
AC 2011-1726: USING VERTICALLY INTEGRATED PROJECT TEAMS TO INSPIRE STUDNET INTEREST IN COMPUTING CAREERS

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Using Vertically Integrated Project Teams: Inspiring Student Interest in Computing Careers

Abstract

This paper reports on a project, InspireCT, which is focused on undergraduate computing education. The central tenet of the project is that computing education will benefit by engaging students in hands-on, team-based projects much earlier in their education. The excitement of student teams working on capstone design projects is commonly observed. The goal of this effort is to allow much less experienced students comprehend and share in that excitement based on their skill levels. Advanced undergraduates working on capstone design projects are at the center of the project. The capstone experience will be shared with less experienced students by teaming advanced undergraduates with beginning undergraduates. This teaming is designed to benefit both the beginning and advanced students. The paper reports on the InspireCT effort: discussing foundations concepts and principles, presenting project goals and objectives, and describing project activities, and future plans.

Introduction

The fact that too few students are majoring in the computing disciplines is well documented. Even with the recent report of some upturn in the number of majors¹, there is a need to continue efforts to attract additional students to computing degree programs. The long term trend shows a substantial under-production of graduates with degrees in computing. For 2006, the most recent year available, there were fewer than 62,000 computing degrees granted². By comparison, the Bureau of Labor Statistics estimates that employment of software engineers is expected to increase by 32 percent from 2008-2018, which is much faster than the average for all occupations. In addition, this occupation will see a large number of new jobs, with more than 295,000 created between 2008 and 2018³. This shortfall of computing graduates is even more pressing when the scarcity of women and other underrepresented groups in computing fields is considered. For example, only about 22% of the computing degrees in 2006 were earned by women².

The authors have been engaged in a National Science Foundation (NSF) funded project to address these challenges to develop an adequate software engineering workforce. The effort is called InspireCT (Collaborative Research: II: From Middle School to Industry: Vertical Integration to Inspire Interest in Computational Thinking). This paper reports on the InspireCT effort: foundations concepts and principles, project goals and objectives, project activities, and future plans.

InspireCT Foundation Concepts

Lack of Interest in Computing Careers

The current instructional approach clearly is not succeeding at attracting and retaining sufficient students. A key problem is that computing education begins with extensive skill building focused primarily on learning to program. Because the first years of computing education focus on

acquiring technical knowledge and skills, many students only view computing in these terms. A missing aspect is student understanding of computational thinking in action. Also, students typically get little appreciation of the software engineering concepts and practices needed to build modern systems. Computing education needs to be altered to help students obtain a more comprehensive view from the beginning. This view must encompass technical knowledge, but also show students the potential of computational thinking in action. In particular, students need to understand the potential of computing to have a direct impact on people and society. This connection has been shown to be particularly important for giving women a more positive view of computing and why they might choose to study it. This issue of negative perception of computing was identified as one of the Grand Challenges of Computing Education. In discussing how to address this challenge, the authors of that effort noted: “The infectious excitement of computing often manifests itself in applications and remarkable advances associated with other disciplines.”⁴

Computational Thinking

The need to attract and retain more computing majors, especially software engineering students, is serious, but the needs do not stop with majors in computing. Computational thinking⁵ is described as thinking that “involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science” and asserts “Computational thinking is a fundamental skill for everyone, not just for computer scientists”. There is broad recognition of this issue in the scientific and engineering disciplines. For example, a 2003 NSF report⁶ notes: “The need for a new workforce – a new flavor of mixed science and technology professional – is emerging. These individuals have expertise in a particular domain science area, as well as considerable expertise in computer science and mathematics.”

We assert that developing computational thinking capacity is a pressing national need, and it is essential for software engineers. Meeting this need will require enthusiastic participation of many more students than those currently choosing computing education. Attracting those students will require new approaches to computing education. For students, inspiration and effective learning activities are key elements for success. Since students may choose their own path of study, especially at the college level, there is a need to inspire student interest in computational thinking in order to attract and retain them in sufficient numbers. Once student interest is sparked, they need to be engaged in activities that will be effective at maintaining that interest and developing computational thinking skills.

