CS4NC

NC COMPUTING EDUCATION SUMMIT

North Carolina Preliminary Landscape Report 2017

ECEP EXPANDING COMPUTING EDUCATION PATHWAYS

THE WILLIAM & IDA FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION

CSTEACHERS.ORG COMPUTER SCIENCE TEACHERS ASSOCIATION

CTE Learning that works for North Carolina

NC STATE Computer Science

UNC CHARLOTTE College of Computing and Informatics

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Why Computer Science Education?

In the last 15 to 20 years, nearly all fields have been radically altered by new technologies. More fundamentally, our approach to problems has been changed by these technologies. We make greater use of data and technology, and, as a result, we are now able to iterate on problems significantly faster. The tools we use every day have also advanced greatly, reaching the stage of essentially acting as appliances - devices and apps that encourage consumption rather than creation, exploration or inquiry. Computers were once thought of as a collection of pieces that had to be built, configured, maintained and tinkered with; they now arrive pre-configured, with auto-updates and an expectation that it automatically connects to the internet. In some cases, devices can no longer even be opened to change a battery or make an upgrade. While convenient, these changes have begun to discourage creation and development for many. Computer Science (CS) education provides students the knowledge, skills and approaches needed to be creators rather than consumers. It empowers them to think about and explore ways to advance the technology, not just use what others have already developed.

The K-12 education system is just beginning to address the importance of students learning CS and the processes of computational thinking–formulating problems and developing solutions with sufficient specificity that they can be carried out by computers. CS education is foundational to many fields; from fashion designers and musicians to quality control experts, entrepreneurs, and managers, the knowledge gained through CS education can accelerate innovation and change the way people create, design and solve problems in nearly any field. It prepares students with tools that not only allow them to lead the way in their chosen field, but also lead change toward social good and have significant positive impact on the world around them. However, the majority of U.S. high schools do not offer a CS course with programming, and computational thinking is rarely integrated into other subject areas or grade levels. As a result, an opportunity gap has developed that is most apparent in the tech industry, where there are nearly 500,000 open tech jobs in the U.S. that pay 50% more than average private sector jobs. That number is projected to more than double within the next 4 years (CS4All announcement, 2016).

Interest vs Opportunity

North Carolina currently has a wealth of CS education programs, activities occurring both in school and in our communities. Schools, businesses, non-profits, museums, science centers, universities and community colleges offer CS workshops, training or community events for students, teachers and families. And there is significant interest from both parents and students. A survey of parents shows that 93% of parents in NC want schools to teach computer science so our children grow up not just using technology, but learning how to create it. In high school, students rank computer science among their favorite subjects, behind only graphic design and performing arts. And during CS week in December 2016, there were over 1200 school events for Hour of Code and over 300,000 visits to the hourofcode.com website from North Carolina.

However, interest and activity doesn't necessarily ensure success in engaging students or providing pathways to long-term opportunities. As stated above, there were over 300,000 visits in NC to the hour of code site in one week in December 2016, yet there are fewer than 6,000 students enrolled in CS courses across the state. Students who learn computer science in high school are 6 times more likely to major in it in college, and women are 10 times more likely, yet girls are 1.5 times less likely than boys to be told they would be good in computer science by teachers or parents.

There is also a significant disparity between CS education and opportunities in the computing workforce. In North Carolina, there are nearly 18,000 open computing jobs with an average salary of $87,000, representing over $1.5 Billion in annual salary opportunities. However, only 18% of schools in NC teach AP computer science; only 1,425 of our nearly 1.5 million students in NC took the AP Computer Science exam in 2016, and only 1,200 students graduated with a computer science degree in North Carolina.

A recent survey by Google and Gallup (2017) shows that groups underrepresented in computer science--women, African-Americans, and Hispanics--do not lack interest, but rather lack both awareness of and access to opportunities. Findings from the survey further indicate that students who do not see people like themselves, and do not have parental encouragement for "doing computer science," may struggle to imagine themselves becoming involved in computer science. Additionally, underrepresented groups may face social barriers, such as an enduring perception that only White or Asian males are good at computer science. A growing number of female and minority teachers and working professionals can provide powerful supports for young women and minorities, but these issues and the strategies to address them, must be addressed in depth in order to create sustainable, impactful change for students in all schools.

