Developing Arduino-based STEM programs at California Community Colleges

By

John Kosmatka, PhD PE
Director, California Space Grant Consortium
Dept of Mechanical & Aerospace Engineering
University of California, San Diego

Janet McLarty-Schroeder
Chair, Physics and Astronomy
Cerritos College
Norwalk, CA 90650

Presented at:
National Council of Space Grant Directors’ Spring Meeting
Westin Hotel, Arlington, Virginia
March 2-4, 2017
Overview

- Background and Summary

- Program Components
  - College Component
  - Faculty Development
  - Student Development

- Continuation Efforts

- Overview of the Cerritos College Program
Many of California’s best and brightest HS students can not afford the University of California ($100K over 4 years), so they choose to attend a California Community College (2 years) and then transfer to the University of California or California State University (2 years).

California has 113 Community Colleges with 2.1 Million Students

Many of these colleges have limited “pre-engineering” programs

Many outstanding students get sidetracked and never achieve their goal

Goal:
Develop a Community College STEM partnership program with NASA and CaSGC. Select 12 Community Colleges (10%). Invest in the college, the faculty, and the students.
NASA Centers & Community Colleges

Southern California
- NASA Armstrong
  - Cerritos College
  - Citrus College
  - College of the Desert
  - Irvine Valley College
- NASA Jet Propulsion Laboratory
  - Los Angeles City College
  - Rio Hondo College
  - Southwestern City College
  - Victor Valley College

Southern California
- NASA Armstrong Flight Research Center
- Jet Propulsion Laboratory

Northern California
- NASA Ames Research Center
  - Butte College
  - Contra Costa College
  - Evergreen Valley College
  - Napa Valley College

Butte College
Sparkfun “CaSGC” Electronics Tool Kit

- Soldering Iron Variable Temperature 50W
- Soldering Iron Stand
- Solder Wick #2 5ft. - Generic
- SparkFun Safety Glasses
- Monocle Magnifier - Illuminated
- Wire Strippers 30AWG
- Digital Multimeter - Basic
- Flush Cutters - Hakko
- Diagonal Cutters
- Solder Lead Free 15-gram Tube
- Pocket Screwdriver Set
- Needle Nose Pliers
Faculty Component

- Develop On-Line “Intro to Electronics/Arduino” Course
  
  *(UCSD Extension – 3 credit Continuing Education, developed by Thought-STEM)*
  
  - 10 modules with 10-20 minute video snippets
  - From “hello world” to sensor/GPS - read/write
  - Homework, projects and on-line office hours

- Arduino Super Kit
  
  - Arduino Uno - R3 SMD
  - Arduino and Breadboard Holder
  - White Solderless Breadboard
  - SparkFun Mini Screwdriver
  - 16x2 White on Black LCD
  - 74HC595 Shift Register
  - 2N2222 Transistors
  - 1N4148 Diodes
  - DC Motor with Gear
  - Small Servo
  - SPDT 5V Relay
  - TMP36 Temp Sensor
  - 3-D Accelerometer
  - 3-D Magnetometer
  - 3-D Gyroscope
  - GPS
  - SD Writer
  - Red, Blue, Yellow, and Green LEDs
  - Red, Blue, Yellow, and Green Tactile Buttons
  - Flex sensor
  - Softpot
  - 6' SparkFun USB Cable
  - Jumper Wires
  - Photocell
  - Tri-color LED
  - 10K Trimpot
  - Piezo Speaker
  - Big 12mm Buttons
  - 330 and 10K Resistors

- NASA Faculty Day Education Office and Researchers for added course content

- Faculty Fellowship and Free Extension Course Tuition
Monthly “Live” NASA Webinars

- Young NASA Superstars talking about their research

- Nanotechnology-enabled Bio and Chemical Sensors for NASA Missions
  Dr. Jessica E. Koehne
  NASA-Ames

