Executive Summary and Findings

- National Call To Action
- Recommendations
  - For All Levels Of Government
  - Federal Government
  - State And Local Governments

Executive Summary and Findings

Computer science and the technologies it enables now lie at the heart of our economy, our daily lives, and scientific enterprise. As the digital age has transformed the world and workforce, U.S. K–12 education has fallen woefully behind in preparing students with the fundamental computer science knowledge and skills they need for future success. To be a well-educated citizen as we move toward an ever-more computing-intensive world and to be prepared for the jobs of the 21st Century, students must have a deeper understanding of the fundamentals of computer science.

Paradoxically, as the role and significance of computing has increased in society and the economy, quality computer science education is being pushed out of the K–12 education system in the U.S. While there are many excellent K–12 computer science courses being taught across the country, in the past five years there has been a marked decline in the number of introductory and Advanced Placement computer science courses being taught in secondary schools. Most startlingly, this decline is occurring when national, state, and local policy makers are seeking to expand the capacity and quality of science, technology, engineering, and mathematics (STEM) education in the U.S. (See Table 1)

Numerous factors are contributing to this growing crisis, but this study finds that current federal, state, and local government policies underpinning the K–12 education system are deeply confused, conflicted, or inadequate to teach engaging computer science as an academic subject. Quality instruction always depends on knowledgeable and well-prepared teachers, on instructional materials that are engaging and carefully developed to enable student learning, and adequate resources and infrastructure to support teachers and student learning. These goals must be supported by a policy framework that sustains teacher development; certification and continuing education; appropriate curriculum development; and student access and interest. When it comes to computer science education, this framework is failing.

This study gathered data from all 50 states (and the District of Columbia) on the extent to which computer science standards (see Figure 1) are incorporated into existing state education standards and where these

TABLE 1

Secondary schools offering introductory (or pre-AP) Computer Science courses, change from 2005 baseline

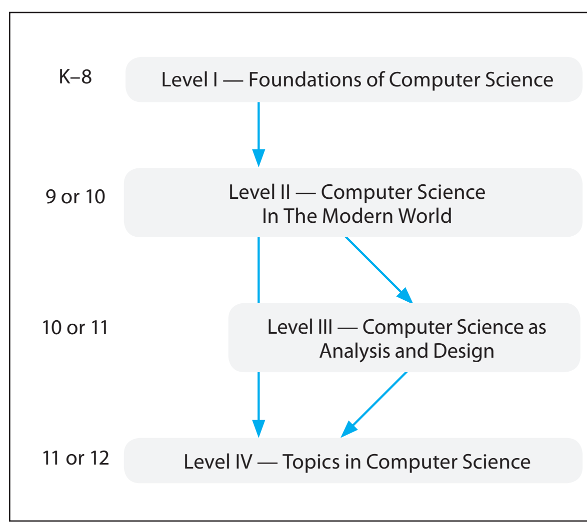
	2007	2009
Yes	-6%	-17%

Secondary offering AP Computer Science courses, change from 2005 baseline

	2007	2009
Yes	-20%	-35%

► *Source: Computer Science Teachers Association survery data of high schools*

FIGURE 1 **Framework for ACM/CSTA Model Computer Science Standards**



computer science outcomes might be found if they do exist in those standards. We also collected data on whether computer science courses taken at the secondary level count toward graduate credit requirements in a required discipline (such as math or science) or as simply an elective credit. This policy framework forms much of the backbone of the education landscape in the U.S. and provides a highly useful way of measuring the current state of computer science education at the secondary school level.

We find there are numerous and significant gaps between current state secondary education standards and nationally recognized computer science standards.[i] **Further, few states allow computer science courses to count toward a student's required credits for graduation.**

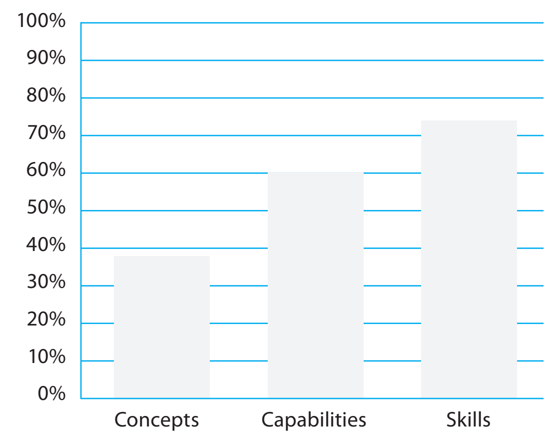
More specifically:

