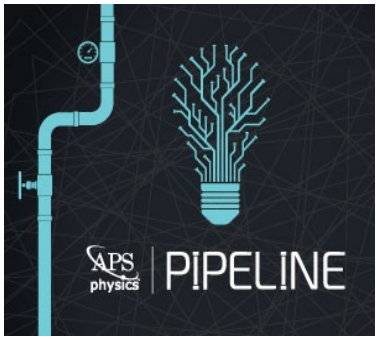
Pop-Up Classes: A Non-Traditional Way to Introduce Technical Skills

Linda Barton



Technical Skills: a crisis forming?

30 - 40 years ago

- Kids messed with go carts, lawn mowers, small boats, toy trains
- Families built or fixed things
- High schools offered shop, technical drawing, etc (at least for boys)

Nowadays

- “Safety” concerns
- Structured playtime, activities, sports, no “messing around”
- Shop and practical courses gutted

Today's incoming physics students have little to no practical hands-on skills!

Am I Imagining this problem???
Survey Physics Students

- >70 physics majors sophomores – seniors
- Ongoing, 4+ years
- Multiple choice and free response questions
- No “physics” related questions (e.g. cryogenics, vacuum) just hobbyist and Home Depot level

The results give me nightmares!

Survey Results – Easy Questions

- Just under 50% have drilled a hole in metal with a drill press
- Under 25% have ever tapped a hole
- < 10% have ever soldered plumbing using a torch
- Less than 10% could answer which is the larger machine screw: 6-32, 10-24, ¼-20, 2-56, 4-40
- Less than 4% knew what those machine screw numbers meant, even approximately

Survey – More Easy Questions

- Only 2/3 knew that US house wiring runs at 60 Hz
- Only half knew that US house wiring is 120 V rms

these were multiple choice questions!

- When **told** that a standard extension cord is 16 gauge (AWG), and asked what a “heavy duty” cord would be, answers split about evenly between 40 AWG and 8 AWG
- Only about a third have built any electronics that involves soldering components onto a board

Open-Ended Question:

"Explain how you would make a flange; that is, a circular metal part with holes equally spaced around it at the same radial distance from the center. What tool would you use?"

Carefully....

I would ask an engineer to help me.

I don't know what a flange is or why you would want to make one.

A CNC machine is needed.

A compass, draw some circles and just drill the holes.

I don't even know what a flange looks like.

I'd give it to a Mech E. I'm pretty sure you need a water jet machine.

To give them credit, a few students mentioned a mill...

Open Ended Question: Hobbies?

"tell me about any hobby you have, or had, where you used your hands to build or fix stuff..."

"I've never had a hobby like this because I never knew where to start..."

"I used to play with Legos" (a very common response)

"I would be able to and/or glad to learn to do any of this if I would use it, but I'm not sure I will."

We have a problem !

Premise: Physics as a discipline depends on the ability of physics practitioners to

- develop instrumentation,
- understand instrumentation,
- design and build dedicated unique instruments

Questions from an Old Curmudgeon...

Are we teaching our students the skills they need to develop or truly understand instrumentation?

For BFY 10, in 2039.... who will be presenting?
… am I the only one here worrying about BFY 10?

The world has changed in 30 years, so that kids no longer learn useful hands-on skills at home. **Has our curriculum changed to re-mediate this**?

Push-Back to Curricular Changes

“That's not physics!”

“We're not training technicians”

“There's no time; they have 'important' things to learn”

