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From 2007-2010 he was Professor and Chair of the Electrical and Computer Engineering Department at Boise State University, Boise, ID. From 2011-2012 he was the inaugural Signal Processing Education Network (SPEN) Fellow. From 2012-2014 he and his wife lived with 20 engineering students in the engineering residential college (ERC) on the Boise State campus.

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Work in Progress: Elementary School Use of the Sidekick Basic Kit for TI LaunchPad™

Abstract

Despite the fact that the Sidekick basic kit for TI LaunchPad™ is intended for a much more experienced group of students, engineers, and makers, we have successfully introduced it into four classes of 5th grade elementary school students. This system mapped well onto the existing science standards of learning established by the State of Virginia. Additionally, the assessment of this process clearly demonstrated that effective learning is occurring.

Introduction

Although the Sidekick basic kit for TI LaunchPad™ is intended for a much more experienced group of students, engineers, and makers, we have introduced it into four classes of 5th grade elementary school students. From here forward, we will refer to the Sidekick basic kit for TI LaunchPad™ as *The System*.

Almost one hundred 5th grade science students used the system over the course of this past academic year. The goal of using the system was to allow the students to develop the skillset necessary to create a series of projects that utilized light emitting diodes (LEDs) and a moisture sensor. These projects fit well within the existing 5th grade science curriculum.

Once the students understood how *The System* functioned, they developed and began testing a series of systems to measure the moisture content of the air at a number of different locations around their school. These systems recorded moisture data for subsequent analysis. This was all facilitated by using the system to:

- discuss and explore open and complete circuits;
- explore inexpensive microprocessors (Integrated USB 2.0-enabled MSP430F5529 16-bit MCU, 40-pin interface, 28kB Flash, 8kB RAM, 25MHz CPU speed);
- create simple programs based on a wide variety of available Energia software example projects; and
- offer a wide variety of loose components, wires, and breadboards to complement follow-on experimentation and discovery.

A basic assessment of the use of the Sidekick Basic Kit for TI LaunchPad™ in this environment is provided in the Assessment section.

Elementary classroom use

Students were told they were going to start a new project in a 5th grade science classroom. On their desks, they found all of the components that we are now calling, *The System*. *The System* consisted of four main elements, both listed and shown in figures:

1. MSP430 Launchpad Evaluation Kit (see Figure 1),
2. Sidekick Basic Kit for TI LaunchPad (see Figure 2),
3. Grove Base Booster Pack (see Figure 3), and the
4. Grove Starter Kit for Launchpad (see Figure 4).

