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# ENGAGING MIDDLE SCHOOL STUDENTS IN COMPUTER SCIENCE: FROM VISUAL PROGRAMMING ON ANDOID TO CODING IN ARDUINO

HUANG, JIDONG & ET AL
CALIFORNIA STATE UNIVERSITY, FULLERTON
ELECTRICAL ENGINEERING DEPARTMENT

Dr. Jidong Huang
Electrical Engineering Department
California State University, Fullerton

Mr. Ye Lu
Electrical Engineering Department
California State University, Fullerton

Mr. Pradeep Nair
Electrical Engineering Department
California State University, Fullerton

Ms. Amy Cox-petersen
Electrical Engineering Department
California State University, Fullerton

**Engaging Middle School Students in Computer Science: from Visual Programming on Android to Coding in Arduino**

**Synopsis**:

This paper presented the results from a study on students' interests and confidence towards computer programming where a group of middle school students learned programming through two sequential approaches: one using visual programming tools to develop mobile Apps on Android; and the other using c codes to program Arduino-based robots.

# Engaging Middle School Students in Computer Science: from Visual Programming on Android to C-Coding in Arduino

Jidong Huang, Ye Lu, Pradeep Nair, Amy Cox-petersen
California State University, Fullerton

## Abstract

This paper presented the results from a study on students' interests and confidence towards computer programming where a group of middle school students learned programming through two sequential approaches: one using visual programming tools to develop mobile Apps on Android; and the other using c codes to program Arduino-based robots.

## Introduction

As once stated by Steve Jobs," I think everybody in this country should learn how to program a computer because it teaches you how to think." Given this view, computer programming is a vital skill, especially for people expected to enter the Information and Computer Science workforce. Therefore, introducing students to computer programming and teaching them how to program is an overarching goal of STEM-Inc, a 3-year National Science Foundation (NSF) Innovative Technology Experiences for Students and Teachers **(**ITEST). Designed as an after-school program for $7^{th}$ and $8^{th}$ grade students and especially students from traditionally underrepresented groups, the project seeks to prepare children early for STEM work fields.

STEM-Inc helps students build interest and self-efficacy towards computer programming. The approach taken by STEM-Inc is through a sequential curriculum started from visual programming to develop mobile applications (Apps) on Android then followed by C-language based coding in Arduino. In general, visual programming is easier for a beginner to learn, however, limited capabilities exist and it supports certain computing platforms only. On the other hand, code-based programming is harder for a beginner to learn, however, it offers expandable capabilities and works for a wider set of computing platforms. Therefore, STEM-Inc seeks to integrate the two approaches to well prepare a student, especially those at an early age for the development of computer programming skills.

During the visual programming stage, students learn how to use MIT App Inventor to develop mobile Apps for Android devices. MIT App Inventor is a block-based drag-and-drop programming tool. It is age appropriate for students at middle schools to learn the basic concepts and form the design-thinking and logic-building skills needed in almost any computer programming applications. After MIT App Inventor, students learn C-programming with Arduino-based devices, such as a robot. Arduino is an open source electronics platform based on easy-to-use hardware and software. It provides a good interface through physical devices for students to immediately test and see the effect of a computer program. Once students learn both, they can develop a computer program to control an Arduino-based robot through a mobile App. This is the final integration stage where students apply their knowledge and create real-world applications.

Along the way, student learning outcomes as well as attitudes and self-efficacy towards computer programming are measured by a set of surveys. Preliminary results show that positive outcomes are observed in both the learning outcomes and student interests and self-efficacy toward computer programming, thus demonstrating the validity of the integrated approach taken by STEM-Inc.

**STEM-Inc Program Description**

The STEM-Inc program is a collaboration involving California State University Fullerton (CSUF)'s Colleges of Engineering and Computer Science (ECS), College of Business and Economics, and College of Education; and the Anaheim Union High School District (AUHSD). It pursues the overarching goal of engaging diverse middle school students in engineering and computer science in order to increase the number interested in STEM studies and careers, especially those who are female and from underrepresented groups.

In this paper, results obtained from student participants from four junior high schools participating in computer science activities in STEM-Inc were examined.