Active Learning through Project Work

For several decades, various notions of active learning have been popular in education. This broad concept covers a wide variety of techniques that all share “instructional activities involving students in doing things and thinking about what they are doing”⁷. Support for various types of active learning is central to the InspireCT project. The goal is to shift away from studying and hearing about computing topics and toward actual participation in computational thinking and software engineering activities.

Not all research supports the notion of active learning. In particular, there is debate about the value of active learning that is completely self-guided⁸. One conclusion of this debate is the suggestion that active learning should be combined with structure and instructor guidance that varies according to the experience/background level of student. A widely used and accepted method of guided active learning is engaging students in realistic design and development projects. Team software development projects have proved to be a particularly effective approach to inspiring students, educating them in software engineering practices, and integrating active learning and computational thinking into a focused activity^{9,10,11}.

The InspireCT Project

InspireCT Goals and Strategy

InspireCT is an NSF funded project involving Drexel University, Embry-Riddle Aeronautical University, and Texas Tech University, and their partners (regional high schools and middle schools) that promote the following goals:

- Goal 1: Attract more students to the study of computational thinking;
- Goal 2: Enhance student learning and ability to apply computational thinking; and
- Goal 3: Enable instructors to engage students with computational thinking in action.

The central tenet of InspireCT is that computing education will benefit by engaging students in meaningful computing projects much earlier in their education, even as early as pre-college. One of the problems with this approach is the lack of technical capability of pre-college and early college students. Another problem is that in some cases there is a lack of adequate instructional support. The InspireCT approach to addressing this issue is a vertical teaming of advanced undergraduates with beginning undergraduates and pre-college students. This teaming will be designed to benefit both the beginning and advanced students. The core focus on undergraduates will be extended in several directions. This approach is being extended to pre-college students and their teachers in grades 6-12. That is, active learning through vertical integration implies that undergraduates and pre-college students will require more support to offset decreasing levels of computing knowledge and experience. Figure 1 depicts the vertical integration approach of InspireCT; it shows all the InspireCT constituents and shows how they are related to the project activities. InspireCT information and material is available at <http://www.inspire-ct.org/>.

InspireCT 2009-2010 Activities

In 2009-2010, the InspireCT participants engaged in the following activities:

- Definition of evaluation instruments and detailed process;
- Planned for vertical integration across computing courses in the major;
- Began collaboration with non-computing courses;
- Secured pre-college partners for InspireCT;
- Developed and delivered an undergraduate InspireCT workshop; and
- Planned and designed pre-college activities.

In the Fall 2009 semester, the investigators communicated with high-school and middle school educators and reached agreement on collaboration on InspireCT goals. Teachers at the high

school and middle school levels were engaged in conversation about how to introduce computation thinking into their classrooms, discussing what would attract their students to computing careers and how their student could be vertically teamed with undergraduate students in meaningful software projects.