Figure 1. MSP430 Launchpad Evaluation Kit

Figure 2. Sidekick Basic Kit

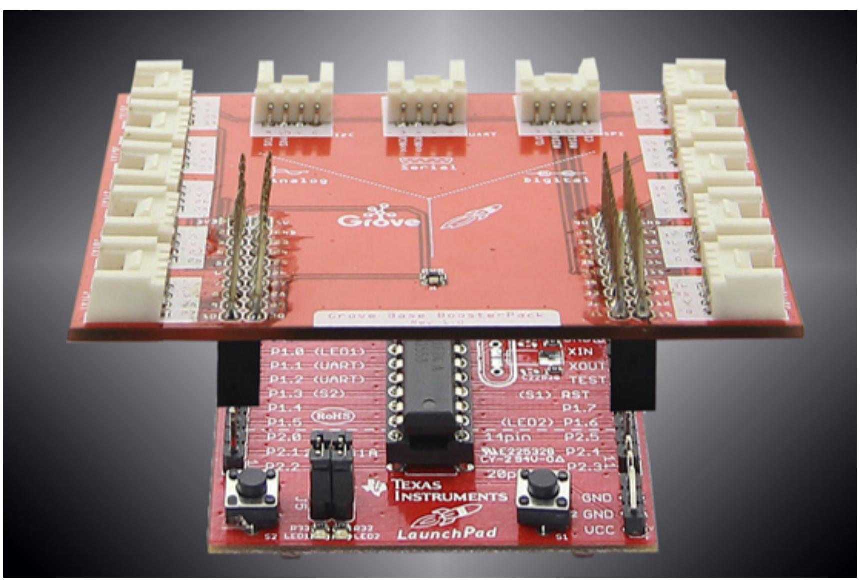

Figure 3. Grove Base Booster Pack

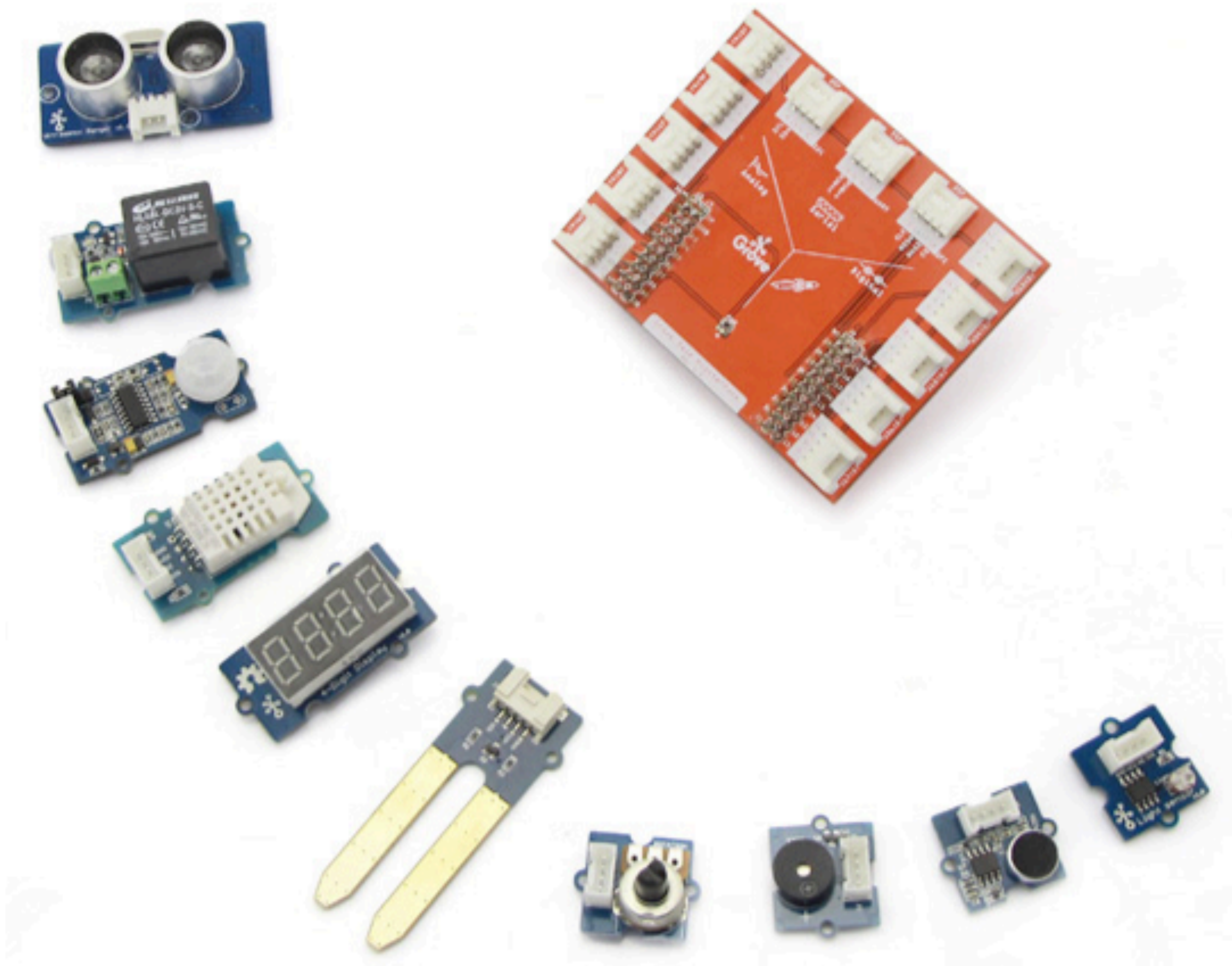

Figure 4. Grove Starter Kit for Launchpad

Students spent the first class lesson exploring the different items, their functions, and brainstorming how things worked. Each student was asked to rate themselves on how comfortable they felt with coding, using *The System*, and performing experiments by themselves. Nine (9) out of the 98 students had some previous experience and exposure with coding. None of the previous coding experience was with anything other than PC/Mac-based programming associated with the Lego Mindstorms EV3 system.

The next lesson, the students were told they would be doing a coding exercise (project). For the following three months, the students spent designated class time, and whatever free time they had, on the classroom computers and building *The System*. They explored the different components of coding through trial and error. The students that were quick to understand how to code became the leaders, and took on the responsibility of teaching their classmates.

As the students slowly began to understand coding, they were given small projects and tasks to complete with *The System*.

Mapping onto the established curriculum

Virginia follows the Standards of Learning (SOL) Curriculum [1]. Every lesson integrated either 4th or 5th grade standards that the students will be tested on at the end of 5th grade. The main standards on which we focused covered the broad areas of Scientific Investigation, Reasoning, and Logic; Force, Motion, and Energy (with emphasis on electricity and circuits); Sound; and Light. Specific standards of the SOLs are listed below. The number format for each SOL is X.Y, where X is the grade and Y is the specific standard being taught. Under each standard are subarea topics. These subareas are concepts that need to be covered to ensure the understanding of the complete standard.

SOL 4.1 and 5.1 states: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

a. items such as rocks, minerals, and organisms are identified using various classification keys;
b. estimates are made and accurate measurements of length, mass, volume, and temperature are made in metric units using proper tools;
