National Center for Women & Information Technology
PROMISING PRACTICES

Unplugged (Case Study 2)

An Engaging Way to Introduce Computing

K-12 Education | Undergraduate

Computing is often a mystery: While people may know how to use computers, they rarely know what makes computers work. "CS Unplugged" uncovers the mystery by exposing students to computer science concepts, such as the nature of data or how data is sorted, but without the computer. The activities in "CS Unplugged" help to shatter the image of computing as long, lonely hours in front of an LCD screen by exposing learners to the kind of reasoning needed for inventing the next great ideas in computing.

"CS Unplugged" activities engage students in learning computer science concepts using hands-on activities. The activity described here, "Sorting Network," illustrates the structures used in parallel sorting networks, exposing learners to sorting, parallelism, and binary comparison through active, kinetic learning. In teams of six, students compare numbers (small or large) and follow simple logic.

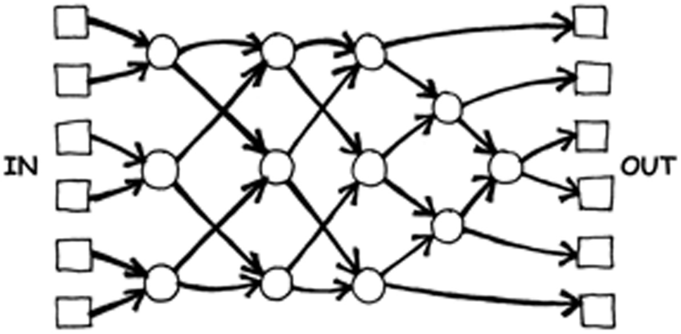
HOW DO YOU DO IT?

Start by drawing the layout to the right on the ground, using chalk on a pavement, masking tape for indoor surfaces, or electrician's tape on a tarpaulin. Each student on the team holds a card with a number on it (for the first time, use the numbers from 1 to 6). The goal is to get the numbers sorted into order.

Each student stands on one of the squares on the "in" side of the diagram. Students follow the arrow to step onto the first circle, where they meet another student and compare numbers. The student with the smaller number follows the arrow out on their left, while the student with the larger number follows the arrow out on their right.

Students continue following the arrows to each circle as another student steps to the circle, each time comparing numbers. The smaller always goes left and the larger goes right. Eventually they will reach the "out" side in sorted order. (The full lesson plan, "Beat the Clock: Sorting Networks" can be found on the website described below.)

The exercise can be extended in a number of ways. For example, students could be timed to discover how quickly they can complete the sorting. For this, use larger numbers so it is hard to see where you are supposed to end up. And there are many questions to ponder: What if the smaller one goes to the right each time? How would you design a layout for sorting three numbers? Thirty numbers? Does it work backwards? Can you design a smaller layout to find the smallest number?



WHAT COMPUTING CONCEPTS DO STUDENTS LEARN?

When three pairs of students are comparing numbers at the same time, it takes much less time than comparing only one pair of numbers at a time. This "Sorting Network" demonstrates parallel computation, one of many ways that computer scientists have devised to sort data quickly. Instructors tell students that they have just learned about the computing concepts behind computer applications with which they are familiar, such as alphabetical lists of files, etc.

Initial evaluations of sessions involving this activity and others show that children gain a better appreciation of what Computer Science is about, and girls in particular respond positively to the logic and problem solving. More detailed international evaluations are underway.

RESOURCES

For more information on this activity and a pdf of the complete teacher's version, see http://csunplugged.com.

Please see NCWIT's Computer Science-in-a-Box: Unplug Your Curriculum, a set of lessons for introducing students ages 9-14 to fundamental building blocks of computer science – without using computers, www.ncwit.org/unplugged.

Case Study Contributor: Dr. Tim Bell, tim.bell@canterbury.ac.nz

NCWIT offers practices for increasing and benefiting from gender diversity in IT at the K-12, undergraduate, graduate, and career levels.

