Effective In-Class Activities for Middle School Outreach Programs

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Abstract - In the summer of 2007, we established the Utah State University Computer Science Outreach Laboratory as a partnership with a local K-8 school. One major advantage of this outreach program is that we are able to interact with all students in the target grades, not only those who are already interested in computers, as would happen with a computer club or other extracurricular program. This paper presents a sampling of the periodic in-class activities led by University faculty members and volunteer students. Through these activities participants have the opportunity to learn about a variety of computing topics. The core goal of this program is to increase the interest levels in computing among these young students. While the long-term effects are not immediately apparent, surveys of participating students indicate that activities are making a valuable impact. This is supported through our personal observations of, and interactions with, the student participants.

Index Terms – K-12 outreach, computing education.

INTRODUCTION

A glaring problem in the computing field today is the lack of females and members of certain ethnic minority groups. While it is important to address this problem at an industry-level, academia must also do its part in encouraging students from these underrepresented groups to pursue computing degrees and careers.

The number of computer-related jobs is expected to continue to climb, and it is questionable if there are going to be a sufficient number of graduates to fill these positions in the years ahead. This provides a fantastic opportunity and challenge to minimize the employment problem by addressing the diversity problem.

In order to address this problem locally, we established the Utah State University Computer Science Outreach Laboratory (CSOL) in partnership with a local public K-8 school. Since 2007 we have provided periodic in-class activities for the middle school aged students.

One major benefit of our program is the ability to interact with all students in the target grades, not only those who are already interested in computers, as would happen with a computer club or other extracurricular activity. This model makes the CSOL a true outreach programs as we are impacting students whom would otherwise not be involved.

This paper focuses specifically on the individual activities and their effectiveness in engaging the students and increasing their interest in computing. Each activity lasts approximately 45 minutes. Sample topics include Internet safety, programming basics, computer hardware, message routing, graphics, and encryption. The presentation formats vary between different activities. Some require individual work, while others incorporate group interaction. Additionally, some may require the use of a computer, while others do not.

One purpose of program is to help create an effective curriculum that can be used as a turn-key program for others to use in their outreach programs. Of particular interest is the use of Interactive Learning Modules (ILMs) that are being developed by the authors as part of an NSF CPATH funded grant. The CPATH grant focuses on the development of web-based learning modules across the computer science college curriculum, but we have been able to incorporate ILMs that teach very basic concepts into our outreach program.

This paper presents a sampling of activities, including an assessment of each activity, and the constraints that must be considered prior to executing an activity. The concluding analysis provides survey and observational results that indicate the activities have a very positive impact on the students.

RELATED WORK

The literature shows a number of studies that investigate the reasons behind the diversity problem (especially among females) in computing [1]-[3], as well as studies that assess programs designed to curtail the problem [4]-[5]. Studies such as these are invaluable resources in designing and establishing a departmental outreach effort.

Technology-related fields continue to expand, providing new and interesting career opportunities for our graduates. In fact, of the top ten fastest growing professions, five are computer related [6]. However, interest in CS fell by 80% between 1998 and 2004, and has dropped 93% since the 1982 peak of CS majors nationwide [8]. Unlike many fields where the representation of women has increased over time, computer science has experienced declines in the proportion of female graduates. In order to match future demands for information technology, we need to increase the participation of both men and women. Increasing diversity enhances the breadth of understanding in leadership positions, gives a different perspective in the marketplace, increases creativity, and improves problem solving, particularly in team situations [7].
Of particular interest to us is the issue of negative perceptions towards computing that are formed in the pre-
High School years among females [9]-[11]. While outreach is important at all levels, this indicates that the pre-
High School years are a critical time where perhaps the greatest fundamental change in how computing studies and careers are viewed can be altered.

THE CSOL MODEL

The CSOL model is centered on a relationship with a local primary or secondary school. More formally, the model is a long-term partnership between a university department and pre-college school at an administrative and a classroom level. The administrative support is important to foster a mutually beneficial program, while the actual face-to-face interaction takes place in the classroom.

