# A Model for Improving Secondary CS Education

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## ABSTRACT
This paper describes how the Institute for Computing Education (ICE) at Georgia Tech is trying to improve the state of computer science education in secondary schools in Georgia. ICE is a partnership between the Georgia Department of Education and the College of Computing at Georgia Tech. The goals for this partnership are to increase the number and quality of computer science teachers and increase the number, quality, and diversity of computer science students. One specific goal is to increase the number of students taking the CS-AP course. We believe that this partnership can serve as a model for other states.

## Categories and Subject Descriptors
K.3.2 [**Computers and Education**]: Computer and Information Science Education – *computer science education, information systems education, curriculum*

## General Terms
Experimentation, Design.

## Keywords
Computer Science Education, Teacher Training, Advanced Placement (AP), State and University Partnerships

## 1. INTRODUCTION
The U.S. Department of Labor predicts that despite the recent decline in the IT industry, computer software engineers and computer systems designers will be among the fastest growing occupations in 2002-2012 [4]. However, the number of computer science students has been dropping across the country [2]. Also worrisome is the lack of women and minorities in computer science [1].

In Georgia there are less than 50 Computer Science Advanced Placement (CS-AP) teachers for over 370 pubic high schools. The Georgia Department of Education would like to offer more computer science classes in high school but doesn't have enough qualified teachers. It is difficult to hire teachers with computer science degrees because they can usually make more money in the

private sector. In addition, most people with computer science degrees have not had any teacher training. One way to solve this problem is to train the teachers that schools currently have to teach computer science. In Georgia, the introductory computer science classes are offered in the Technology and Career Education Department. The teachers in this department are business teachers who have little or no computer science experience, other than using computer applications.

Another goal is to increase the number, quality, and diversity of students who take computer science classes in high school. In many of the schools there are very few students taking computer science classes, especially the AP class. Most of the students who *do* take computer science classes in high school are white males. Few of the students who *do* take the AP class actually take the exam and the pass rate among those is low.

These problems are not unique to Georgia. Many states face a shortage of qualified computer science teachers. Most of the students taking the CS-AP course across the country are white males. ICE has been created to address these problems in Georgia, and can serve as a model for other states.

## 2. WORKSHOP DEVELOPMENT
In the spring of 2004 the Institute for Computing Education (ICE) was created. ICE offered its first workshops in the summer of 2004. ICE is also offering year-round teacher support by the appointment of Barbara Ericson as Director of Computer Science Outreach at Georgia Tech.

### 2.1 History
In November 2003, the first annual meeting of Georgia Tech's Diversity Advisory Board in the College of Computing took place. Invited members were nationally recognized professionals from academia and business who shared a vested interest in increasing diversity in the field of computing. The Director of Technology and Career Education for the Department of Education in the State of Georgia was one of the participants. As a result of the issues raised that day, Georgia Tech and the Department of Education agreed to work together to address these problems. This partnership was formally announced at a press conference in June of 2004 by the Dean of the College of Computing and the State School Superintendent.

The Institute for Computing Education (ICE) at Georgia Tech was created and its first activity was the creation of two summer workshops: one aimed at teachers of the CS-AP, and one aimed at preparing teachers to teach an introductory computer science course called Programming and Systems Management.

The goal was to increase the number of qualified AP teachers by both training the current teachers and by starting to train teachers

with little or no previous computer science experience. The plan is to get teachers started by having them teach the Programming and Systems Management course. After a year or two of teaching that course, they would take a summer AP workshop and start teaching the AP course.

## 2.2  CS-AP Workshop Development

The CS-AP exam switched from being in C++ to Java in 2004. The exam also changed to place more emphasis on object-oriented principles. Even experienced AP teachers need some help in making the transition from C++ to Java, and help in understanding object-oriented principles. One teacher on the AP mailing list has complained that his students have gone from doing well on the exam when it was in C++ to failing the Java version. We developed the AP workshop to assist teachers in making the transition from C++ to Java and to help them understand object-oriented concepts.

To develop the CS-AP workshop we used input from current AP teachers. The teachers reported that they most needed help with how to teach object-oriented principles, the Marine Biology Case Study, and data structures.

Barbara created slides and exercises for the workshop based on her experience teaching undergraduate and continuing education courses. Each lecture was 30 minutes or less and was followed by a hands-on activity that could be used to teach the concepts. Activities included role-playing, object-oriented analysis using UML diagrams and CRC cards, and programming.

## 2.3  Programming and Systems Management Workshop Development

The goal for this workshop was to begin to prepare teachers with little or no computer science experience to teach the Programming and Systems Management course. This course is an introductory computer science course with a heavy emphasis on learning to program. We also wanted to educate the teachers as to what computing means in the 21$^{st}$ century.

### 2.3.1  Gathering Information from Teachers

To develop this workshop Barbara visited teachers who were currently teaching the Programming and Systems Management course. The teachers reported that they initially felt unprepared to teach computer science, which wasn't surprising since they usually didn't have *any* training. Some teachers took classes at local colleges, but reported feeling intimidated because of having to take the classes with computer science majors.