The limited access to formal computer science education contributes to the shortage of women, African-Americans, and Latinos in computer science related positions. Nationally, In 2015 only 22% of students who took the AP computer science exam were female, and only 13% were African-American or Latino. The Code.org fact sheet for North Carolina points out that, in 2015, only 22% of the state's high schools provided a computer science advanced placement course; only 1,198 North Carolina students took this AP course; with less than the national averages of female and minority students participating. Further data from Expanding Computing Education Pathways (ECEP) Alliance shows that in 2016, the Computer Science A advanced placement exam was passed by only 702 North Carolina students (of 97,000 high school seniors), with only 149 of those students being female, 24 Black (4 female) and 41 Hispanic (10 female). North Carolina Department for Public Instruction data show that in 2016-17, of 4962 students enrolled in non-AP computer science courses, only 22% are female, 16% Black, and 10% Hispanic. In short, the engagement of students in computing is not just a matter of equity—all people deserve the opportunity to engage in rewarding work that is integral to solving increasingly complex global challenges (Barnes & Thiruvathukal 2016).

Until recently, access to computing education has largely been through programs that disproportionately engage those with access to the "preparatory privilege" of extra experience in science, technology, engineering, and mathematics (STEM) and computer science (Margolis, 2008). To truly create opportunities for students in North Carolina, we must establish a shared vision that can bring together the programs, courses, new ideas, and initiatives already underway in our state. Collaboration, and communication through a coordinated effort will not only accelerate progress but also bridge gaps in the system in ways not possible previously. As such, broader impact is possible toward the goal stated in the 2016 Computer Science for All announcement, to "Empower all American students from kindergarten through high school to learn computer science and be equipped with the computational thinking skills they need to be creators in the digital economy, not just consumers, and to be active citizens in our technology-driven world."

A Coordinated Statewide Approach

Furthering the teaching and learning of computer science in K-12 education requires progress in multiple aspects of the education system. This includes creating student opportunities, access and equity; empowering highly qualified, highly skilled CS teachers; developing relevant and accessible CS courses and curricula; establishing CS policy and leadership; and engaging our communities in broadening participation in CS. To this end, we will need to take a systemic approach to develop sustainable and scalable approaches to preparing students in computational thinking and computer science. To do so, we must build upon the substantial body of related work already in place, scale the innovative ideas and new practices in schools, museums, community centers and businesses, and leverage long-term successful working relationships of stakeholders throughout the state to build a strong community, a shared vision, and a coordinated effort for CS Education.

In 2016, the K-12 Computer Science Framework was released to provide a framework and guidance for systemic change in CS Education. Developed by a national collaboration of CS education organizations (Association for Computing Machinery, Code.org, Computer Science Teachers Association, Cyber Innovation Center, and National Math and Science Initiative) in collaboration with states (including North Carolina), school districts, and businesses throughout the nation, this Framework captures the importance of computer science for all students and provides the foundational concepts and related practices that drive a successful, systemic approach to bringing together all stakeholders and supporting elementary, middle and high school students.

North Carolina is uniquely positioned today to leverage the collective interest and numerous CS activities toward a more intentional, strategic, and coordinated effort that will move computing education forward and broaden access, opportunity and participation for all students. In fact, without a stronger statewide coordinated effort, there is growing potential for confusion around what programs are available in informal and formal learning spaces, how they support one another, and how students

can navigate the path through middle and high school, into college and universities, and into computing careers. Our state maintains a unique balance of local focus, regional pride, and statewide collaboration that brings together the key stakeholders across NC to support successful statewide coordinated efforts to improve education in NC. Recent initiatives such as the NC School Connectivity Initiative and the NC Digital Learning Initiative have demonstrated success in bringing cross-sector partners together resulting in greater network infrastructure for our schools and coherent long-term strategies for digital-age teaching and learning in NC.

