Implementing Computer Science Endorsement Program for Secondary School Teachers
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ABSTRACT
Computer Science has been driving scientific innovations, fuelling growth in Information Technology and increasing productivity in all sectors of the economy for decades. The quality of our education system and its capacity to produce an adequate number of graduates trained in Computer Science will determine the United States’ capability to expand and maintain the nationwide IT infrastructure vital for economic growth. Unfortunately, there has been a serious decline in student interest in Computer Science over the last decade, and the proportion of high school graduates applying to study Computer Science continues to drop. One strategy that can stop and possibly reverse this decline is to create an awareness of Computer Science as an interesting discipline and an attractive career option within the secondary school system. This objective can only be achieved if we have appropriately trained and knowledgeable Computer Science teachers in our schools. This paper describes an attempt by a university in Georgia for realizing this goal — a Computer Science endorsement program for secondary school teachers.

Categories and Subject Descriptors
K.3.2 [Computers and Education]: Computer Science and Education - Computer Science Education

General Terms
Human Factors.

Keywords
Computer science endorsement, teacher certification, Computer Science education, secondary level.

1. INTRODUCTION
Computer Science has been behind the rapid growth of information technology and the accompanying economic growth for more than five decades. Every sector of the economy is directly or indirectly impacted on by the use of computing technology. Clearly, future economic growth and prosperity of this country rely heavily on the strength and skills of the IT and computing workforce that will be responsible for expanding and maintaining the nationwide IT infrastructure. The Bureau of Labor Statistics predicts that from 2008 through 2018 more than 1,500,000 high salary computing jobs will be created in the U.S., thereby making computing technology one of the fastest growing occupational fields [1]. However, to date, there is a huge discrepancy between the demand for workers in Computer Science related fields and the supply of qualified candidates produced by the educational system. Educators and Computer Science professionals believe that students in high schools lack the opportunity to become well prepared to pursue studies in this area at the college level [3], thus contributing to the shortage in the workforce. Bill Gates, Chairman of Microsoft Corporation, stated that "Computer Science employment is growing by nearly 100,000 jobs annually. But, at the same time studies show that there is a dramatic decline in the number of students graduating with Computer Science degrees[5]."

As a solution to the problem, the CISE (Computer & Information Science & Engineering) Directorate of the National Science Foundation (NSF) has proposed the CS/10K Project to revitalize high school computing education [2, 3]. The goal of the CS/10K Project is to develop an effective high school curriculum that will be taught by 10,000 well-prepared teachers in 10,000 high schools by 2015. The biggest challenge to the CS/10K Project is the supply of these 10,000 well-trained CS teachers, since few school teachers have a formal CS background. The NSF envisions launching and supporting high quality teacher preparation programs which will train and certify both in-service and preservice teachers in various fields of Computer Science.

According to a study conducted by the CSTA (Computer Science Teachers Association) there are 20 states in the U.S. that neither require nor grant teacher’s certification for teaching Computer Science [4]. It is evident that there is an urgent need for developing teacher preparation standards for Computer Science. This necessity motivated a regional university in Georgia to develop the first teacher’s endorsement program in Computer Science with support from a National Science Foundation Broading Participation in Computing (BPC) grant. This program, first offered in Fall 2010, is designed to prepare highly skilled CS teachers for secondary schools in the U.S. This paper describes the process followed in implementing this endorsement program. The paper is organized as follows – section 2 describes the background and motivation for this project, section 3 presents details of the implementation process, and section 4 concludes the paper.