Out of the 83 students who had completed pre and post surveys from the study during project year 2014 to 2015, 32.1% of them are female and 67.9% of them are male. In addition, 40.2% of the 83 student participants identified themselves as Hispanic or Latino (Figure 1). Most students

in the program had neither participated in any other after-school or summer STEM programs nor participated in programs such as robotics camps and mobile technology development or design program. Student mentors are all from CSUF with different majors including Electrical Engineering, Computer Engineering, Mechanical Engineering, and Computer Science. Two CSUF graduate student mentors were hired as the assistants to give guidance to develop training materials in the area of robotics and mobile application development.

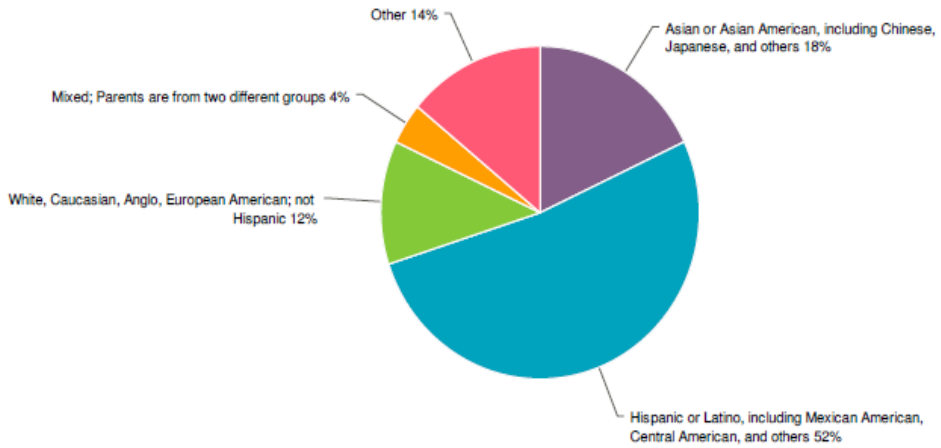


Figure 1: Ethnicity of Student Participants in STEM-Inc (2014 - 2015)

**Visual Programming in STEM-Inc**

The MIT App inventor is a platform for students to develop mobile applications (apps) on Android. It is a block-based programming tool that allows students even at a very early age to learn programming concepts and actually build real functional mobiles apps for Android devices. Student are introduced to this web-based tool and taught how to use it through multiple examples and tutorials during the program. Students are given the chance to test the examples on the Google Nexus Android-based tablets. At the end, students are grouped into their teams to design their own mobile applications.

**Motivation on Visual Programming**

Although mobile apps have impacted people's daily life, most middle school students, including those participating in this study, were not confident to develop mobile apps on their own. Therefore, the visual programming module in STEM-Inc is designed to help students gain skills

in mobile apps development; and help them gain more confidence towards their general computational skills.

## Visual Programming Class Design

The teaching of visual programming started from college mentors from CSUF demonstrating sample functional blocks including commands, logic, variables and more; and creating sample applications using MIT App Inventor. Every CSUF engineering mentor was educated and trained before working with middle school students in the program. Under the mentor's guidance, each student participant in STEM-Inc was then required to develop several sample Apps at three different levels: 2 basic ones, 2 intermediate ones, and 1 advanced one. At this stage, in depth coverage of computational thinking skills, including logic building, command sequencing, variables and parameters were taught by the mentors to the student participants through learn-by-doing methods. When the majority of the student participants were able to handle those sample Apps on their own, the curriculum then moves on to a Mobile App design contest, in which students worked in groups to design a Mobile App using their own ideas. In this stage, it's mostly student self-driven with mentors just providing technical supports when needed.

## Results of the Learning on Visual Programming

From the first-year results of STEM-Inc, it was observed that all student participants were able to complete the sample Apps; and over 90% of the student groups were able to finish an App for the Mobile App contest.

In addition, pre and post-surveys were administrated to evaluate students' knowledge about and self-efficacy towards Mobile App development. In pre-survey, only 30% of the students strongly agree they know about the main components of a Mobile app; and this number increased to 65.4% at the post-survey. In pre-survey, around 40.8% of the students know about mobile development platforms; and this number increased to 67.9% in the post-survey.