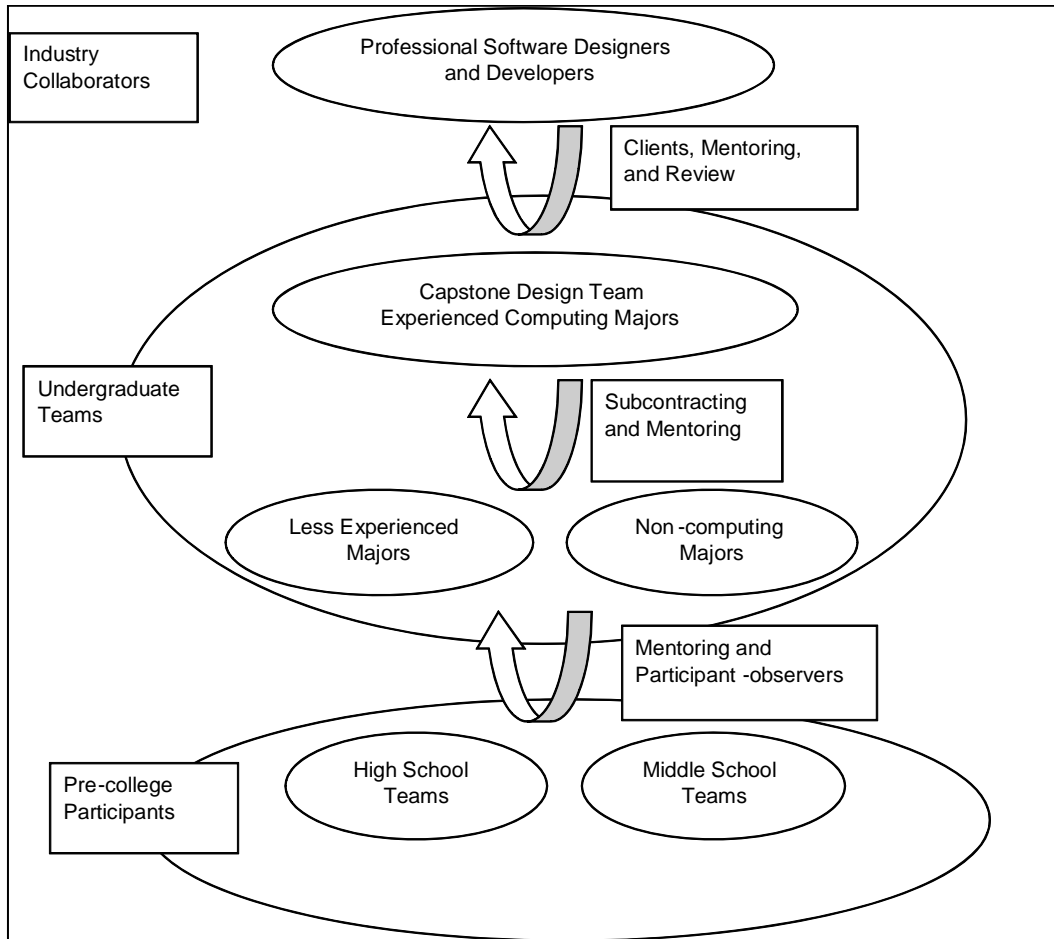


Figure 1: InspireCT Activities and Participants

In the Spring 2010 semester, the participating universities completed the following:

- Began planning InspireCT activities with pre-college partners.
- Identified pre-college courses and programs that were appropriate for introducing computational thinking activities and recruiting students for vertical teamed projects. A wide spectrum of courses were identified: courses in AP computer science, web applications, business computing, game design, and honors physics; and special programs in simulation and robotics, communication and multimedia technology, design and manufacturing technology.
- In collaboration with the InspireCT project, several undergraduate students and high school teachers were funded through research grant supplements (Research Experiences for Undergraduates (REU) and Research Experiences for Teachers) to extend and deepen their experiences with the InspireCT project.
- Developed material for an InspireCT workshop for undergraduate computing faculty. The workshop goals were as follows:

- Explain InspireCT goals, concepts, and practices.
- Discuss the problems in inspiring students to seek careers in computing, including the difficulty of attracting women and other underrepresented groups.
- Explain the need to collaborate with pre-college faculty and students and industry professionals
- Define particular strategies and approaches for creating or extending computing outreach to students in grades 6-12.
- Implement a plan (drafted at an InspireCT workshop) to incorporate InspireCT elements into their curricula.

InspireCT 2010 Workshop

A workshop was hosted by Texas Tech University in June 2010 and was focused on undergraduate computing faculty. There were nineteen participants (fourteen undergraduate faculty, two community college faculty, two high school teachers, and one middle school teacher) in addition to the three InspireCT investigators and ten REU Site project students from Texas Tech University. Workshop activities consisted of the following:

- Discussion of general concepts such as Computing Curricula and Computational Thinking, Active Learning, Teamwork & Capstone Project Models, and Peer mentoring;
- Two panels: one on InspireCT activities made up of InspireCT investigators, one on computational thinking, made of pre-college teachers and undergraduate students;
- Presentations by high school and middle school teachers on their InspireCT activities, thus far; and
- Four team exercises.