- Consistent with efforts to improve "technology literacy," states are focused almost exclusively on skill-based aspects of computing (such as, using a computer in other learning activities) and have few standards on the conceptual aspects of computer science that lay the foundation for innovation and deeper study in the field (for example, develop an understanding of an algorithm). See Figure 2.
- Major gaps exist in the adoption of computer science standards at the secondary (high school) level. **Only 14 states have adopted secondary state education standards for computer science instruction to a significant degree (defined as more than 50% of ACM and CSTA's national model computer science standards)**, leaving more than two-thirds of the entire country with few computer science standards at the secondary school level. Further, 14 states (and the District of Columbia) do not have even one upper-level standard for computer science instruction as part of their secondary education standards.
- Only 10 states allow computer science courses to count as a required graduation credit for either mathematics or science, as noted in Table 2. Further, no states require a computer science course as a condition of a student's graduation despite national broad-based education studies calling for all stu-

TABLE 2

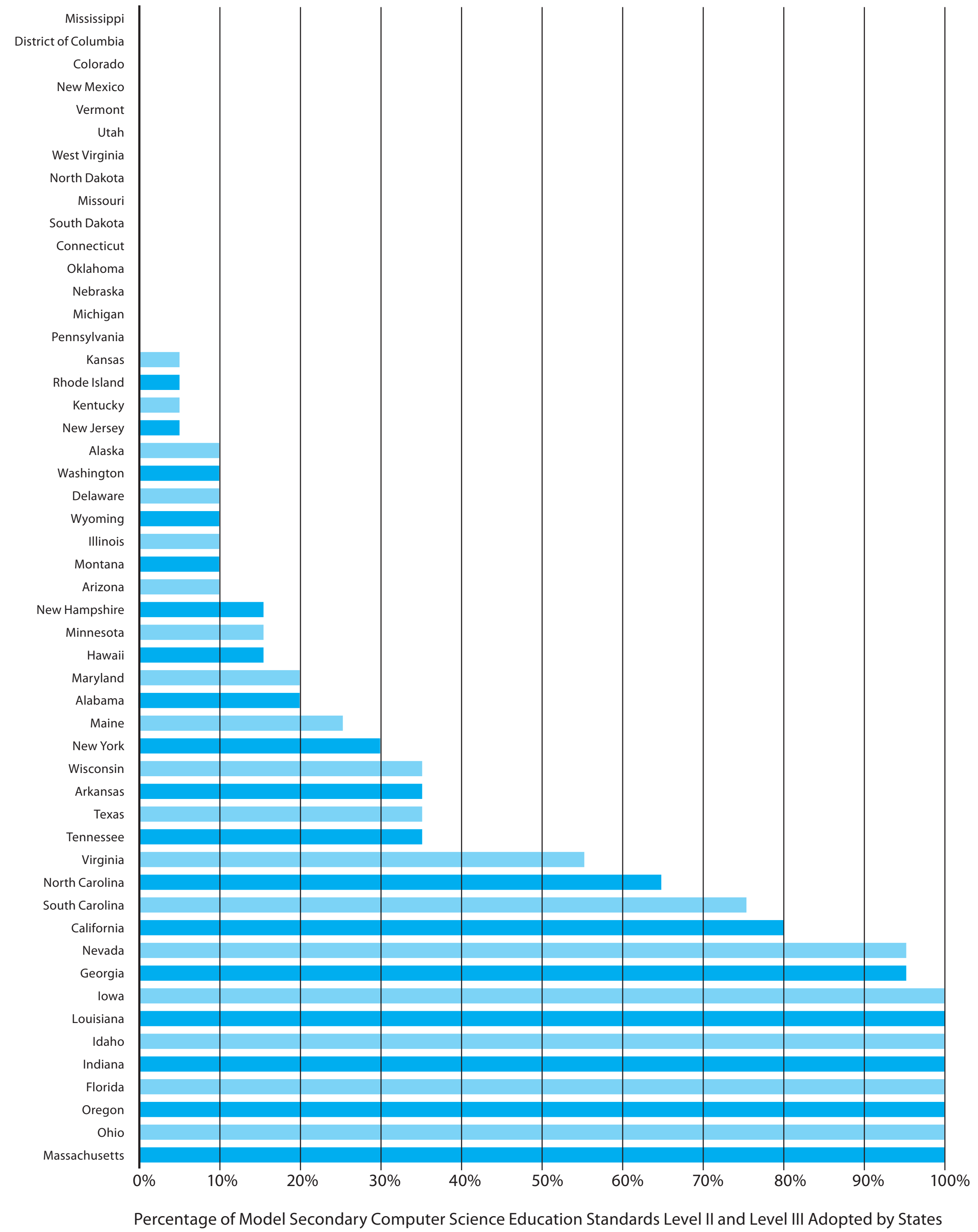
State	Computer Science Science as part of the "core"
Georgia	Science
Missouri	Math
New York	Math
North Carolina	Math
Oklahoma	Math
Oregon	Math
Rhode Island	Math
South Carolina	Math
Texas	Math
Virginia	Math

