

# PREPARING FUTURE SECONDARY COMPUTER SCIENCE EDUCATORS

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## ABSTRACT

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*Although nearly every college offers a major in computer science, many computer science teachers at the secondary level have received little formal training. This paper presents details of a project that could make a significant contribution to national efforts to improve computer science education by combining teacher education and professional development. A computer science endorsement program will prepare preservice teachers in: basic skills and concepts, programming, algorithm design, computer system components, data bases, and social issues related to computer use. A series of professional development workshops will improve the content knowledge of current teachers, enabling them to teach computer science concepts and information technology fluency.*

## INTRODUCTION

Strengthening the quality of teachers and teaching has been central to efforts to improve American education in recent decades. America's competitive edge in today's world depends on an educational system capable of producing young people and citizens who are well prepared in science and mathematics, including computer science.

The National Science Board (NSB) report, *America's Pressing Challenge -- Building a Stronger Foundation* (2006), expresses concerns with the condition of U.S. pre-college education in science, technology, engineering, and mathematics (STEM). *Science and Engineering Indicators*, (2006) reinforces these continuing and growing concerns. The

reports concluded that there is a need to make drastic changes within the nation's science and mathematics classrooms. If not, our nation risks raising generations of students and citizens who do not know how to think critically and make informed decisions based on technical and scientific information. The two reports recommended that our nation must devote the necessary resources to revitalize our pre-college STEM education system.

The NSB reports identified priorities for ensuring a world-class education in STEM for all Americans. The reports consistently point to the critical role of teachers in helping students to learn and achieve. Today's teachers are being called on to provide the nation's children with a high-quality education and to teach in new ways. Many of the NSB recommendations focus on improving pre-college education in STEM. The following two recommendations coupled with the author's long interest in research have motivated this project:

1. Higher-education leaders should work to strengthen teacher-education programs to provide school teachers with a deeper understanding of the content of mathematics and science.
2. Teacher professional development is essential to improving teacher quality. Changes in teaching practices will occur if teachers have consistent and high-quality professional training.

## BACKGROUND

Computer Science is an established discipline at the collegiate and post-graduate levels. In the United States alone, nearly every undergraduate college offers a major in computer science, and more than 100 universities offer Ph.D. programs in computer science. Together, these programs produce about 45,000 baccalaureate and 850 PhD degrees each year (Tucker, 2004). Oddly, the majority of secondary computer science teachers across the nation have received minimal or no formal training in computer science (Pontier, 2005). One important reason for this anomaly is the lack of formal computer science education programs at institutions of higher education across the nation. Another important reason is the lack of training opportunities for existing teachers. This article addresses these two reasons and highlights a planned project that aims at providing teacher education and teacher professional development experiences at Ashland University.

The planned project envisions providing significant contributions to the national efforts aiming at advancing STEM education in the USA.

Toward this vision, the project contributes to the development of exemplary undergraduate computer science education by focusing on the following two related main areas:

1. **Teacher Education.** The goal is to strengthen teacher education by creating a high-quality computer science education program at Ashland University. The objective of the program is to prepare candidates to teach secondary computer science. Meeting International Society for Technology in Education (ISTE) standards, "candidates completing this program will exhibit knowledge, skills, and dispositions equipping them to teach application usage, computer science concepts, information technology fluency, and computer programming."
2. **Teacher Professional Development.** The goal is to promote participation in teacher professional development and improve the quality of teacher training by providing sustained quality professional development experiences to K-12 in-service science teachers in rural North Central Ohio. The objective of these experiences is to increase and deepen participants' content knowledge enabling them to teach computer science concepts and information technology fluency.

In the remainder of this article, a formal Computer Science Teacher Education Program is discussed and three comprehensive workshops aimed at providing high-quality and sustained teacher professional development experiences are described. Concluding remarks present the expected measurable outcomes of the project.

## COMPUTER SCIENCE EDUCATION

Among all ideas spawned by all sciences over the last fifty years, none has transformed our lives as profoundly as have computers. Virtually all aspects of our lives have been affected, and a wealth of new concepts has been generated. "To function in society in the 21st century, it is essential for the average citizen to understand at least the principles of computer science." (Tucker, et al. 2003)

Computer Science is a mainstream discipline that can no longer be ignored by public schools in the 21st century. Much evidence confirms an urgent need to improve the level of public understanding of computer science as an academic and professional field. To meet this need, schools must introduce the principles and methodologies of computer science to all students, whether they are college bound or workplace bound. To

achieve this goal, schools must have qualified and well trained teachers in computer science (Tucker, 2004).

