CONNECTING UNDERGRADUATE PROGRAMS TO HIGH SCHOOL STUDENTS: TEACHER WORKSHOPS ON COMPUTATIONAL THINKING AND COMPUTER SCIENCE

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ABSTRACT

The high school preparation of future computer science undergraduates can be varied and depends strongly on the experiences and subject knowledge of their high school teachers. In an effort to connect undergraduate computer science programs to high schools for future student success in college, a public comprehensive university is hosting high school teacher workshops to help teachers enhance their teaching effectiveness. This has established a pathway from the university to the high school. Pre- and post-workshop surveys show that these teacher workshops have changed the perceptions high school teachers had regarding careers in computer science.

INTRODUCTION
High school students are commonly exposed to traditional math and science (Biology, Chemistry, Earth Science, and Physics) as part of their high school curriculum but exposure to computer science and associated computational thinking is frequently absent from the high school experience in the United States. One theory is that today’s classroom teachers are not aware of the materials available to them for use with students and are not aware of the professional opportunities available to their students upon graduation. While using computers may be part of the learning experience for students, problem solving and an understanding of what computer scientists, computational scientists, and information technologists do after college is not universally held among the teaching population in high schools [1, 2].

The importance of computer science to the national curriculum has been addressed by some states with teacher certification programs [3]. This paper does not presume to address the large topic of K-12 teacher certification in computer science, but instead provides an experience report on university faculty interaction with high school teachers during which improving student preparation for university study in computing and computer science was the focus. By holding teacher workshops for high school teachers, a public comprehensive university updated and enhanced ideas current high school faculty had regarding applications of computers in the sciences and the utility of computational thinking in high school.

VENUE AND AUDIENCE

The decline in computer science (CS) majors in the United States is known [4, 5]. Between 2000 and 2007, enrollment in Computer Science by undergraduates in the United States declined 50%. More than half of the college students that initially declare a major in computer science change their majors prior to graduation and the majority of students stop studying computer science by the end of freshman year [6]. Over the years, a number of university outreach efforts have been used to attract students to the major. Faculty visits to high school classrooms, high school student visits to university campuses, and interaction with faculty, are often thought to be the ideal recruiting vehicle. In reality, for all but the most selective institutions, getting students excited about computing may encourage them to major in computer science or information technology – but not necessarily in the visiting faculty member’s department. The high school students may (probably) go elsewhere. A correspondence between university and college faculty visits to high school classrooms and increasing enrollment in the major at the home institution is non-existent. Furthermore, students move on and university faculty visits to the high school must be annual or bi-annual at the least to keep student awareness of computer science high.

An alternative paradigm was considered: what if the emphasis of university and college faculty moved from engaging high school students to engaging their teachers? High school teachers have the potential for tremendous impact on their students, and do not leave a high school with the 4-year predictability that students do. The importance of high school teachers in recruiting undergraduate computer science students has been recognized by others, and well-regarded multi-day regional residential workshops, such as those held by the CS4HS group over the past five years [7], demonstrate the utility of teacher workshops in enhancing teacher effectiveness in high school computer science.
education. However, the one-day effort presented here is more inclusive, as math, science, and computer science teachers from high schools are welcome, not just computer science teachers, and the one-day workshop has the potential to impact a larger group of teachers. Additionally, this one-day workshop allowed teachers who would otherwise not been able to travel away from home for a week of professional development to attend. Another benefit is that one-day workshops can be and are presented more than once a year, with new workshop talks and presentations added to subsequent offerings.

As a result of this thinking, and in coordination with the College of Education, a one-day workshop for high school math and science teachers was developed, offering teachers continuing education units (CEUs) if they attended. By holding the workshop on the university campus, university students and facilities would be available for demonstration and discussion. This would offer the greatest opportunity for high school teachers to ask questions and exchange ideas in a manner which might not be possible in their home school and district. With the support of the Computer Science Teachers Association (CSTA) [8] and the National Center for Women and Information Technology (NCWIT) [9], a workshop proposal was developed and vetted by local high school faculty and CSTA chapter members. Once consensus was reached, the event was promoted and registration via a website [10] was conducted.

