CS4HS:
An Outreach Program for High School CS Teachers

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ABSTRACT
In this paper, we describe a pilot summer workshop (CS4HS) held at Carnegie Mellon University in July 2006 for high school CS teachers to provide compelling material that the teachers can use in their classes to emphasize computational thinking and the many possibilities of computer science. Diversity and broadening participation was explicitly addressed throughout the workshop. We focused on broadening the image of what CS is – and who computer scientists are – since the reasons for under-representation in the field are very much the same as the reasons for the huge decline in interest. We describe the design of the workshop along with results from initial surveys and evaluations. Short-term evaluations show that this workshop was successful in changing the perception of CS for these teachers and giving them the impetus to include broader topics in their programming courses for the upcoming school year. Future surveys will track the long-term effect of this workshop.

Categories and Subject Descriptors
K.3.2 [**Computing Milieux**]: Computers and Education – *computer science education, curriculum, literacy, self-assessment*.

K.7.0 [**Computing Milieux**]: The Computing Profession – *General*.

General Terms
Algorithms, Design, Human Factors, Theory.

Keywords
Computer science education, high school education, careers, computational thinking, broadening participation, workshops.

1. INTRODUCTION
Colleges and universities have seen a dramatic decline in enrollment and student interest in computer science in the last five years. The 2004-2005 CRA *Taulbee Survey* reports that the number of new undergraduate CS majors in the United States has dropped by more than 30% since 2001-2002. [8] Even more alarming, according to a study at the Higher Education Research Institute of the University of California, Los Angeles (UCLA/HERI), the percentage of incoming undergraduates among all degree-granting institutions who indicated they would major in computer science has declined by 70% between fall 2000 and 2005. [5] Additionally, the College Board reports that enrollment in AP courses has increased in all disciplines except CS which has seen a *decline* of 6% in 2004 and 7% in 2005. [2]

All of these reports indicate quite clearly that the field of computer science is facing one of its most challenging periods. Many academics and industry leaders in the field of computing agree that CS education is important for the economy, with computing and information technology jobs still in high demand. Yet, this message does not seem to be getting to high school students who hear of lack of jobs due to the dot-com bust and outsourcing. Additionally, guidance counselors and administrators at the high school level do not understand what computer science is and what jobs are available for students studying computer science and information technology.

At Carnegie Mellon University, we designed and ran a workshop for high school CS teachers called CS4HS (Computer Science for High Schools) to address this problem by providing resources and course material for these teachers to bring back to their classrooms. The course material goes beyond computer programming to show students the breadth of computer science and how computer science relates to other disciplines and their own lives. It is intended that the teachers will be able to include this material in their courses during the school year. For AP CS teachers with rigid syllabi, we have encouraged them to use this material after the AP exam is administered, when typically they have 2-4 weeks of class time to fill before the school year ends.

This paper outlines the design and evaluation of our pilot CS4HS workshop held in July 2006. We also include plans for future work and observations at the end of this paper.

2. WORKSHOP DEVELOPMENT
A great deal of effort was made to bring presenters on board who share our philosophy that, in order to improve our chances at broadening interest in computer science in colleges and universities, we need to address the needs of CS teachers at the high school level. High school teachers were recruited through announcements on various education mailing lists (SIGCSE, AP) and at several education conferences.

Forty eight teachers attended the workshop, coming from schools across the United States along with one participant from Mexico

SIGCSE'07, March 7-10, 2007, Covington, Kentucky, USA.

and one presenter from Israel. The workshop ran from Friday evening, July 21, 2006 through Monday morning, July 24, 2006.

2.1 Pre-workshop Survey

At the start of the workshop, we distributed surveys to get information about the teachers who were attending. A majority came from Pennsylvania (12), Maryland (9) and New York (5). Other states that had more than one teacher included Texas, Wisconsin, Arizona and Virginia.

High school teachers accounted for most (7/8) of the attendees, with the others coming from middle schools and colleges/universities. A majority of the teachers taught at public schools (public 29, private 8, no answer 11), and most taught in co-ed environments (co-ed 37, all-male 1, all-female 0, no answer 10).

Besides education degrees, the majority of the attendees had a computer science or mathematics degree as well. Some teachers reported having degrees in business and finance, educational technology, or electrical and computer engineering. Nine reported having no other degree besides an education degree.

Surprising to us, the most common response (35%) to the query: "In what department is your CS course taught?" was Business. Other teachers reported that their CS classes were taught in the Math department (25%), Technology department (19%), Computer Science department (15%), and Science department (2%). This reinforces the responses given to another survey question that asked about certification for teaching CS courses in which a number of teachers indicated that a business certification was required to teach CS in their districts rather than a CS or mathematics certification.

