YSP[Hack] Electronics Workshop 2016

Retrospective commentary by Ben Artin

May 15, 2016

Summary

In spring of 2016, YSP[Hack] — the YSPH student group dedicated to creating a supportive environment for learning computer skills pertinent to public health — departed from its previous practice of coaching participants through existing self-paced study materials, and organized a semester-long workshop in electronics, led by Ben Artin (YSPH/YSM 2018). The workshop received $700 in funding from YSPH Student Affairs.

The workshop had four principal goals:

- Enable participants to understand and discuss ongoing developments in hobbyist and consumer electronics, but familiarizing them with the basic terminology of the field.
- Empower the participants to form realistic ideas for what electronic devices they could build, by teaching them about different constraints (including mechanical, electrical, design, and human-device interaction constraints) that apply in the field.
- Provide every participant with the resources and the expertise needed to built an electronic device they can take home with them at the end of the semester.
- Create an enjoyable experience for all participants.

Nearly forty students expressed preliminary interest in the workshop in a late-2015 survey. Of those, eight attended the initial meeting, and seven continued participation throughout the semester.

All seven came up with an idea for a device they wanted to build; five built a working prototype. A video of the highlights is available at `vimeo.com/airbornemint/ysph-electronics-2016`.

According to a post-workshop survey, all four principal objectives were accomplished. The final cost was approximately $750, all of which came from YSPH SA; $700 was provided specifically for the workshop, and the remaining $50 came from general YSP[Hack] funds.

Overall, the workshop was successful, and a fun learning experience for everyone involved.

Workshop structure

The workshop consisted of a thirteen weekly 90-minute meetings on Tuesday evenings, starting with the second week of the spring semester.

The first six meetings alternated between a lecture meeting (in which new material was presented, immediately followed by a hands-on exercise with the new material) and office-hour meeting (in which no new material was presented, but participants could come to catch up on any material they missed from previous weeks, or simply to continue their hands-on exploration).

Starting at the seventh meeting, the participants used their newfound knowledge to come up with project ideas. These ideas were refined and executed — to a varying degree of success — over the remaining six meetings.

No planned new material was presented in the last six meetings; they mainly consisted of ongoing hands-on work and project refinement, with the occasional detour into new skills as needed for the projects.

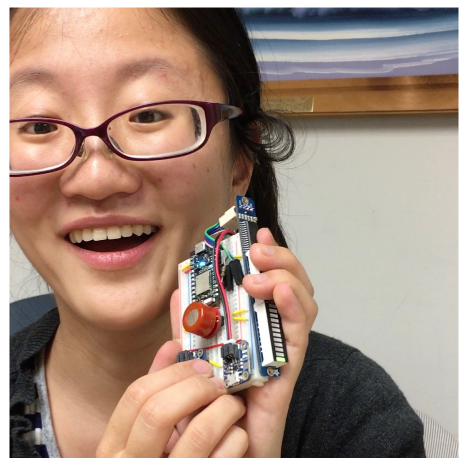
Participant projects

Tian-Tian Cai: Internet-connected breathalyzer

Tian-Tian (YSPH 2016) created a battery-operated breathalyzer; ability to post breathalyzer results to social media can be added in the future.

This project emphasized challenges of miniaturization, internet connectivity, and interpretation of biometric sensor data.

Lessons from this project would be applicable to remote environmental monitoring, such as live tracking of air quality in urban or industrial environments.



Kelsie Cassell: Internet-connected laundry monitor

Kelsie (YSPH 2017) worked on a sensor that can differentiate between a running household washer/dryer and an idle one, and can automatically notify its user when a laundry cycle is complete.

This project emphasized challenges in battery-operated devices (such as power consumption) and internet connectivity, as well as challenges of interpreting sensor data.

Lessons from this project are relevant to motion-sensing, such as earthquake detection or tracking of sleep patterns.

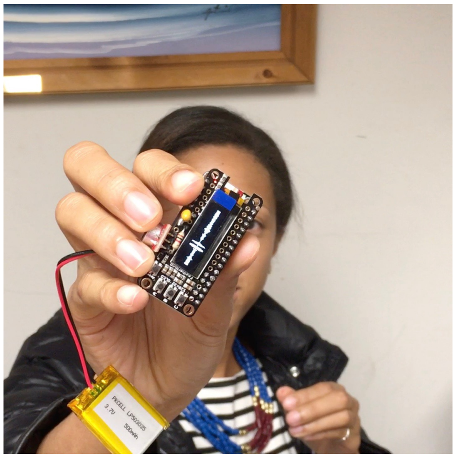
Casey Covarrubias: Wearable light controller

Casey (YSPH 2017) incorporated sensors and lights into an elbow-length costume glove, enabling the wearer to control the lights by flexing their fingers.