More importantly, in pre-survey, 37% of the students knew how to use a mobile app development platform to develop an App; and this number significantly increased to 62% as shown in Figure 2. In the mean time, the number of students who didn't know how to use mobile app development platforms has significantly decreased from 38% to 10%.

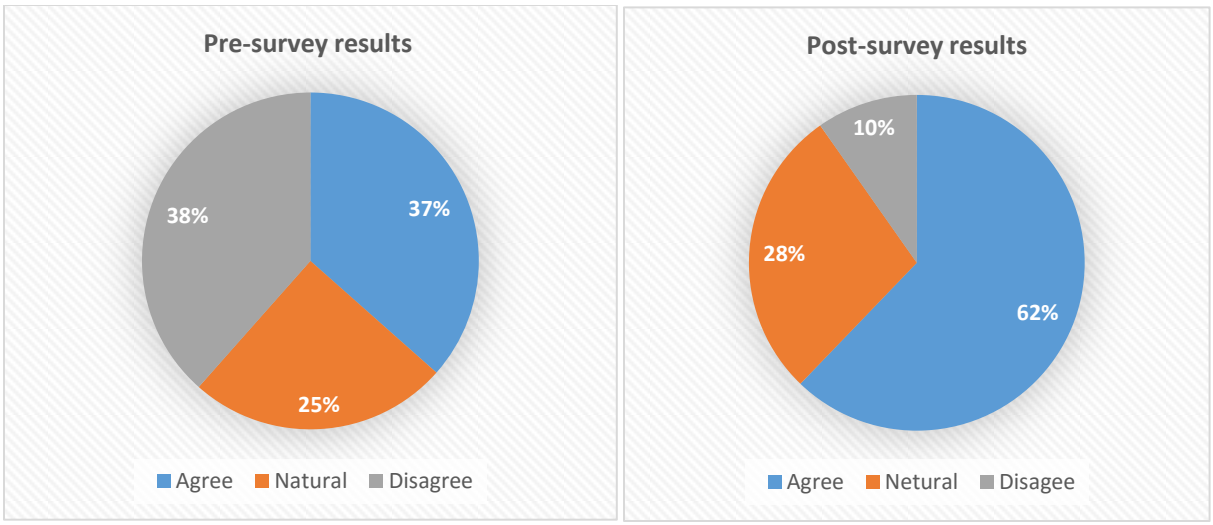


Figure 2: Pre- and Post-survey Results for Question: Knowing how to use a Mobile App development platform to develop Mobile Apps

Similarly, in pre-survey, only 20% of the students knew how to build a mobile app that can access various features of a mobile device; and this number significantly increased to 54% as shown in Figure 3.

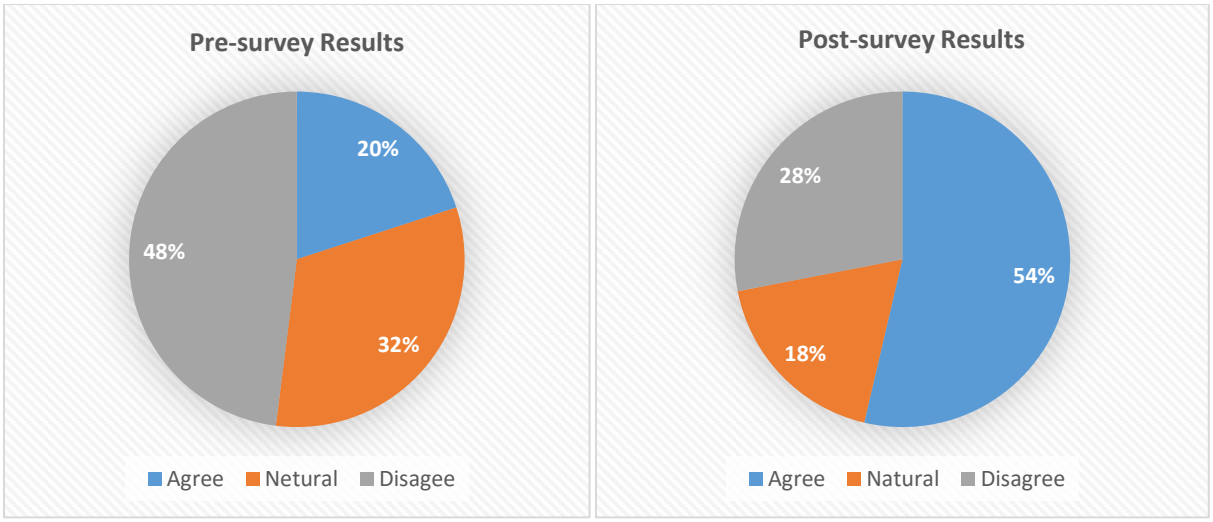


Figure 3: Pre- and Post-survey Results for Question: Knowing how to build a Mobile App that can access various features of a mobile phone or tablet

