Computational Thinking in High School Courses

Vicki Allan
Computer Science
Utah State University
Logan, Utah 84322
vicki.allan@usu.edu

Valerie Barr
Computer Science
Union College
Schenectady, NY 12308
barrv@union.edu

Dennis Brylow
Math, Stat & CS
Marquette University
Milwaukee, WI 53201
brylow@mcs.cs.mu.edu

Susanne Hambrusch
(Moderator)
Computer Science
Purdue University
W. Lafayette, IN 47906
seh@purdue.edu

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1. SUMMARY
The number of undergraduates entering computer science has declined in recent years. This is paralleled by a drop in the number of high school students taking the CS AP exam and the number of high schools offering computer science courses. The declines come at a time when career opportunities in CS continue to grow and computer science graduates are seen as crucial in building a globally competitive workforce for the 21st century. Efforts aimed at reversing the declining interest in computer science include curriculum revisions at the undergraduate level at many institutions, a re-design of computer science AP courses [1], and the inclusion of computational thinking into disciplines outside computer science [3].

This panel discusses four projects of computer science researchers collaborating with high school teachers on integrating computing and computational thinking into their courses. The majority of the high school teachers involved is teaching science and math courses. They are teaching a diverse group of talented and college-bound students. The goal of all projects is to integrate computing into disciplines represented in the high school curriculum and to raise the awareness of computer science as an exciting and intellectually rewarding field.

This panel will outline recent and on-going activities and interaction with high school teachers. Each panelist will describe how he/she got involved and the nature of the interaction. The panelists will talk about their individual projects, outline their visions for future interactions, and how their effort can be replicated by others. The session will briefly describe NSF’s RET program which provided teacher support for three of the four projects. The session will then be opened for discussion; the audience will be encouraged to ask questions and contribute additional ideas for the inclusion of computational thinking in high school courses.

2. SUSANNE HAMBRUSCH
The "Science Education in Computational Thinking (SECANT)" project at Purdue University collaborated with two high school physics teachers to incorporate selected material of the Matter&Interaction (M&I) Curriculum with computational thinking principles into high school physics courses [3]. The high school course includes three weeks of Python programming focusing on computational methods and visualizations crucial to the M&I Curriculum. Lab material developed within this project gives a first introduction to programming. Throughout the school year, students use computation to illustrate and simulate physical principles and models, and they apply computational thinking concepts. The computational concepts include designing repeated processes through iterations, determining how data generated is stored and represented, abstracting and generalizing physical processes, and visualizing the collected data to observe patterns and other phenomena.

This approach is currently implemented in the AP Physics course. The high school devotes a full year to AP Physics and has some flexibility on what material to cover. Introducing computation into AP Physics provides a unique opportunity to upgrade the non-prescribed part of the AP course and to interest and expose high-ability students to computation. A future plan is to include selected computational material into Physics 1 and 2.

The panel presentation will describe challenges and successes of this on-going effort. This will include highlights on how decisions were made on what computational material to include, how software installation issues were resolved, how students with widely different problem-solving interests and abstraction abilities were engaged, and how the use of visualization and encouraging creativity played a key role in keeping students interested.

3. VALERIE BARR
The Union College CS department is engaged in a project to “Create a Campus-Wide Computation Initiative”. The goal of this project is to interest non-CS students in the role of computation in their field and encourage them to seek a strong computational foundation. Each summer, the project works with a number of faculty-student pairs who design a curricular element (labs, module, or complete course) that will infuse computation into their discipline. The ten academic departments who have pursued
this opportunity include Astronomy, Biology, Classics, Economics, Film Studies, and Political Science.

In Summer 2009, the project collaborated with two teachers from Bard High School Early College (a joint project of Bard College and the NYC Dept. of Education). One teaches chemistry, physics, and math while the other teaches math and statistics. Each teacher chose one course into which to initially infuse computation, a 10th grade advance math course and a statistics course. In both cases the infusion will take place across the entire semester, rather than being limited to one discrete part of the course (as an early college program, Bard runs on a college model with two semesters per year). One teacher will be weaving computation into a statistics course, using Sage (built on Python), while the other will be using Python to introduce computation into a 10th grade advanced math course. As the other courses, computation will be used to support the disciplinary work, but at the same time students will be introduced to programming, problem solving, and computational thinking.

The panel presentation will include discussion of the interactions and on-going collaboration between the high school and college faculty, and the roll out of the revised high school courses. The modified courses will complete in January 2010 and teacher and faculty, and the roll out of the revised high school courses. The panel presentation will include discussion of the interactions and on-going collaboration between the high school and college faculty, and the roll out of the revised high school courses. The modified courses will complete in January 2010 and teacher and faculty feedback will be available by the time of SigCSE.

4. DENNIS BRYLOW
For five years, the “Linking Mathematics and Computer Science” summer workshop series at Purdue has sought to inform and inspire high school mathematics teachers, arming them with the tools to motivate state-mandated curriculum topics with powerful examples in computer science. This past year, Marquette University has instituted a “Computational Thinking for the Sciences” spin-off workshop aimed at high school science teachers. For both workshop series, our goal is to exploit the natural linkages between existing topics in secondary school math/science and post-secondary computer science and engineering. Rather than concentrate on adding new, additional content into high school courses already bursting with mandates, we seek instead to show the many ways in which current topics are deeply important to students who choose to pursue college degrees in computer science, information technology, engineering, or the hard sciences. We offer enrichment activities that encourage algorithmic thinking and logical exploration. In the laboratory component of the workshops, we also generally teach tools designed to help high school and middle school students explore computation and computer-based problem solving: past tools have included Alice, SketchUp, and VPython.

The panel presentation will describe the challenges inherent in recruiting high school math/science teachers, designing coherent computational content within the strictures of a multitude of state curriculum standards, and making a workshop relevant for teachers ranging from pre-Algebra and Trigonometry to AP Physics and Biology.

5. VICKI ALLAN
Some who are trying to make changes in computer science curriculum have been believers in the "Field of Dreams" motto, "If you build it, they will come" or perhaps "If you build it and design a good book around it, they will come." This fails to account for the fact that we may not understand what "it" we should build, nor the fact that "they" are so busy they may not be able to come.

The Computer Science department of Utah State University has been funded to create and evaluate a collection of Interactive Learning Modules (ILMs) which can be used to transform computer science education (csilms.usu.edu). In addition to using the ILMs to engage Computer Science students in learning, we also seek to use such modules to attract new students to the discipline. Much research has suggested that the effort to entice more students to computer science needs to begin much earlier than the first day of college.

To help us design and evaluate material for use in K-12, four teachers were brought to the USU campus. Benefits of this interaction are many. While college professors know which skills are required to pursue a degree in computer science, they may not know how to get young students to that level of competency. Engaging activities need to be built around competencies specified in the state standards. The RET teachers helped us to understand how those competencies are being interpreted and what support the teachers need to succeed in achieving them. Many of the administrators who decide the curriculum in technology and computers substitute computer literacy for computational thinking. It takes a merger of both viewpoints to find activities that satisfy both state standards and the goals of computational thinking. The panel presentation will discuss ways others can use the customizable ILMs to support computational thinking in local schools.

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7. REFERENCES