The development of a shared vision for a coordinated statewide effort is vital to accelerate and advance opportunities for students across our state and help us grow our computing education networks of educators and computing industry professionals alike. As a state, we can provide greater resources and supports with a large-scale network, accelerating access in schools across the state, and reaching beyond the early-adopters and pilots to ensure we have the necessary teacher, school and community supports in place to broaden CS participation and opportunities for all students in North Carolina.

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Essential Definitions

Computer Science refers to the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society.

Computer Literacy refers to the general use of computers and programs, such as productivity software, performing an Internet search or creating a digital presentation.

Information Technology often overlaps with computer science but is mainly focused on industrial applications of computer science, such as installing and operating software rather than creating it.

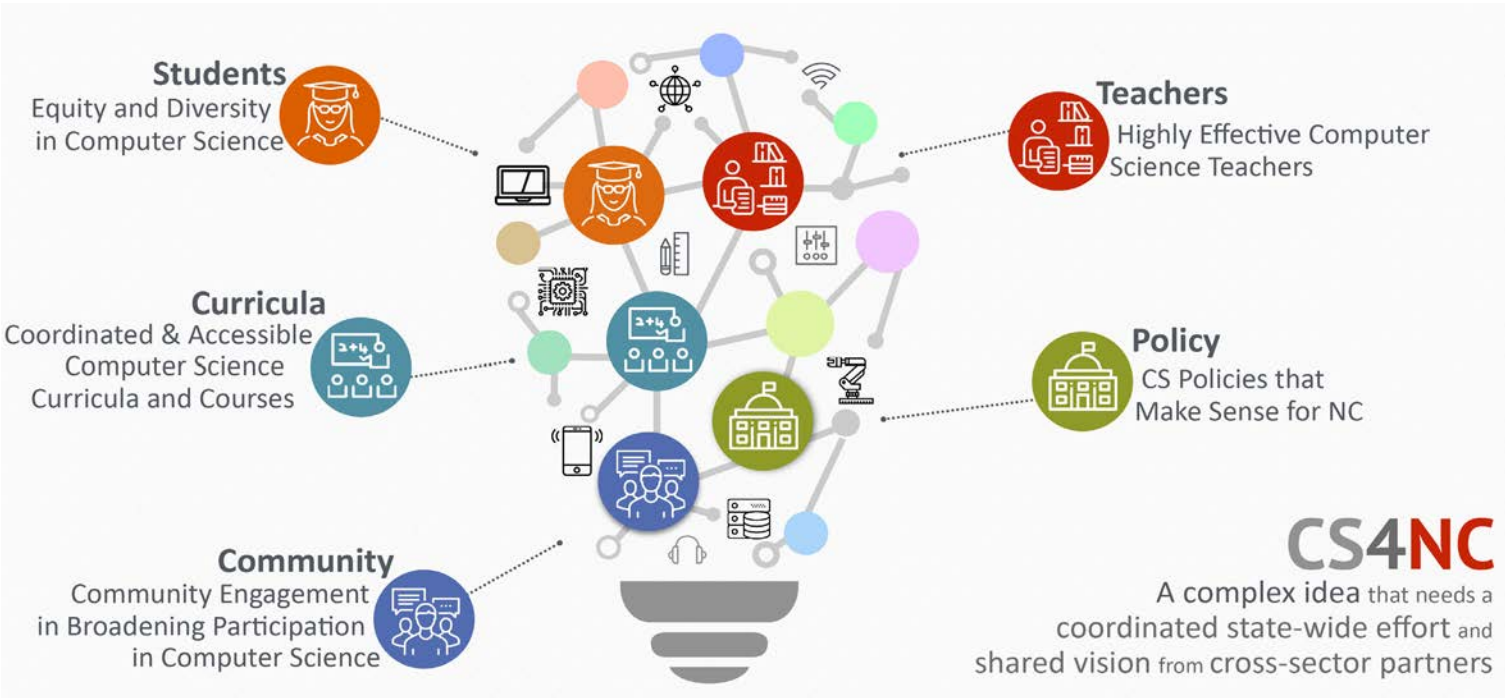
Computational Thinking describes the thought processes involved in expressing a problem and a solution in ways a machine (either human or computer) can understand and implement.