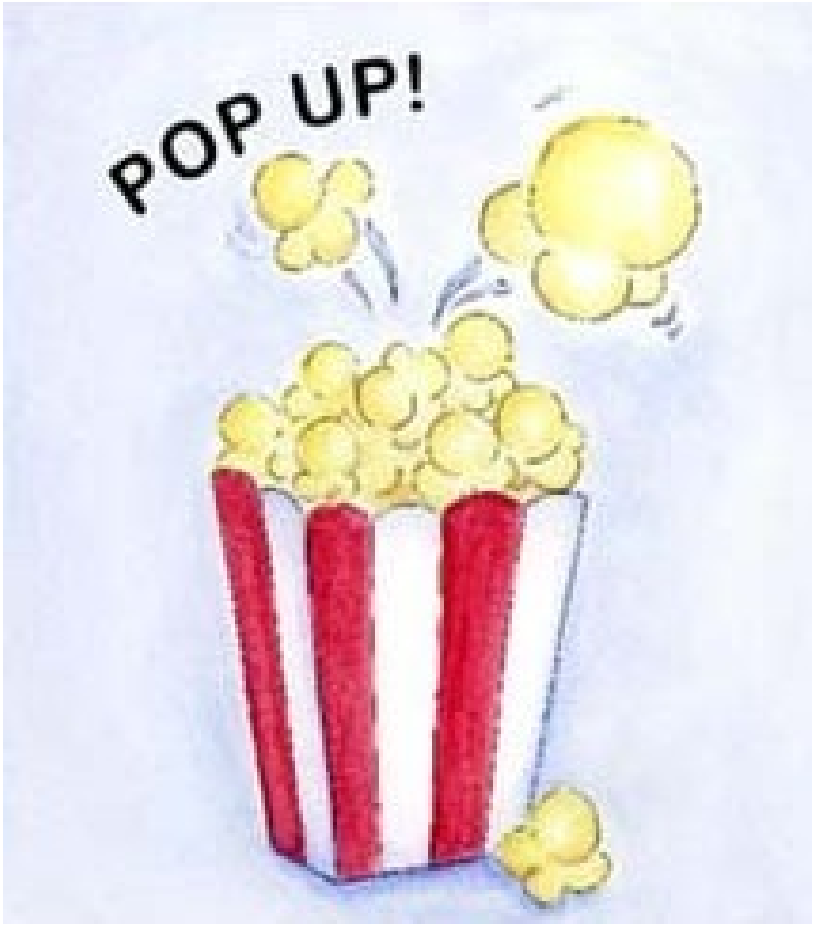
“These things are too dangerous, there's too many regulations”

“Who is going to teach this stuff anyway?”

“You want to give academic ***credit*** for this???”

*Teaching **thinking** skills is valued and accepted.*
*Teaching **tinkering** skills … not so much.*

Pop – Up Classes !



Just a cute name

It's better to ask forgiveness than permission.....

End run around curriculum committees and other rules, traditions, and prejudices

“Justified” by student interest

What is a Pop-Up?

- Usually short – one to four sessions
- Volunteer faculty (*not part of normal teaching load*)
- Volunteer students (*not credit bearing*)
- Little to no cost to student (possible fees for supplies, but no tuition cost)

  off the books, under the radar

Why do Pop-Ups?

- Allows faculty to try out new material (test kitchen)
- Allows “off the mainstream” material to be incorporated without broad agreement in the department
- Allows students to “dabble” without large investment of time or commitment of credits (smorgasbord)
- Fast turn around from conception of idea to implementation

They're just FUN!

Simple kit building – soldering

12 students, 4 solder stations

Friday afternoon 2 hours

just before holiday break

This class filled

2 hours after announcement

(I only had 12 kits)

Total mayhem! They don't know how to solder...

CONS:

I funded this ($90 for the 12 kits)... they kept the trees.

Only ONE kit worked without my re-working lots of it... they really don't know how to solder. NOTE: Kit is labeled “beginner ages 8 and up”.

PROS:

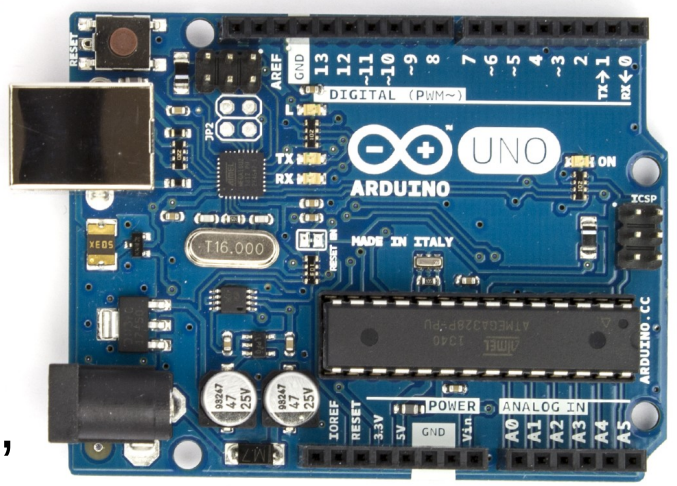
Students are ***begging*** to do it again, or build other kits

Our Electronics Measurements course has re-instituted building a soldered kit

Velleman kit available Jameco.com

Arduino Intro

Resources: (~$300)



- 6 “shoeboxes” each with Arduino, protoboards, wires, assorted LEDs, buzzers, transistors, resistors, motors, diodes, switches, relays

- DVMs, power supplies, lab space borrowed from department

Two sessions, two hours each – second one optional, only come back if you want to

I've run this several times now – students asking for more

Arduino classes limited to 12
Students worked in pairs if class full (6 setups)
Students brought their own laptops
Students had ALREADY installed the IDE

No prior programming experience required at all

Many students had never had Electronics Lab thus needed help with protoboard, diode polarity etc

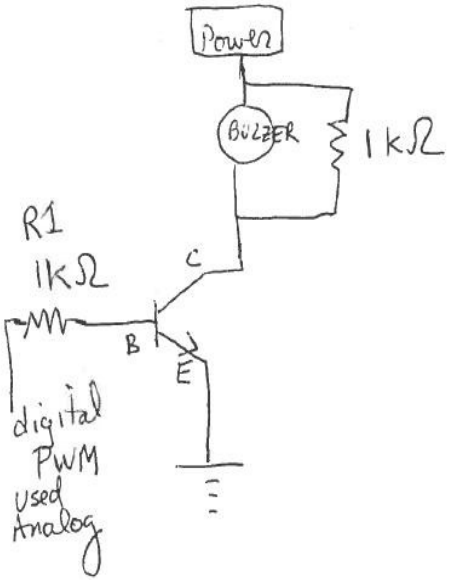
---> instructor is *VERY* busy!

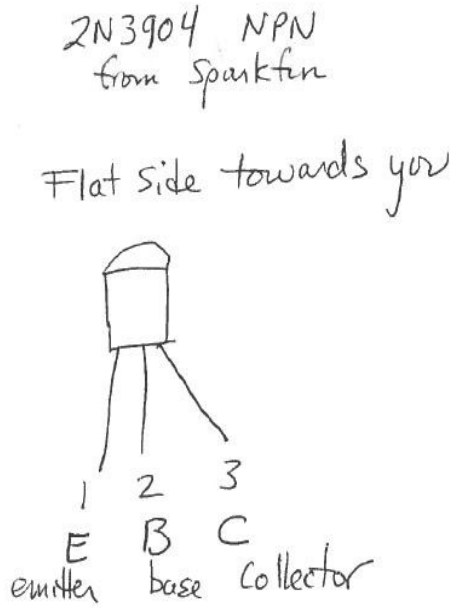
Guided Exploration – Handouts:

- Begins with “type this code in, build this very simple circuit” - for ONE blinky LED – very prescriptive
- Suggests adding another LED, changing blink sequence... let the student figure it out
- Subsequent sections add circuit elements, add code fragments – buzzers, motors, etc
- All are just ***suggested*** fun things to try
- Builds coding skills and hardware familiarity in somewhat systematic way

Teach them to Dabble!

Keep it casual, e.g.