FIGURE 2 National Snapshot: Adoption of Computer Science Standards*



*categories of computer science education standards

FIGURE 3 **Secondary School Standards Level II and Level III Adoption by State**



dents to be required to take some computer science in secondary education.[ii]

- There is deep and widespread confusion within the states as to what should constitute and how to differentiate *technology education, literacy and fluency; information technology education;* and *computer science as an academic subject*. We have elaborated on this critical issue in the section titled "K–12 Computer Science Education Background and Issues."

These findings stem from one key fact about computer science courses: generally, computer science is not considered by states and/or local school districts as part of the "core" curriculum that students must take in order to graduate from secondary school. School administrators, as well as federal and state program managers, need to make tough decisions about how to allocate scarce resources. Being part of the core curriculum often makes the difference between courses (and teachers) that are given resources and those that are not. How courses count in a student's academic career and whether subject-matter standards exist to measure progress often determine whether a subject is considered part of the core curriculum that a student must complete. And we have shown (in Table 2) that computer science courses typically do not count as either required mathematics or science courses and are not part of the core.

There is also a deeper and more troubling trend stemming from the lack of K–12 computer science education. In 2008, 17% of Advanced Placement (AP) computer science test takers were women, even though women represented 55% of all AP test takers.[iii] Further, only 784 African American students nationwide took the AP Computer Science exam.[iv] There is a significant lack of access to upper-level computer science courses for many under-represented populations, creating a major equity issue for access to this critical knowledge and this problem is growing. Lack of access to K–12 computer science education, or "privileged knowledge," is what education researchers[v] have described as a significant social justice issue for the 21st Century.

In addition, another study[vi] released in December 2008 by the Computer Science Teachers Association (CSTA) exposes another crucial problem in the overall education policy framework. State certification programs for computer science teachers are either non-existent or deeply flawed. The crisis in computer science teacher certification can be attributed to two key factors:

- a lack of clarity, understanding, and consistency with regard to current certification requirements, and
- where certification or endorsement requirements do exist, they often have no connection to computer science content.

It is clear there are major gaps in education policy needed to support quality computer science instruction for all K–12 students. Here, we offer detailed recommendations for all levels of government to address this growing crisis and to put computer science in the core of a student's education.

National Call to Action

No other subject will open as many doors in the 21st Century, regardless of a student's ultimate field of study or occupation, as computer science. At a time when computing is driving job growth and new scientific discovery, it is unacceptable that roughly two-thirds of the entire country has few computer science standards for secondary school education, K–8 computer science standards are deeply confused, few states count computer science as a core academic subject for graduation, and computer science teacher certification is deeply flawed. These are national failings and ones that we can ill afford in this digital age.

Parents must ask difficult questions about how computer science is being introduced to their children in K–12 education and demand that schools move beyond the current basic technology literacy curriculum. Policy makers at all levels need to review how computer science is treated within existing policy frameworks and schools, and ensure that engaging computer science courses based on fundamental principles of the discipline are part of the core curriculum. Now is the time to revitalize K–12 computer science education and ensure universal access to computer science courses by making it one of the core academic subjects students require to succeed in the 21st Century.

Recommendations for Federal, State, and Local Governments

For All Levels of Government

- Clearly define computer science education.

Federal Government

- Support state planning and implementation grants to improve computer science education;
- Build partnerships and national networks of support;
- Create pre-service and professional development opportunities for computer science teachers;
- Appoint blue ribbon commission to review the computer science teacher certification crisis; and
- Expand K–12 computer science education opportunities within existing federal programs.

State and Local Governments

- Create a well-defined set of K–12 computer science standards based on algorithmic/computational thinking concepts;
- Count computer science courses toward a student's core graduation requirements either as a computer science credit or as a mathematics or science credit;
- Develop courses to implement new computer science standards;
- Develop assessments for computer science education;
- Categorize computer science courses as academic courses;
- Expand professional development opportunities and recruit new computer science teachers;
- Expand access to computer science courses for under-represented populations; and
- Create flexible certification programs for computer science education grounded in the knowledge of the field.