Beginning the Conversation

In an effort to establish a baseline for the conversation, this preliminary landscape report represents a snapshot of the key factors for developing a coordinated computer science education plan for North Carolina. The proceeding sections discuss the key components of our CS education landscape - students, teachers, curricula, community engagement, and policy - an interconnected set of pieces that form our existing foundation but also represent the building blocks for transformation:

- First, the **STUDENTS** section provides current enrollment data and demographic distributions for the existing computer science courses offered in public schools. These data reflect national trends, especially with regards to underrepresented populations.
- Next, the report highlights the landscape for current and aspiring **TEACHERS** of computer science in NC, including the status of teacher preparation programs and teacher licensure policies.
- To give context to students and teachers in computer science education, the **CURRICULA** and its implementation are considered within the context of the standard course of study.
- While formal computer science education in our public schools supports students who have chosen to include it in their education, many programs exist through **COMMUNITY ENGAGEMENT** to foster interest in students who otherwise may not select computer science courses.
- Ultimately, **POLICY** drives the education program in NC. Understanding the policies currently impacting computer science education is critical for determining the forces that can hinder or facilitate initiatives to increase participation in computer science education.

By convening a summit with representatives from multiple constituencies, the goal is to begin the conversation that defines a path to move from the environment captured in this landscape report to a shared vision for computer science education for all students in North Carolina, or CS4NC.

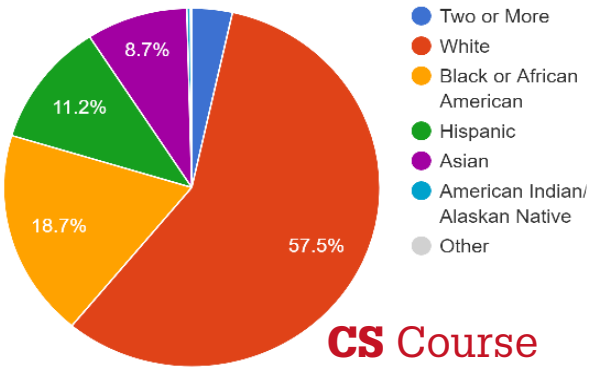


Students: Equity and Diversity in Computer Science

In North Carolina last year, 5,189 students enrolled in non-AP computer science courses through Career and Technical Education (CTE), while an additional 1,238 students took the AP Computer Science A exam, representing less than 1% of the state's high school population. Computer science is available to every student in the state either virtually, face-to-face, or by dual enrollment with a local community college. Many rural districts in the eastern and sandhills regions of the state do not have students enrolled in computer science courses, and over two thirds of the enrollments are clustered in seven counties. In addition, students in North Carolina perform more poorly on the Advanced Placement exam than the national average. In 2016, 54% of students in NC scored a 1 or a 2 on the AP Computer Science A exam, compared with the national average of 35.7%. Black, Hispanic, American Indian, and multi-racial students tended to earn a lower score on the AP exam than their white and Asian counterparts.

The computer science field was once largely dominated by women, yet according to Google's 2014 diversity report, only 31% of the workforce at Google are women. This gender gap is reflective of CS education in North Carolina, where girls make up only 22.8% of the students enrolled in computer science courses.

