Flipping (and Scrambling) Introductory Electronics

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Ah, the nicely organized linear sequence of topics that make a well-designed course... that's how I've been teaching electronics, but it's now how most of us actually *learned* electronics. I really learned electronics by building "bomb" triggers for a dorm-wide game of "Gotcha" as a sophomore in college. I'm sure most of us have similar learning experiences: we want to make a specific device, we find we need to know more about some sub-topic to make it work, and by the time we're done we've learned something.

The linear approach to topics in electronics doesn't support this learning model, and to some degree even masks the interdependencies of the topics. I want to do better than that; I want to structure my course in a way that helps students appreciate what they're doing and why they're doing it and where they are going. I want to arrange the course so that they have to —and want to— take responsibility for their learning.

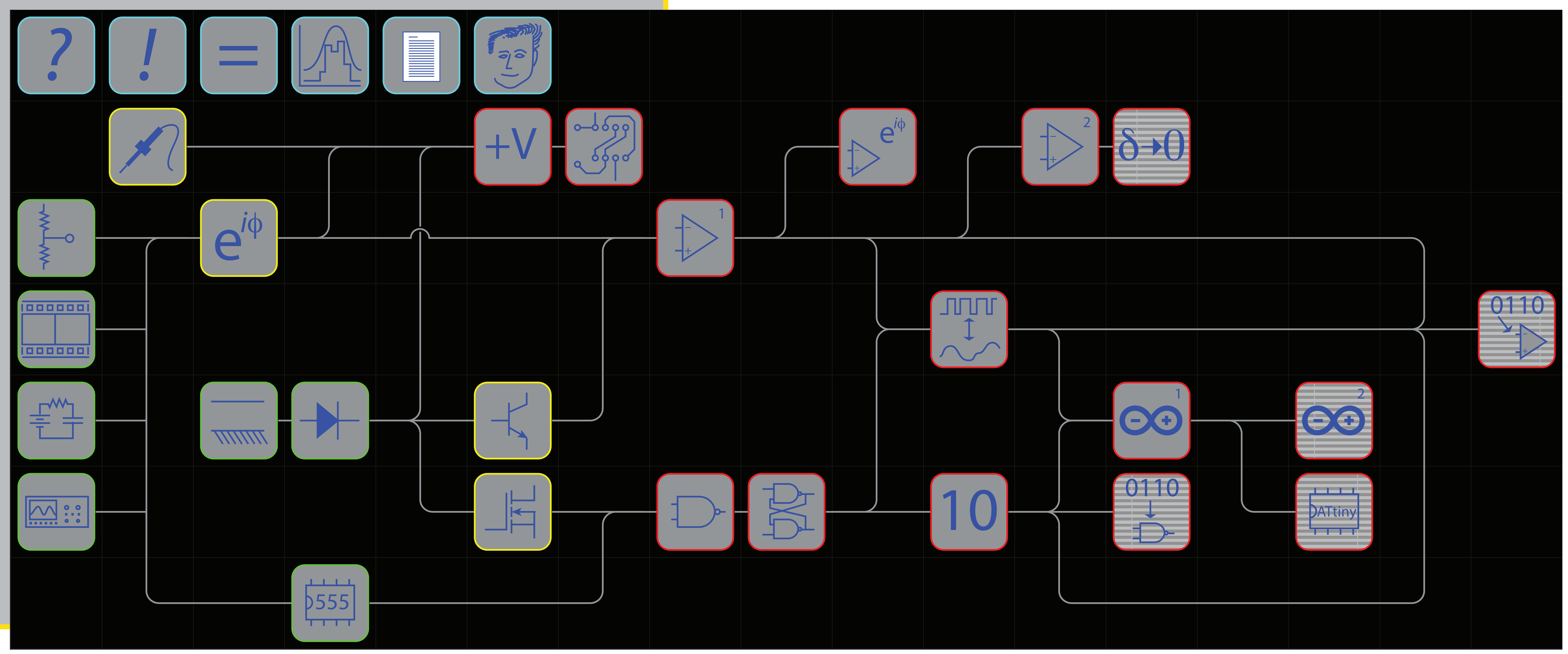
This is my first shot at it.