Recommendations

In the U.S., most of the authority for determining what education is required of students and how their knowledge is measured is held at the state or at the school district level. The federal government also provides a layer of funding and policies that heavily influences education. Because the levers for education reform rest at multiple levels of government, policy makers at all levels must work toward creating a much more robust, clear, and coherent structure committed to ensuring that computer science is a core academic subject. Here are our specific recommendations on how federal, state, and local policy makers can close the significant gaps we have identified in this report.

For All Levels of Government

Clearly define computer science education.

As schools have increasingly stepped up the integration, use, and teaching of information technology, distinctions between these areas and computer science have blurred. Educators and policy makers consistently confuse the *use of technology and teaching of technology literacy* with *teaching computer science as a core academic discipline* within the STEM fields. In fact, this confusion is a fundamental reason behind many of the policy issues we have identified in this report. These related but distinct concepts must be clearly defined. Below we offer the following definition of computer science as a discipline and elements that can be considered appropriate for computer science curricula.

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; and,

Computer science education includes the following elements: design (both software and hardware), creation of digital artifacts, abstraction, logic, algorithm development and implementation, programming paradigms and languages, theoretical foundations, networks, graphics, databases and information retrieval, information security and privacy, artificial intelligence, the relationship between computing and mathematics, the limits of computation, applications in information technology and information systems, and social impacts of computing.

Federal Government

Support state planning and implementation grants to improve computer science education.

We must incentivize states to develop specific plans to improve computer science education. As our research reveals:

- Few states have defined K–12 learning standards for computer science education and, where they exist, they are focused predominantly on developing computing skills instead of teaching computer science concepts;
- Few states are ensuring computer science's place in the secondary school graduation requirement rubric;
- Computer science teacher certification programs do not exist in many states and when they exist are often flawed; and
- There are significant gender and equity issues regarding access to computer science education that must be addressed.

The federal government needs to catalyze action in the states to address the lack of computer science standards; assessments; graduation credits/requirements; and teacher preparation, professional development, and certification. **We recommend Congress create a grant program to fund states to assess the current state of computer science education, develop plans for its improvement, and implement state and local reforms.** Further, these grants should prioritize access to computer science education for under-represented groups.

Build partnerships and national networks of support.

There are a number of stakeholders outside of the education system that can be brought together to improve computer science education. A broader capacity initiative would build support for the goals and efforts of state planning and the implementation of grants. **We recommend Congress create a K–12 computer science education partnership program for local education agencies, institutes of higher education, non-profits, and businesses** that would:

- Develop curriculum;
- Implement outreach programs;
- Develop teacher support networks; and
- Evaluate state and local computer science education.

K-12 COMPUTER SCIENCE IN ACTION
Reaching Out to Middle School Girls

Computer science does not sit on the sidelines at The Girls' Middle School in Mountain View, CA; it is at the core. All students must take three years of computer science courses. Reaching girls early, before they even really understand what computer science is, helps overcome a persistent perception that computer science is "geeky" or unwelcoming to females.

The curriculum engages students in higher-order thinking and introduces them to the breadth of the field, including:

- designing/creating robots;
- building entrepreneurial websites;
- creating animations and simulations; and
- solving real-world problems, such as designing approaches to govern traffic at a busy intersection near the school.

One former student said, "I've learned that learning computer science is a process where you need to learn one thing before you move on to the next. Once you have mastered a concept, creating something you're proud of can be easy and fun."

Create pre-service and professional development opportunities for computer science teachers.

Despite the existence of National Council for the Accreditation of Teacher Education accreditation requirements for computer science, very few pre-service teacher preparation programs have the current capacity or coursework developed to prepare computer science teachers. As course offerings in computer science grow, particularly with plans to introduce a new Advanced Placement Computer Science Principles[vii] course into schools, we need a program to expand the number of certified K–12 computer science teachers with computer science expertise. **We recommend Congress create a program that would make competitive awards for schools of education working in collaboration with relevant programs in computer science to develop coursework leading the K–12 certification of computer science teachers.**

Appoint a blue ribbon commission to review the computer science teacher certification crisis.

Certification programs and requirements for computer science teachers must be reformed or built from the ground up. Often they do not exist and when they do they are typically not connected to actual computer science content knowledge. **We recommend the Secretary of Education establish a blue ribbon commission of state officials, discipline experts, practitioner organizations, and practitioners to review state computer science teacher certification requirements and share best practices.** A panel could draw on existing studies for models of computer science teacher certification and identify best practices for states to adopt.

Expand K–12 computer science education opportunities within existing federal programs.

