In Computer Science & Information Technology Symposium, New York, NY, USA, July 2011.

When Robots aren't for Everyone—A Smorgasbord of Exploratory Computing Experiences

Matthew Meyer and Elizabeth Sklar
Department of Computer and Information Science, Brooklyn College
Department of Computer Science, The Graduate Center
The City University of New York
Brooklyn, New York 11210 USA
meyer,sklar@sci.brooklyn.cuny.edu

1 Introduction

Recent trends in computer science teaching at the introductory level have advocated the integration of context-based examples to capture students' diverse interests and expose them to a range of computing applications. Topics such as web design, game programming, and robotics have been successfully deployed in classrooms at high school and undergraduate levels. Over the last 5 years, we have contributed to these experiences by developing and implementing contextualized curricula in courses offered to inner-city high school students. Our syllabi include not only web design, game programming and robotics, but also a wide range of other topics, including PC hardware, cryptography, network security, GPS[1] and GIS[2], computer graphics, computer animation, and agent-based simulation. In all of these modules, we focus on the use of free software tools in order to minimize costs and maximize students' access to tools outside the classroom. The title of our presentation reflects one of our findings: that amongst our inner-city students, robotics has not been as popular as we expected; and when given a choice of topics, more students have chosen areas that appear more immediately relevant to their daily lives and interests.

In our presentation, we will share the high school computer science curriculum materials developed under the **Bridges to Computing** project (`http://bridges.brooklyn.cuny.edu`). Funded by the National Science Foundation (NSF) under their Broadening Participation in Computing (BPC) program (grant #05-40549), Bridges focuses on the transition years from high school to college. Bridges involves academic and social components geared toward high school students, and early and advanced college students. Bridges' offerings for New York City public high school students include our *Does It Compute?* summer workshop (an intensive 11-day course), as well as *Computing Prep I* and *II* (two courses offered in the Fall and Spring respectively). Students who pass a Bridges course receive a high school science elective credit through a partnership with the City University of New York (CUNY) College-Now program (`http://collegenow.cuny.edu`).

We begin with a discussion of our students: who they are, where they come from, and what their stated interests are. Then we highlight six reusable curricular modules that we have developed, tested and refined in our high school courses over the last 5 years. Finally, we close with a summary of feedback from students who have attended our courses. Our goal with the proposed presentation is to broaden the pool of curricular resources available to high school computer science teachers.

2 Who are our students?

Since Summer 2006, Bridges has reached more than 275 students from nearly 60 public high schools in Brooklyn and around New York City. Participants are largely immigrants from Asia, the Middle East, Africa, the Caribbean, Eastern Europe. Figure 1a shows the regions where parents of students attending the summer workshops in 2006 through 2009 were born. Most students have had little or no previous exposure to computer science. Bridges courses are constructed so that students are first introduced to several topics, after which they are allowed to pick a topic to research further. Figure 1b shows the percentage of students who picked each topic in the summer workshops from 2006 through 2009, illustrating that students are curious to learn about a wide range of topics, especially once they have been given a taste of something new.

Students who attend our courses complete an application that incorporates a pre-course survey. This application and subsequent feedback surveys provide us with demographic data, as well as information about students' interests

[1] Global Positioning System
[2] Geographic Information Systems

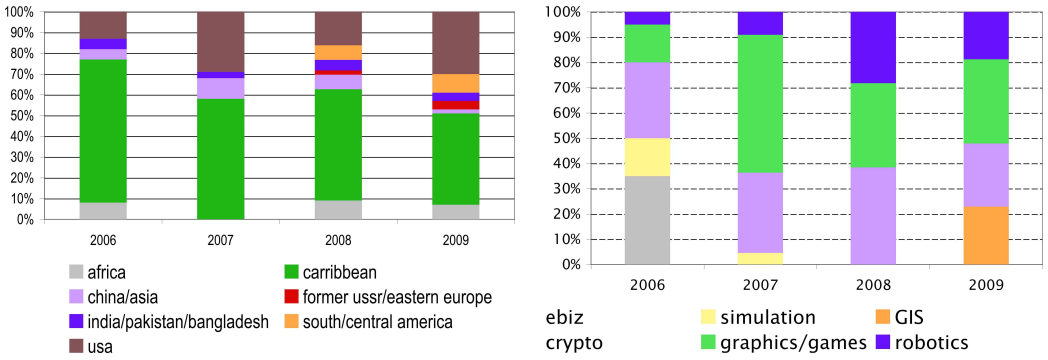

Figure 1: Students have diverse backgrounds and interests.

and their backgrounds in computing. These surveys have helped us create a strong picture of the population that we serve. When asked what topics interest them, many students stated that they want to learn how to write games because they play games. But equally many mentioned a range of other interests, for example:

- "I want to be an inventor and a programmer."
- "...I always wanted to learn how to write in codes."
- "I [am] interested in cybercrime and different hacking software."
- "...I want to work with the police department."
- "...I would be able to work as a spy or a hacker."