It starts with a "technology tree". This is my new homepage for the course: each icon represents a learning module, the paths between icons represent prerequisites for that module. Students can take any valid path they wish through the material.

For example, to complete basic logic they will need to understand MOSFETs and complete the 555 timer exercises. They will not need to first do the module on passive filters.

Clicking on a module opens a page specific to that topic. The page gives a summary of the module, including why it's interesting and what we can do with it. It links to lab exercises, relevant textbook sections, online resources, and problems to test understanding of the topic.

As the class progresses, students can log in to see how they are doing. The icon colors change to reflect completion status: Green = passed, Yellow = available, Red = not yet. (The webpage is generated by a Python script which makes user-specific pages easy.)



Factors that make this course approach possible at Chico State:

1) I have colleagues who have no idea what I'm doing, but they think it's pretty cool. They give me the freedom to screw up in whatever manner I think best.

2) "Electronics for Scientists" is the first semester of a two-semester Advanced Lab sequence. I teach the second semester also, so there's nobody complaining that I didn't properly cover topic *x*. (Except me.)

3) The course usually has only 0b0110 to 0xC students, so it's possible to manage the level of individualized attention necessary.

Tools Used:

Illustrator: created icons and tech-tree elements
XML: description of module icons, default colors, and layout of icons on homepage
mysql: record student progress
Python: generate dynamic homepage from XML and mysql, generate module pages

Administrivia

- Course Info
- Class Announcements
- Login
- Grade Info
- Datasheets
- Instructor Info

Basics (no pre-reqs)

- Soldering
- Voltage Divider
- LabVIEW
- RC basics
- Lab Instruments
- Semiconductors

Required core material

- Passive Filters
- Diodes
- 555 Timer
- Voltage Regulation
- BJT
- JFET/MOSFET
- EAGLECAD
- Op-Amp basics
- Logic 0
- Logic 1
- Active Filters
- A/D and D/A
- Binary
- More Op-Amps
- Arduino

Optional material

- PID Control
- FPGAs
- Advanced Arduino
- Microcontrollers
- PSoCs

Fridays...

... are quiz days. By Wednesday of each week, students must inform me of the module(s) on which they want to test themselves that Friday. They can test on any yellow module: passing turns the module green. They can also re-test on green modules to improve their score, if they feel that they've improved their understanding of that module since their last test.

Tests may be written:

What is the power dissipated by resistor R2 in this circuit?

Calculate the value of R and C in this 555 circuit so that the output will have a frequency of 42 Hz.

Conceptual:

Sketch an amplifier with a gain of 12 and a corner frequency suitable for audio applications.

You want to drive Helmholtz coils using a microcontroller. Explain how you will do this.

Practical:

Here is an LF411 and a handfull of other parts: build a 2-mA constant-current source.

Use this 'scope to show pulses from that Geiger counter.

or even Show-and-Tell:

You designed and etched a circuitboard using EAGLE-CAD? Let's see it.

Module Grading:

1 — Troll
2 — Study, re-take
3 — Pass
4 — Mastery
5 — Synthesis

Based on previous semesters, the amount of material in the required portions of the tech tree is a reasonable goal for the average student. The optional modules are things I wish we could get to in class but never do. The syllabus explains that "only 'A' students need attempt them... we'll see if that works!

Why this poster?

These are not Physics Education Research results:

~~"Use this in your classroom for 7.3% (±25%) improvement in student comprehension!"~~

This is not a tested course redesign:

~~"I tried this last semester and it seemed to work!"~~

This is a request for help.

I believe that this tech-tree approach will help the students better understand how topics are linked and interdependent in this introductory electronics course. It should give the more motivated/talented students opportunity to go beyond the material covered in the "standard" course. It has the potential to increase the amount of "off-topic hacking" that often amplifies the real learning in a course like this. These potential benefits, and others, are tantalizing enough that I'm willing to try it next spring.

But this approach also has the potential to fail spectacularly. If you see a looming failure mode that I'm missing, tell me about it! Talk to me — I need your ideas, experience, and helpful suggestions.

Homepage (content in progress):

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