The federal government has numerous programs focused on improving or expanding both formal and informal K–12 STEM education programs. We have consistently found that these programs focus resources on the "core" curriculum implemented in schools. These biases are usually subtle, ranging from requiring teacher certification (which is an issue for computer science teachers) to requirements to measure improvement from baseline assessments in "science" or "mathematics." **We recommend Congress and the Administration define K–12 STEM education programs to explicitly include computer science and expand opportunities for K–12 computer science education within the Department of Education and the National Science Foundation.**

In particular, we recommend Congress ensure computer science education is part of work carried out by NSF's Education and Human Resources Directorate, including its Math and Science Partnership program and at the Department of Education through its National Center for Educational Statistics. Further, we recommend Congress expand funding for K–12 computer science education within the Computer and Information Science and Engineering (CISE) Directorate at NSF as CISE is currently funding several critical projects in support of computer science education.

Many of the recommendations for the federal government are embodied in legislation recently introduced by Representative Jared Polis, the Computer Science Education Act (H.R. 5929), and we call on Congress to pass this legislation.

State and Local Governments

Create a well-defined set of K–12 computer science standards based on algorithmic/computational thinking concepts.

The confusion surrounding existing computing-related standards is impeding much-needed reform of computer science education. State standards have focused largely on technology literacy leaving computer science concepts mostly ignored. Where computer science standards do exist, they are usually part of various other academic subject areas. Since standards establish the framework for education carried out within the schools, **we recommend all states review their existing education standards and create a set of independent, grade-appropriate K–12 computer science standards informed by the ACM/CSTA Model Curriculum for K–12 Computer Science.** These standards should seek to integrate algorithmic/computational-thinking concepts across the curriculum at the K–8 level and allow for academically rigorous and independent computer science courses at the secondary school level.

Count computer science courses toward a student's core graduation requirements either as a computer science credit or as a mathematics or science credit.

Current or new computer science courses often do not "count" as part of a student's required coursework. Quite often computer science courses are counted as nothing more than electives. Given the academic demands on college-bound students, it is unlikely that secondary school students can afford to take computer science as an elective. Further, because computer science is not part of the "core" curriculum, administrators are less inclined to introduce new courses or invest scarce resources into existing courses.

Being part of the core curriculum is made even more important as efforts are underway to expand the core. National organizations such as Achieve.org and the National Council of Teachers of Mathematics have pushed states to adopt requirements that students take four-course sequences in English, mathematics, science and social studies (sometimes called the "4x4" model) at the secondary level. Computer science should be listed as one of the courses that counts as either mathematics, science or computer science credit within these efforts. ACM and CSTA have made some progress in this area. Achieve's America Diploma Project (which is a model many states are following) lists Advanced Placement Computer Science as a capstone course in a four-course mathematics sequence. [viii]

In many states computer science resides within the Careers and Technology Education area and the technology credit has been the only way in which students can apply computer science to meet graduation credit requirement. Some states (most recently Texas) have removed the requirement for graduating students to complete a "technology" credit. The most common rationale for the elimination of this requirement has been that it was originally intended to ensure that students achieve a basic level of computing proficiency by graduation and that these requirements are now being met by students before they enter secondary school. The elimination of the technology credit has therefore, inadvertently, *reduced* the likelihood that college-bound students will choose to study computer science.

We recommend states and/or local districts (depending on state law) allow computer science to count as a

K-12 COMPUTER SCIENCE IN ACTION
Connecting Teachers and Higher Education

Launched at Carnegie Mellon University in 2006, Computer Science for High School (CS4HS) is a summer workshop engaging secondary school (and some K–8) teachers with each other and university faculty. The workshops illustrate teaching computer science principles so students experience computer science as much more than programming and application use. The connections formed during the workshop help overcome the sense of isolation that secondary schools teachers often feel.

CS4HS has grown rapidly. With support from Google and others, including CSTA, in 2010 workshops were held at 20 sites in the U.S. and 15 sites in Europe, the Middle East, and Africa. Post-workshop surveys show that many teachers changed their definition computer science from simply programming to computational principles and have subsequently altered their approach to instruction.

For more information, visit Google's site:
http://www.cs4hs.com/

and Carnegie Mellon's site:
http://www.cs.cmu.edu/cs4hs/

required mathematics or science credit, or specifically require a computer science credit to graduate. Further, we recommend that where a technology literacy course requirement exists, states and local districts allow a computer science course to count toward this requirement.

