Learning Computer Science without Computers. Learning Image Processing without Math.

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Abstract
In this paper, we present an outreach program entitled *CS in the Community* where university students studying towards a degree in Computer Science interact with middle school students to introduce them to ideas and basic tools in Computer Science through hands-on activities, including arts and games. An extension to this program was piloted in which Image Processing was taught using these methods.

Keywords: Computer Science; Image processing; middle school; hands-on; art; games.

ACM Classification Keywords:
K.3 COMPUTERS AND EDUCATION
I.4 IMAGE PROCESSING AND COMPUTER VISION

Introduction
As part of a municipal initiative in the city of Haifa, Israel to promote STEM studies in underprivileged communities, the department of Computer Science at the University of Haifa, initiated an outreach program termed "Computer Science in the Community". The program recruited university students studying towards a degree in Computer Science to meet with middle school students and to introduce them to ideas and basic tools in Computer Science through hands-on activities, including arts and games. The program has been operating over the last 4 years with over 80 university students interacting with over 400 children.

The target population of the program are students in middle school (grades 8-10) in disadvantaged neighborhoods, as well as special target groups in schools - such as girls-only classes and students who are not naturally inclined to scientific studies.

The aim of the program is to expose students to scientific thinking, promote computational thinking, including algorithmic thinking, problem solving, data representation and abstraction. All this in a learning

Figure 1: CS in the Community Activities. Left to right and top to bottom: Antennae coverage around the globe. Hiding secrets in pattern. Graph algorithms with pretzels and M&Ms. Recursion. Sorting ourselves via sorting network. Resource allocation

environment that is engaging and non-threatening, involves students in hands-on and creative activities, promotes participation as individuals and in teams and is basically – fun. The program introduces an atypical learning environment and shows students that learning can be achieved in ways that differ from the conventional and allows students to flourish in this environment where they are repressed in the standard classroom. Finally, the program enables informal interaction between university students and middle schoolers, allowing the former to serve as role models for the children and present them with the possibility of they too finding their way into higher education.

The success of the program induced an extension to the program in which Image Processing was taught using these methods.

CS in the Community in Practice

The program included 12 weekly meetings that took place in a classroom in the middle school. Class size was between 5 and 15 students. The schools were

instructed to assign to the program only children who wanted to participate. Some schools chose gender specific classes or encouraged non-mathematically oriented as well as challenged students to participate in the program.

Each meeting usually focused on a single topic originating from the field of Computer Science such as Binary Numbers, Sorting, Recursion, Divide and Conquer and more (although a wider field of was often taken including topics such as antennae coverage, GPS, computational biology and more).

The initial part of the program followed the activities and ideas from the program *Computer Science Unplugged* [1] and translated into Hebrew [2]. In the latter part of the program, the children were introduced to topics and activities developed by the university students themselves and tailored to their specific class.

Outcomes

We are currently developing a quantitative assessment tool to evaluate the quality of the program, its long-term effects on the schoolchildren, and the retention of tools acquired during the program. However, discussion and interviews with the children on the last day of the program, showed a strong positive response in terms of their subjective report of knowledge acquisition, their engagement and enthusiasm throughout the program. A majority of the children wanted (and actually requested) the program to continue. But most moving were the responses of students relating to their surprise and satisfaction in overcoming fears, and anxieties in learning science and math oriented topics. Several (girls) stated that the program led them to "believe in themselves and their capabilities".

Most surprising however, were the responses of the university students who taught in the program, when interviewed following the last meeting of the program. A vast majority of the University students stated that this program was the *most difficult* of all their university courses. It was not due to complicated academic content, rather it was challenging, in terms of interacting with younger children, and maintaining classroom focus. But most challenging, was the difficulty of translating, tailoring and simplifying topics from the university level understanding they are used to into a simplified hands-on lesson that is engaging and fun.