The NSB reports (NSB, 2006) recommended that "it is absolutely essential for our nation's long-term prosperity and security that we remain a world leader in science and technology." This requires the efforts of elementary and secondary schools as well as higher education institutions. Elementary and secondary schools have a unique opportunity and responsibility to address this need by educating young people in the important subject area of computer science, and thus better preparing them for effective citizenship in the 21st century (Tucker, 2004). On the other hand, institutions of higher education have the obligation to strengthen their teacher education programs in order to produce more effective teachers. The main goal of the project presented in this article is to contribute to ongoing efforts to strengthen the U.S. computer science teaching force. The first component of the planned project will culminate in the creation of a Computer Science Education (CSED) endorsement program at Ashland University.

The CSED Endorsement Program prepares candidates to serve as teachers of Computer Science. The focus of the program will be on preparing the candidates in the more technical aspects of computing. The program is designed to meet the standards set forth by the International Society for Technology in Education (ISTE/NCATE) and will be implemented through a teacher preparation endorsement program.

The CSED program will provide prospective computer science teachers with specialty content preparation in computer science. It will provide the candidates with experiences selected to develop a breadth and depth of knowledge of computer science. Courses and performances fulfilling the program requirements will include experiences beyond the beginning level in computer science. Therefore, the CSED program will employ the broad definition of computer science as an academic and professional field: "*Computer Science* is the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society" (Tucker, 2004, p.2). Thus, the proposed program will provide candidates with preparation in several aspects of computing including basic skills and concepts, programming, algorithm design, computer system components (hardware and software), databases (information retrieval and security), and social aspects (interactions, implications, and issues).

The CSED program will be a collaboration between three departments from two colleges at Ashland University: The Department of

Mathematics and Computer Science (College of Arts and Sciences); The Department of Curriculum/Instruction (College of Education); and The Department of Education Foundations (College of Education). As a result, the program will provide prospective computer science teachers not only with preparation in computer science, but also with experiences in methods, techniques, and strategies related to teaching computer science. Courses and experiences will be carefully selected from existing courses in the three departments, and new courses will be designed to meet the ISTE standards.

### TEACHER PROFESSIONAL DEVELOPMENT

Ongoing efforts to raise academic standards in STEM require teachers to have knowledge and skills that many did not acquire during their initial preparation for teaching. The changing and expanding demands of teaching jobs have prompted increased attention to the importance of professional development in providing teachers with opportunities to acquire new knowledge and keep abreast of advances in their field (SEI, 2006).

Computer Science is a young area of study that is continually evolving. The majority of computer science teachers across the nation have received minimal or no formal training in computer science and, as a result, are faced with unique challenges that do not exist for teachers of other STEM subjects (Pontier, 2005). Providing these teachers with professional development opportunities will increase their intellectual vibrancy in the classroom.

A series of teacher professional development experiences is planned within this project. The target segment of educators for these experiences will be in-service K-12 teachers in rural areas in North-central Ohio. The focus of these experiences will be on preparing the participants to teach general computer science courses. The workshops are designed to enable teachers to use today's technology in their own fields, and to build their capability to independently learn and use new technology as it evolves throughout their professional lifetime.

The workshops will provide candidates with experiences selected to develop a breadth of knowledge of computer science and a depth of knowledge of computer programming and Web technology. The workshops will consist of experiences beyond the scope of computer literacy. They will include experiences on active use of algorithmic thinking (including programming) to solve problems.

The series of workshops will consist of three experiences on (a) Logic

and Computing, (b) Web Publishing, and (c) Computer Programming. These workshops will be conducted on the main campus of the university. Workshops 1 and 2 will be held on five consecutive days for eight hours each day. Due to the scope of the material to be covered, the Computer Programming Workshop will be held for eight hours each business day for two weeks and will follow the other two workshops in sequence.

The *Logic and Computing Workshop* will introduce the candidates to the computer science discipline. The workshop will begin with the design of hardware using digital logic, which establishes a scientific foundation for a variety of topics. Other components of the workshop will include information processing, the algorithmic solution of problems, and the study of algorithmic processes. The workshop will be held for a total of 80 hours. Upon successful completion of the *Logic and Computing Workshop*, teachers will be able to:

- Identify and describe the basic components of a computer and the relationships between them.
- Describe the essentials of how software and hardware interact to solve a problem.
- Investigate problem-solving strategies and techniques and develop algorithms for classic problems such as sorting and searching.