**C-language based coding in STEM-Inc**

In addition to the visual programming experience using the drag and drop programming platform, the student participants in STEM-Inc also experienced traditional computer programming through the use of C-language programming.

In order to make C-coding fun and interactive for students at this age group, they have been instructed to learn C-coding through the programming of a robot. The robotic kits, Arduino-based Robotics Shield Kits from Parallax are used in STEM-Inc. These kits are beginner-friendly; and no prior programming experience is necessary to work on these kits. The platform for C-code to drive the robot is an Arduino microcontroller. Arduino is an open-source prototyping platform based on easy-to-use hardware and software. It provides students with a fundamental understanding of C programming as well as exposure to technologies in real-world.

## C-Coding Class Design

Using samples from Parallax, students were taught by the mentors how to assemble the kits and integrate various electronic components including some sensors, for example distance, temperature and motion sensors, onto the kit to make robots function in different ways. Working in groups, the students then learned about basic programming in C to complete different tasks on the robot including driving/navigating the robot on its own; and instructing the robot to follow lines and avoid obstacles on the way through the use of sensors. Through practicing per mentor's guidance, students also learned about the basics of C-programming, including syntax, logic-building, task-planning and variables and parameterizations.

## Results of the Learning on C-Coding in a Robot

Similar to mobile app development, the learning results of C-Coding were also measured by pre- and post-surveys. Figure 4 summarizes the results of using a robot to learn C-programming. As shown in figure 4, before attending STEM-Inc, the majority of students did not know how to make or program a robot. And after STEM-Inc, the majority of students claimed that they now knew how to make or program a robot. For example, in pre-survey, only 8% of the students claimed that they knew how to program a robot using a microcontroller; and this number has significantly increased to 57.3% at the post-survey.