ENVIRONMENT

Nationally, discussion regarding CS preparation at the high school level usually considers AP Computer Science test preparation and results as the strongest indicator of student success at the college level in computer science. While this remains true, there are many students who are not exposed to computing or computational thinking in high school despite personal interest and aptitude, and unless they are quickly located on a university or college campus may not be able to master the skills needed in the time provided for university success in computer science. Due to these factors, by the time students get to post-secondary education, it may already be too late for future success in computing.

Therefore, the goal of this workshop was to address the educational ramp from high school to university – the ramp which is the approach for students considering computer science or any discipline involving computational thinking. In light of NSF’s planned “10,000 school project” [11] which seeks to develop a new pre-AP secondary school curriculum in fundamental concepts of computing and computational thinking, with the goal of having this new curriculum taught in 10,000 schools, a professional development pipeline to current math, science, and computer science teachers is vital.

With the professional development model in mind, workshop notices were circulated to potential workshop participants through local CSTA chapter e-mails to members, graduate education classes, and the superintendent offices of regional school district offices. Additionally, an AP Computer Science list server received a posting from a CSTA member, which also reached another community of potential workshop participants. These approaches worked well, with the CSTA chapter e-mails being the most effective. The workshop notice was directed at high school math, science, and computer science teachers and the workshop participants came strongly from those areas,
with many teachers having primary responsibilities which included teaching computer science or mathematics. Physics, chemistry and biology teachers also attended.

Workshop Presentations

The workshop day started with a welcome. Two 90-minute sessions were offered in the morning. After lunch, three 90-minute sessions were offered. On occasion, popular morning offerings were repeated in the afternoon, so the participating teachers did not have scheduling conflicts. Usually, at least five topics were provided on the workshop registration site, in order to offer a selection. A sample of recent workshop presentation topics is provided in Table 1.

| Computational Concepts with Alice          |
| Modeling Tools for Science and Mathematics |
| 3-D Visualization                      |
| CS, IT: Computational Science and Your Students: Why Not? |
| CS Unplugged: Computing without a Computer |
| Preparing Students for University Success in Computing |
| Project Interactivate-toolkit for high school mathematics |
| Easy Java Simulations                   |

Table 1. Representative Workshop Presentations

Future workshops will include sessions on peer-led team learning (PLTL), pair programming, and hosting and preparing students for student programming contests. Discussions between workshop sessions and over lunch have been very productive, with university faculty hearing about activities in the high schools, and high school faculty viewing university student research posters and demonstrations.

Survey Results

Pre-workshop surveys administered identified that the teachers attending the workshops usually have at least five years of teaching experience and many have more than fifteen years of experience. The majority are from public, suburban districts; a few are from private schools. Some C++ programming is taught to students, but the Java programming is taught by more teachers. Most participants had never attended a computer science or computational thinking workshop before. The high school teachers considered themselves good at programming, and spreadsheets, with lesser skill reported in database management and computer-based modeling. Their expectations for the workshop included networking opportunities, learning about computational thinking, and understanding more about professional opportunities in computer science for their students.

After attending the workshop, post-workshop surveys were completed. All teachers indicated that they felt much more comfortable advancing the use of computing and computational thinking in their classes – which ranged from computer science, to high school mathematics and science topics. The potential for infusion of computational science throughout their curriculum was a real success story from the day, as far as the
university faculty were concerned. Problem-solving techniques using computational tools, take-back curriculum materials, career opportunities for students, and preparing their students for success in computing at the university level were all additional positive outcomes from the workshop.

The presenting university faculty had been particularly concerned that the workshop participants have materials, including web sites and exercises, which could be used in the high school classrooms. This is a distinction of this effort and this emphasis shined through, as workshop participants were very grateful that demonstrations and lectures they had attended resulted in not only verbal ‘take-away’, but also classroom-ready hands-on materials. This was a factor in rating this event as “one of the most outstanding professional development events I’ve attended” as one participant stated. The modeling and visualization tools demonstrated seemed most suited for the computer science and mathematics teachers, although chemistry teachers indicated that they planned to use the modeling and visualization tools also.