Develop courses to implement new computer science standards

Standards provide the overall framework for educational progress, but without courses and support for teachers, they are meaningless. The *ACM/CSTA Model Curriculum for K–12 Computer Science* provides a four-part framework (as noted in Figure 1) for integrating computer science standards throughout the curriculum at the K–8 level and, building upon that, a two or three course sequence at the secondary level. Given the crowded curriculum in today's schools, we realize that it is not always possible for schools to consistently provide the full roster of computer science courses. **We recommend, at a minimum, educational authorities fund the development of courses that integrate ACM/CSTA Level I standards into courses at the K–8 level and provide students with the Level II course and either the Level III course or the Computer Science AP course (Level IV) at the secondary level.** In this report, we have highlighted several courses that were developed using the *ACM/CSTA Model Curriculum for K–12 Computer Science* currently taught at some schools.

Develop assessments for computer science education

The recent provisions focused on measuring student performance in the Department of Education's Race to the Top Fund[ix] and the Administration's *Blueprint for Reform*[x] are continuing a now well-established trend that data should underpin curriculum decisions. In fact, a deeper look into many programs (such as the NSF's Math and Science Partnership) shows that, as a prerequisite for funding, there must be baseline assessments to measure student performance. Assessments for computer science education are virtually non-existent, putting these courses at a significant disadvantage for funding from programs that require data and for administrators who seek data. **We recommend states develop computer science assessments to measure student performance against the standards they have developed.**

K-12 COMPUTER SCIENCE IN ACTION
A New Model for Engagement

The Los Angeles Unified School District has partnered with UCLA, CSTA, and the National Science Foundation on a new approach to secondary school computer science education. *Exploring Computer Science* is a one-year college-preparatory course, based on the ACM/CSTA model curriculum, being offered in some of LA's most diverse schools. This course provides a comprehensive introduction to the problem-solving nature of computer science and is coupled with an extensive teacher-support plan.

Course Details:

- Appropriate for 10–12th graders; Algebra I prerequisite;
- Rigorous curriculum develops high-level computing skills;
- Real world, socially relevant, interdisciplinary, and creative applications of computing; and
- Approved as counting toward the "g" requirement for California public university system admission.

In the first year of implementation, the course was offered in 16 Los Angeles schools and enrolled over 900 students. Under-represented minorities accounted for 85% of enrollment.

For more information see: http://www.exploringcs.org

Categorize computer science courses as academic courses

A major contributing factor to the confusion about computer science education is that computer science or "computing" courses are organized into various departments within schools. For example, some are placed in the mathematics or science departments and some are within the vocational education departments. When computer science courses are placed within vocational education, they are rarely part of the "core" curriculum a student must take. Further, the curriculum for these courses tends to be focused on broader IT or technology skills rather than deeper computer science concepts. **We recommend school districts classify computer science courses as academic courses rather than as vocational or technical courses.**

Expand professional development opportunities and recruit new computer science teachers

As noted previously, there are very few pre-service teacher education programs preparing teacher candidates to teach computer science. In addition, anecdotal evidence strongly suggests that computer science teachers already working in the profession are afforded far fewer opportunities for relevant professional development and that these opportunities are lessening as state, district, and school budgets shrink. **We recommend as states adopt standards, develop new courses, and address teacher certification issues, they expand the opportunities for in-service and pre-service computer science teachers.**

Expand access to computer science courses for under-represented populations

Almost as startling as the disappearance of K–12 computer science courses nationally has been the lack of access to computer science courses for under-represented minorities[xi] (African Americans, Latinos, and Native Americans) and socio-economically challenged groups. Also, there exists a significant gender gap in students enrolling in advanced computer science courses.[xii] As computing becomes the foundation for innovation in the 21st Century, providing access to the skills and knowledge computer science offers will create opportunities for all groups. Denying access creates major equity issues. Further, diversity improves innovation. A study has found that computing teams comprised of both women and men had higher success rates than male-only teams.[xiii] **We recommend state and local governments dedicate resources to ensure all students, regardless of gender, race, or socio-economic status have access to at least one rigorous computer science course in secondary education.**

Create flexible certification programs for computer science education grounded in the knowledge of the field

Many states do not have certification programs for computer science teachers and, when they do, these programs often have no connection to actual computer science content and pedagogical knowledge.[xiv] K–12 teachers come to the computer science classroom from a variety of pathways and are typically from one of the following constituencies:

- new teachers: college or university students working towards their first teacher certification;
- veteran teachers with a certification in another area who have never taught computer science;
- veteran teachers with a certification in another area who have experience teaching computer science; and
- individuals coming from business with a computer science background and no teaching experience.