> "Whether our children want to become farmers, doctors, teachers, or entrepreneurs, it'll be easier for them to achieve their dreams if they have some background in computer science. Coding teaches them the creativity and problem-solving skills that are necessary for success."
> -John Thune, US Senator

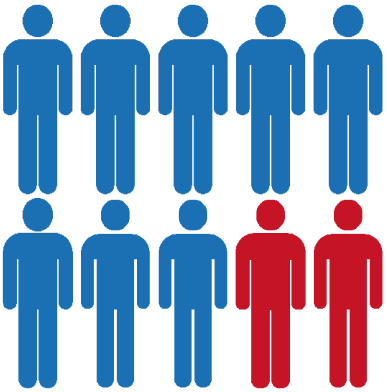


CS Course **Enrollment,** 2016-17

There is also a significant racial gap in the technology industry. At Google, 91% of the workforce is white or Asian. Yet, in non-AP computer science courses in NC, student enrollments closely match the overall student population. But at the Advanced Placement level, white and Asian students are significantly overrepresented, comprising nearly 80% of the students who took the AP Computer Science A exam in 2015-2016 in NC; black students represented only 7% and Hispanic students represented 9% of those who took the exam.

CS courses and experiences give students an opportunity to explore career paths they may have never thought of previously. Consider the last computer game you played or app you downloaded. Now, take a moment to think about all of the people involved in making that game or app a reality. Of course, there were software developers, but there were also graphic artists to design the characters and the interface, sound designers designing the music, writers to create dialogue, guides and gameplay, physicists who make virtual worlds function realistically, mathematicians and architects helping to design the virtual structures, and among many others, accountants and project managers making sure everything runs on time and on budget.

ONLY 22% of the 5000 students taking CS courses are female



Computer science jobs are high paying jobs, earning almost double North Carolina's median income and representing a significant opportunity for students in the state. A majority of students in the state are classified as economically disadvantaged, yet only 33.8% of enrollments in computer science computer science courses were from economically disadvantaged students. Some students may decide not to code or program computers, but for many others who might want to pursue a career as a programmer, understand how computers work, or simply learn new ways to solve problems and create the future, the opportunity is not available to them.

Think About...

- Enrollment in CS courses is relatively low, even though students indicate interest and enjoyment in CS courses.
- Students across NC have access to CS courses, either online or face-to-face, yet enrollments are concentrated in urban areas.
- Female students and low-income students are underrepresented in all CS courses. Black and Hispanic students are significantly underrepresented in AP courses.

Barriers...

- Making coding courses available and encouraging students to take these courses.
- Math Anxiety - Many students have angst for higher math courses which is a barrier to enrollment in CS courses.
- Connecting CS courses to the variety of professions that incorporate CS concepts.

Highly Effective Computer Science Teachers

The success of statewide computer science education is predicated on having a sufficient number of highly effective teachers to support the increased demand and opportunities. Currently, only one of the schools in the UNC university system offers a degree in Computer Science Education, and only two others offer degrees in CTE supporting the computer science programming strand. In addition, only one of the remaining schools suggests or recommends computer science courses as electives, which could be used to satisfy the computer science endorsement. To meet the teaching needs as computer science education scales across the state, teacher preparation programs will need to specifically address computer science opportunities. Furthermore, these programs will need incentives to entice participants to remain in the education sector, as the job market for computer science workers continues to grow.

> "Technology is just a tool. In terms of getting the kids working together and motivating them, the teacher is the most important."
> - Bill Gates

While addressing teacher education programs will help increase the pipeline of computer science teachers, there will remain significant demand for teachers who can teach computer science courses in addition to their existing area of expertise. In North Carolina, the path to endorsement (add-on licensure) to teach computer science requires college credit in computer science. This endorsement is rarely obtained, and there is no distinction in the level of endorsement between high school and middle school teachers. While a recent policy adjustment will reduce the required number of credit hours for this endorsement, there needs to be a concerted effort to create multiple accessible pathways that encourage teachers to develop their CS skills when teaching these courses.

In order to successfully impact students from underrepresented populations, these students must experience computer science activities early in their schooling to offset the societal biases that tend to adversely affect participation. One of the most successful initiatives broadening participation in computer

Just 3 out of **every 1,000** teachers in NC are **CS** teachers

science and introducing computational thinking is the Hour of Code program by Code.org. Through this effort, thousands of North Carolina teachers have actively engaged in bringing computer science to their classrooms. Much of this enthusiasm is in elementary and middle school grades where there are no dedicated courses. While organizations such as Code.org offer free professional development opportunities to K-5 teachers, there remains a significant need for additional resources to help teachers expand computational thinking and coding across the curriculum beyond just an hour of code.

