The New Educational Imperative: Improving High School Computer Science

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Agenda

• Purpose of the New Imperatives report
• Setting the context for CS education
• The research
• Factors in successful curriculum development
• Factors in successful curriculum implementation
• Improving teaching
• Calls to action
Purpose of New Imperatives Report

- **Making the case for Computer Science education**
  - Many of the people making the decisions about what our students should be learning have no idea what computer science is, let alone why it is vitally important to students.

- **Expanding our perspective**
  - In an increasingly global and technology-driven economy, it is important to look at what other nations are doing to improve their long-term competitiveness.

- **Looking at the research**
  - We needed a complete review of the research that included what has been done in other countries.

- **Exploring the key questions**
  - What has been shown to work or not work?
  - What are the primary attributes of a rigorous curriculum?
  - What are the factors that shape an effective implementation plan?

- **Providing key strategies and solutions**
  - Who are all the stakeholders?
  - What can each of them do to improve computer science education in the U.S.?

- **Disseminating the Information**
  - We had to have a plan to get this report into the hands of decision-makers.
Defining Computer Science

Computer science is neither programming nor computer literacy. It is the study of computers and algorithmic processes including their principles, their hardware and software design, their applications, and their impact on society. Computer science therefore includes:

- Programming
- Hardware design
- Networks
- Graphics
- Databases and information retrieval
- Computer security
- Software design
- Programming languages
- Logic
- Programming paradigms
- Artificial intelligence
- Computational limits
- Applications in IT and IS
- Social issues of computing
Setting the Context

- U.S. Computer Science Education
  - No national computer science curriculum for K-12
  - Lack of leadership at the legislative and policy levels
  - Insufficient funding for instruction, resources, professional development
  - Complex and contradictory teacher certification requirements
  - Salaries that do not compete with industry
  - Confusion about computer science as a discipline versus computing across the curriculum
What the Research Tells Us

- Students need a broad overview of the field
- Learning must include both theory and practice
- Instruction should focus on problem solving and algorithmic thinking
- Concepts must be taught independently
- Students need to be taught real-world skills
- Instruction must include integrative and interdisciplinary knowledge
- Students should be introduced to advanced topics
- Students need to understand abstraction, complexity, modularity, and usability
- Programming instruction must include algorithm design, program correctness, and program efficiency
- Teachers need to motivate and engage all students
- Teaching and learning activities should be designed to address common misconceptions about computer science
Common Myths that Plague Us

- Myths
  - Computer science equals programming
  - Computer science equals computer literacy
  - Computer science is just a tool to be used in other disciplines
  - Computer science is not a scientific discipline
  - Computer science is a male field

- Fixes
  - Develop a high-standard, uniform, mandatory computer science curriculum
  - Use software that appeals to both genders
  - Make computing exciting and challenging
  - Implement a vigorous computer career counseling program
  - Explore race differences and interest in computing
Ten Principles of Curriculum Design

- Focus on underlying scientific principles
- Develop student familiarity with abstraction, complexity, modularity, reusability
- Focus on problem solving and critical thinking
- Help students develop a range of capabilities/skills independent of technologies
- Give a broad overview of the field, its history, and computing use in other disciplines
- Deal explicitly with design, maintenance, and analysis
- Enable students to scaffold new ideas, concepts, and skills across a series of courses with age-appropriate outcomes
- Use teaching strategies that make the content engaging to all students
- Interweave conceptual and experimental issues
- Don’t confuse computer science with computer literacy
Five Implementation Requirements

- **Support:**
  - The initiative must have top-down and grassroots support and agents must be in place at all levels to ensure continued enthusiasm and support

- **Stakeholder buy-in:**
  - External groups must have a role in the review process (teachers unions, professional associations, parent councils, universities/colleges, business/industry)

- **Resources:**
  - Schools, teachers, and students must be provided with the resources they need for successful implementation (hardware, software, textbooks, reference materials, manipulatives)

- **Professional development:**
  - Teachers must receive training to allow them to master the curriculum content and effective teaching strategies

- **Timeframe:**
  - Every step takes time and real system change takes up to ten years. Giving less time than truly needed to accomplish any step along the implementation path from vision to reality can condemn the entire process to failure
Five Qualities of Exemplary Teachers

- **Problem-solving Approach:** Exemplary computer science teachers use a problem-solving approach that allows students to examine problems from different angles and perspectives and formulate solutions.

- **Real World Focus:** Exemplary computer science teachers motivate students by having them create real-world artifacts with an intended audience and encouraging them to understand the essential link between the problem, the user, and the solution.

- **Explicit Emphasis on Design:** Exemplary computer science teachers explicitly teach and use the software design process, ensuring that students master the steps involved in designing, creating, testing, and debugging software.

- **A Welcoming Environment:** Exemplary computer science teachers make their classroom a welcoming environment for all students (especially young women and minority students) and find creative ways to engage all students with examples and exercises that are relevant to their lives.

- **Modeling Life-long Learning:** Exemplary computer science teachers serve as role models for their students by continuing to enhance their own teaching and technology skills and by exploring new ideas and new technologies.
Seven Systemic Changes to Improve Teaching

- **Mastery of Knowledge:** New high school computer science teachers should be required to have completed an undergraduate degree in computer science or a comparable degree program.

- **Standardized Pre-service Programs:** All teacher preparation programs should be required to adhere to the National Council for Accreditation of Teacher Education (NCATE) standards for high school computer science educators.

