas liberal arts colleges desire to provide students with a solid background in problem solving and life-long learning focus. They do teach specific skills like Python, C++, Java, Swift and other languages but avoid focusing on the latest technologies (such as a specific JavaScript library or specifics of Cloud services) because they change so often. One possible solution could be partnering with industry (a single business or multiple) to allow industry to teach students the courses for specific skills

PRIVATE COLLEGES AND UNIVERSITIES
GROUP TWO OF TWO - COMMENTS FROM CS DEPARTMENT CHAIRS

- A primary limiting factor for growth in CS enrollment and degree production is the bottleneck of hiring additional faculty. For private colleges, our salary range is often below corporate employers. It is difficult to find qualified instructors.

- Many private colleges require internships from students but are having difficulty placing interns, sometimes in competition with renowned non-Ohio based IHEs like Purdue.

- At a recent convening of engineering deans, CS was the hottest topic. This discipline is on the minds of engineering deans regionally.

- Some programs are growing very quickly from 100 -> 500 students in just a few years. But there is a problem with diversity. Less than 25% female, approximately5% minority. Need support for attracting these students.

- We do not need students with CS background necessarily. We need strong understanding of algebra and logic.

- Choose Ohio First scholarships are helpful, but we have more allocations than students to give them. (At least two institutions made this point)

- Mathematics is the great filter. Students are afraid of math, but they shouldn't be. We do not require calculus.

- One of the better pathways to CS is through community colleges. Students can arrive with 60 hours of credit, but one limitation is that they are not learning "CS" as four-year

universities define it. They are arriving with networking, cyber, certifications, but not logic and computational thinking or programming familiarity. Some students come for CS, but realize it is not IT and they switch programs.

- Some colleges have capacity to add students right now, but there was an expression of the need for more computer labs and some pressure from programs like nursing on access to labs, computers, etc.

- Other colleges, particularly the faster growing CS programs (larger programs), are at capacity limit. They need new faculty added. They need to double labs. There is some resistance from other departments who worry about cannibalization, express resentment toward CS departments for growing.

- Possible support from the state could include grants for more innovative curriculum, but the state will have to tell us to hire teaching faculty, not just research faculty. Districts tend to hire research first and this can crowd out teaching capacity.

- Grants for K12 teachers to take certifications would be helpful. Project Lead the Way is a good example, we need funding for programs like that.

- Some high schools do not realize there is a CS degree at our college. This is an issue.

- Important to train HS teachers not just in content but in engaging pedagogy. If you bore students, you will lose them right away. My son took AP courses but was not as engaged as when at home with me. Don't teach with PowerPoint slides.

- A programming contest for Ohio, hosted at colleges and universities, would be great. The Ohio Council of Teachers of Mathematics (OCTM) has a math contest and this is a great introduction to college and getting students thinking about math in college.

TWO YEAR COMMUNITY COLLEGES
COMMENTS FROM CS DEPARTMENT CHAIRS

- For some of our institutions, CS is already a top two enrollment program, rivaling popular programs such as nursing. In other two-year institutions, enrollment for CS is relatively small and there is little demand from students to enter this discipline.

- Generally, most of the two-year colleges commented about the difficulty of hiring qualified faculty and non-teaching staff such as high school liaisons as a result of scarcity of applicants and/or inability to offer high enough wages to compete with other employers in the labor market.
- High school students sometimes arrive at college with a shallow understanding of

computers based on experience with Chromebooks, as contrasted with "real computers." As a result, more students today students require introductory courses that teach operating systems like Microsoft Windows, Microsoft Office and related software.

- Several of the community college representatives indicated that, although high-paying jobs are available, students seem not interested in these programs. Students may need inspiration in high school to understand these jobs are not just "sitting in a cube" anymore.

- Ohio high schools are often teaching "front end" computer related skills such as graphic design, website design and light application coding interfaces rather than the "logic" that is necessary for more advanced, creative development such as software development or programming.

- Some two-year colleges have experienced success with deeper engagement in the community. Sending flyers to schools. Talking with local businesses. This generates higher enrollment in programs.

- High schools may not have the specialized staff to offer many CS courses, but we do. It would be great if more Ohio high schools could partner with two-year colleges to offer courses to students, whether through College Credit Plus or not. We need more "pathways" partnerships with high schools.

- We have many post-degree students seeking certificates to continue their education. They already have a bachelor's degree or a master's degree, and they want a certificate in a particular skill area that supports their career growth. This is not as common with associates degree students. There are some employers that do want a student, even with a bachelor's degree, to get an associate degree on top of that to work for them.

- We need to show students what these jobs are actually like so they can understand them. They are not familiar with the jobs so they can't envision themselves filling them.

# # #

Appendix L:
Integrated Postsecondary Education Data System (IPEDS)
Ranking States by % of Degrees in CS and Growth Rate, 2015-2020

Computer science degrees, all levels (associates, baccalaureate, masters and beyond)

State	2015 CS degrees	2020 CS degrees	2020 pct of degrees awarded in all disciplines	Rank of 2020 pct of all degrees	pct chg, 2015-2020	Rank of pct chg
Ohio	**4,105**	**4,895**	**3.6%**	**33**	**19.2%**	**34**
Indiana	3,472	4,748	5.2%	15	36.8%	21
Kentucky	1,288	5,913	10.7%	2	359.1%	1
Michigan	4,310	5,382	4.8%	18	24.9%	30
Pennsylvania	7,407	9,927	5.9%	11	34.0%	25
West Virginia	1,191	1,406	4.6%	23	18.1%	37
U.S. Total	**141,182**	**201,608**	**4.8%**		**42.8%**	