We also asked our teachers how their students might define computer science. "Programming" was the main response from 26 of the teachers (54%). Other common responses included "what computers can do/how computers work", "how to use the Internet", "playing/making games", and "problem solving". It is clear from the initial survey that many students do not understand what computer science really is.

When asked "What is the single greatest reason for the decline in enrollment in CS courses and programs at the high school level?" our teachers offered a variety of reasons:

- outsourcing reports in the media
- dot-com bubble burst/not enough high-paying careers
- increased amount of required courses and tests
- elective status/competition with many other electives
- lack of understanding of CS by guidance counselors and administrators
- ill-prepared teachers/lack of interest
- difficulty of material/not "fun enough"
- irrelevance to students
- male-dominated discipline
- lack of meaningful curriculum and standards

Looking at this initial data, we can clearly see that high schools need considerable help to motivate students to study computer science. Computer programming courses in high schools are becoming smaller and more isolated with competition from many elective courses that students find more relevant and less difficult. Informal discussions with the teachers indicated that many schools are considering dropping their computing offerings or moving them to more vocational departments, a worrisome possibility for all workshop participants.

Teachers fear that many CS courses at the high school level will disappear before national standards can be developed to address the need for some form of K-12 computer science education. The hope is that the material provided by CS4HS, showing that CS is much more than just Java programming, might help new students to become curious about CS and take the current computing courses that high schools offer while educators work on defining a national standard for teaching CS at the high school level.

2.2 Workshop Format

Our workshop began with a dinner social on Friday night, meant to get all participants (teachers, organizers, presenters) to meet each other and feel more comfortable. One activity that we prepared was to have the participants perform a "birthday sort" where they form a large circle and order themselves based on their birth month and day. This sort resembled a radix sort in execution, as participants sorted themselves first by month, and then by day. With over 50 participants we were hoping to have "birthday collisions" (people with the same birthday), and this did occur, along with a teacher celebrating his birthday that very day. Participants were asked to find out two things that they shared with their next neighbor, and each participant introduced the next person in line to the group, mentioning these commonalities. This activity can be used in computer science classes during the first few days to help introduce students to each other and introduce a few CS ideas at the same time.

The formal workshop began on Saturday with a keynote address advocating the need for computational thinking as a subject in primary and secondary education. [7] A speaker from Google then discussed the use of activities from *Computer Science Unplugged* [3] in a classroom setting. *Computer Science Unplugged* is a textbook that offers engaging exercises that teachers can use in K-12 classes that illustrate fundamental computing principles without the need for a computer. Activities range from counting in binary using cards with varying amounts of dots to parity checking using a standard deck of playing cards. In addition to these exercises, participants learned what types of careers CS majors can pursue with respect to Google.

The workshop continued Saturday afternoon with material on teaching principles of computation as an introductory computer science course for students with no background in computing. This was followed by two talks illustrating how to explore great theoretical ideas in computer science using food. Each participant donned a special apron and learned about how to cut cake fairly to illustrate fair protocols and how to flip pancakes into size order to illustrate algorithmic bounds (see Figure 1).

Figure 1: Put on your aprons! Teachers learn how to use food to illustrate great ideas in computer science.

Saturday's activities ended with a discussion and lab session on how to use humans as computers to solve problems that are still considered quite difficult for computers today. [6]

The workshop on Sunday featured several panels focusing on the drop in interest in CS by high school students, issues of careers for CS majors and how CS careers can make a difference for people in the world's struggling areas. The first panel focused on broadening participation in CS with suggestions including a "road show" performed by student peers to other classes to illustrate what CS is all about, a professionally-produced video to showcase all the careers that women can pursue in information technology from the Center for Women and Information Technology at the University of Maryland, Baltimore County, and an examination of micro and macro cultural influences on participation trends in CS and the importance of positive encouragement by family and teachers. [4] Another panel focused on careers and social responsibility in CS, with suggestions on types of jobs students can pursue upon graduation, information about the effects of outsourcing, and projects that allow students to perform socially relevant work using information technology.

Sunday's workshop activities also included a session on computational biology, illustrating how ideas from computer science have influenced other fields. Participants learned about matching algorithms for DNA strings and discussed the process of DNA matching in forensics. Another session focused on the use of robots in the classroom to motivate students, focusing on a new robot that can be used to teach elementary programming concepts in a fun and interactive way (see Figure 2).

Figure 2: Program the robot to respond to colors that it sees.

The workshop wrapped up on Monday morning with a discussion of cognitive tutors and their use in the classroom [1] followed by a group participation exercise (described below).

2.3 Workshop Exercise

On Sunday evening, we separated the teachers into groups randomly, and we asked each group to come up with four responses that best answer a question given to them. The questions were designed to have the teachers think about what they had learned at the workshop and generate ideas that all of the teachers could take back to their own schools for the next year. This section outlines the 7 questions used, along with the responses given by each group.