A growing body of professional development programs is available across NC for both new teachers and those already engaged and experienced with CS education. These programs are increasing the number of teachers with some CS training, but there is a great deal of disparity and disconnect among professional development offerings, and many simply focus on training a specific course or curriculum. To ensure quality CS courses for students throughout their K-12 experience, a more robust professional learning community should be supported to bring together CS educators, including CTE teachers, AP teachers and teachers exploring opportunities with integrating computer science and computational thinking into their standard course of study.

3 colleges offer CS as a teacher preparation pathway

Think About...

- Less than 300 teachers in NC currently teach computer science courses.
- In 2015, only 18 students graduated from NC universities with degrees supporting computer science education.
- Current policy requires teachers to have explicit computer science coursework to be endorsed to teach computer related courses.
- Professional development opportunities are disconnected and often only focus on training to teach a specific courses rather than developing a broader understanding of CS or a professional learning community for CS teachers.

Barriers...

- Motivating teachers to pursue CS certification when there are limited opportunities to teach CS based on existing course offerings.
- Budget constraints make the addition of new teachers less likely; thus, CS teachers often come from other roles or disciplines.
- As computer science jobs are in high demand, recruiting college graduates with CS coursework, knowledge, and skills into the teaching profession is increasingly difficult.

Coordinated and Accessible Computer Science Curricula

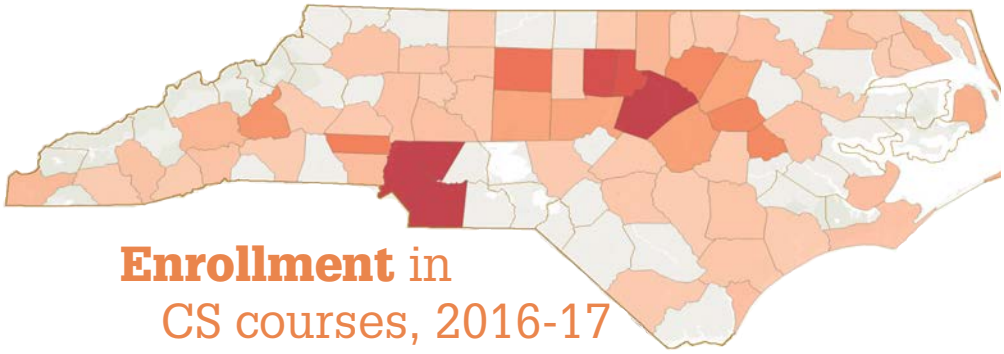
Computer science courses and curricula have been in schools for decades. Unfortunately, very little has changed in the world of K-12 computer science education since its introduction, despite the fact that computers have grown to impact virtually every aspect of the way we live today. Much as they were thirty years ago, computer science courses are uncommon on many high school campuses and virtually non-existent in K-8 schools. Even when offered, these courses tend to be designed to teach a narrow skillset to self-identified populations rather than cultivating a way of thinking for all and broadening the interests of those in underrepresented populations in the field of computer science. While there may have been a time when the technology and tools required to study computer science were limited, the near ubiquitous access to computers, networks and other technology in schools in NC, combined with the proliferation of simple interfaces for software development and learning CS has removed these implementation barriers.

50% of **NC Principals** consider **Searching** the Internet to be **computer science**

In North Carolina, there is no comprehensive computer science program; it is fragmented across multiple departments. Despite the fact that North Carolina's Standard Course of Study details Information & Technology Essential Standards, these standards are limited to computer literacy and do not define computer science or computational thinking standards. Most of the courses supporting computer science education are offered through Career and Technical Education (CTE) programs; however

> "If you can program a computer, you can achieve your dreams. A computer doesn't care about your family background, your gender, just that you know how to code. But we're only teaching it in a small handful of schools. Why?"
>
> - Dick Costolo, Former CEO, Twitter

these courses presuppose an interest in technical fields of study. Additional computer science courses are offered through mathematics departments, but they are limited to advanced courses as determined by the College Boards' Advanced Placement Program or the International Baccalaureate program. As a result of these disconnects, CS courses can become disjointed rather than connecting and building toward the development of strong CS and computational thinking knowledge and skills.