2. BACKGROUND AND MOTIVATION
A 1997 report from the Information Technology Association of America found that 190,000 jobs in the IT industry remained unfilled because of a shortage of qualified workers [6]. After interviewing 441 CEOs of the fastest growing U.S. companies, Coopers & Lybrand reported that 66 percent viewed the shortage of qualified workers to be their greatest concern [7]. Other studies—including a detailed analysis issued by the Computing Research Association (CRA) [8] and two reports from the Office of Technology policy in the U.S. Department of Commerce [9,
Rigorous academic computing is not properly taught in high schools in the U.S. Many schools offer IT courses only as Career and Technical Education, and those courses are limited to very basic IT literacy. While Advanced Placement (AP) CS courses do prepare high school students for college-level CS education, these courses are taught in less than 10% of U.S. high schools. Even in these schools, AP CS is programming-oriented and does not focus on the fundamental concepts of Computer Science. Also, because of its extremely programming-oriented content, it sends the wrong message to prospective students about the true nature of Computer Science. Equating Computer Science with just programming leads to relatively few students taking AP CS [4]. For example, only 15,537 students took the AP CS test in 2008, compared to 222,835 who took Calculus AB, or 108,284 who took Statistics [4]. Obviously, reform in high school Computer Science curriculum and its teaching has become an absolute necessity. To address this problem, the National Science Foundation has proposed the CS/10K Project, which aims at developing “an effective new high school curriculum for Computing, taught in 10,000 high schools by 10,000 well-qualified teachers by 2015.” [2]

The immediate motivation for the work described in this paper came from the study conducted by the Computer Science Teachers Association (CSTA) to gather information on the current state certification requirements for K-12 teachers of Computer Science, and compare it across states [4]. According to this study, Georgia is one of the 20 states in the U.S. that do not grant a Computer Science endorsement for teachers. The state of Georgia is also among 20 states that do not require a CS endorsement at any level of teaching [4]. Clearly, the need to address this issue on an immediate basis was there. Accordingly, the decision was made to offer a secondary school endorsement program to fill in the void that currently exists in Computer Science teacher certification in the state. To maximize the reach of such an initiative and the benefit that would result from it, it was decided to offer the endorsement program online as well.

3. PROCESS OF IMPLEMENTING THE COMPUTER SCIENCE TEACHERS ENDORSEMENT PROGRAM

Implementation of the Computer Science endorsement program was guided by the requirements for teacher endorsements established by the Georgia Professional Standards Commission (PSC). The following steps were undertaken in order to meet the standards set forth by the PSC:

- Ensuring the programs aligned with the teacher preparation unit's Conceptual Framework
- Developing of the curriculum, including the specific courses within that curriculum
- Developing programs of study that detailed the recommended sequence of courses
- Developing transition points that could be used to assess student progress in the program
- Developing and/or identifying opportunities for student field experiences and clinical practice
- Developing and/or identifying assessments that would be used to measure student progress and provide evidence of meeting the PSC standards
- Soliciting professionals to serve on the advisory board
- Gathering faculty background information including vitas
- Participating in the program review

3.1 Conceptual Framework

Initial preparation for the program review required that the endorsement program be aligned with the teacher preparation unit's Conceptual Framework, which focuses on excellence in teaching, scholarship and professionalism. These three qualities encompass the highest standards represented in the ten principles outlined by the Interstate New Teacher Assessment and Support Consortium (INTASC) and the five core assumptions of accomplished teaching of the National Board of Professional Teaching Standards (NBPTS). As such, development of the program focused on the inclusion of best practices in the preparation of teachers as a means of improving student learning (teaching), on coursework that combines knowledge with practical applications (scholarship), and on providing prospective and in-service teachers with the opportunity to develop an in-depth knowledge in the area of Computer Science (professionalism).

3.2 Curriculum Development

Both the undergraduate and graduate programs were built around existing Computer Science courses, with additional courses added as needed to meet the PSC standards. The undergraduate program was designed for students already enrolled in the teacher education program, or who plan to enroll in the teacher education program. The graduate program, on the other hand, was designed for candidates who already have a bachelor's degree in a teacher education field, or a teaching certificate, or are currently enrolled in a Master of Art in Teaching program. Both programs were centered around effective pedagogical strategies such as the use of lecture/discussion, problem solving, reflective activities, Computer Science laboratory experiences, and field placements in Computer Science classrooms in grades 6-12. Through these experiences, it was felt that candidates would develop a deeper understanding of the content that they would be responsible for teaching in the Computer Science classroom setting. These strategies would also give candidates opportunities to broaden and enhance their repertoire of instructional strategies for addressing the needs of diverse learners as they participate in a community of learners beyond that of their own schools or preparation programs. The following details the specific curriculum implemented as part of each program.
Undergraduate