Keep it loose

```
val=digitalRead(SWITCH); //decide if switch pin 2 is hi or lo

if (val==HIGH) {          //   if its hi, blinky pattern
… insert your code for whatever blink pattern you like …
}

else {                              //if its lo, shut the LEDs off
```

Keep it fun

open ended hardware suggestions,
just snippets of code as teaser examples

Guided handouts try to gently build hardware skills systematically (digital out, digital in, analog out, analog in...) and coding skills systematically (simple directives, then IF THEN ELSE, then loops) all with snippets and fragments so they can improvise

Usually by one hour in, they are “off to the races” and going off-script, trying things – which is great

They seem blissfully unaware that they are learning to code in compiled C, by just doing it

Second class – using Arduino for drive relays so as to handle power devices, switching AC devices

Quite a few have purchased their own Arduinos and are building things on their own or taking their skills back to research and capstone projects. One taught this course several times.

Machining Skills

- Band saw
- Drill Press
- Tapping

- Basic Milling – make slotted optical bases

- Must do online safety class first
- Work ONLY aluminum, brass, plastics
- Include info on lubrication, tool speeds, etc

Small shop – no machinist – I only can handle 4 students MAX

Computational

- Intro to gnuplot
- Intro to LaTeX
- Installing dual-boot Linux/Windows systems
- Basic Linux use
- Intro to Numpy, Scipy (soon)

Other faculty doing some now:

- BASH scripting
- Some Astro packages

Pop-Ups Coming Soon

- Neo Pixels … fun circuits to build, use Arduinos to control
- Advanced Milling – rotary platform, dividing head
- Cryogenic thermometry – measure temp profiles in a block using various transducers, play with LN2
- Dis-assembly and cannibalizing parties – one for old dead equipment, one for old dead computers
- Things the students request (if I know how or can learn)

Logistics and Planning

You need a fun-looking announcement – you are SELLING this to volunteers!

Post it where students hang out

Make sure the dept technicians are on board

Be sure to include sign-up info and size limit

Not too much advance notice or fuss – one week

Logistics, Continued

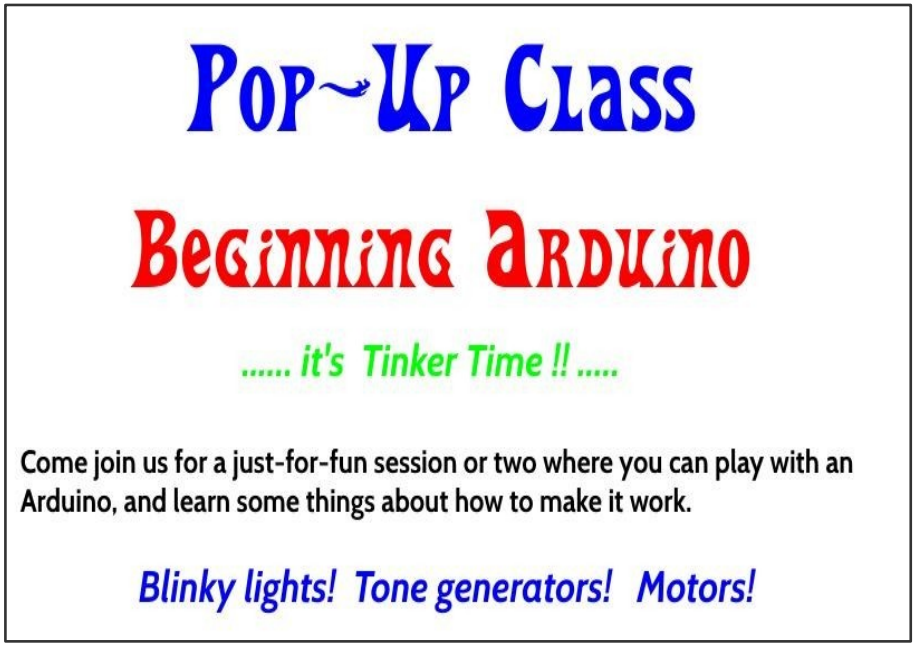
Timing is everything
- Friday afternoons
- Early evening

Avoid exam times, stressful times

2 hours is plenty

Seek student input

Seek student help - they come back to help/teach



Advice – Expect Mayhem

- Arduino class … 12 students, inexperienced programmers, no electronics background

  Me bouncing around the room: “you need a curly bracket here”... “the diode is backwards”... “add a pull up resistor”... “don't forget to compile first” ...