If you had the power to take your students on 4 field trips to places near most high schools that illustrate the greatest impact of CS in their lives, where would you take them?

- Hospital/medical center. This is near most HS and the tech has gotten very advanced, and hospitals affect everybody.
- 911 emergency center.
- Media center. See public people outside news broadcasting stations; show the type of technology it takes to deliver the news (TV or paper) to people every night.
- Logistics company - UPS, FedEx, etc., to show the technology for routing all of the packages. Other things might be grocery stores to show inventory control.

What 4 books would you recommend for your students to read to get them interested in the possibilities available to them as a computer scientist?

- John Bentley's programming pearls
- Asimov, I, Robot
- Gödel, Escher, and Bach
- Out of their minds, the lives and discoveries of 15 great computer scientists

If you had the ability to add CS modules to other courses at your high school, which 4 courses would be the most likely candidates? What modules would you add and why?

- Anywhere in the business curriculum, e.g. just-in-time notion of inventory
- English as a second language class - write algorithms to help with directions, reading, and writing; have the librarians take a search unit and incorporate Boolean algebra.
- Art - teach them to create a simple webpage, then talk about images (leads to 2-d arrays)
- History class - history of computer science. Students can do a project on an individual, focus on the roles of minorities and women, or look at WWII codebreaking and other technology in a historical context.

Give an example of a topic you teach in an AP course in CS that can be applied to each of the following 4 high school areas: science, history, economics, and film/media.

Use sorting, searching and storing in these contexts:

- Science: Dissecting a frog, periodic table, organic compounds, taxonomy of science
- Economics: Graphs, inventory, data analysis and search (stocks)
- History: Dates, timelines, info on past and present wars, key people in history
- Film and Video: Splicing video

What are 4 concrete things you can do as a teacher to increase enrollment in CS courses given the current constraints you have as a teacher?

- Educate your current CS students: Emphasize CS is not just programming and show that there is a social component of CS – technology projects for disadvantaged people.
- Outreach education beyond the classroom: use professionally developed DVD highlighting IT careers, perform a road show for middle school students, PTAs, faculty meetings and alumni.
- Collaborative projects with other teachers: math, physics, and technology department
- Contact local chapters of professional organizations to come in and promote CS.

If you were to hold a summer program at your high school for girls to introduce them to the world of computing, what 4 projects

would you have them work on that would have the greatest impact?

- Career explorations - guest speakers, professionally-made DVD illustrating CS careers
- CS Unplugged activities
- Introduce programming concepts using an environment like Alice.
- Robotics – A little success gets students very excited.

What are the 4 most important resources you need at your high school to explain the importance of CS in a student's education (whether he/she goes to college or not)?

- Supportive and knowledgeable administrators and PTA, school board etc.
- Materials that explain computational thinking but also how it helps meet NCLB criteria.
- Supportive and knowledgeable peer level champions - how CS helps other teachers teach their own disciplines (e.g. DNA genome project, linguistics, etc.)
- Funding! We need a collaborative effort between universities and industry and the secondary school community so that the US doesn't lose its edge.

3. EVALUATION

Participating teachers were given a number of anonymous evaluations and surveys during the event to get demographic information as well as to gauge the short-term effectiveness of the workshop. In particular, we were interested to see how the teachers' perception of the field of CS might have changed after seeing all of these different applications. Results are presented in this section for some key questions of the survey.

3.1 Workshop Presentations

We asked teachers to rate each workshop event on a scale of 1 (poor) to 7 (excellent). Average responses are given in Table 1.

Table 1: Average Scores for Each Workshop Session from 1 (poor) to 7 (excellent).

Topic	Avg. Score
Keynote: What is Computational Thinking	6.3
Computer Science Unplugged/Google	6.8
Teaching the Principles of Computation	6.3
Food for Thought: Great Ideas in CS using Food	5.2
Games with a Purpose (Human Computation)	7.0
Panel: Broadening Participation in CS	5.6
Algorithms in Computational Biology	5.2
Panel: Careers and Social Responsibility	6.3
Using Robotics in the Classroom	6.0
Developing Cognitive Tutors	6.6
Workshop Exercise	6.4

The highest rated sessions included those that gave teachers practical exercises that they felt they could use immediately in their classes. Activities that were more theoretical in nature earned lower scores; teachers responded that these activities would be harder to teach to students due to their own background and to weak mathematical skills of some of their students.

In response to a direct question about the potential use of the workshop material in their classes for the next school year, the average response was 6.05. Indeed, most teachers said they were going to incorporate some aspect. Of the topics most likely to be used, the *CS Unplugged* material was the topic selected the most.