Overall, the workshops have been very successful, with participants asking about future workshop dates and suggesting topics which might be added in the future. The importance of computational thinking and computer science to their students’ future was very clear to the participants, as well as the resources which were available to them in the form of local university faculty. Comments are listed in Table 2.

<table>
<thead>
<tr>
<th>Comment</th>
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<tbody>
<tr>
<td>I am more aware of advances in this field and career paths available to</td>
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<tr>
<td>those with degrees in Computer Science and Information Technology.</td>
</tr>
<tr>
<td>I will encourage more students to consider computer science as a major.</td>
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<tr>
<td>Became aware of the term “computational thinking” and plan to emphasize</td>
</tr>
<tr>
<td>it in my classes.</td>
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<tr>
<td>I learned that computing may be done on all levels and with minimal</td>
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<td>prerequisites.</td>
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Table 2. A Sample of Workshop Attendee Comments on the Post-Survey

The strongest endorsement has come from the repeated workshop participants. By varying the program with each workshop, prior participants are able to find new sessions to attend, and have indeed returned to succeeding workshops after their initial experience. Table 3 shows the most important part of the workshop – the change in perception of computer science as a major and the host university as a choice for their students.
I would recommend Computer Science, Computational Science, or Information Technology to my students as a career.

<table>
<thead>
<tr>
<th>Pre-Workshop</th>
<th>Post-Workshop</th>
<th>Percent Change</th>
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<tbody>
<tr>
<td>45%</td>
<td>72%</td>
<td>27% increase</td>
</tr>
</tbody>
</table>

I would recommend my students consider attending the Workshop Host University for college.

<table>
<thead>
<tr>
<th>Pre-Workshop</th>
<th>Post-Workshop</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>33%</td>
<td>63%</td>
<td>30% increase</td>
</tr>
</tbody>
</table>

Table 3. Comparison of high-school teacher attitudes pre- and post-workshop

LESSONS LEARNED

Schedule the workshop early in the school year. High school teachers are busy during late May or June, with advanced placement examinations, final exams, moving-up ceremonies, proms, and graduation. Our first workshop was held in June, which resulted in a smaller turnout than expected. Subsequent workshops have been held during the fall, with greater attendance.

Work with your prospective audience when developing the workshop agenda. Local CSTA chapters are of invaluable assistance in reviewing drafts.

Consider whom you’d like to invite—and make sure you do. Targeted outreach to magnet schools and alumni can be very effective. E-mail specific professional communities you would like to include.

Think off-campus. Consider inviting speakers from outside the university who may be collaborators or employers of your students. This will provide interesting perspectives, and real-world stories, which are a strong complement to the workshop agenda. Our efforts have included several national and international speakers, which have been very well received by our participants, who appreciated the expertise which was shared with them, both from the ‘locals’ and the ‘out-of-town’ people.

Do a post-mortem. Follow-up with your participants and within the workshop team to see what additional ideas and insight may have developed. The team meeting should be held shortly after the workshop concludes. Plan on following up with your workshop participants by building a mailing list of math, science, and computer science high school teachers in your region which can be used to further develop post-event networking and communication.

SUMMARY

The workshop has become a regular campus event, with both high school teachers and university faculty looking forward to it and thinking about what might be useful to include in the workshop agenda. Current university computer science and information technology majors enjoy volunteering at the event and answering questions about their own preparation prior to university and their experience once on campus. This has served to personalize the ‘computer science student’ to the high school teachers in such a way
that they can share with their students, when they return to their high school, what a computer science major really works on and how he or she got to that point.

The effectiveness of the workshop in the high school community is rated highly as increasing awareness of opportunities in computing and information technology at the local university. Teachers openly indicate that they are now suggesting to their students that they consider majoring in computer science or information technology and consider the local university. With first-hand knowledge of the faculty, resources, and facilities, this recommendation is of the highest priority. A tracking project is underway to identify students recruited to the major as a result of their teacher’s workshop experience as well as to determine how frequently high school teachers are able to work with the materials shared with them during the workshop.

REFERENCES


[7] www.cs.cmu.edu/cs4hs/ Explorations in Computer Science for High School Teachers


[9] www.ncwit.org National Center for Women and Information Technology

[10] www.kean.edu/~cssc