- Kit building class … 12 students, none have soldered before.

  Me bouncing around the room: “tin the iron first”.... “yikes you've blown the trace off the board”... “dont forget the polarity”...

- BASH – all different platforms, backgrounds
- Installing 3 flavors of Linux on 8 different computers at once... yikes!

Mostly they need the ATTITUDE of “it can be done, we'll figure it out” as the take-away - the experimentalist mind-set.

Coping with Chaos

- Adjust your class size to suit your tolerance
- Set your expectations reasonably
- Don't get flustered. The idea is to have fun.
- ***Draft more experienced students to help.***
- Learn to say “Just try it”, “uh... I dunno”, and “let's see what happens” Stop being a professor!

Remember – you are teaching the art of TINKERING. It's not a linear or systematic process, it's a attitude..

Pop-Ups - copied from Engineering & Entrepreneurship curricula

- Often pop-ups used for MakerSpace credentials/ certification
- Engineering has apparently realized and acknowledged the skills-gap for hands on work, and are backfilling with pop-ups
- Senior design projects may include mandatory pop-up short course pre training

Pop-Ups at Texas A&M engineering

- Electronic Component Selection
- Microcontroller 1 & 2
- Electronic Measurement 1 & 2
- Soldering 1 & 2
- Labview Basics, MATLAB Basics
- Android Programming
- CAD 1, 2 & 3
- Solidworks certification
- EIC Shop Access
- Intro to Lathes
- Lathe 1, 2 & 3
- Intro to Mill
- Mill 1, 2 & 3
- Basic Hand Tools
- Basic Power Tools
- Woodworking
- Welding 1, 2 & 3
- Laser Cutting
- 3D Printing 1 & 2
- PCB Design 1 & 2
- Foam Cutting
- Injection Molding & Vacuum forming

plus a list of professional-skills pop-ups

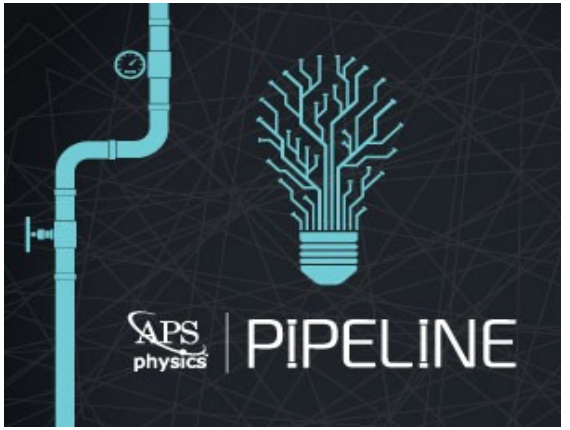
https://engineering.tamu.edu/academics/eic/pop-up-classes.html

Pop-Ups: Issues Moving Forward

- Institutional backing?
  - PopUps do not generate tuition revenue
  - Uses faculty time and institutional resources
  - Personally, my dept has supported with $$ (not time)
- When you get busy - pop-ups die. E.g. 2017.
- Goal: “Badging” or some form of accreditation
  - Formalize the curricula so it “counts” for students and faculty both?
- Be careful what you wish for;
  - this can balloon into a lot of requests for a lot of things very quickly!

APS PIPELINE Network

- Six member institutions: Loyola University Maryland, Rochester Institute of Technology, Wright State, UC Denver, George Washington University, and William & Mary.
- Advised by experts from established physics entrepreneurship programs (e.g. Carthage College, Case Western, Kettering University)



- Goals are:
  - to **deliver tested PIE curriculum** to a wider cohort of practitioners.
  - to **assess of effects of PIE implementation** on student and faculty attitudes towards innovation and entrepreneurship, and **examine barriers** to PIE implementation
  - to **build a community** of expert practitioners who can mentor other institutions.
- Activities are varied in scope and resources needed; institutions varied in culture and resources available.

www.aps.org/programs/education/innovation/index.cfm

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