On a monthly basis, faculty members from our department, along with volunteer undergraduate and graduate students, go to our partner school for activities. The activities last approximately 45 minutes per class, and we do the activity for four classes over two days.

This model provides a number of very important benefits. First, following the formation of the partnership we have not spent any time or effort in recruiting participants to our outreach program, as the program is incorporated into the classroom. This is significant as we have a limited amount of time we are able to devote to the program.

A second benefit is that we are able to interact with both a diverse, and a large set of students. Diversity, in this case, refers to the interest of students, as we are able to interact with every student, not only those with an existing interest in computing, as would be typical for an extracurricular club or summer camp. Many participants fall into the underrepresented group categorization. Each activity reaches approximately 130 students. In our opinion, any outreach activity of this size would be considered a resounding success. This is even more significant when considering that we do not engage in recruiting or marketing activities for the program.

Typically, three to five of our students volunteer their time to help with the activities. While the help from university students is not absolutely necessary for a successful activity, it allows us to provide more personalized attention to the young students. We are able to do activities in small groups, which has resulted in some very quiet students to engage in the activity more than they would normally, according to their teacher.

The long-term goal of this project is to have participating students enroll in computing-based majors upon entering college. However, it will be a number of years before we will be able to make that assessment. Thus, for now we measure our success through surveys and observations, as will be presented. These early results are very promising, leading us to have great hopes in the long-term impact our work will have on the young students.

ACTIVITIES

This section details a sampling of the activities we have done at the CSOL. There are a number of types of activities that can be done, as well as a great variety of topics. Topics of our past activities include programming basics, message routing, algorithms, Internet safety, and encryption.

In providing these sample activities, we note that constraints may exist which determine the types of activities which may be feasible. The constraints may be technological, or they may be the result of human resources. The following activities were selected as they vary greatly in the approach. Included with each description is a discussion on possible constraints and how they may be addressed, as well as a brief assessment of the activity.

I. Interactive Learning Modules and Hands on Activities

The authors are engaged in an NSF CPATH funded grant focused on building web-based Interactive Learning Modules (ILMs) for use across the computer science college curriculum. An ILM is a self-contained lesson that provides students the opportunity to learn topics in an engaging way through small educational computer applications.

While the ILMs are designed for use in college-level classes, we have had success incorporating ILMs that teach very basic concepts into our outreach program. In addition, during the summer of 2009, we were able to develop a number of 6-12 grade specific ILMs as part of an NSF RET supplemental grant that supported four public school teachers to work on the project with us.

Figure 1 is a screenshot of an ILM that is part of a lesson about computer hardware and internal components. The lesson consists of a two different ILMs, with Figure 1 showing the ILM pertaining to internal hardware components. The second ILM focuses on external hardware and peripheral devices.

The main window contains the interactive application that allows students to click on components and learn about their function. The student then drags and drops the piece into the appropriate position in the computer. If the student places the component incorrectly the piece simply returns to its original position outside the computer housing. The images are actual photographs of the inside of a computer and the individual components. Thus, the activity simulates, as much as possible, the actual experience of putting together a computer.

On the right side of the browser window is a section for instruction and assessment. Individual teachers may customize this portion of a lesson to best meet the needs of their class. The instruction panel can be used for assessment and supports a number of different types of questions. The given example contains multiple-choice questions that the students must answer. The responses are recorded and the teacher can use these for grading and assessment purposes.
As part of this outreach activity we incorporated a hands-on experience. While the majority of the students worked on the web-based lesson, a small group of 4 – 5 students would work on an actual computer at the front of the room. We supplied the computer to the classroom as it was destined for the junkyard. Outdated and broken, it served no useful purpose, but provides a fun resource for the class.

Due to the number of students and time allotted, each group was only given 6 minutes to identify key components, remove them from the computer while they explained what the component did, and then finally “install” the pieces back into the computer. One teacher or volunteer student was involved in this activity at all times asking questions about components and helping students figure out where things go and how to get them in.

