CS FOR ALL

Finding a Role for *Your* Department

CS for All @ NSF

CS for All is a national effort announced by the Office of Science and Technology Policy (OSTP), led by the National Science Foundation (NSF) and the U.S. Department of Education (ED) in partnership with other federal agencies and private partners, to ensure Computer Science (CS) education is available to **all** students across the U.S.

NSF's efforts and the growing momentum for CS education and STEM education broadly taking hold across the country have helped to pave the way for CS for All.

CS for All will leverage and expand NSF and ED investments in CS education and STEM education more broadly. The effort accelerates ongoing efforts to build the knowledge base and capacity for rigorous and engaging CS education in schools across the nation. It will also bring together NSF and other federal agencies with private partners to support professional development for educators to teach CS.

Why CS for All?

- **CS for All empowers our Nation's students with computational thinking:** CS courses enable students to develop skills and competencies in problem-solving, critical thinking, creativity and collaboration that will help them excel in today's increasingly digital and computational world.
- **CS for All addresses an important workforce development need:** There are over 600,000 high-paying technology jobs open across the U.S., and by 2018, 51 percent of all STEM jobs are projected to be in computer science-related fields.
- **CS for All provides rigorous CS to all U.S. schools:** CS is taught in less than 25 percent of K-12 schools across the country, and even fewer middle or elementary schools offer academically rigorous computer science experiences.
- **CS for All expands access to CS:** Women, girls, minorities, and persons with disabilities participate in computing in very low numbers, which is a loss of talent, creativity, and innovation for the discipline and nation.

LEARN MORE AT:

nsf.gov/csforall

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A Role for *Your* Department

Researching Computer Science Education

Jeff Forbes

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Unlike some other STEM disciplines that have a long history in K-12, computer science has not developed a robust research base on the teaching and learning of its fundamental concepts and skills. Computer science education researchers are building the knowledge and tools that informs the education and computer science communities' understanding of effective teaching and learning in computing. Examples follow:

CSTeachingTips

Effective teaching requires *both* knowledge of CS, "Content knowledge," and general teaching knowledge, "Pedagogical Knowledge." Colleen Lewis's research group at Harvey Mudd College is compiling and evaluating *pedagogical content knowledge* for computer science. Csteachingtips.org is a curated, evidence-based set of CS teaching tips to help teachers anticipate students' difficulties and build upon students' strengths.

CSTEACHINGTIPS

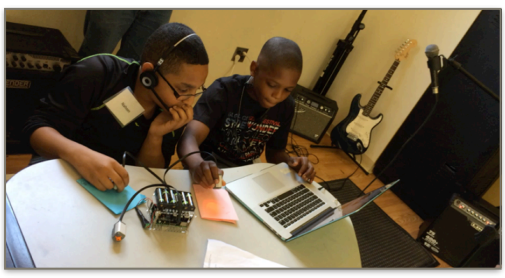
csteachingtips.org

Playful Computation

Ben Shapiro's Laboratory for Playful Computation at the University of Colorado is investigating how new ways of teaching computer science to middle- and high-school students can simultaneously broaden participation in computing and develop a generation of computer scientists who are able to correctly reason about and implement concurrent, distributed, networked systems.

PLAYFUL COMPUTATION

atlas.colorado.edu/lpc



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Involving Your Undergraduates

Lori Pollock

Computer and Information Sciences, University of Delaware, Principal Investigator, CS 10K: Developing and Supporting Computer Science Teachers via Strategic Partnering (pollock@udel.edu)

A major challenge for broadening participation in computing within K-12 settings is the lack of trained teachers. While professional development programs provide opportunities for the development of knowledge, skills, and pedagogy in teaching computing, teachers need ongoing support throughout the academic year. CS Departments can support K-12 teachers during the academic year by providing necessary mentoring and incentives to college students with technical skills to provide desired classroom support while improving their confidence and communication skills and engagement in the community.