Enrollment in CS courses, 2016-17

Recently there has been significant national efforts to redefine the key concepts and principles of computer science education. The AP Computer Science Principles curriculum, which was initially piloted in NC in 2014, represents the first significant output of these efforts. In addition to addressing the fundamental concepts of computer science, the course also introduces the role of computers in our society and a focus on creative problem-solving with technology, not necessarily through coding. The recent publication of the K12 CS Framework and the soon to be released Computer Science Teachers Association Computer Science Standards have been developed in context with the new AP course resulting in a more comprehensive multidisciplinary approach to teaching computer science. These developments will enable NC to define a set of standards and curricula that meet the needs of its students.

Think About...

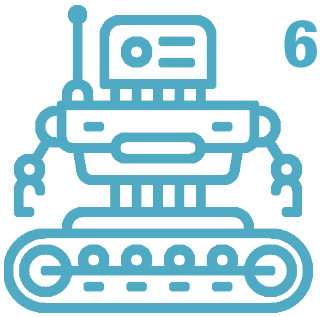
- Less than 1% of all courses offered in NC are related to Computer Science or programming (which is less than the number of Latin language courses).
- In the Standard Course of Study for NC, there is no mention of computer science in the Information & Technology Essential Standards.
- In the Information & Technology Essential Standards, the emphasis is limited to technology as a research and presentation tool.

Barriers...

- In NC, CS curricula are disconnected - AP and IB courses are offered through mathematics, while all other CS courses are offered by CTE departments.
- While growing CS course offerings at the secondary level is a clear process, integrating computational thinking and CS in K-8 requires significant effort across disciplines and grade levels.

Community Engagement in Broadening Participation in CS

Learning is not just about what happens during the school day. There are opportunities in many communities to learn about computer science. Official and unofficial clubs, classes and camps are available to young people across North Carolina after school, in community centers, museums, and even places of worship. National corporations like Google, Microsoft and SAS devote resources to developing and supporting programs that encourage computer science and computational thinking at all ages. Organizations like Girls Who Code, TechnoloChicas and Black Girls Code work on expanding participation of underrepresented groups. Both the Boy Scouts of America and the Girls Scouts offer STEM-related badges: the Boy Scouts have specific badges for game design, programming and more; the Girl Scouts have increased the number of badges related to computer science. The list of community programs is long, yet specific programs and activities can be hard to find, learn about or coordinate in a way that gives students an ongoing, meaningful CS learning experience.



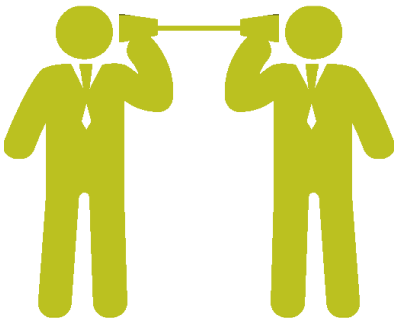
60% of **NC schools** offer **clubs** or after school **programs** in **computer science**

In North Carolina the numerous CS experiences available to students outside of school not often coordinated or connected, resulting in an unclear statewide picture of opportunities for students. For example, there are many FIRST and Vex Robotics clubs and competitions across the state, but there are only 15 Girls Who Code clubs, one Black Girls Code club, and no evidence of a TechnoloChicas club. Summer STEM camps are offered across the state with some

offering computer science-related curriculum such as iD Tech programming camps, camps to learn about cybersecurity and coding boot camps for kids. Universities and colleges offer CS experience embedded in ongoing STEM outreach programs such as the UNC Math Science Education Network. Additionally, new camps and clubs come and go, often based on the interest of a small number of advocates and community activists.