c. estimates are made and accurate measurements of elapsed time are made using proper tools;
d. hypotheses are formed from testable questions;
e. independent and dependent variables are identified;
f. constants in an experimental situation are identified;
g. data are collected, recorded, analyzed, and communicated using proper graphical representations and metric measurements;
h. predictions are made using patterns from data collected, and simple graphical data are generated;
i. inferences are made and conclusions are drawn;
j. models are constructed to clarify explanations, demonstrate relationships, and solve needs; and
k. current applications are used to reinforce science concepts.

SOL 4.3 states: The student will investigate and understand the characteristics of electricity. Key concepts include:

a. conductors and insulators;
b. basic circuits;
c. static electricity;
d. the ability of electrical energy to be transformed into light and motion, and to produce heat;
e. simple electromagnets and magnetism; and
f. historical contributions in understanding electricity.

SOL 5.2 states: The student will investigate and understand how sound is created and transmitted, and how it is used. Key concepts include:

a. compression waves;
b. vibration, compression, wavelength, frequency, amplitude;
c. the ability of different media (solids, liquids, and gases) to transmit sound; and
d. uses and applications of sound waves.

5.3 states: The student will investigate and understand basic characteristics of visible light and how it behaves. Key concepts include:

a. transverse waves;
b. the visible spectrum;
c. opaque, transparent, and translucent;
d. reflection of light from reflective surfaces; and
e. refraction of light through water and prisms.

Projects

The first projects helped the students understand the different components of *The System*. The students were provided hands-on experiences with the probes, screw terminals, input analog source, test points, and the different interfaces. As they progressed, they made closed circuits which resulted in lighting an LED board through user push buttons. The Grove Starter Kit allowed the students to explore: a buzzer, 4-digital display, a relay, passive infrared (PIR) sensor, an ultrasonic ranger, light sensor, rotary angle sensor, sound sensor, moisture sensor, and a temperature humidity sensor.