The initial framework for the undergraduate curriculum was based on five first and second year Computer Science courses and two upper division Computer Science courses currently offered:

- Introduction to Information Technology
- Computer Science 1 and Lab
- Computer Science 2
- Computer Organization
- Data Structures
- Programming Languages
- Computer Networks

In addition, two teacher preparation courses were developed to fill the gaps required for the curriculum to meet the PSC standards:

- Methods of Teaching Computer Science
- Practicum in Computer Science

This curriculum was designed to emphasize fundamental programming and Computer Science concepts including data structures, programming languages and networking while incorporating a course in how to teach Computer Science and a practicum that will allow students to demonstrate their teaching abilities.

Graduate

The endorsement curriculum for graduate students with little or no previous Computer Science academic experience was based on six courses--four existing Computer Science courses and two teacher preparation courses:

- Fundamental Principles of Computer Science
- Fundamentals of Computer Programming and Data Structures
- Programming Languages
- Computer Networks
- Methods of Teaching Computer Science
- Practicum in Computer Science

3.3 Programs of Study

The undergraduate program of study, as shown in Table 1, was developed based on a fall semester entry and a typical four-year undergraduate program, taking into account the typical scheduling of the courses, and the fact that the upper division courses are not offered every semester.

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<th>Table 1 Undergraduate Program of Study</th>
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<td><strong>Fall</strong></td>
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3.3.1 Transition Points

Transition points serve as opportunities to assess student progress in the program and to recommend changes as necessary. The following describes the transition points that were developed for both the undergraduate and the graduate endorsement programs.

As part of the undergraduate program, the following four transition points were developed:

- Admission to Teacher Education Program
- Entry into Student Teaching
- Exit from Program
- Induction
These transition points will be administered as part of the teacher preparation program. Admission to the teacher education program and into student teaching will be based on satisfactory completion of certain undergraduate core courses, a minimum GPA of 2.5 and completion of a background check. The "Exit from Program" transition will include the following:

- Minimum 2.5 GPA calculated on all undergraduate coursework
- Grades of C or better in all courses related to major
- Satisfactory ratings on all components of the Model of Appropriate Practice (MAP) Evaluation (see section 3.5.3 for a description)
- Satisfactory ratings on all components of the Dispositions Evaluation
- Satisfactory completion of portfolio

The "Induction" transition point evaluates student progress one to two years after completing the program. This evaluation will survey students and obtain their evaluations of their preparation as teachers. At the same time, these students' employers will be surveyed and asked to evaluate the students as teachers.

As part of the graduate program, three transition points were developed:

- Program entry
- Program exit
- Induction

To enter the graduate program, the following requirements were established:

- possess an undergraduate degree from an accredited institution
- maintain a minimum GPA of 2.75 on all attempted coursework
- hold a clear, renewable teaching certificate or be admitted to a Master of Arts in Teaching (M.A.T.) degree program

The decision was made to allow candidates to be admitted provisionally provided they maintained a minimum GPA of 2.5. If admitted provisionally, candidates must complete nine hours of graduate coursework with grades of B or better in each course for admission status to be changed to regular.

To exit the program, the following criteria were established for graduate students:

- Minimum 3.0 GPA calculated on all graduate coursework required in endorsement program
- Grades of B or better in Fundamental Principles of Computer Science and Fundamentals of Computer Programming and Data Structures and grades of C or better in all other required coursework; no more than two (2) grades of "C" or below in graduate courses
- Satisfactory ratings on all components of the Field Experience Evaluation
- Satisfactory ratings on all components of the Dispositions Evaluation
- Satisfactory completion of portfolio

The “Induction” transition point for the graduate program is the same as that for the undergraduate program.