Source: IPEDS Data

Endnotes

1 JobsOhio research utilizing Lightcast

2 https://www.bls.gov/oes/current/oes_oh.htm#15-0000 and US Census Quickfacts (Ohio), https://www.census.gov/quickfacts/fact/table/OH/INC110220

3 The NASEM report uses the term "foreign workers" so this report follows that standard when citing its findings.

4 "Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments" , the National Academies of Sciences, Engineering and Medicine, 2018. https://www.nap.edu/read/24926/chapter/14#175

5 "Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments," the National Academies of Sciences, Engineering and Medicine, 2018. https://www.nap.edu/read/24926/chapter/14#175

6 https://www.nationalacademies.org/news/2017/10/colleges-and-universities-should-take-action-to-address-surge-of-enrollments-in-computer-science

7 https://advocacy.code.org/2021_state_of_cs.pdf, page 5 in the pdf, page 1 in the report

8 https://www.nap.edu/read/24926/chapter/14#182

9 ODHE analysis utilizing IPEDS data 2015-2020 on CIP degrees percentage and growth.

10 ODHE analysis utilizing IPEDS data 2015-2020 on CIP degrees percentage and growth.

11 https://www.nationalacademies.org/news/2017/10/colleges-and-universities-should-take-action-to-address-surge-of-enrollments-in-computer-science

12 Computer Science Poll, Ohio Excels and Public Opinion Strategies, June 2022

13 Gallup, Amazon, Developing Careers of the Future, June 2021, https://www.gallup.com/analytics/354740/study-of-student-interest-in-computer-science.aspx

14 https://www.ecs.org/wp-content/uploads/State-Info-Request-Computer-Science-Requirements-for-High-School-Graduation.pdf

15 http://billstatus.ls.state.ms.us/documents/2021/html/HB/0600-0699/HB0633SG.htm

16 https://www.govtech.com/education/k-12/mississippi-makes-compsci-courses-a-requirement-in-public-schools.html

17 Research conducted by JobsOhio using Lightcast.

18 https://www.brookings.edu/research/what-do-we-know-about-the-expansion-of-k-12-computer-science-education/

19 https://codes.ohio.gov/ohio-revised-code/section-3301.012

20 https://k12cs.org/wp-content/uploads/2016/09/K%E2%80%9312-Computer-Science-Framework.pdf

21 https://www.census.gov/data/tables/2020/econ/school-finances/secondary-education-finance.html

22 https://www.lsc.ohio.gov/documents/budget/134/mainoperating/EN/appropriationspreadsheet-hb110-en.pdf

Endnotes

23 https://www.ecs.org/wp-content/uploads/State-Info-Request-Computer-Science-Requirements-for-High-School-Graduation.pdf

24 https://www.bostonglobe.com/2021/12/07/metro/rhode-island-might-overhaul-its-high-school-graduation-requirements/

25 http://billstatus.ls.state.ms.us/documents/2021/html/HB/0600-0699/HB0633SG.htm

26 https://www.govtech.com/education/k-12/mississippi-makes-compsci-courses-a-requirement-in-public-schools.html

27 https://www.ed.gov/coronavirus/factsheets/teacher-shortage

28 https://brill.com/view/book/edcoll/9789004399990/BP000017.xml

29 Images of Computer Science, Google/Gallup, 2015. https://services.google.com/fh/files/misc/images-of-computer-science-report.pdf

30 2021 State of Computer Science Education report, Executive Summary, Page 2, https://advocacy.code.org/stateofcs

31 https://www.congress.gov/bill/117th-congress/house-bill/3602?s=1&r=83

32 https://www.vox.com/2017/9/25/16276904/president-donald-trump-ivanka-tech-stem-computer-science-coding-education-amazon-google

33 https://www.theverge.com/2016/12/11/13849766/obama-computer-science-for-all-funding

34 https://www.nsf.gov/news/news_summ.jsp?cntn_id=137529

35 https://edtechmagazine.com/k12/article/2015/12/what-essa-means-future-computer-science-and-stem

36 Educators who hold an active, standard Ohio teaching license with the previous Computer/Technology (111770) endorsement and who now wish to teach computer science courses may do so without mentorship or an employment-based request. The educator still must pass the assessment exam. Some may still prefer to pursue a supplemental license instead in order to secure an license endorsement.

37 https://adecm.ade.arkansas.gov/ViewApprovedMemo.aspx?Id=4716

38 https://advocacy.code.org/2020_state_of_cs.pdf

39 https://www.sciencedaily.com/releases/2022/02/220224113751.htm

40 https://www.northcentralpa.com/education/pa-invests-in-stem-computer-science-for-k-12-schools/article_361409a2-5454-11ec-ada8-f7e2eeb50771.html

41 http://governor.sc.gov/news/2021-11/south-carolina-recognized-leader-k-12-computer-science-education

42 https://www.edweek.org/teaching-learning/virginia-becomes-first-state-to-require-computer-science-instruction/2017/11

43 https://www.wdbj7.com/2022/04/19/governor-google-announce-support-computer-science-partnerships/

Endnotes

44 https://wvde.us/99692-2/

45 http://nap.edu/24926

46 https://www.census.gov/quickfacts/fact/table/OH/INC110219

47 https://www.bls.gov/oes/current/oes_oh.htm#00-0000 and https://livingwage.mit.edu/states/39

48 National Academies of Sciences, Engineering, and Medicine. 2017. Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments. The National Academies Press, Washington, DC. https://doi.org/10.17226/24926

49 https://www.burning-glass.com/research-project/coding-skills/

50 https://www.naceweb.org/uploadedfiles/files/2022/publication/executive-summary/nace-2022-winter-salary-survey-executive-summary.pdf

51 http://nap.edu/24926