Examples:

PARNERS4CS

sites.udel.edu/partner4cs

STARS ALLIANCE

starscomputingcorps.org

COMPUTING TEAMS 4 YOUTH

sites.google.com/site/computeteams4youth

Parners4CS

Lori Pollock, Terry Harvey, James Atlas, Chrystalla Mouza and Partner4CS's CS10K project in Delaware developed a course-based model that engages undergraduate CS, mathematics education and education majors in field experiences in teaching CS. The 3-credit course, which counts toward a CS major or minor combines college classroom meetings with visits in middle or high school classrooms where undergraduate participants co-plan and co-teach computing lessons with a practicing teacher. The 75-minute on-campus class time is devoted to identifying and implementing CS teaching resources targeted toward CS principles, modeling classroom lessons with CS unplugged and other resources, discussing teaching pedagogy, preparing and analyzing lesson plans, and reflecting on the field experiences and teacher partnering experiences. Undergraduates co-plan, adapt, and co-lead lessons, and start after-school programs.

STARS Alliance

Tiffany Barnes, Teresa Dahl and STARS Alliance is a community of regional partnership among academic, K-12 schools, professional and community groups catalyzed by the STARS Leadership Corps (SLC), a leadership program that engages undergraduates in computing outreach, research, and service to broaden participation in computing. The STARS model is a curricular or co-curricular service-learning program for college students where Corps students collaborate with regional K-12 schools, industry, and community partners to inform, engage, and prepare upcoming students for entry and success in college computing programs. The student-led regional engagement includes peer mentoring, team projects, and research experiences.

Computing Teams 4 Youth

Lori Pollock and Terry Harvey and the Computing Teams 4 Youth project designed a course focused on interweaving software engineering practice, service learning, and development of soft professional skills. CS student teams partner with middle school teacher teams to create learning games for classrooms, and then conduct classroom instruction and observation. The partnership targets middle school students (grades 6-8) and math, science, language arts, and social studies teachers in a low-income, high-crime regional school.

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Collaborating with Education Departments and Schools

Kimberly Hughes

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Computer Science departments can partner with colleges and schools of education to support the preparation of computer science teachers, to develop effective K-12 computer science curriculum, and to collaborate on computing education research.

PREPARING MORE CS TEACHERS

DEVELOPING INSTRUCTIONAL MATERIALS

RESEARCHING COMPUTER EDUCATION

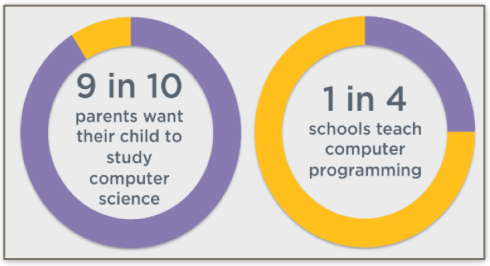
Preparation of more Computer Science Teachers is needed to address low numbers of K-12 students receiving high quality CS instruction.

CS departments can collaborate with colleges of education to develop teacher certification pathways. A variety of program models exist:

UTeach, operating at **The University of Texas at Austin** and 43 other universities, recruits undergraduate STEM majors to also earn teaching certification without adding time or money to their degrees.

Purdue University allows any teacher education student to add CS supplemental licensure with an additional 20 credit hours of coursework.

Boise State University operates IDoCode, offering a Graduate Certificate Computer Science teaching endorsement (20 credits) or a MS in STEM Education with Computer Science emphasis (36 credits).



Development of high quality computer science instructional materials and courses is needed in order to engage a more diverse population of students in CS throughout their K-12 careers.

CS departments can collaborate with curriculum developers and instructional designers in colleges of education on development of courses and instructional materials that integrate relevant CS content, concepts and tools with effective pedagogy. Samples NSF-supported High School CS curriculum development projects:

Exploring Computer Science is an introductory high school course designed to engage students in computational thinking and practice. Housed at UCLA Center X.

Bootstrap integrates math and computing education to enable equitable access to and success in both subjects for all students in grades 6-12.

AP Computer Science Principles introduces students to the foundational concepts of computer science and challenges them to explore how computing and technology can impact the world. Courses include *The Beauty and Joy of Computing* (UC Berkeley), *Mobile CSP* (Trinity College), and *UTeach CS Principles* (UT Austin).