The *Web Publishing Workshop* will introduce the candidates to the world of Web design and programming. It will teach them concepts and processes needed for the creation of Web pages. The hands-on workshop will be designed for learning through doing. The workshop will be held for a total of 80 hours. Upon successful completion of the *Web Publishing Workshop* participants will be able to perform the following tasks:

- Build, format, and maintain static Web pages using HTML (HyperText Markup Language) and CSS (Cascading Style Sheets).
- Manage the design and creation of Web sites individually and as a team member.

The *Computer Programming Workshop* is an introduction to computer programming using the C++ programming language. Although the syntax of the language will be covered, the emphasis of the workshop will be on problem-solving and program design. The workshop will be held for a total of 80 hours. Upon successful completion of the *Computer Programming Workshop*, attendees will:

- Gain understanding of the principles of structured programming.
- Learn design methods and development techniques of computer programs.
- Gain understanding of the constructs of the ANSI C++ programming language.
- Be able to write medium to large size C++ programs using classes.

As can be seen from the descriptions given above, the workshops can provide candidates with preparation in several aspects of computing including basic skills and concepts, programming, algorithm design, and Web technology. It is expected that candidates successfully completing the series of workshops to be K-12 teachers who will:

Be able to use today's technology in their fields.

- Have the capability to independently learn and use new technology as it evolves throughout their professional lifetime.
- Be able to plan and deliver general computer science courses that use a literacy or a fluency approach to computing.

### CONCLUDING REMARKS

There is a dire need to strengthen the computer science teaching force in the USA. The main goal of the project reported in this paper is to contribute to the development of exemplary undergraduate computer science education by addressing two related areas: computer science teacher education and teacher professional development. Towards this vision, the project has great potential to provide the following contributions:

- Establishing a sound and high-quality computer science education program that graduates prospective computer science teachers who have the a breadth and depth of knowledge of computer science.
- Providing professional development experiences with content linked to subject-matter knowledge. Based on an extensive review of studies, it was found that the programs showing the greatest effects were those that focused on subject-matter knowledge and on student learning in a particular subject (America's Pressing Challenge, 2006)
- Providing sustained and intensive professional development opportunities. Numerous studies indicate that sustained and intensive (60 to 80 hours) professional development is an important factor in influencing change in teachers' attitudes and teaching behaviors (America's Pressing Challenge, 2006).

The broader impact of the project on the preparation of computer science teachers can be summarized as follows:

- A growing body of research shows that teacher subject-matter knowledge is significantly associated with student learning. A college minor in a subject has been accepted as the minimum prerequisite for teaching that subject (Science and Engineering Indicators, 2006). The proposed CSED Endorsement Program will exceed this requirement.
- There is a trend that teachers of computer science at the secondary level have a minimal formal computer science background (Pontier, 2005). The proposed CSED Endorsement Program will provide formal computer science education to prospective computer science teachers.
- The computer science field of study is young and growing exponentially. Multiple challenges are an issue to all involved in the computer science field due to the evolving nature and relative newness of the field (Pontier, 2005). As advances in this field of study continue to evolve, schools and their computer science teachers should not be left behind (Pontier, 2005). The proposed series of workshops will provide experiences to existing teachers to enable them to develop and teach general computer science courses at their schools.

The current generation of students consists of technology “natives,” who have grown up using sophisticated communication and information technology. However, while students know how to use technology, they do not have the grasp of science and engineering that underlie that technology (Science and Engineering Indicators, 2006). This project has a clear and strong relation to student learning as evidenced by the following:

- The project consists of activities that will prepare our teachers to teach our increasingly technologically sophisticated K-12 student body. This preparation will enable the teachers to shift away from just learning to use the computers towards more effective use in supporting instructional goals and instruction.
- Research shows that a student who has teachers with the knowledge and skills needed to teach science effectively is more likely to be able to close the achievement gaps that he or she experiences. This student will be prepared as an individual for success in work and life (America’s Pressing Challenge, 2006). This project aims at providing prospective and existing computer science teachers with experiences selected to develop a breadth and depth of knowledge of computer science.



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