Since the teachers didn't have much experience in the field, they tended to teach directly out of the book. In one of the classes Barbara observed, the teacher went step-by-step through the activity in the book while most of the students played computer games. A few students tried to follow along but gave up when they encountered any problems. Several of the teachers reported that students find the exercises in the books to be boring and irrelevant. Some of the students even drop the class when they realize that, contrary to their expectations, they won't be writing computer games.

### 2.3.2  Workshop Approach

In order to make the workshop interesting for the teachers and the students we adapted an introductory computer science course at Georgia Tech. The course was developed specifically for non-majors and to encourage diversity [3]. This course teaches computer science concepts in the context of manipulating and creating media: pictures, sound, movies, and text. Students at Georgia Tech have found these exercises motivating and creative. One student reported turning in her homework and then, "my roommate and I continued work on it just to see what else we could do."

This course has been successful at Georgia Tech as seen by an increase in the success rate (defined as getting an A, B, or C in the course versus withdrawing, or getting a D or F). The average success rate for the CS1 course designed for majors was 72.2% for the years from 2000-2002. The average success rate for the course designed for non-majors over the last 3 semesters was 88.83%. The non-majors course is over half female and the females were also more successful in this course. In the fall of 2003 the success rate for women in the course for non-majors was 88.36% which was higher than the success rate for men: 84.71%. In contrast the success rate for women in the course for CS majors was 77.86% while it was 82.18% for men.

### 2.3.3  Language Choice

One of the issues during the development of the Programming and Systems Management workshop was what language should it be taught in? The state was recommending that it be taught in Java but not requiring it. Many of the teachers who were currently teaching introductory computer science courses were using C++ or Visual Basic. The course that we were basing it on at Georgia Tech was using Python.

We chose to teach it in Java because we wanted the Programming and Systems Management course to become a feeder for the AP course. Students should benefit from more experience in Java if they continue on to take the CS-AP. Another hope was that the teachers would develop their Java skills and eventually be able to teach the CS-AP course.

### 2.3.4  Content

We used image manipulation exercises to give the teachers experience with declaring variables, writing class and object methods, working with one and two dimensional arrays, iteration, and conditionals. Example exercises were negating an image, mirroring an image, doing chroma-key to replace a background, drawing on an image, and creating a simple animation. Each exercise was preceded by no more 30 minutes of lecture and example. After the first week the teachers were asked to create an image collage with the same image appearing at least 4 times in the collage with at least 3 different image manipulations done to it and then the whole thing had to be mirrored horizontally. The collages can be viewed on the teacher pages accessible from http://coweb.cc.gatech.edu/ice-gt/95. Several of the teachers created more than one collage. By the end of the second week we had teachers doing simple animation.

## 3.  WORKSHOP DETAILS

Eighteen teachers registered for the AP workshop and 41 registered for the Programming and Systems Management workshop. However, only 17 teachers actually attended the AP workshop and 30 teachers actually attended the Programming and Systems Management Workshop. Some teachers cancelled and some just didn't show up for the workshops.

The 30 hour AP workshop was held from Tuesday to Friday and teachers earned 3 hours of continuing education credit. The 60 hour Programming and Systems Management workshop was held from Monday to Thursday over two weeks and the teachers earned 6 hours of continuing education credit.

The workshops were held at the Georgia Tech Hotel and Conference Center in Atlanta Georgia. The teachers were required to stay at the hotel. We scheduled lecture and exercises during the day and some additional evening exercises and demonstrations of research at Tech for the evenings.

We offered the teachers more than just computer science instruction. Each workshop had a presentation on how to encourage diversity in the classroom. The Programming and Systems Management workshop had a panel discussion by current Georgia Tech students. And, the teachers got to see current research projects in computer science.

Each teacher received a new laptop to use during the workshop, with all the materials loaded that were needed for the workshops. Most teachers were able to take their laptops home with them at the end of the workshop. We hoped that the laptops would enable the teachers to continue learning on their own at home. All teachers were given a CD with the materials from the workshops as well. We had digital cameras and scanners available so that teachers could use their own pictures in the exercises.

We had a group of undergraduate students who assisted during the workshops as well as three graduate students. This was very useful in making sure that all the teachers got help quickly when they were doing exercises.

## 4. RESULTS

The teachers were asked to fill out a survey at the end of both of the workshops. Participation was voluntary. We got 17 out of 17 responses from the AP workshop and 27 out of 30 responses from the Programming and Systems Management workshop.

The surveys were comprised of a series of five questions to gather information about the teacher (gender, ethnicity, experience), 30 questions with 5 categories of responses (strongly agree, agree, neutral, disagree, and strongly disagree) about the workshop. It also included open ended questions on what areas didn't get addressed in the workshop, how to improve the workshop, and what where their needs throughout the year.

### 4.1 Overall Results

A combination of the results from the two workshops shows that 79.5% of the teachers reported that they felt more capable in programming after the workshop. 93.18% of the teachers reported getting ideas of *what to teach* from the workshops, and 90.91% of the teachers reported getting ideas on *how to teach* from the workshops.