The significant lack of communication and coordination raises uncertainty about not only access and opportunity for all students in NC, but also about the level of participation and engagement across programs. Finally, the disconnect from school courses creates a significant missed opportunity to take the excitement and fun that students experience while participating in community programs and encourage enrollment in CS classes that can extend their interest to further learning in the classroom.

91% of **Parents** **want** their **kids** to learn **CS**



7% of **Principals** believe there is enough **demand**

Think About...

- Corporations such as Google, Microsoft and SAS offer complete curriculum for use in the classroom.
- Universities and community colleges offer summer camps in Computer Science.
- There are a significant number of for-profit and non-profit organizations offering CS experiences to all ages within communities.
- Community activities are often very disconnected from one another and from classes in schools.

Barriers...

- Other activities (such as sports) compete for student time both within and beyond the school day.
- Awareness of opportunities poses a challenge to successful implementation of programs.
- Financial and resource investment from organizations offering opportunities is significant to allow for affordable programs.
- It takes significant time investment to develop and deploy a sustainable a program; some programs simply come and go with changing interests.

CS Policies that Make Sense for North Carolina

Two of the most significant policies impacting computer science education across the United States are related to availability/requirement of CS courses and fulfillment of graduation requirements. Currently in North Carolina, every high school student has access to a computer science by way of the NC Virtual Public School. While on the surface this can be interpreted as meeting the policy goal of accessibility, a more systemic approach is needed to address students at all grades in order to increase opportunity and to impact the underrepresented populations. For a successful implementation of CS education across North Carolina, policy must reflect the unique needs and demands of the state, ensure a balance of quality, rigor and flexibility for students, and align with other statewide education initiatives so it can be leveraged throughout all levels of K-12 education.

> "Who knows what technology will emerge in the next five years, let alone 20. Yet the education we provide our children now is supposed to last for decades. We cannot train them for jobs that do not even exist yet, but we can provide them with the minds and tools they'll need to adapt to our ever-changing set of circumstances.
> - former NC Governor Jim Hunt

In NC, there are two means by which computer science courses can fulfill graduation requirements. First, certain computer science courses offered through mathematics education can satisfy a core graduation requirement for one of the required four mathematics credits. In addition, computer science courses offered through Career and Technical Education (CTE) can fulfill one of the general electives. Unfortunately, while both of these paths are approved options for North Carolina graduation requirement policy, there are inconsistently interpreted in higher education admission policies. Clear policies on K12 computing education can bridge these gaps to ensure credit bearing courses and higher education admission standards align to create productive paths for students to engage in CS education.

Status of **9 Policy Ideas** in NC to make Computer Science **Fundamental** to K-12 Education

As with all policy discussions, identifying the best approach to link to efforts across NC is a critical driving factor. There are dedicated federal programs to support improvement of CTE programs across the nation, and as a result support some CS education. Opportunities are growing for new CS courses; innovative approaches to teacher professional development are becoming more widely established; and statewide initiatives such as the NC Digital Learning Initiative and the NC School Connectivity Initiative continue to improve our school systems. To successfully implement a more comprehensive, coordinated approach to CS education and computational thinking in NC, well-informed policies will be needed to leverage current activities, lead change, and resolve current and future obstacles.

Think About...

- Although all students have access to computer science courses via virtual or online courses, these courses do not necessarily result in increased access for underrepresented populations and don't ensure a high level of quality or support in all schools.
- While North Carolina awards math credits for select computer science and CTE related courses, the UNC system only recognizes one of these courses (IB Computer Science) to fulfill the admissions requirement.
- Because NC does not have an adopted set of computer science standards, it is challenging to provide consistent credit for computer science courses.

Barriers...

- Because computer science courses are mostly designated as CTE courses, there is an implicit statement that the course content is only relevant to a limited set of students, teachers and programs.
- Availability of virtual / online courses for all students appears to satisfy a policy need, but, alone, it does not ensure quality CS experiences for all students or resolve issues of accessibility, equity, and diversity.