3.2 What is Computer Science?

In addition to evaluations of each session, we also surveyed the teachers anonymously before and after the workshop to find out how they would define CS as teachers. We wanted to see if the presentations in the workshop would alter how they viewed CS. Before the workshop began, the following responses were given as definitions of CS (number of responses given in parentheses):

***Before workshop*: What is computer science?**

Problem solving/algorithms (19)
Learning/using programming languages (6)
Study of computation (3)
Data organization/manipulation (2)
Disciplined approach to areas involving computing (3)
Study of abstraction (2)
Study of computer software and hardware (2)
Use of computers in society (2)
Exploration of logic (1)
Study of information technology (1)
Using computers to perform repetitive/mundane tasks (1)

After the workshop, we asked the same question and received the following overall responses:

***After workshop*: What is computer science?**

Developing computational thinking skills for all aspects of life (10)
Problem solving techniques/algorithms (8)
Use of computers to solve real world problems (6)
Computers effect on society (4)
CS is not just programming (3)
Study of computers effect on other disciplines (3)
Using problem solving/algorithms to develop programs (2)
The science of computing (2)
Creative thinking and problem solving using technology (1)
Studying how computers and humans interact (1)
Developing technologies to solve problems (1)
Techniques for designing computers (1)
CS is an exciting and growing field (1)

Our survey indicates that after the workshop, most teachers saw CS as a field that was much bigger than computer programming. A number remarked that they saw connections between CS and other fields that would allow them to present CS so that students would find computing more relevant to their own lives.

When comparing answers from the same teacher before and after the workshop we found that over half wrote a new definition of CS that reflected some aspect of what they learned at the workshop. Specifically, several teachers who indicated programming in their original definition either left it out or indicated that computer science dealt with more than just programming skills. Additionally, a number of teachers modified their definitions to include the fact that computer science skills can be used in real world problems in a number of disciplines.

Thus, our initial surveys indicate that most of the teachers who attended CS4HS left the workshop with a different view of CS than when they arrived.

In anticipation of planning another workshop for 2007, we surveyed our teachers on the workshop structure. Some of the key responses we received include the following:

- Overall, the length of the workshop was good and the amount of material was good.
- Teachers would like to see the following topics addressed in future workshops: security, multimedia, forensics, web page design.
- Teachers want less math and theory and more hands-on sessions. Some teachers did not want us to ignore programming.
- Most teachers want more packaged lesson plans that they could bring back and use immediately since their preparation time is very limited during the school year.

Overall, the responses indicate to us that CS4HS was a very necessary start in improving our chances of showing high school students that CS should be a part of their education.

4. SUMMARY & FUTURE WORK

Our pilot summer workshop for high school CS teachers was rewarding and a successful beginning. Our goal was to provide for these teachers additional material that they can use in their computing classes in the next year to show students that CS goes well beyond computer programming skills. Since many of these students only take one computing course (if any), this will allow these teachers to give their students a better idea about what computer science really is, and we hope that it will spark interest to pursue additional CS study at the college level. We also hope that these students will tell their younger friends that they should give CS a try since computer science is exciting and since thinking computationally is relevant and crucial in many fields.

Our work with the teachers who attended CS4HS is not over yet. At the middle and end of the next school year, we will be sending all of the teachers a follow-up survey to monitor what aspects of the workshop they used in their classes. Additionally, we will be surveying these teachers after the next two school years to see if they can detect any changes in enrollment that may be a result of the changes they made to their classes due to the workshop. We have also set up a wiki that teachers can use to communicate with us and with each other to discuss how the workshop material has changed their classes. An early comment from one enthusiastic teacher indicates potential changes:

> "I am sitting here making sure all my t's are crossed and i's dotted for my Intro. to CS. course this year. Looking back at my notes from previous years I realize how much the CS4HS meeting helped to change my thinking about what this course is all about. Previous courses have been 'jumps off the high dive right into programming syntax'. This year the first 8 weeks are shaping up to be much more about computational thinking, problem solving,…"

We plan to offer another CS4HS workshop in 2007 that incorporates our findings and that expands our efforts to new schools. Several teachers from our first workshop are working with us to develop more concrete lesson plans for some of the workshop topics based on the feedback we received. We also plan to join forces with other universities across the United States to help them adapt our pilot model to other venues. Some of these universities will work with teachers within a specific state while others will work with teachers in a specific city; we will continue to reach out at the national level. Additional information about this workshop and future activities of CS4HS can be found at http://www.cs.cmu.edu/~cs4hs/ .

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6. ACKNOWLEGMENTS

This summer workshop was partially funded by generous donations from Google and the Center for Women and Information Technology at the University of Maryland, Baltimore County. Additional support was provided the CSTA (Computer Science Teachers Association) and by the School of Computer Science at Carnegie Mellon University. We thank all of the presenters who gave up their valuable time to address this urgent need. Special thanks go to the teachers who attended CS4HS and who have brought this information back to their schools to begin a movement to change the direction of CS education in North America.