The State of Secondary Level Computer Science Education in the United States

Dr. Chris Stephenson
Agenda

• Linking skills shortages and educational needs
• Why computer science is crucial for students
• Current challenges
• Transformation is underway
• The Computer Science Teachers Association
The New Skills Crisis
The U.S. View of the New Global Economy

“We know that the nation that out-educates today will out-compete us tomorrow. And I don’t intend to have us out-educated.”

President Obama

“Keeping America's brainpower advantage is the single best way in a global economy to keep good jobs from going overseas to China, India and other fast growing countries. Congress will enact no more significant piece of legislation this year.”

— Senator Lamar Alexander R-TN
Re: The America Competes Act of 2007
Fastest Growing Occupations

Projected Percent Change, STEM Occupations 2006-2016

Industry Average: 10%
Network Systems Analysts: 53%
Computer Software Engineers: 45%
Computer Systems Analysts: 29%
Biological Scientists: 9%
Chemists: 8%
Electrical Engineers: 5%
Mechanical Engineers: 4%

The Future Workforce – The High School Pipeline:
AP Mathematics and Science Exams 1997-2007
Female Participation in AP Science Tests
1997 and 2007 Participation Rates

- Total AP Tests
- Biology
- Environmental Science
- Statistics
- Chemistry
- Calculus
- Physics
- Computer Science

1997 Female Participation Rate
2007 Female Participation Rate
Why Computer Science is Critical in Secondary School
Computer Science is Distinct from Literacy

- Computer science is the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society. (ACM Model Curriculum)

- Computer Literacy: The ability to use various software applications (often called “point and click education”)

- Educational Computing/Educational Technology: The use of computers to support learning across the curriculum
CS Provides Essential Knowledge

- Foundational knowledge (problem solving/design)
- Better preparation for college/university/workforce
- Exposure to the field/possible careers
- Link to innovation
The Importance of Transferable Skills

Students who study computer science learn a number of vital skills that can be transferred to any subject area and contribute significantly to their performance as professionals:

• Problem solving skills
  ▪ Problem definition, solution design, implementation, testing, revision
  ▪ Creativity, perseverance, teamwork

• Design skills
  ▪ Designing and working to specifications

• Logic and reasoning
  ▪ The ability to analyze a problem and break it down into a logical sequence of steps

• Computational thinking
  ▪ Drawing on fundamental concepts in computer science to analyze and solve problems.
  ▪ Thinking at multiple levels of abstraction
Why?

- We consider it critical that students be able to read and write, and understand the fundamentals of math, biology, chemistry and physics. To be a well-educated citizen in today’s computing-intensive world, students must have a deeper understanding of the fundamentals of computing as well.

- In the U.S. there is also a powerful link to securing the cyber-infrastructure, protecting national security, and making the energy infrastructure more efficient. All of these are linked to computer science.
Current Challenges
Defining Computer Science

“Computer science is the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society.”

— The ACM Model Curriculum for K-12 Computer Science”
http://csta.acm.org/Publications/sub/Documents.html
Computer Science Includes…

- Programming
- Hardware design
- Graphics
- Databases and information retrieval
- Computer security
- Software design
- Programming languages and paradigms
- Logic
- Translation between levels of abstraction
- Artificial intelligence
- The limits of computation
- Applications in information technology and information systems
- Social issues (security, privacy, intellectual property, etc.)
Decentralized Decision-Making

The decision-making authority for publicly funded schools in the U.S. is exceedingly complex, but it is safe to generalize in the following ways:

• Decisions regarding the distribution of federal funding are made at the federal (national) level but these primarily affect low-income urban schools

• Most of the funding for schools is determined locally, so the quality of individual schools varies enormously based on the wealth of the school community

• Decisions regarding teacher qualifications and teacher certification are made at the state level and the rules differ markedly from state to state

• Decisions about curriculum are made at the local level (there are no national curriculum standards for any academic discipline) and so what students learn varies enormously from school to school and even from classroom to classroom
Systemic Issues

- Students (and parents) believe that there are no career opportunities in the high tech industry
- We are still battling the nerd stereotype
- Universities do not require incoming CS students to have taken CS courses in high school
- CS education is so fragmented that a CS course designation has no real meaning
- So many schools are placing their computers in the tech department that universities no longer believe that high school CS courses are academic courses like other sciences and math
The Great STEM Push

• Much of U.S. educational policy is now focusing on STEM:
  — Science
  — Technology
  — Engineering
  — Mathematics
Where is the C in STEM?

• Although computer science is a critical element of STEM learning, there is confusion about how it fits in the curriculum.

• In K-12, “technology” is commonly translated to mean either access to hardware and software or learning to use applications.