This hands-on portion of the activity was very popular with the students. Prior to starting the activity we asked how many of them had taken apart a computer, with a few students having done so in each class. For most students it was a new experience and it was very enjoyable. We only had two rules: no student could grab a piece of the computer from another student; and no student could tell another student what they could or could not do. Even typically very quiet students got very involved in the activity.

This activity is possible in a variety of situations. An individual teacher can use this activity, as only the hands-on group needs oversight. The students on the computers are able to complete their tasks in a self-guided manner. In our case, however, we had a number of volunteers who were able to look over the shoulder of students on the computers and ask questions about what they were doing. The young students seem to really enjoy this personalized approach to the activities, even though it is not a critical piece to completing the activity.

This activity assumes that the classroom is equipped with Internet capabilities. We presume that obtaining a broken computer is possible though a parent donation or from a discarded computer within the school. Thus, this activity is one that can be accomplished in any computer class.

II. Programming with Alice

We believed we were taking a bit of a risk when we decided to use Alice as part of an outreach activity. The activities only last 45 minutes, and that includes time to gain the students’ attention, make any regular class announcements, and introduce the activity. While we did not doubt that the students could catch on, we worried that the time limitations would leave the students in a state of confusion, as they might need more time to grasp the system. Fortunately, our worries quickly proved to be unnecessary.

During the introduction of this activity we ask the students about programs they use at home or at school. Responses include word processing, email, web browsing, and many other common applications. We then talk about things they use that have programs, even if they don’t realize it. They are surprised when we mention cameras, iPods, DVD players, and other such systems. We conclude the short introduction with a brief discussion about computer programmers and how they build all of these things we use. Finally, we tell them that they are going to build a program, just like computer scientists do.

In our experience with using ILMs, we have observed that students enjoy the self-paced nature of the activities and stay on task much better than class-paced activities. Thus, instead of teaching a lesson about Alice, we gave them instructions on how to get to the introductory tutorial, then allowed them to work at their own pace. The built-in tutorials are very good, and most students were able to complete the assigned tutorial without asking any questions. Between the teacher and our small group of volunteers we were easily able to answer any questions that did come up.

Once the students finished the tutorial they were simply “set free” to experiment with the program. About 10 minutes into the activity we stopped everyone and gave a quick lesson about how to add objects to the program. At that point, however, many students had already figured out how to do that. We stopped the class one other time to introduce the “do together” box to enable them to create parallel movement/actions in their programs.

We were quite amazed at how quickly most of the students were figuring out new things and creating funny and interesting “movies”.

The volunteers were each in charge of a small group of students and answered questions, and provided motivation and direction by helping students come up with ideas for their movie, and figuring out how to make it happen.

The classroom has the capability of displaying an individual student’s computer display on the classroom project. This enabled us to pick a few of the best programs and show them to the whole class. The first time we did this activity, however, this feature was not available, and we allowed students to circle the room during the last 5 minutes to see each others’ work.
The Alice activity was meant to be a simple introduction to programming. What followed, however, was a complete surprise. The first instance of this activity was in April of 2009. The following school year we had students asking when we were doing Alice again. We were surprised that after such a long period of time they remembered the activity and were anxious to do it again. We finally did the activity again in January 2010. When we announced the activity of the day many students responded with cheers. Needless to say, that is not the typical response to a daily lesson.

At the start of the February 2010 activity we asked how many students had downloaded Alice at home. An informal survey of raised hands indicates that approximately 20% (about 5-7 students from each class of 30) tried it at home. We were excited that approximately half of the students were girls. Many that tried just continued learning the system on their own, while a few completed the more advanced tutorials.

We have not tried this activity without student volunteers. It might be difficult for a single teacher to turn 30 students loose to work on their own, as answering questions on an individual basis might become overwhelming. However, in our experience, having 2-3 people answering questions would be possible.

In the second year we had a number of students who had completed the activity previously. Instead of repeating the first tutorial, these students completed the second. Even though almost a year had passed, they were able to quickly jump in, finish the tutorial, and use their new skills in their programs. The number of questions asked in the classes that included these students was less than in other classes.