  Dr. Morgan Cable
  NASA JPL

- On the Minimum Induced Drag of Wings
  Dr. Oscar Murillo
  NASA Armstrong

- Advances in CubeSat Swarm Technology
  Dr. Matt Sorgenfrei
  NASA-Ames

- Exploring the Arctic with Under-Ice Rovers
  Dr. Andrew Klesh
  NASA JPL

- Wing Aeroservoelastic Studies and Control of Flexible Aircraft
  Dr. Dr. Peter Suh
  NASA Armstrong

Nanotechnology-enabled Bio and Chemical Sensors for NASA Missions

Advances in CubeSat Swarm Technology

Exploring the Arctic with Under-Ice Rovers

Wing Aeroservoelastic Studies and Control of Flexible Aircraft
Student Component

- **Individual Arduino “Mini-Inventors Kit”**
  - *Faculty Mentoring*
  
  - SparkFun RedBoard
  - Breadboard - Self-Adhesive (White)
  - Servo – Sub-Micro Size
  - Hobby Gearmotor – 200 RPM (Pair)
  - Temperature Sensor – TMP36
  - Mini Photocell
  - SparkFun USB Mini-B Cable – 6 Foot
  - Jumper Wires – 7” M/M 30 AWG (30 Pack)
  - LED – RGB Clear Common Cathode
  - Red, Blue, Yellow, and Green LEDs
  - 10K Trimpot
  - Momentary Pushbutton Switch – 12mm
  - H-Bridge Motor Driver 1A
  - Battery Holder - 4xAA to Barrel Jack Connector
  - 330 and 10K Resistors
Student Component

- **Arduino Team Project (3 teams per college)**
  - 4 students per team

- **Location, Altitude and Sensor Data Package**
  - *Model rockets or near space balloons*

- **Solar Tracker and Collector** *(Optimum pointing of solar panels at sun)*

- **Weather Monitoring and Prediction**
  - *Temperature, humidity, dew point, wind speed*

- **Health-Care Monitoring**
  - *GPS path (calories burned), heart rate, blood pressure, muscle twitch, CO*

- **Air Pollution measurements** *(gas and particle measurements)*

- **Security Cameras** *(remote sensors turn on still and/or video cameras)*

- **Robots** *(ground, boat, UAV, rotorcraft)*
Student Component

• NASA Center Student Day (mid-August, 40-80 students per center)
  • Lab Tour
  • Poster Session of their Arduino Project (Audience: NASA Researchers)
  • Meeting with NASA Education Office – Fellowships, Internships

• Student Fellowship (completion of program)
Summary

- Over 300 Students Supported
- 51% underrepresented
- 32% females
- 62% first in their families to attend college
Path Forward (2017-)

- 10 Community Colleges (open competition each year)
- 10 student CaSGC fellowships per campus
- 3 - 6 “Live” Webinars
  - Three NASA and up to three academic or aerospace Industry
- Faculty Component
  - UCSD Extension On-Line Arduino Class (as needed)
  - Fellowship
- Student Component
  - Individual Arduino Kit
  - Team Project Stipend
  - NASA Student Day (Posters and Tour)
  - Fellowships

Southern California
- Cerritos College
- College of the Desert
- Irvine Valley College
- Los Angeles City College
- Miramar College
- Rio Hondo College
- Victor Valley College

Northern California
- Butte College
- Mendocino College
- Woodland College
Cerritos College and the CA Space Grant Consortium
Who we serve

- Cerritos College is a public two-year college in southeastern Los Angeles County that serves a 52-square mile area with a population of 749,402.
- Cerritos enrolled 23,805 students in Fall 2016.