We recommend states adopt a multi-level model that provides the requisite knowledge (both technical and pedagogical) for computer science teachers while balancing the diversity of teacher backgrounds. Any preparation program for computer science teachers must include the following four major components:

- Academic requirements in the field of computer science;
- Academic requirements in the field of education;
- Methodology (a methods course) and field experience; and
- Assessment to document proficiency in general pedagogy, for example the Praxis II Principles of Learning and Teaching Test.

The CSTA report *Ensuring Exemplary Teaching in an Essential Discipline: Addressing the Crisis in Computer Science Teacher Certification* has detailed models to meet these goals.

Examples of States Moving Toward Reform

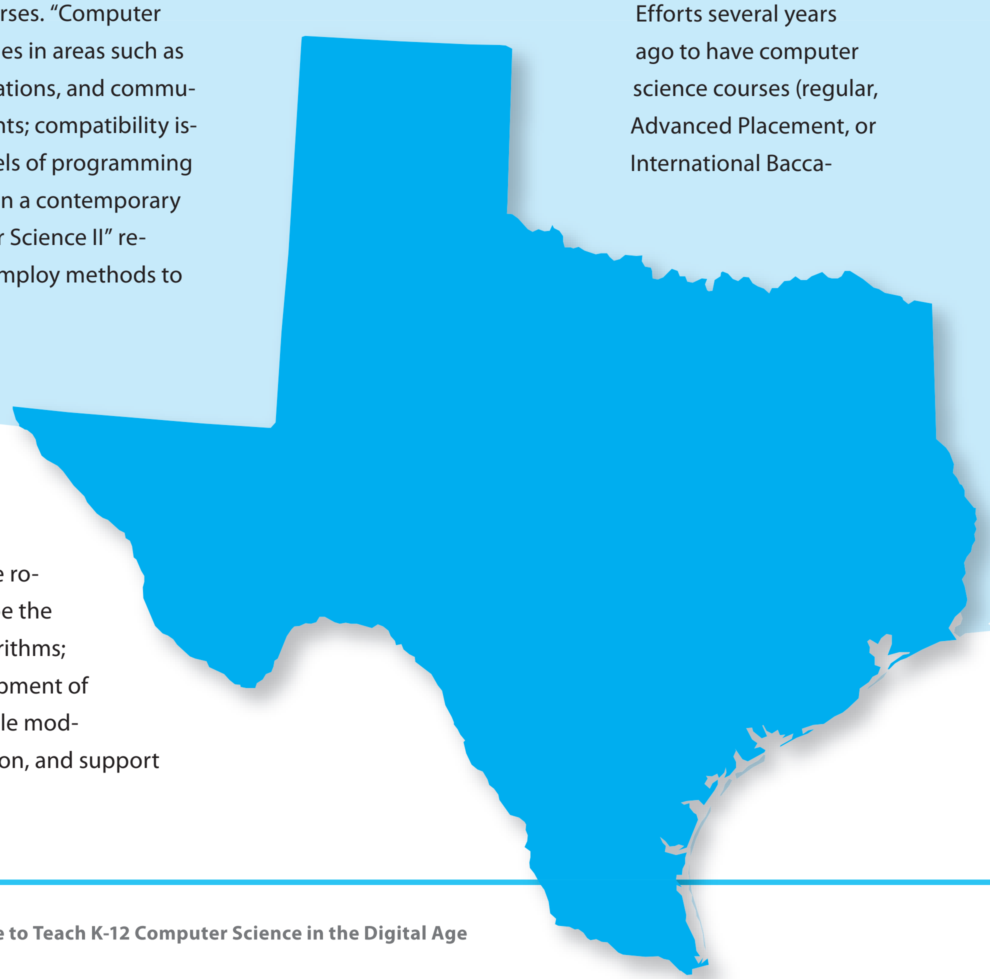
Ascertaining the extent to which computer science standards are truly incorporated into student learning in any given state is challenging on many levels. As mentioned previously, computer science standards, when they exists within state standards documents, are often not classified as computer science standards. Rather, they are classified under any possible number of discipline areas including math, science, technology, and business. This makes them difficult to find and even more difficult to assess. And where computer science standards do exist, there is no guarantee they are actually being addressed in the classroom; that is, while courses that cover these standards may be on the books, they are not necessarily being taught in every school. As the following two state exemplars demonstrate, even in states that have taken leadership and created a solid core of computer science standards and courses to address and access these standards, there are still systemic issues that can derail the best of curricular intentions.

TEXAS

Texas has a long history of computer science education in K–12 and has deeply embedded computer science standards at the high-school level. In Texas, the computer science standards are embedded within the Texas Essential Knowledge and Skills for Technology Applications standards. The required standards are addressed in a series of courses at the elementary, middle school, and high-school level. These include "Technology Applications, Kindergarten–Grade 2," "Technology Applications, Grades 3–5," "Technology Applications (Computer Literacy), Grades 6–8," "Computer Science I," and "Computer Science II."