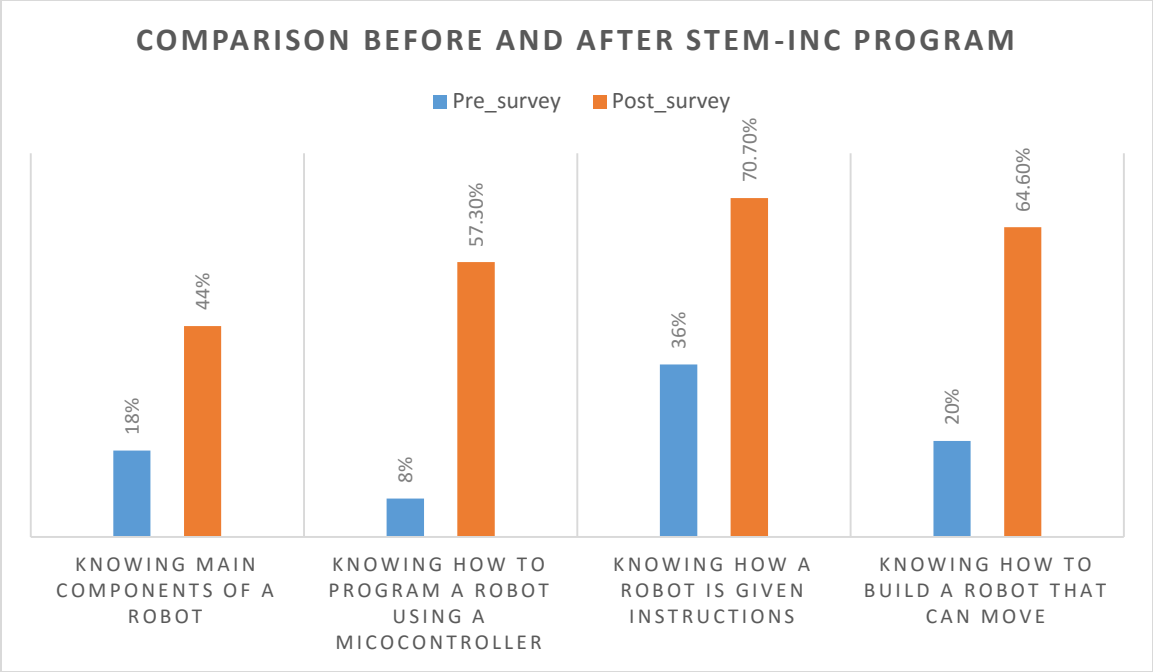


Figure 4: Pre/Post-Survey Comparison of C-Coding Skills on a Robot

**Mobile App-controlled Robotic Car Contest in STEM-Inc**

Following the conclusion of the mobile app and arduino-based robotics academy, students worked in groups to design a mobile app-controller robotic car for a racing contest at each school. In this step, they learned about combining the concepts and skills from both MIT App Inventor and Arduino hardware interfacing and software programming to set up a mobile app on the tablet and use it as the interface to drive the Shield Robotic car through Bluetooth-enabled communication links. Their completed robotic cars went into a race on racing tracks built by the students.

By participating in this type of activity, students were engaged in a practical problem-solving process, including problem formulation, engineering design, implementation, testing, and refining solutions. The learning outcomes of this process were also documented by pre- and post-survey results as shown in figures 5 through 7.

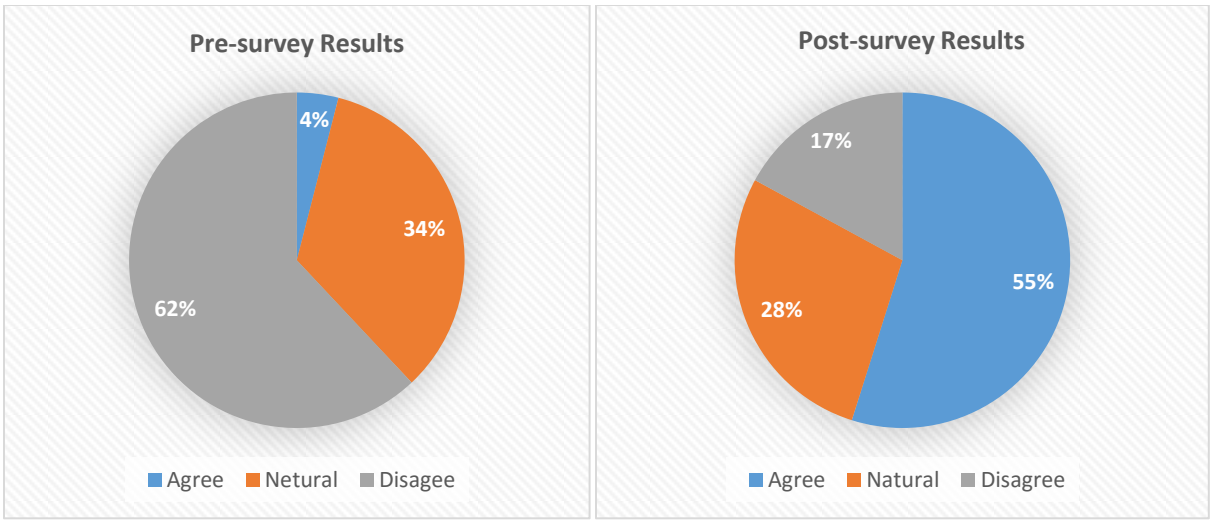


Figure 5: Pre- and Post-survey Results for Question: I know how to develop a set of requirements for an Engineering/Computer Science product.