As the students became more familiar with writing code, the functions of *The System*, and the different projects they could create, their confidence increased. They were tasked with creating a project that would help the school. Through brainstorming, they decided that they wanted to create a moisture sensor with *The System*. At this point, they were in the middle of their project-based learning (PBL) assignment.

The PBL assignment for the Light and Sound unit was to design a classroom. Coles Elementary School is located near Marine Corps Base Quantico, and throughout the day, students hear the Marines conducting live-fire artillery exercises. The students were tasked with developing the most light and sound efficient classroom, to help minimize nearby distractions. With new schools being built every year, students were to design a classroom, and develop a blueprint of how they believe the classroom should be built, to present to the County School Board.

In Light, we discuss: opaque, transparent, and translucent to help with windows, and in Sound, we discuss insulation; and how sound travels through different mediums: solid, liquid, and gas. With all of these different standards from the SOLs, the students then create, enhance, and present their solutions to the PBL assignment.

Part of the assignment was to make a scale model of the students' proposed classroom. They thought that a moisture sensor would help with deciding what type of materials with which to build the classroom, where to build the classroom, and what conditions were needed for a healthy environment. The class decided to code *The System* to read a moisture sensor through the four-digital display, which would light up the LED board.

The project was slow to start. Decisions on where to put the moisture sensors, how to appropriately read the results, and what choices would be the most effective for the project quickly rose to the forefront of discussion. Once *The System* was coded, students had one week to run tests around the school.

The moisture sensor was read through a 4-digit display and a 10 LED display array. Any 4-digit display reading above 600 would lead to all 10 LEDs being illuminated. For our purposes, the more moisture in the air, the more LEDs would turn on. There was a 0.2 second delay from when the moisture sensor was in contact with the water, to when it would read on the 4-digit display. When the moisture sensor was submerged in water, the 4-digit display read 620.

<u>Project results</u>

The five trial areas around the school were:

1. the front office,
2. upstairs classroom,
3. downstairs class room by the large 100-gallon trout tank,
4. downstairs classroom that had no upstairs, and
5. an outside trailer.

The students selected the front office, because it is always warmer than the rest of the school. They chose the upstairs classroom to see if height would be a factor. They chose the downstairs classroom, that had no upstairs, because they wanted to investigate if a single level classroom had any effect on the surrounding moisture. They chose the room by the trout tank, because they wanted to know if the water and the running chiller (that has to be set at 48 degrees Fahrenheit) had anything to do with the moisture. Finally, they chose the outside trailer, because they wanted to know if the outside conditions had any effect on the inside moisture.

<u>Assessment</u>

Through three separate trials, on three separate days, students were able to successfully conclude that the most moisture was found in the trailer. The front office was a close second. The students were able to effectively prove that the remaining three (downstairs single level classroom, classroom by the trout tank, and upstairs classroom) all had the same moisture levels.

At the end of the experiment, students were given the same questionnaire and survey as in the beginning. There was a 100% increase in confidence.

1. 85 out of the 98 students felt that they could perform the experiment by themselves, and
2. 57 of the 98 said they could successfully code without help from a partner.

This assessment clearly indicates the effectiveness of project-based coding at the elementary school level.

Conclusions

About 10% of the students were previously exposed to graphical programming as members of the school's Robotics Team. The Robotics Team competes in the First Lego League (FLL) every year using the LEGO Mindstorms EV3 system [2].

For all of the students, this was the first command-line programming that they had experienced. Despite their lack of familiarity with traditional command-line programming, we considered this experience to be a great success, especially given that a real-world problem was being solved, with actual student designed circuits, sensors, and hardware in the loop.

Acknowledgement

The MSP430 Launchpad Evaluation Kits and the Sidekick Basic Kits were provided by Texas Instruments to the first author for use in her Elementary School classroom.

References

[1] http://www.doe.virginia.gov/testing/sol/standards_docs/

[2] https://www.lego.com/en-us/mindstorms