Growth in computing education research is needed to address challenges related to teaching CS more effectively and to a broader audience at all education levels.

CS departments can leverage collaborations with researchers in education and the learning sciences in colleges of education to expand the CS knowledge base. The Computing Community Consortium recently highlighted this need and recommended addressing questions such as:

- How should we teach computer science, from programming to advanced principles, to a broader and more diverse audience?
- How can we ensure that we retain this more diverse audience through inclusive pedagogy and generally more effective teaching?
- How can teaching approaches and their assessment (regarding student learning) scale effectively?
- What training should K-12 teachers receive? What methods have been shown to be effective?
- How can computer science teaching adapt to how different people learn and build on age related learning progressions?
- How should computing be taught and integrated into other disciplines?

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Catalyzing State Partnerships

Mark Guzdial

School of Interactive Computing, Georgia Institute of Technology, Principal Investigator, Expanding Computing Education Pathways (ECEP) Alliance (guzdial@cc.gatech.edu)

The U.S. education system is decentralized, with states and districts in control of K-12 school. *CS for All* has to happen at the local level, and college and university CS departments can lead the effort to make change in their state. Examples follow:

CAITE

caite.cs.umass.edu

CS MATTERS IN MARYLAND

csmatters.org

GEORGIA COMPUTES!

gacomputes.cc.gatech.edu

ADDITIONAL LINKS:

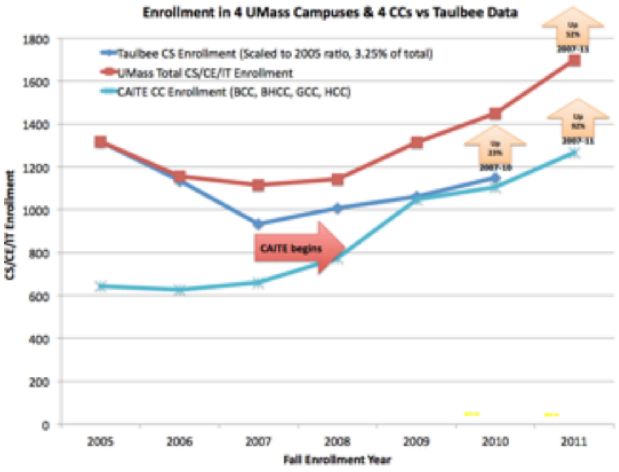
ECEP Website: ecepalliance.org

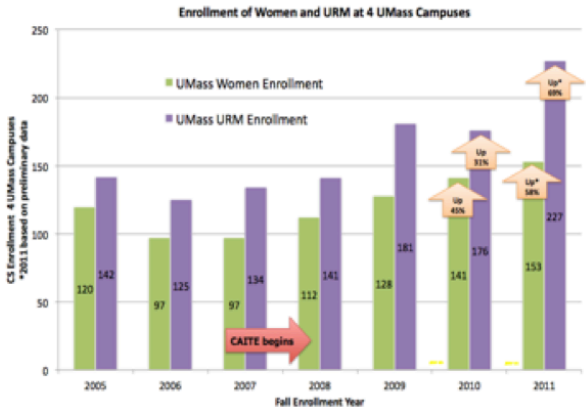
State of the States: Progress toward CS for All: http://cacm.acm.org/blogs/blog-cacm198790-state-of-the-states-progress-toward-cs-for-all (bit.ly/29XGAbO)

Broadening Access to Computing Education State by State: http://cacm.acm.org/magazines/2016/2/197417-broadening-access-to-computing-education-state-by-state fulltext (bit.ly/29JoRG2)

CAITE

Rick Adrion was the PI for the Commonwealth Alliance for IT Education (CAITE), which had a dramatic improvement on diversifying CS enrollment in the University of Massachusetts (U Mass) system. CAITE was successful by engaging a network of campuses, across the U Mass system and community colleges in Massachusetts. They made a significant effort at smoothing the transition of diverse students from community colleges to U Mass CS departments, then used methods like Peer Mentoring to retain those students successfully.