78% of these first-time students are Hispanic

More than 70% of our Hispanic students receive need-based financial aid.
STEM Majors

2712 STEM majors
About 11% of students
(Spring 2016)

- 1669 Males
  - in life sciences: 26%
  - in physical sciences: 69%
  - in math: 5%

- 987 Females
  - in life sciences: 36%
  - in physical sciences: 26%
  - in math: 6%

Genders
- Females: 36%
- Males: 62%
- Unknown: 2%
Ethnicity of STEM Majors

- Hispanic/Latino: 63%
- Asian: 18%
- Other: 19%
- White: 4%
- Unknown: 8%
- African-Americans: 3%
- Alaskans/Native American: 3%
- Other, Non-White, Two or more races: 3%
- Pacific Islander: 1%

2712 STEM majors (Spring 2016)
Selection process

- Advertise (flyer, email, etc.)
- Information session
- Online application form
  - Name and contact information
  - Declared major, goals, and projected transfer date,
  - Citizenship status,
  - Previous STEM/Computer classes taken,
  - A question about using hands to build or fix something,
  - A request to confirm availability for the times we would be meeting,
  - Name and contact of a reference person.
- Review Applications, student transcripts, and contact references
- Conduct interviews
  - 24 the first year and 29 the second year.
- Contact students with offer of acceptance
- Place student in groups of 4
  - We spread out those with computer backgrounds and those of similar majors and mixed genders. This brought people of diverse backgrounds together and gave them great incentive to be creative and work together.
Applicants

- 66 in year 1 (18 female)
  - For 12 positions funded by grant and 4 funded separately

- 54 in year 2 (16 female)
  - For 18 positions funded by grant and 2 funded separately
<table>
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<tr>
<th>Category</th>
<th>Year 1</th>
<th>Year 2</th>
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<tbody>
<tr>
<td># of Students at start (end)</td>
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<td>20 (19)</td>
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<td>Underrepresented Minorities</td>
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<td>First generation college</td>
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<tr>
<td># of females</td>
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<td>Disability</td>
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<td>5</td>
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<tr>
<td>US Veteran/Military</td>
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<td>3</td>
</tr>
<tr>
<td>Receiving Awards from Grant</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Receiving Awards from other sources</td>
<td>4 (2 PR: Iran and Taiwan, and 2 US Citizens)</td>
<td>2 (1 DACA, 1 PR from Nepal)</td>
</tr>
<tr>
<td>Ethnicities</td>
<td>9 Hispanic, 5 Caucasian, 1 Persian, 1 Taiwanese</td>
<td>15 Hispanic, 2 Caucasian, 1 Asian, 1 Indian, 1 Nepalese</td>
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</tbody>
</table>
Aquaholics

“I would share that it has really change my direction in school. Due to my time in that internship I have found a love for working in robotics. I am currently working as part of a team called Titan Rover at CSUF.”
I really enjoyed the program because it gave me real hand experience at making a project with a team. This really has helped my ability to perform as a team.

Methodology:

**Abstract**

A device that supplements a tutor and the "long time" exercise. This device helps us to train beginning musicians to create and control fundamental dynamic variations, using a time-based system. The device is essentially a musician’s work-out device.

**Background**

Many people dread attending children’s band concerts because they sound bad. The more insightful explanation is that children’s concerts display little to no ranges in dynamic variations, creating an air of disinterest within the audience.

Fig. 1: A UCLA student being recorded with Audacity in an empty closet room.

**Methodology: Who to Test**

- We defined beginner musicians as someone with no years of experience and someone who is in high school.
- We defined Professional Musicians as someone with 5 years of experience and someone who is in college.
- We tested players only, because the time-based system was designed for use with a more advanced performance level.
- Our test subjects attended UCSC and CSULB high school and performed in harmony and in groups.
- We tested four students, each performed a solo in a practice room with the audio program Audacity, and took two recordings of the background. Age of the student, number of years they had been playing, the time of day, and the distance from the music school were known.
- The data was collected from a single recording. The data was then input into Audacity to test the output.

**Results**

The data collected from the recordings was analyzed using Audacity. The data was then input into the program for analysis.

**Future Research**

We would like to have a larger sample of students, preferably different age groups. We would like to add a mini-waveform visualizer to the device to further determine accuracy, which is usually undertaken from a visual arts standpoint.