Image processing Unplugged

The idea of teaching CS through hands on activities, was extended in a pilot study to teaching Image Processing (IP). Image Processing is an area in CS (and Engineering) that deals with acquisition, analyzing, and enhancing digital images. (basically – behind the scenes of photoshop). The field involves many relatively complex algorithms and relies on mathematical formulations and tools. On the other hand, IP is associated with visual content that is easily understood. IP outcomes can be easily evaluated visually and defects and noise in an image is easily seen. Furthermore, many of the image characteristics and algorithms have a physical interpretation (e.g. an image can be viewed as a topographic map with pixel values indicating height above ground). Thus, we were able to peel away most of the mathematical formulations, in teaching Image Processing, and exchange them for physical metaphors and demonstrations. Furthermore we were able to incorporate various hands-on activities to simulate IP algorithms as well as introduce the workings of devices

related to images. Thus the children built a pinhole camera, became printers by using stickers and implemented IP algorithms such as edge-detection and filtering by coloring in images, thresholding by creating green-screen images and build plastic holograms. In a sense, instead of using technology (such as 3D printers, scanners, cameras) to teach topics, we use art and low-tech activities to teach technology.

Images below demonstrate some of the activities.

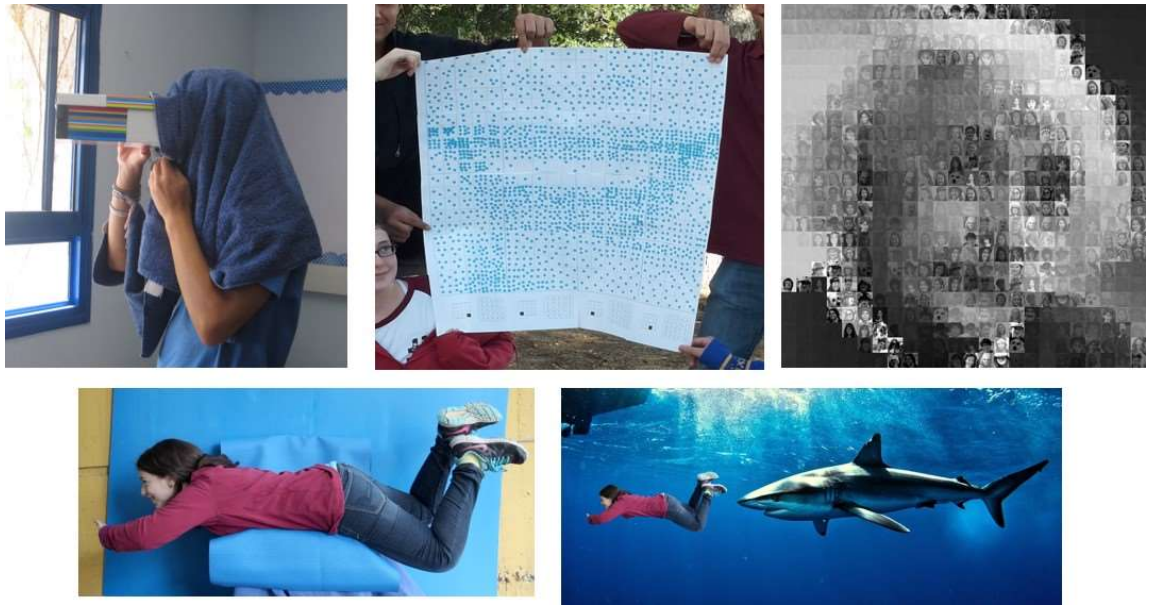

Figure 2: Image Processing Unplugged. Left to right and top to bottom: Building a pinhole camera. Becoming a printer. Image Mosaic Art (Tone Mapping). Green Screen - filming. Green Screen – result.

References

1. Tim Bell, Jason Alexander, Isaac Freeman, Mick Grimley. 2009. Computer science unplugged:school students doing real computing without computers. *Journal of Applied Computing and Information Technology*, 13, 1: 20-29.
2. Benny Schor, Shimon Schoken, Computer Science without Computers – in Hebrew. Retrieved April 23, 2018 from http://www.csunplugged.org.il/