Texas also provides standards for a number of additional computing technology courses. "Computer Science I" includes learning outcomes in areas such as operating systems, software applications, and communication and networking components; compatibility issues; differentiation among the levels of programming languages; and coding proficiency in a contemporary programming language. "Computer Science II" requires students to determine and employ methods to evaluate the design and functionality of the process using effective coding, design, and test data; use appropriately and trace recursion in program design comparing, iterative, and recursive algorithms; manipulate data structures using string processing; create robust programs; identify and describe the correctness and complexity of algorithms; and analyze models used in development of software including software life cycle models, design objectives, documentation, and support among other learning outcomes. Although the standards are not included within the state standards documents, Texas also offers the Advanced Placement Computer Science course in many schools. Texas also strives for a close alignment of its standards with both teacher certification requirements and professional development opportunities for teachers within the state.

Computer science education in Texas, however, continues to face a number of key challenges. Texas recently removed the Technology Applications credit from all three of its high school diploma plans, significantly reducing the incentive for students to take computer science courses in high school. Efforts several years ago to have computer science courses (regular, Advanced Placement, or International Bacca-

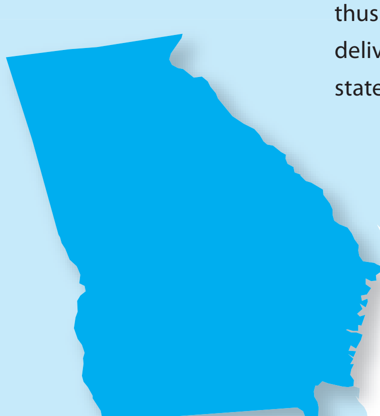


laureate) count as the fourth year science or math graduation credit resulted in approval as a fourth year math credit only for the recommended diploma program and not the higher 'recognized' diploma. In addition, Texas also continues to face a shortage of teachers who meet the current teaching certification requirements.

GEORGIA

Georgia serves as an excellent example of a state where significant gains have been made with regard to the incorporation of computer science standards into the state standards. Efforts to develop these standards began with a review of the framework and standards presented in the *ACM/CSTA Model Curriculum for K–12 Computer Science*. This framework was then adjusted to more accurately reflect local learning needs and priorities. There are four courses in the Georgia computing pathway: "Computing in the Modern World," "Beginning Programming," "Intermediate Programming," and "AP CS A."

"Computing in the Modern World" was designed to provide all secondary school students with the opportunity to gain an understanding of the diversity of the computing technology that surrounds them, as well as engage them in the exploration of topics such as Web design, problem solving and critical thinking, data (both understanding and storage), and an introduction to the power of programming. This course is superior to many of the applications courses currently offered in other states because it is intended to have students become active developers of computing technology rather than passive users and consumers.



The "Beginning Programming" course offers many of the topics found in a computer science course, including an introduction to hardware and software components; the design and use of algorithms to solve computational problems; the use conditional statements, iterative statements, and data structures such as variables, arrays, lists, stack, and queues. The "Intermediate Programming" course builds upon and extends knowledge and skills gained in the previous course, requiring students to build an interpreter and compiler, demonstrate knowledge of the key concepts of software engineering, and apply problem solving techniques to advanced problems. It requires students to use advanced programming techniques and constructs such as convditional statements, iterative statements, variables, arrays, lists, stacks, queues, and advanced mathematical expressions as well as to demonstrate knowledge of advanced object-oriented concepts such as polymorphism, interface, inheritance, encapsulation. This course also requires a deeper understanding of the limits of computation. Students in Georgia also have the opportunity to take a higher-level Advanced Placement Computer Science course. The standards for this course are described and stipulated in curriculum guidelines provided by the College Board.

In addition to developing a solid set of computer science standards and courses to address those standards, Georgia has also worked to closely couple its standards with its professional development programs for teachers, thus ensuring that teachers are better prepared to both deliver content and assess performance relating to these state standards.

Finally, Georgia is one of a handful of states that allows computer science courses to count as a "core" credit toward a student's graduation requirements. Students earn a science credit by completing a computer science course.

This is not to say, however, that Georgia has not faced challenges with regard to the implementation of these standards. The fact that the computer science content standards reside within business education standards has created challenges with regard to teacher certification and has required the state to take a flexible position where teacher eligibility is concerned. Also, fiscal problems within the state have led to the reassignment of teachers and the cancellation of rigorous computer science courses in many schools.