Acknowledgements

- UCLA Department of Physics and Astronomy, California State University, Northridge
- CSULB Department of Physics and Astronomy, California State University, Long Beach
- CSULB Department of Mathematics and Computer Science, California State University, Long Beach
- California Space Grant Consortium

Word Cloud:

- Tone Deaf
- UCR Comp Sci
- UCSB Physics
- CSULB Comp Sci/Math

Words:

- I really enjoyed the program because it gave me real hand experience at making a project with a team. This really has helped my ability to perform as a team.
- Through our analysis, we have found that these musicians have been playing longer and are more control over their playing.
- Through our fact sheet, we have been able to show to some extent the legitimacy of our results. An experience increase, range in dynamic variation occurred (see Fig. 4).
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- Through our fact sheet, we have been able to show to some extent the legitimacy of our results. An experience increase, range in dynamic variation occurred (see Fig. 4).
“Joining the program at Cerritos College helped me a lot to meet new people who helped me get into my next research program which was at Carnegie Observatories in Pasadena and an amazing experience.”

“On presentation day at Armstrong Flight Research Center, we were given helpful information about summer research programs and we had the opportunity to ask our questions. That helped me learn where to apply for summer programs and what they look for.”
“I just recently got a call back for a full-time summer internship with a Department of Defense missile defense contractor to work as a Software Engineer/Cyber-security intern. They were especially interested in my time working on the Arduino project and what my team did.”
Concentration of light on solar cells

“I honestly learned so much from being in Arduino. I learned how to code in the Arduino software and see my group’s project come alive. That had to be one of the most satisfying feeling yet. This program helped further develop my problem solving skills. You learn early on that not everything works on the first go. Which meant getting creative with your group to troubleshoot through the kinks.”
“I loved the program because it allowed me to practice my programming skills on actual hardware and taught me a ton about circuits and how they work. I have a better understanding of Arduinos and am still learning more here at Pomona.”
Martian Regolith Analyzer

“I really became attracted to programming and while I was completely novice when I started, I have now programmed in C++, Java, JavaScript, Python, SQL, as well as other languages.”
Semi-Autonomous UAV with Metal Detection

“Participating in the CA NASA Space Consortium Grant not only opened my eyes to how much I enjoyed being able to be hands on and to build things but it gave me a chance to do something that was a once in a lifetime opportunity.”
Radioactivity detector

“I think the program was an excellent way to practice on communication and social skills. This is a project that really required all the team to put in. It requires coordination, communication, dedication and time. I really think this program gives students a chance to experience something new and something that can relate to the engineering world.”
“The program was a spectacular experience! Though the most interesting, helpful and exciting part of this program were the fellow students. In this program people who were passionate about their majors, science and careers really made this exciting. We would “NERD OUT,” which is what we called it, when we rambled on about our love for a science topic. This form of connection with other students was priceless and certainly allowed us to gain friends, colleagues and connections for life.”
## Acknowledgements

### NASA HQ Education Office
- Dr Lenell Allen

### NASA Center Education Directors
- Elizabeth Cartier, NASA Ames Research Center
- Francisco Pena, NASA Armstrong Flight Research Center
- Roslyn Soto, NASA Jet Propulsion Center

### ThoughtSTEM and UCSD Extension

### Community College Faculty Mentors

### Southern California
- Cerritos College
- Citrus College
- College of the Desert
- Irvine Valley College
- Los Angeles City College
- Rio Hondo College
- Southwestern College
- Victor Valley College
- Janet McLarty-Schroeder
- Lucia Riderer
- J. Carl Farmer
- Alec Sim
- Jayesh Bhakta
- Gisela Spieler-Persad
- R. Bakhiet
- Michael Butros

### Northern California
- Butte College
- Contra Costa College
- Evergreen Valley College
- Napa Valley College
- Francesco Madero
- Jon Celesia
- Alfred Gonzalez
- Erin Quealy