Once the transition points were identified, the field experiences, assessments and additional artifacts used in evaluating student progress at the transition points needed to be identified. These transition point evaluation tools and techniques are discussed in more detail below.

### 3.4 Field Experiences and Clinical Practice

Field experiences are a required part of the endorsement program in order to provide the teacher candidate with practical experience as a teacher teaching Computer Science. These experiences will also serve as opportunities to evaluate the candidate's teaching abilities and to recommend improvements where necessary. Both undergraduate and graduate students are required to complete 60 hours of field experiences as part of the program in order to ensure the quality of learning.

During the 60 hours of field experience, candidates are required to be engaged in a variety of teaching-related activities that include observing Computer Science classes in grades 6-8 or 9-12, assisting other Computer Science teachers in coordinating classroom activities, working with individual students or small groups, and planning and teaching lessons and units. Candidates will be required to keep a field experience log where they will record their observations and activities as well as their own reflections on different issues. They will have this log signed by the cooperating classroom teacher and include it in their professional portfolio. In addition, each candidate's teaching will be evaluated by the cooperating teacher and/or a university supervisor using a Field Experience Evaluation instrument. Cooperating teachers and supervisors will also evaluate candidates' dispositions using a Dispositions Evaluation instrument.

In addition to more formal field experiences in a middle or high school Computer Science classroom, student candidates will be allowed to satisfy the 60 hour requirement by participating in Computer Science summer camps and/or evening classes (for example, teaching basic programming languages such as Alice to middle or high school students).

In addition to the field experiences requirement, student candidates in the undergraduate endorsement program will be required to complete a 15-week student teaching experience in which they will be required to take over all classroom responsibilities for a period of at least four consecutive weeks.

### 3.5 Assessments and Evidence for Meeting Standards

To evaluate success in meeting the program requirements and teacher preparation standards and for providing evidence that candidates were meeting the program standards, five primary assessment tools were proposed:

- Content GPA (content knowledge)
- Professional Portfolio (Field Experiences and Clinical Practice)
- Field Experience Evaluation
- Dispositions Evaluation
- Graduate and Employer Surveys
3.5.1 Content GPA

Undergraduate
Candidates' progress will be monitored each semester by their advisors in the teacher preparation unit. Candidates must earn a C or higher in all courses that are part of the program. Those who do not earn a C or higher in these courses may retake them; otherwise, they will not be able to continue in the program. To exit the program, candidates must have a minimum 2.5 GPA calculated on all undergraduate work attempted and grades of C or better in all required program coursework.

Graduate
Candidates' progress will be monitored each semester by their advisors in the teacher preparation unit. Candidates must earn a B or higher in the foundational courses, Fundamental Principles of Computer Science and Fundamentals of Computer Programming and Data Structures. Those who do not earn a B or higher in these courses may retake them; otherwise, they will not be able to continue in the program. In the other courses in the program, candidates must earn a C or higher. Those who do not earn a C or higher may retake the courses; otherwise, they will not be able to continue in the program.

To exit the program, candidates must have a minimum 3.0 GPA calculated on all required graduate coursework in the program. Grades of B or better are required in Fundamental Principles of Computer Science and Fundamentals of Computer Programming and Data Structures and grades of C or better in all other required coursework. Candidates may have no more than two (2) grades of "C" or below in required graduate courses.

3.5.2 Professional Portfolio

The professional portfolio will be used to assess candidates' knowledge of the program objectives and standards. It will contain a collection of artifacts representing all program standards, and may include the candidate's philosophy of professional practice, work samples, lesson and/or unit plans, field experience and clinical practice logs, and evaluations. Candidates will provide written reflection statements for each artifact. The portfolio will be initiated at the beginning of the candidate’s program and artifacts will be added throughout the entire program in specific courses. Students will be required to organize their portfolios according to program standards.