This project emphasized challenges of wearable technology (such as limitations in power, size, and comfort required to create a viable wearable product), as well as it strengths (such as reliance on natural movements of the human body).

Lessons from this project are valuable in assistive technology — for example, devices that facilitate communication for people with speech impairments.

McKinley Kelcy: Voice waveform recording



McKinley (YSPH 2016) built a handheld device that can record approximately 2 seconds of audio and display it as a waveform on the built-in screen.

This project emphasized challenges of miniaturization, battery safety, and visual display of sensor information.

Lessons from this project are relevant to portable data-recording devices, such as a continuous glucose monitors.

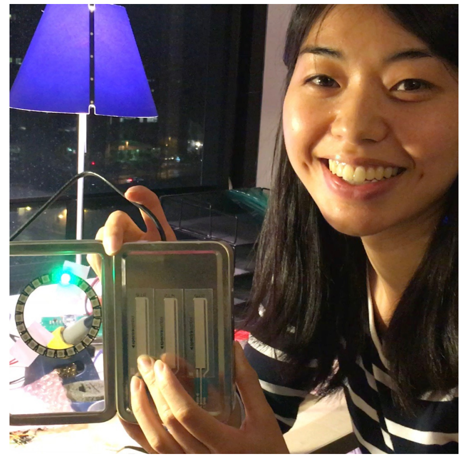
Elina Kurkurina: Internet-connected plant monitoring system

Elina (YSPH 2017) worked on a device which records soil moisture and ambient illumination for her house plant, and loads this information over Wi-Fi into a Google Docs spreadsheet.

This project emphasized challenges of internet connectivity (such as access to network infrastructure) and difficulties in translating sensor data into actionable information.

Lessons from this project are valuable in time-sensitive environmental monitoring, such as measurements of water quality in a household or a municipal supply.

Christine Lo: Portable light controller

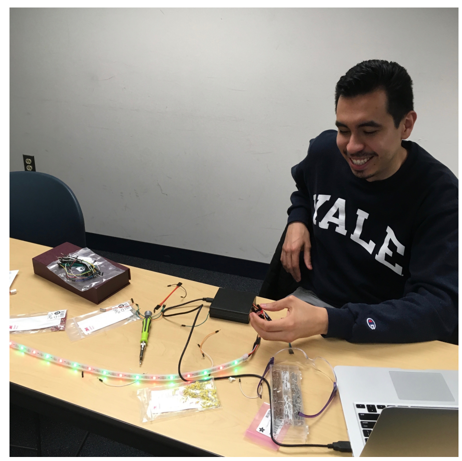


Christine (YSPH 2016) created a portable light controller, which consists of a 4" × 5" × 1" clear-top box with embedded sensors and lights, and allows the user to control the lights by touch.

This project emphasized challenges of creating portable user interfaces (such as limitations on size, shape, and responsiveness) and the importance of mechanical design in electronic devices.

Lessons from this project are valuable in design of touch-based communication interfaces — for example, a device that facilitates communication in noisy environments.

Raymond Pichardo: Internet-connected toilet seat monitor



Raymond (YSPH 2017) built a device that can illuminate a toilet seat that has been left up, as well as notify the user via text message if the seat is left up for too long.

This project emphasized challenges of designing human-machine interfaces for household devices, safely deploying electronics in unsupervised areas, and delivering notifications remotely to mobile devices.

Lessons from this project are applicable in remote monitoring and notification systems, such as medical alarms or intrusion alarms.