• State “computing” standards often include no computer science content.
Which Courses Count and Who Can Take Them

• Because computer science is an “elective” rather than a “core” course it is becoming increasingly difficult for students to fit it into their schedules

• This situation is exacerbated by the trend to increase the number of math and science courses students must take in order to graduate (when CS is counted as neither)

• Computer science courses are often classified as a “technology credit” rather than an “academic credit”

• Access to rigorous computer science courses is often limited to high end schools with low minority populations
CS Teacher Certification is a Total Mess

- Many states have no requirements at all so anyone can teach computer science.
- Most people (teachers and administrators) don’t know what the requirements are in their own states.
- Some states have requirements that have absolutely no connection to computer science content or teaching.
- Some states have requirements that are impossible to meet (requiring teachers to have taught courses that do not exist).
- Teacher preparation programs are not preparing computer science teachers because they are designed to prepare teachers for professional certification.
Transformation Underway
Positive Changes

Advanced Placement Computer Science
  • CSTA is working with the College Board and the National Science Foundation to create a new AP CS course that will be both rigorous and engaging for all students

Curriculum
  • More than 25% of secondary schools have implemented the ACM Model Curriculum for K-12 Computer Science

Professional Development
  • 90 workshops to help teachers improve both their knowledge of computer science and their teaching skills (in partnership with colleges and universities)

Career Information
  • Our careers brochures and posters are in every secondary school in the country

Teacher Leadership
  • Our Leadership Cohort project is providing leadership and outreach training to two teacher leaders from each state, creating a cohort of master teachers who are working for improvements at the local level
Recommendations for Improving Computer Science Education in the U.S.

- In discussions to harmonize state STEM education standards, make sure computer science is part of the discussion
- Expand efforts to increase the number of females and underrepresented minorities studying computer science
- Clarify and expand professional development opportunities for K-12 computer science teachers
- Focus research funding on K-12 computer science education to address gaps in understanding how students engage this field
- Efforts to strengthen middle school education should include provisions to introduce these students to computer science
- Review how states can better coordinate, clarify, and improve existing teacher certification requirements for computer science teachers
The Computer Science Teachers Association
Why CSTA?

• CSTA was founded in 2004 in response to growing concern about the state of computer science in secondary schools (lack of curriculum, little professional development, no teacher certification)

• The original funding was provided by the ACM with the ideal that CSTA would eventually become self-sustaining
CSTA Today

CSTA is an international membership organization of >7300 members, (67 from New Zealand!)

• CSTA is a learning community
• CSTA is an advocacy organization
• CSTA is a provider of professional development for teachers
• CSTA is a research body
• CSTA is a provider of resources
CSTA’s Mission

• The Computer Science Teachers Association is a membership organization that supports and promotes the teaching of computer science and other computing disciplines. CSTA provides opportunities for K-12 teachers and students to better understand the computing disciplines and to more successfully prepare themselves to teach and learn.
CSTA’s Goals and Objectives

Creating a community of individuals and organizations working together to address critical issues in K-12 computer science education.

**Promote a Better Understanding of Computer Science**: Provide visibility, influence policy, and generate resources that illuminate computer science as an essential academic discipline.

**Develop Research and Resources**: Conduct original research and serve as a direct-to-practitioner channel for the dissemination of research and resources that address current knowledge gaps.

**Support National Standards**: Facilitate the implementation of national curriculum and teacher certification standards to support consistent excellence in learning and teaching.

**Support Teacher Excellence**: Provide multiple levels of professional development to improve teachers’ technical knowledge and pedagogical skills.

**Opportunities**: Promote computer science as a field of study and as a career destination that provides a wealth of opportunities to students regardless of their gender, race, or socio-economic status.
CSTA Resources

- Policy and Information Documents: *The New Educational Imperative (International Ed.)*, Ensuring Exemplary Teaching in an Essential Discipline
- The *IT is all about me* poster invites students (especially young women) to consider a career in the computing disciplines and makes connections between popular professions and computer science.
- The *Imagine Your Future in Computing* brochure helps students make connections between the technologies they use every day and the courses and the career opportunities available to them.
- The *Source* web repository is a searchable database with more than 200 unique resources: lesson plans, modules, presentations
  - Every resource is reviewed by a committee of experts to ensure that it is complete, relevant, appropriate, and pedagogically sound
  - The classification system links directly to the ACM Model Curriculum so you know immediately which course and learning outcomes it addresses
CSTA Publications

- CSTA website (csta.acm.org)
- CSTA Voice (published bi-monthly)
- CSTA Advocate blog (blog.acm.org/csta/)
- Podcasts
- Videos
- Original research (national studies tracking CS education)
THANK YOU!

Chris Stephenson  
Executive Director, CSTA  
Phone: 1-541-687-1840  
Fax: 1-541-687-1840  
cstephenson@csta.acm.org

CSTA website: csta.acm.org