This case study describes a research-inspired practice that may need further evaluation. Try it, and let us know your results.

ncwit.org Authors | Lecia Barker and J. McGrath Cohoon

NCWIT Investment Partners: National Science Foundation, Avaya, Microsoft, Pfizer, and Bank of America

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PROMISING PRACTICES

How Do You Introduce Computing in an Engaging Way?

with Case Study 2

K-12 Education | Undergraduate

Experience with computers between boys and girls has equalized, but boys continue to have greater knowledge of computing and programming *concepts* than do girls. Not so in biology, chemistry, or mathematics, where both boys and girls are encouraged to provide evidence of proficiency when they apply to college. High school study of these subjects familiarizes students with the content and concepts, and gives them confidence. The result is that women's undergraduate completion rates have neared parity in these disciplines.

Because IT study is elective in almost all K-12 schools, developing relevant and interesting assignments that appeal to a broader audience is recommended for:

- fostering a climate where the non-predisposed can belong both academically and socially
- recruiting students who are not predisposed to pursuing computing
- exposing fundamental computing concepts to inexperienced learners

Is prior programming experience required for students to be successful in an IT program? Most undergraduate departments would say no. That is, experience with programming is not the same as expertise in problem-solving, algorithmic thinking, or computing theory. Yet research shows that introductory courses and their embedded assignments work better for students who have *some* experience with programming.

Research also shows that students with programming experience are more confident and more successful in introductory courses than are their inexperienced peers. Students with lower grades or less confidence are less likely to persist in an IT major. What is more, when introductory courses have limited opportunities for talking to other students (e.g., collaborative learning), inexperienced students have little information on which to judge whether they belong academically in the major. Hence more women than men switch out of IT majors (most often to other sciences or mathematics).

MAKING IT MEANINGFUL

Educational researchers emphasize the importance of linking educational materials and curricular programs to students' existing knowledge and experiences. When class syllabi list topics and assignments that focus on unfamiliar concepts with limited, if any, relationship to a student's life experience or interests, she or he is unlikely to take that class. High school curricula contribute to low enrollments in college computing because, under the existing educational policy of election, computing is rarely required in secondary schools. This means that students are likely to have a narrow and inaccurate view of what IT study involves, what careers are possible, or what kind of people "do" IT. Given the very small proportion of females who study computing in high school, females are less likely to choose IT in college.

The challenge to educators at all levels is to develop engaging assignments and curriculum that can appeal to a variety of students with different learning styles, interests, socio-cultural backgrounds, and abilities, while maintaining the rigor of the discipline. Putting the concepts of computing in appealing contexts and building on existing competence can both reduce entry barriers and level the playing field for those with limited experience.

Creative assignments that teach algorithmic thinking while also calling on students' existing knowledge or interests, may serve to both recruit and retain students. When experienced and inexperienced students use non-computer-based assignments to learn computing concepts, they quickly realize that their peers with programming experience are not necessarily better at algorithmic thinking, just more experienced with programming. Building confidence through relevant and interesting assignments is a promising practice for motivating student enrollment and retention.

RESOURCES

Lecia Barker and William Aspray, "The State of Research on Pre-College Experiences of Girls with Information Technology." In McGrath Cohoon, J. and W. Aspray (Eds.) *Women and Information Technology: Research on the Reasons for Under-Representation*. Cambridge, MA: MIT Press, 2006.

Joanne McGrath Cohoon and William Aspray, "A Critical Review of the Research on Women's Participation in Postsecondary Computing Education." In McGrath Cohoon, J. and W. Aspray (Eds.) *Women and Information Technology: Research on the Reasons for Under-Representation*. Cambridge, MA: MIT Press, 2006.

NCWIT offers practices for increasing and benefiting from gender diversity in IT at the K-12, undergraduate, graduate, and career levels.

Visit www.ncwit.org/practices to find out more.

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