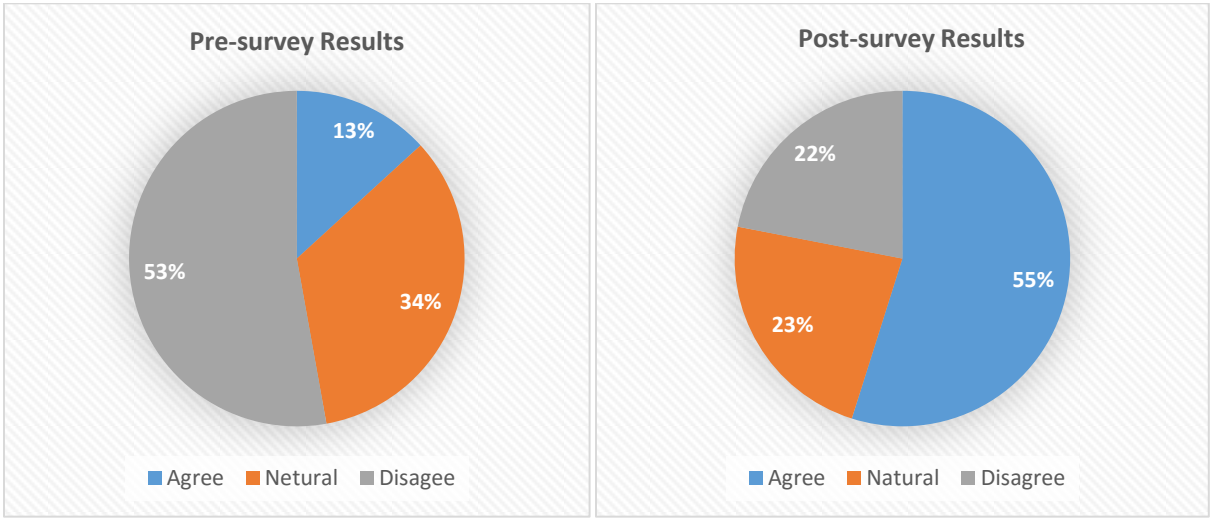


Figure 6: Pre- and Post-survey Results for Question: I know how to implement an Engineering/Computer Science design project based on a set of requirements

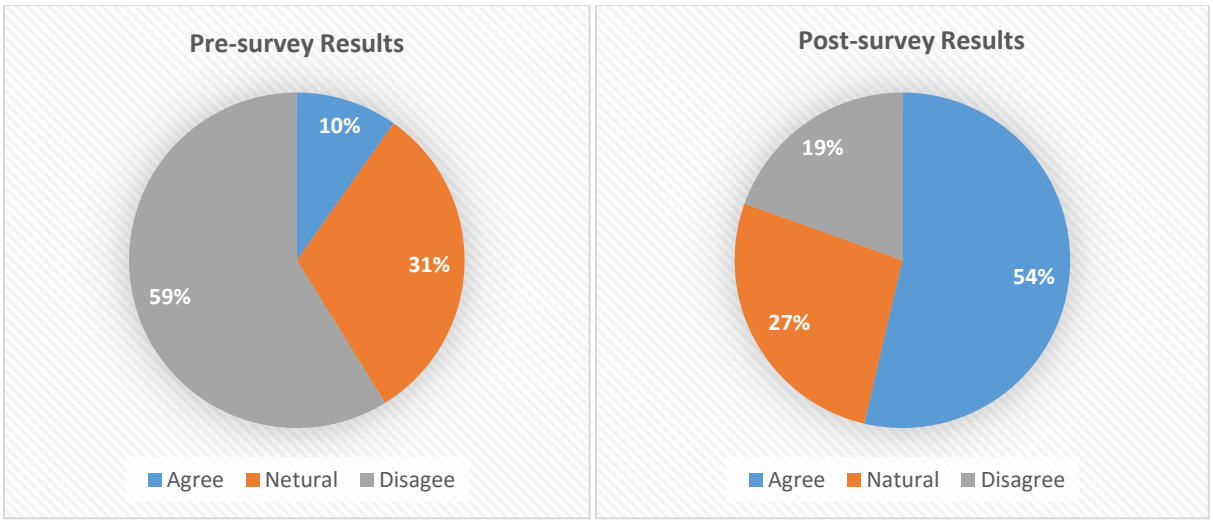


Figure 7: Pre- and Post-survey Results for Question: I know how to evaluate an Engineering/Computer Science product based on a set of requirements

## Summary

Through an integrated learning experience in STEM-Inc, positive outcomes had been observed on students' learning towards computer programming in both visual programming and C-coding modules. The cumulative experience of combining visual programming with C-coding through the robotic car racing, also demonstrated positive learning outcomes in students' understanding of engineering/computer science design process.

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