CS Matters in Maryland

Marie desJardins led the effort to grow CS education in Maryland. *CS Matters in Maryland* did a landscape survey to understand what CS was being taught in the state, how CS was counted towards high school graduation requirements, and where they needed to grow. She organized two summits that shared information about the state of CS education in Maryland, consider options, and developed recommendations for action. She drew in cross-sector collaboration across a dozen Maryland school systems; industry, government, and nonprofit groups; and community colleges and universities.

Georgia Computes!

Barbara Ericson was hired as the Director of CS Outreach at the College of Computing at Georgia Tech in 2004. In 2006, she was one of the leads for the new *Georgia Computes!* BPC Alliance. By 2012 when the project ended, over 1/3 of the high schools in Georgia had some teacher who went through Barb's CS educator professional development, and those high schools produced more than half of all the undergraduates from Georgia in intro CS courses in Georgia in 2010. Much of Barb's focus was on broadening participation in Advanced Placement CS, since many who take AP CS go on to undergraduate CS. During GaComputes, the number of female, Black, and Hispanic AP CS exam takers increased by 237% (+161), 223% (+89) and 446% (+21), respectively.

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Supporting Advanced Placement CS Principles

Owen Astrachan

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After many years of development and piloting, the new Advanced Placement® CS Principles course will officially be offered in high schools across the country. This course, eight years in the making, has been developed by the College Board in collaboration with more than 30 leading CS educators and teachers, and it has been piloted at universities and in hundreds of schools. It is intentionally designed to be rigorous, engaging, empowering, and relevant to a broad range of students. It focuses on the fundamental concepts of computing, including programming but also creativity, algorithms, data, abstraction, problem solving, networking, and societal impacts.

CS Principles itself is a framework, not a curriculum, and a number of different curricula have been developed to align with that framework, including NSF-funded projects (such a the Beauty and Joy of Computing, Thriving in Our Digital World, Mobile CSP, and CS Matters) as well as courses produced by Code.org, Project Lead the Way, and others.

Examples of actions that departments can take to support AP CS Principles:

LEARN MORE AT:

apcsprinciples.org

- Give credit or placement for AP CS Principles
- Offer a course for non-majors that aligns with the AP CS Principles framework
- Get your institution to add CS to its list of Recommended courses for high school students

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Grant Opportunities

Jan Cuny

National Science Foundation (jcuny@nsf.gov)

LEARN MORE AT:

nsf.gov/csed

As one of the lead Federal agencies supporting the CS for All Initiative, the National Science Foundation (NSF) plans to make available $100 million over the next four years to accelerate its ongoing efforts to enable rigorous and engaging CS education in K-12 schools across the nation. The funding will support research on the teaching and learning of CS, with an emphasis on equity, scalability, and sustainability. Projects can focus on topics including instructional materials, pedagogy, teacher professional development and support, online communities of practice, and learning progressions. Most efforts will need significant involvement from higher education—collaborations of CS and Ed School faculty, education researchers, and social scientists—often working together with local school districts and teachers.

Examples:

EXPLORING COMPUTER SCIENCE

exploringcs.org

This introductory high school CS course was developed at UCLA by education researchers, computer scientists, and CS teachers in partnership with the Los Angeles Unified School District (LAUSD). Thousands of students take ECS in LA each year and data shows that the ethnic/racial make-up of ECS participants roughly approximated the ethnic/racial make-up of LAUSD (73% Latino, 10% African-American); females were only slightly under-represented in ECS (42%). *These are astounding percentages for a high school CS class!*

ECS is scaling nationwide. It is currently taught in schools in San Jose, Spokane, Milwuakee, Chicago, Washington D.C., Wisconsin, Broward County, San Francisco, New York City, Utah, Massachusetts, and Mississippi, among others.

CHARLES COUNTY, MD

Charles County, MD has provides CS education through multiple, high quality CS experiences for all students in all schools with the goals of increasing the number and diversity of students choosing to study advanced STEM programs of study, and establishing an exemplary systemic model for teaching and learning of Computer Science. In building their K-12 curricula, they built on 16 different NSF-supported research projects.