3 Reusable Curricular Modules

Bridges courses are comprised of a number of reusable curricular modules. Each module is a stand-alone, project-based learning unit that can be customized for different students, instructors and settings. Recurring educational themes have been woven into each of the modules including: the basics of imperative, procedural and object-oriented programming; the fundamentals of computer hardware; and the exciting employment and research opportunities that exist within the many sub-fields of computer science. Courses are conducted through student-centric hands-on activities, with limited lecture time. The aim is for students to become comfortable with a range of uses for computing applications and begin to absorb the tenets of computational thinking.

We have identified several advantages to using this indirect, mix-and-match approach. First, it acknowledges that not all topics will interest all students, and increases the likelihood of each individual student finding a topic that interests her/him. Second, it allows students to have multiple hands-on, project-based experiences within one course. Finally, by showing students the wide range of topics encompassed by the ever-expanding field of computer science, it helps break down preconceived notions among students about what it means to be a computer scientist.

The modular **Project Units** we have created are composed of 1-3 lectures, 1-3 labs, 1 or more homework assignments and a final "unit project". In addition to units on web design, game programming and robotics, we have developed modules that cover a diverse range of computer science subjects. Our project units include:

- **PC Hardware and A+ Certification:** How many of your students have ever opened up a computer? In this module, students are given a brief overview of A+ certification (`http://www.comptia.org/`) and the physical components of a "bare bones" computer system. The final project is a "computer autopsy", where students disassemble old discarded machines, and then try to reassemble them sufficiently to reach the BIOS screen.

- **Cryptography:** Have you ever wanted to send a secret message? This module introduces cryptography (writing secret messages), cryptology (breaking secret codes) and technologies such as symmetric-key, public-key, and certificate systems. For their final projects, students use GNU's free OpenPGP tool to create their own public/private key set, allowing them to send and receive email messages that only their chosen friends can read. This topic provides a context for discussion of privacy in social networks (`http://www.gnupg.org/`).

- **Network Security:** What does a hacker actually do? This module introduces the technologies that underly the Internet and the World Wide Web, focusing on the Internet Protocol Suite (Application, Transport, Internet and Link layers). In the unit project, students use Wireshark to eavesdrop on messages sent over an unencrypted network, and NMAP to scan the ports of a target machine. This module introduces and enforces the principles behind the "ethical hacker" movement (`http://www.wireshark.org/` and `http://nmap.org/`).

- **GPS and GIS Systems:** How does Garmin[3] know I should turn left here? This module explains latitude and longitude and details how the modern satellite-supported GPS system works. Students study GIS, and learn how GPS data can be used to display geographically linked information on maps. For their final projects, students use Google Maps and GIS concepts (they may also use cameras) to create maps to illustrate problems/ possibilities in their own neighborhoods (`http://maps.google.com/`).

- **Introduction to Graphics Programming:** How does computer animation work? This unit introduces the basic terminology used in 2D computer graphics (e.g., bitmaps, vector images, hex colors), and interactive programing, covers multiple techniques for creating animated images and establishes the conceptual framework used to create 3D images. In the final project, students create interactive, animated graphics programs using Processing (`http://www.processing.org`).

- **Agent-Based Simulation**: How is simulation different from animation? This module introduces agents, agent-based programming and multi-agent systems. Students are shown how interacting agents pursuing individual goals can accomplish complex tasks, and how agent-based programming can help manage complexity in large problems. Simulations of systems in the everyday world are discussed (traffic patterns and social networks). In the unit project, students design and create programs that model well-defined problems or phenomena using NetLogo (http://ccl.northwestern.edu/netlogo).

As well, we have created **Support Units** to help prepare and reinforce topics that are covered in the Project Units. These units are composed of only 1-2 lectures and include: Careers in Computing; A (Brief) History of Computer Science; Electricity and Binary Numbers; CyberCrime and How to Protect Yourself Online; and Connections to Computer Programming Concepts.

4 Contribution

Many high schools, particularly those in cities like Brooklyn, simply do not have the resources or expertise to offer computer science courses without external support. Thus, we are reaching out to high school teachers to share our free materials and make them aware of the myriad of other materials that are freely available online. We have offered Teacher Engagement for Computer Science (TECS) Workshops (`http://tecs.acm.org/`), including a week-long program coinciding with our high school summer workshop, to help teachers gain the knowledge and confidence necessary to incorporate these materials into their schools' existing curricula or after-school programs. A variety of insights have been gained on the needs of high school teachers and how the Bridges program might further the development of computer science courses in their schools.

Those attending our presentation will be given a short overview of how the successful Bridges classes are designed and run, with a focus on how to engage diverse students, especially female and minority students, for computer science classes. We will present a number of useful and practical materials and lessons learned that can be shared broadly with K-12 computer science teachers, including our own freely available course modules, and detail the material and infrastructure requirements to support them. Attendees will receive hand-outs summarizing the materials and where to find them.

[3]Garmin is a company that produces popular GPS devices.