- **Certification standards:** State teacher certification requirements for high school computer science teachers should adhere to a consistent (and enforced) national standard that would allow for greater clarity and mobility from state to state.

- **Professional Development:** School districts should provide regular professional development for computer science teachers to allow them to keep their knowledge and skills current.

- **Focus on Teaching:** School districts should employ a sufficient number of technical specialists with responsibility to ensure that computer hardware, networks, and software is maintained, freeing teachers to concentrate on their teaching.

- **Competitive Compensation:** Salaries for computer science teachers should be commensurate with those offered in industry to ensure that the best possible candidates prepare and apply for teaching positions.

- **Professional Affiliation:** All high school computer science teachers should be members of professional associations that support their discipline-based knowledge and provide a teaching community that mentors celebrates them.
Call to Action

**Federal Government**
- Talk about computer science
- Include computer science in the discussion of 21st Century skills
- Insist the STEM funding includes computer science
- Support new research
- Provide funding for teacher professional development
- Nationalize teacher certification requirements
- Explain why we need CS skills to remain competitive as a nation
- Explain why outsourcing is not a concern
- Help parents and students understand that there are jobs available

**State Government**
- Require students to take at least one computer science course
- Reverse funding cutbacks for computer science education (equipment & materials)
- Make sure there is appropriate professional development for teachers
- Ensure appropriate teacher certification requirements
- Provide pathways for current and incoming teachers to become exemplary teachers
- Talk to community members about future job needs
- Encourage businesses to mentor schools/teachers/students
- Explain why outsourcing is not a concern
- Point teachers to groups such as CSTA that provide curriculum and resources
Call to Action cont.

❖ School Districts
  – Reverse funding cutbacks for computer science education (equipment & materials)
  – Put policies in place to ensure that teachers are qualified
  – Review curriculum to make sure that it includes appropriate computer science content
  – Make sure the curriculum is both welcoming and rigorous for all students
  – Provide professional development opportunities to help teachers keep pace with both technical and pedagogical change
  – Provide technical support staff so teachers can concentrate on teaching
  – Provide opportunities for teachers to meet and mentor each other
  – Make sure that school counselors have access to and are providing information about computer science careers and educational pathways
  – Point teachers to groups such as CSTA that provide curriculum and resources

❖ Principals
  – Reverse funding cutbacks for computer science education (equipment & materials)
  – Ensure that teachers are qualified
  – Review curriculum to make sure that it includes appropriate computer science content
  – Make sure the curriculum is both welcoming and rigorous for all students
  – Provide professional development opportunities to help teachers keep pace with both technical and pedagogical change
  – Provide technical support staff so teachers can concentrate on teaching
  – Provide opportunities for teachers to meet and mentor each other
  – Make sure that school counselors have access to and are providing information about computer science careers and educational pathways
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Call to Action cont.

- **Teachers**
  - Review your computer science curriculum to make it sure provides needed skills and knowledge
  - Make sure the curriculum is both welcoming and rigorous for all students
  - Model life-long learning in the classroom
  - Lobby for funding (materials, hardware, software)
  - Speak to parent groups, students and other teachers about student opportunities in computer science
  - Help dispel the myth that there are no jobs
  - Work with school counselors to make sure that they are providing up-to-date/relevant information
  - Meet with teachers from across the district to share resources and ideas
  - Become a member of a professional association

- **University/College Faculty**
  - Require students entering your program to have taken a high school computer science course
  - Create different entry points for students with different computing experience levels
  - Interact with and support local high school computer science teachers and students
  - Provide teachers with clear information regarding your expectations for incoming students
  - Create opportunities for your students to mentor high school students
  - Provide relevant/comprehensive professional development opportunities for teachers
  - Provide career information to teachers, students, parents, and school counselors
  - Ensure that teacher education programs include computer science
  - Help teachers work on grant applications
  - Be knowledgeable about the *ACM Model Curriculum for K-12 Computer Science*
Call to Action cont.

**Business and Industry Leaders**
- Make sure conversations about national competitiveness include computer science as a key component in maintaining our innovative edge
- Help improve the public’s understanding of the variety of jobs available to computer scientists
- Include computer science in the 21st Century skills discussion
- Explain how outsourcing trends can be addressed by providing an adequate supply of skilled computer scientists
- Build partnerships with schools that promote and demonstrate excellence in computer science education
- Support the implementation of the *ACM Model Curriculum for K-12 Computer Science*
- Require projects seeking funding from your institution to demonstrate consistency with these standards
- Fund new research that will help improve computer science education
- Fund new professional development opportunities for teachers
- Support initiatives that ensure that all computer science teachers receive appropriate and adequate pre-service training
Coming Soon from CSTA

- The Source Online Repository for K-12 Teaching and Learning materials
- Searchable database of state-level computer science teacher certification requirements
- Formation of an expert committee to produce a white paper on establishing workable models for computer science teacher certification
- Careers in Computing brochure for middle school students and parents
- The 2007 Computer Science and Information Technology Symposium (June 28, 2007 in Atlanta, GA)
- The 2007 National Survey of High School Computer Science Education
- Conference presentations: SIGCSE, NECC, CCSC
- Working with NCWIT via the K-12 Alliance to develop a Girls Gotta Have IT kit for dissemination at the National Educational Computer Conference
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