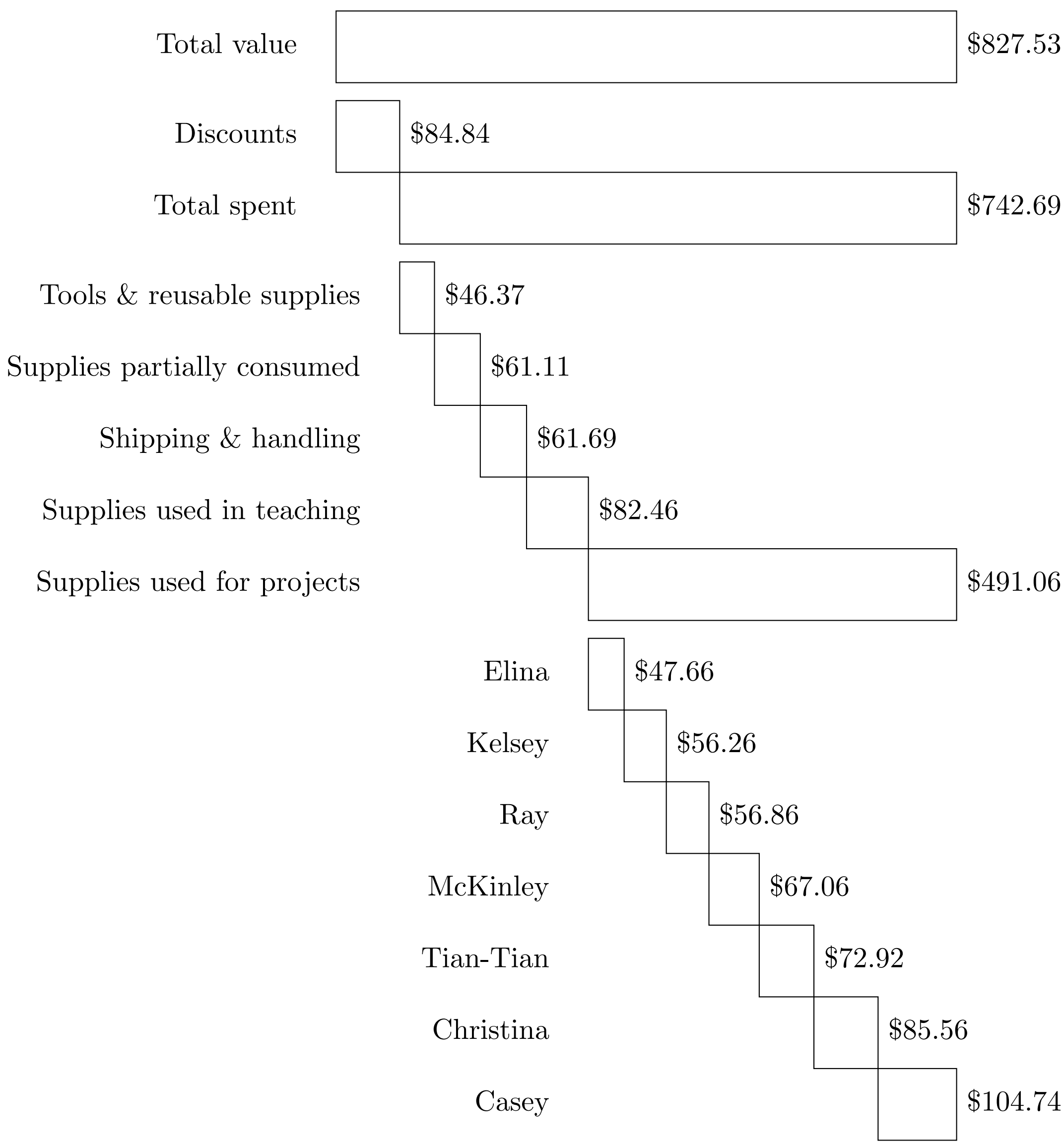
Budget breakdown

Cost of the workshop included cost of parts and tools, and cost of shipping. Supplies used for the workshop can broadly be divided into four categories:

- **Supplies used for projects**: electronic and mechanical parts (such as motion sensors) that were available during hands-on experimentation and were subsequently incorporated into a project. They are not available for future use.
- **Supplies used in teaching**: electronic and mechanical parts (such as LED indicators) that were available during hands-on experimentation, weren't incorporated into any project, and remain available for future use.
- **Supplies partially consumed**: electronic and mechanical parts (such as wires) that came in multi-packs. Some portion of these was incorporated in a project, and the unused portion remains available for future use.
- **Tools and reusable supplies**: electronic and mechanical tools and parts (such as storage bins) which are, by their nature, reusable and therefore remain available for future use.

We were able to save a significant amount of money by taking advantage of weekly discounts, educational discounts, and bulk order discounts.

Budget breakdown by spending category:



Lessons learned

Workshop structure

This workshop structure was well-suited to its goals, as it allowed each student to first gain some general skills, then work on their own project at their own pace. However, this incurred a substantial overhead in instructor time (by requiring me to keep track of seven individual projects, and plan ahead to manage feasibility, parts procurement, and implementation of each project) as well as funds (by making it difficult to consolidate shipments of parts needed at various times by various projects).