However, only 56.82% reported feeling ready to teach computer science in the fall. And 45.45% of the teachers wished that the workshops had given them more ideas on what to do in their teaching.

Most of the teachers liked the residential requirement and found it valuable (80%). "Yes, it eliminated personal distractions and allowed me to focus on learning the materials. Also gave me time to collaborate with other teachers after class." "The residential part was phenomenal. It kept us here, allowed for wonderful

interaction, and reduced the stress of commuting, home distractions, and meals. The food + service allowed us to relax and took the "school" feeling away (since we are on summer vacation after all)."

The residential requirement was difficult for some, especially if they had small children. "I would have preferred to go home mostly because I have a small child but I did enjoy the demonstrations & the chance to work with the others on assignments / projects."

Most teachers enjoyed the demonstrations of research being done at Georgia Tech. "The demos were awesome. I wish I had thought ahead & had a video camera to record demos." "Awesome! They let us see what type of research is being done using computers - Leave them all & just add to them if possible." Many also enjoyed the panel of students. "The grad students gave excellent info & I think a tape of them talking to us would be a great tool for showing students what computer science can do."

### 4.2 AP Workshop Results

The AP workshop had 94.12% of the teachers feeling more capable in programming. 88.24% of the teachers reported getting ideas on **what to teach**, and 94.12% got ideas on *how to teach*. 76.47% of the teachers felt ready to teach computer science in the fall.

**Gender Breakdown**

| Male | Female |
|------|--------|
| 64.71% | 35.29% |

**Experience Breakdown**

| Never Taught CS | Never Programmed |
|-----------------|------------------|
| 11.76% | 5.88% |

We had interesting results on the question of what needs weren't addressed by the workshop. Nearly a third (29.41%) of the teachers said that they had problems that weren't addressed by the workshop. Most wanted additional information such as lesson plans or sample test questions. One teacher reported that one of the problems was not enough computers.

### 4.3 Prog. and Sys. Workshop Results

The Programming and Systems Management workshop had 70.37% of the teachers feeling more capable in programming. 96.30% of the teachers reported getting ideas on *what to teach*, and 88.89% got ideas on *how to teach*. Only 44.44% of the teachers felt ready to teach computer science in the fall.

**Gender Breakdown**

| Male | Female |
|------|--------|
| 18.52% | 81.48% |

**Experience Breakdown**

| Never Taught CS | Never Programmed |
|---|---|
| 44.44% | 37.04% |

Over a third (37.04%) of the teachers said that they had problems that weren't addressed by the workshop. Of these, four teachers noted their students were, "low-level thinkers that had difficultly grasping abstract ideas." Three teachers requested help with recruitment of students into their classes. One teacher indicated a need for better equipment.

## 5. CONCLUSIONS

The teachers did say that they learned quite a bit from the workshops. One teacher reported, "This was the best (non-college credit) workshop I have ever taken." The Programming and Systems Management teachers did find the media manipulation approach to be interesting and fun and thought that their students would enjoy it as well. The teachers particularly enjoyed the demonstrations of research projects at Tech and the panel of students. However, many teachers still felt that they weren't completely ready to teach computer science.

Overall the AP workshop teachers felt more prepared than the Programming and Systems Management teachers, probably because they had more experience to begin with. You can't expect teachers without any experience to feel ready to teach computer science after only a two-week workshop. But, with additional support and follow-up workshops we hope that they will be able to teach computer science.

One teacher told us that she hadn't wanted to come to the workshop because she wasn't comfortable with computers and thought it would be boring and too math-based. She was surprised to find that she was having fun. The hope is that some of the Programming and Systems Management teachers will gain confidence over time and eventually become AP teachers.

The features that we feel are the most critical for applying this model to other states are:

- A partnership between the Department of Education and a top technical university.

- Gathering information from teachers about what they are currently doing and what they need.

- Creating short lectures with hands-on activities that are interesting and motivating.

- Covering more than just the computer science concepts. The teachers found both the demonstrations of research projects and the panel of students valuable.

- Year-round support and follow-up.

## 6. FUTURE PLANS

ICE will be holding one and two-day workshops throughout the year. We have created mailing lists for the teachers. ICE also has a web site (http://coweb.cc.gatech.edu/ice-gt/) where teachers can ask questions and look for resources. Barbara is available for questions, classroom visits, and resource creation. Several of the teachers plan to bring their students to Georgia Tech on field trips to see demonstrations of research projects. Several teachers have asked that Georgia Tech students come and talk to their students.

ICE plans to offer the two summer workshops again and hopes to offer additional workshops. One of the survey results was that many teachers (29%) wanted a slower pace, so we would like to have a Programming and Systems Management workshop just for teachers with no computer science experience. Another useful workshop would be aimed at teachers who have never taught the AP class. ICE would also like to offer summer workshops to middle and high school students to increase their interest in computer science.

Mark Guzdial and Barbara Ericson are working on a book that could be used to teach the Programming and Systems Management course (or as a CS1 text). It should be available by the fall of 2005. Many of the teachers expressed an interest in this book and all teachers were given a working draft of the first chapters.

## 7. ACKNOWLEDGMENTS

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