3.5.3 Field Experience Evaluation

Undergraduate
The tool that will be used to evaluate the undergraduate field experiences is the Model of Appropriate Practice (MAP). This tool is based on Charlotte Danielson’s framework for teaching (http://www.danielsongroup.org/theframeteach.htm) and was created for initial teacher candidates. It puts into practice the principles of the Conceptual Framework underlying the endorsement program. It acknowledges that, with guidance of faculty, teacher candidates must undertake and manage the process of developing an understanding about teaching and learning for themselves. Through their coursework and field experiences, teacher candidates should gain competence in engaging students in constructing important knowledge.

Graduate
The tool that will be used to evaluate the graduate field experiences is the Graduate Model of Appropriate Practice (GMAP). The GMAP was based on the NBPTS Core Propositions and was developed for evaluating candidates in advanced teacher preparation programs.

3.5.4 Dispositions Evaluation

The Teacher Candidate Disposition Evaluation is an instrument used to assess teacher candidates’ dispositions. The Graduate Dispositions Evaluation instrument is used during the field experience to assess in-service candidates’ dispositions. Corresponding rubrics are used as guides to evaluating candidates’ dispositions. Both undergraduate and graduate candidates’ dispositions will be assessed in the methods and practicum courses by university faculty and cooperating teachers. Program advisors will counsel with any candidates who have unacceptable ratings on any component, and develop remediation plans as needed. Results of dispositions assessments will be shared with Computer Science program faculty and the advisory board members for analysis. Data collected from these evaluations will be used to make decisions regarding candidate performance, program quality, and unit operations.

3.5.5 Graduate and Employer Surveys

Graduates of the Computer Science Endorsement program will be contacted and asked to complete a brief, Web-based survey designed to elicit candidates’ perceptions of their preparation as teachers. Employers of the graduates will also be contacted and asked to complete a brief Web-based survey for each graduate they supervise. The survey will ask employers to rate candidates on job performance. Program coordinators, department chairs, faculty, and staff will use data from the Graduate and Employer Surveys to make decisions regarding candidate performance, program quality, and unit operations.

3.6 Advisory Board

An advisory board for this program was instituted in order to provide feedback on the program and to make recommendations for improving the curriculum. Several middle and high school teachers together with the director of the Career and Technical Education for the local school district were solicited and agreed to serve on the board. This board will meet two or three times each year to discuss the program and to make recommendations for improving it.

3.7 Program Review

During February 14-17, 2010, a three-member team representing the Professional Standards Commission conducted an electronic review of the undergraduate and graduate endorsement programs to determine if the proposed programs met or exceeded the following Georgia standards:

- Candidate knowledge skills and dispositions
  - Content Knowledge for Teacher Candidates
  - Pedagogical Content Knowledge for Teachers
  - Pedagogical and Professional Knowledge and Skills for Teachers
  - Student Learning for Teachers
  - Professional Knowledge for Other School Professionals
  - Student Learning for Other School Professionals
  - Professional Dispositions
Assessment system and unit evaluation
- Assessment System
- Data Collection, Analysis, & Evaluation
- Use of Data for Program Improvement

Field experiences and clinical practices

Diversity

Faculty qualification, performance and development

Unit governance and resources

Standards specific in Rule 505-3-01

Program content standards

The program received “Developmental Approval” by the Professional Standards Commission on May 13, 2010.

4. CONCLUSION

The decline in students interested in Computer Science over the last several decades may threaten the United States’ capability to compete in a world built around an ever increasing need for information technology and computing professionals. In this paper, the authors have described an effort aimed at arresting and possibly reversing this trend by implementing a Computer Science endorsement program for secondary school teachers. The process involved a careful review of teacher preparation standards, development of both an undergraduate and a graduate curriculum, programs of study and transition points. Field experiences, clinical practice, assessments for measuring student progress as well as an advisory board to assist in improving the program have been put in place. After a careful review by the Georgia Professional Standards Commission, both the undergraduate and graduate Computer Science endorsement programs for secondary school teachers were approved. Steps are currently underway to market the program and to make it as widely available to prospective and in-service teachers as possible. Implementation of this online program will no doubt play a significant role in improving the standard of Computer Science teaching at schools for the foreseeable future.

5. ACKNOWLEDGEMENT

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6. REFERENCES