III. Message Routing

The message routing activity is one that does not use computers at all. The activity is introduced with a discussion about the Internet and how data gets from one place to another. We also talk about the U.S. mail system and students explain how they think the entire system works.

The activity is taken from the CS Unplugged website [12]. Each student is given a number, which we printed on 3x5 index cards. One card is pinned to the students’ shirt, and the other two are used as “messages” in the system. Students are arranged in varying “architectures” such as a circle, grid, or a line.

The message cards are passed out randomly with one card withheld. The rules follow that a neighboring student may pass a card to the student who only possesses one card. The goal is for every student to possess the cards that match the one pinned to their shirt.

We started with small groups to help the students understand the card passing rules. Over the course of the period, we increased group sizes and changed the architecture. With each new configuration we had a competition between each group to see who could finish the fastest. We concluded with a circle comprised of the entire class.

One of the most interesting things we observed in this activity was the interaction between the boys and the girls. As the groups increased in size it seemed that the girls dominated the group in giving directions for how the cards should be passed. We even did a “boys vs. girls” competition and it was interesting to see the organized and coordinated effort of the girls, with lots of talking and discussion. The boys, on the other hand, did not have the same coordinated effort. We do not make any claim about the reasons for this difference, as there are many possible reasons. We note this simply because it was enjoyable for us to observe the different types of social interaction.

This activity is one of many that can be drawn from the CS Unplugged website. We had a few volunteers to help us with this activity, but we believe it is possible with a single teacher, or only a few volunteers. One change that would probably need to be made is that the initial round may need to be shown by example with a small group doing the activity and others watching.

ANALYSIS

The long-term goal of this project is to increase the number of majors entering computing-centered fields. This assessment, however, will not be available for many years as our outreach laboratory has only been existence for a short time. Thus, our assessment to this point is only based on our own observations and through surveys completed by the students.

In many ways we feel our purpose is to motivate students to be interested in computing. During monthly 45-minute lessons we feel limited in our ability to actually prepare students for studies in computer science. Additionally, because we are targeting middle-school students, the computer curriculum is focused on basic computer skills, not topics that are designed to prepare students for future studies.

As mentioned previously, interest levels in computing among young students, particularly females and those of underrepresented minority groups, are low among High School students. Thus, by acting as a motivating force, we hope to increase the interest levels among our participating students. We feel it is valuable to focus on activities that are memorable and enjoyable, in order to increase interest levels. We want students to associate computing with the fun and exciting activities we provide.

I. Observations

We have no doubt that the students enjoy our monthly activities. Initially, we were surprised by the excited and positive reactions we received from students when they saw us in the hallway before class, or as they walked into the classroom while we were setting up.

The middle school teacher has often commented that he is surprised that certain students will make comments, ask questions, or simply become engaged with the activities, as
these students typically are very quiet and keep to themselves. For these individual students we believe the activities have been very beneficial.

As stated previously, an informal survey showed that approximately 20% of the students downloaded and used Alice at home, including a number of the female students. This was very exciting to us as it shows that many of the students have a real interest in our activities.

We are typically able to have 2-4 volunteer university students attend each activity. It appears that the young students enjoy the interaction with the older college students. The individualized attention is something that is not possible with a single teacher. We have done a few activities without volunteers, or with only a single volunteer, and do not believe that a lack of help hinders the ability to perform many types of activities. However, the volunteers do seem to add significantly to experience of the students.

As the students appear to enjoy each of our activities, it is important to solidify in their minds the tie between their experience and computer science studies. After completing a few activities in the second year of the CSOL, we asked the students what department we were from. Most knew we were from Utah State University, but none knew we were from the department of computer science, even though we would mention the name each visit.

In order to ensure that they knew which department we were from we used a “word of the day”. Each time a teacher or volunteer said the word of the day, the students had to yell, “Computer Science Uggh”. Since that time we have not repeated that activity, but the students remember us. When we ask where we’re from at the start of each activity a handful of students will shout the word of the day phrase back. Among the rest of the students, the vast majority will simply say, “Computer science”. While this may appear to be a silly exercise, we believe that the students do know who we are, and that they associate the activities with computer science.