The four team exercises covered the following:

- Team Exercise 1: Teams described challenges and concerns they see in introducing InspireCT concepts;
- Team Exercise 2: Teams determined ways for collaborating with other stakeholders in an InspireCT project: precollege teachers and students; industry practitioners, other faculty at the same institution, and faculty from other institutions;
- Team Exercise 3: Teams determined the elements of a plan (goals, methods, activities) for developing an InspireCT program in a fictitious program; and
- Team Exercise 4: Teams and individuals developed plans for implementing an InspireCT program at their institutions.

Team reports on the exercise results are available at <http://www.inspire-ct.org/>. Of particular interest are the Exercise 4 reports on how an individual or group planned to implement an InspireCT program. Ideas included the following: using lower level classes to subcontract for certain aspects of a senior capstone project (e.g., requirements and design review, low level coding, and system testing); involving UPE (the computing honor society) and ACM chapter students in mentoring lower classmen and high school students; and adding computational thinking to freshman college experience courses. One challenge expressed was how to get the program faculty to accept the computational thinking concept.

Table 1 is derived from one of the Exercise 4 results; it outlines a schedule for Mainland High School (in Daytona Beach, Florida) working with Embry-Riddle Aeronautical University to implement a vertical integrated software project. The plan is the work of undergraduate faculty and high school teachers and embodies some of the key concepts of the InspireCT project. The Embry-Riddle/Mainland exercise results also included a plan for the development and delivery of InspireCT high school teaching modules. In addition to AP computer science, modules in computational thinking would be developed for Physics, Algebra II, 9th Grade Research (a Search and Sort activity), Business Computer Programming, and Business applications (an Excel and computation problem).

Table 1: Vertical Integration Plan

<u>Overview:</u>	This is a vertically integrated team project involving students from Embry-Riddle Aeronautical University and Mainland High School working on a common design project. College students will take the lead on the development while outsourcing products to the high school students. High school student liaisons shall be periodically embedded within the college design project.
<u>Participants:</u>	<ul style="list-style-type: none"> • Embry-Riddle Faculty • Embry-Riddle Computer and Software Engineering Capstone Design Students • Mainland Faculty • Mainland Capstone Design Students
<u>Activities/Timeline</u>	
Summer	<ul style="list-style-type: none"> • Determine high-level details of a design problem • Create assessment plan
September	<ul style="list-style-type: none"> • Embry-Riddle developing requirements with customer • Mainland students work on warm-up projects • Mainland Crystal Process introduction
October	<ul style="list-style-type: none"> • Embry-Riddle delivers lecture on inspection process • Mainland students perform inspection with Embry-Riddle student mentors • Embry-Riddle/Mainland determines product to outsource to Mainland students <ul style="list-style-type: none"> ➤ Non-critical path or done in duplicate • Mainland students embedded in the Embry-Riddle senior design course periodically (throughout project) – deadline mid-October
November	<ul style="list-style-type: none"> • Embry-Riddle develop a design based on requirements • Mainland begins working on outsourced item
December	<ul style="list-style-type: none"> • Mainland delivers outsourced item. • Embry-Riddle/Mainland students participate in joint critical design review
Spring	<ul style="list-style-type: none"> • TBD / Revised given fall semester. New task will be outsourced with an early April delivery.

The Next Steps

The Fall 2010 semester involved the development and delivery of high school computational thinking material and the creation of vertical teams. At this point activities and materials are under development and not analyzed and reported further.

The following future activities are planned for 2011:

- Continue collaboration with non-computing courses;
- Extension to computing courses for non-majors;
- Development of materials for broader dissemination;
- Pre-college activities - trial implementation;
- Pre-college activities – collection of instructional material;
- Engage with industrial representatives as InspireCT partners;
- Develop and deliver workshop focused on pre-college activities; and
- Implement vertical integration across computing courses in the major.

Two additional workshops are planned for summer 2011 and 2012. The main objective of the 2011 workshop is to expand on building relationship with additional pre-college students and teachers, and continue our activities with university faculty. The main objective of the final workshop (summer 2012) is to collect and share the experience gained throughout the project, and provide a forum for industry representative, faculty, and pre-college participants to discuss and plan for additional activities. An ongoing activity is to assess the extent and quality of InspireCT influence, and to evaluate the degree to which the InspireCT goals have been achieved.

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