Some aspects of this can be mitigated by having a ready supply of a variety of low-cost parts (which can later be replenished in bulk, thus reducing shipping cost and time spent on procurement). It doesn't make any sense for YSPH to invest into this directly, but a partnership with outside groups that stock relevant supplies (such as Yale Center for Engineering Innovation & Design (CEID), ceid.yale.edu or MakeHaven, makehaven.org) would likely be beneficial in the future.

Access to tools

The first half of the workshop (teaching of electronics knowledge) required minimal tools; while some of the parts used for the workshop needed assembly, this assembly was done outside of the workshop using basic soldering equipment. A multimeter was useful for troubleshooting during this part of the workshop.

The second half of the project (completion of individual projects) required substantially more tools, in order to meet design and esthetic goals. Without those tools, every project would have turned out as a mess of wires.

I don't regret the decision to explore design and aesthetics of electronics; the transition from a mess-of-wires prototype to a tidy device gave the participants a deeper sense of completion. However, the equipment required (for soldering, cutting, and crimping) was easily worth over $100.

I had the requisite equipment on hand; if I hadn't, I would have pursued a partnership with CEID or MakeHaven, which would added more time or increased the cost of the workshop.

Workshop scope

The overall plan was to cover content in four broad areas: general electronics and prototyping; types and uses of sensors; types and uses of indicators and displays; and connectivity with Bluetooth or Wi-Fi.

This scope was ambitious, yet doable with reliable participation. However, participation was not reliable due to other demands on participants' time, and thus some projects were not completed, and some were reduced in scope.

Fortunately, this variability in participation was anticipated based on prior YSP[Hack] experience, and therefore the format of the workshop intentionally allowed for flexible attendance. This paid off at the end of the semester when several participants' schedules opened up (after thesis deadline), allowing substantial progress on their projects.

In the future, a more realistic scope would be to include only the first three sections of content (general, sensing, and indication), and leave connectivity for a follow-up workshop.

Choice of supplies

The central components of these projects (known as *microcontrollers*), were procured from vendors with excellent track record in quality and support (Adafruit, adafruit.com, and Particle, particle.io). The microcontrollers were chosen for their outstanding documentation and good balance of functionality and price.

Other parts largely consisted of assorted multi-purpose sensors and indicators, procured from Adafruit and SparkFun (sparkfun.com).

These vendors and products did not disappoint, with the notable exception of some problems interfacing Particle microcontrollers to Android phones; it is unclear whether those problems were due to unreliability of Android software or a malfunction of Particle products.

Parts selection, conducted during December 2015 and January 2016, was laborious. I chose to stay away from learning kits (many of which are available from the same vendors); using such kits would have saved me a lot of time researching the various parts and tools, but it would have cost substantially more.

This is an ongoing challenge in running workshops in which participants make a thing of their choosing: preemptively purchasing parts that are ultimately unused can be expensive, but missing a part that would make someone's project viable can be expensive (due to unpredictable shipping costs) and time-consuming (due to consolidation of orders to mitigate cost of shipping).

Adafruit is currently attempting to address this problem by creating a product (Circuit Playground, adafruit.com/product/3000) with a delicate balance of cost, features, and expandability. This product will not include any Bluetooth or Wi-Fi support, but since connectivity turned out to be one ambitious goal too many, I suspect that Circuit Playground will make an excellent tool for this type of workshop in the future.

Workshop cost

If I had taken connectivity off the agenda from the start, the total cost of the workshop, using parts available at the beginning of 2016, would have been reduced by approximately $130 (15% of the budget). Some projects actually undertaken would not have been viable without Wi-Fi support, but I have no doubt other project proposals would have emerged instead.

With Adafruit Circuit Playground — thanks to the components included in it — the cost of a similar future workshop (again without Wi-Fi support) could be further reduced by $50.

Conclusion

I am glad I organized this workshop, and grateful for all the encouragement and support I received from YSP[Hack] leadership and YSPH.

Particularly gratifying was the enthusiastically positive feedback I have received from the participants, most of whom have expressed a desire for ongoing exploration of this nature, and asked me for future assistance — which I will be happy to provide.

Though I don't know when my schedule will permit me to repeat this, I have learned valuable lessons about organizing, teaching, and funding workshops, and I hope to put them to good use.