II. Survey

We have conducted two surveys over the past two years. At the end of the 2008-2009 academic year we completed a short survey asking general questions about the activities. This year, we completed a survey specific to the Computer Building activity described earlier.

The end of year survey included 72 students. Approximately 100 students were involved in the activity, so not all students responded. The interpretation of the survey results requires some subjective analysis. The class teacher has indicated that for many students it does not matter what is asked, you will receive a negative answer. Thus, while a fair number of students indicated all zeroes on the questions that asked to rate their enjoyment/interest, it may not actually indicate true feelings. We have not observed any students appearing to be completely disinterested in any activity.

On a 0 – 10 scale, the students rated their enjoyment of the activities at a 7.6. As one main purpose is to motivate students we feel this is an indicator of success.

Of the remaining rating questions, the most important asks the students to rate how the activities have changed how they enjoy computers. “0 = I like it less now, 5 = about the same, 10 = like it much more now”. The average rating was 6.9. This is a positive result and supports what we observe in the classroom.

The survey includes some free response questions which, again, requires some subjectivity in reviewing. There are many positive responses such as, “Come more. A lot more!” and “Awesome”. However, there are some such as, “Bring cookies”, and others which show that the students didn’t care about the survey.

The single activity survey had similar results that require some subjective analysis. However, the overall results are still very positive. 120 students completed the survey.

When asked if the activity was enjoyable, 42% stated that it was “extremely enjoyable”; 36% said it was “somewhat enjoyable”; 14% said it was “not enjoyable or frustrating” (no opinion); and 8% said did not enjoy the activity at all. The free response questions indicate that the hands-on activity was the favorite part of the activity.

Through our observations and the student surveys we believe that the monthly activities are having a positive impact on the students’ interest levels in computing. While the surveys are somewhat difficult to interpret, as it is clear that many students do not take them seriously, our observations, as well as that of the teacher, indicate that we are making a positive impact.

FUTURE OUTLOOK

We are excited and look forward to a lasting relationship with our partner school and host of the USU Computer Science Outreach Laboratory. As we refine activities we look forward to creating a packaged “system” that we can share with others who desire to create a similar outreach program.

It will be many more years before we are able to assess the long-term impact of our program. In the short-term, however, we believe we are making a positive impact on the students while they are in the years where interest in computing often wanes.

In order for our program to reach its greatest potential, we must add to our program and interact with the students as they enter High School. This, however, requires time resources which we do not currently have available. We are still hopeful, however, as our university is located in a “college town” where many students stay for college. In addition, we are able to participate in the recruiting activities at the high school, which our participating students attend. Thus, we are hopeful that our work will still have an impact that will last until the time the students make decisions about college.
We hope to be able to extend our reach to other local public schools, but, again, time constraints prevent us from doing so. It is obvious that our model does not scale. It could be modified to become a package of activities for a teacher to use, but the “special guest” aspect of activities is an important one for the students. Otherwise, the activities become just another lesson by the same teacher. We are not concerned with the lack of scalability, as we are pleased that we are able to interact with over 100 students on a regular basis with relatively little time commitment.

CONCLUSION

This paper presents a sampling of activities that we have conducted at the Utah State University Computer Science Outreach Laboratory. The CSOL is a partnership with a local public K-8 school with the goal of providing fun and exciting computing-centric activities for middle school students. Studies show that students’ interest in computing often wanes during the pre-High School years. Thus, our goal is to increase interest levels in computing for the purpose of increasing the number of students enrolling in computing-based studies.

Through student surveys and our own observation, we believe we are making a positive impact on the students. While surveys are difficult to interpret due to the attitude toward filling out the surveys of some students, generally, the results support our own observations. Students are excited to see us there for activities, and are actively engaged for the entire activity.

The long-term goal of increasing enrollment numbers at the college level will not be assessable for many years. However, we are encouraged by early indicators of our success in motivating students and increasing interest levels.

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REFERENCES


CS Unplugged: http://www.csunplugged.org

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