

## **Introduction**

My main goal for this thesis is to explore an effective way to teach engineering concepts. Frequently formulas are learned by rote repetition without an understanding of how fundamental principles relate to each other. With interactive learning software, I believe I could help clarify the meaning of a current lesson and how it fits within the context of engineering. In particular, I will focus on electronics and math applications within the context of computer engineering. I would also like to research materials and effective teaching styles from other Universities/Institutions. For example, the animated electronics concept demonstrations from Florida State University (specified in the *Java Application* section) could be incorporated into my interactive software.

After consultation with Joe Zachary, I've decided to develop electronic component software with concepts similar to the Logisim software that is incorporated in his introductory computer course. His online course introducing Unix will provide guidance for my interactive software efforts. I have also consulted with Neil Cotter on his current high school outreach project to determine how I could help him convey the fundamentals of electrical/computer engineering. The project chosen is software emulation of an electronic circuit board kit used for high school students. I will develop a drag and drop graphic representation of the electronic components and circuit board in this physical kit. My software will contain interactive components that will be emulated as well as explained through illustrations. Layers of information will also be included to teach electronics fundamentals and the concepts behind the given circuit.

Different projects within the program are outlined in Prof. Cotter's outreach website which includes .html pages describing the details of each project: [http://www.ece.utah.edu/~eectools/\\_Outreach/\\_Outreach.htm](http://www.ece.utah.edu/~eectools/_Outreach/_Outreach.htm) I will start with the pictures of the circuit board and electronic components and use them as the graphic components of my software.

The main bulk of the program will focus on analog electronics. Electronic components (listed in the *Electronic Components and Concepts in the Software* section of this paper) are introduced and explained in regards to the circuit board kit given to students. These components and electronic circuit concepts along with them are applied to schematic diagrams, illustrating documentation in the field. These lessons form the foundation of the subsequent projects within the program.

## **Effective Teaching Styles**

Effective teaching styles according to my thesis will include the pedagogy of teleology as explained by Immanuel Kant. Teleology in this application is seen as illustrating how all concepts of a subject fit together from the beginning of a course. In my interactive software, an electric circuit project is seen in its entirety with all the component parts fitting into the whole sum. The individual lessons are then elaborated on and referred back to that original context.

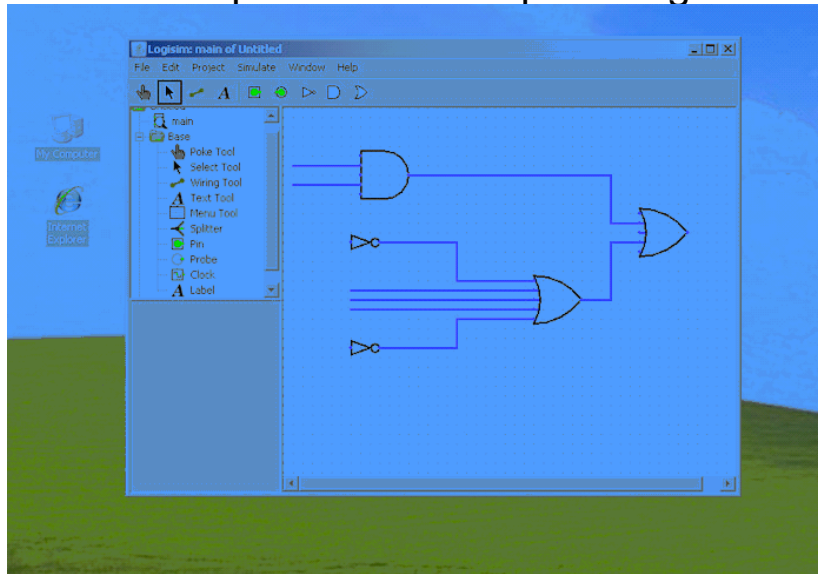
Additionally, different teaching styles will be incorporated that have been shown to reach a larger range of students. Visual teaching affects a different part of the brain than a logical approach. Interactivity also engages the mind in a multi-faceted way that reading alone cannot provide. Particularly interactive software allows for experimentation which gives an understanding of concepts that cannot be achieved by rote repetition. All these approaches will be a part of the interactive software that is the basis for my thesis. The visual in addition to logical modes of teaching are supplemented with the kinesthetic learning that is presented with the physical electronic circuit boards.

### **Interactive Software**

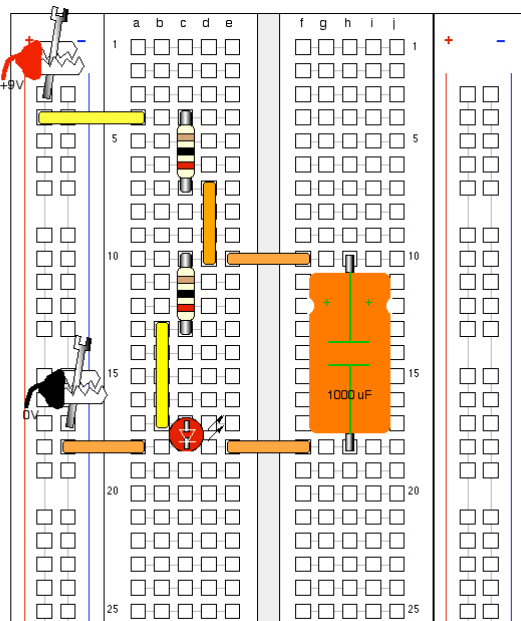
There are many excellent examples of interactive software online and in courses from other universities that clearly describe science, mathematics and engineering concepts. For example, the electronic component software used in Professor Zachary's course was developed by a professor at Hendrix College. In addition to developing a specific circuit simulation program for Professor Cotter's high school outreach, I intend to have an expanded focus of explaining the concepts of electronics and applied math illustrated by the program. This approach will help tie together these concepts together. To do this, I will also utilize existing materials such as listed in the *Java Application* section below. These will be incorporated into my software if they have been shown to be effective at teaching the fundamental electronics concepts.

The interactive software concept will encompass ideas from HowThingsWork.com and more generally interactive layers of information. In other words, the software begins at a high level description of a circuit with a graphic representation. A student could then click on an element of the circuit, such as a specific component to go to a lower level explanation of that element. Each layer will delve into a subject that the student could further learn from. For example the student could click on a capacitor in an RC circuit project. The click would lead to a page that explains how a capacitor works with possible Java animations and interactivity to illustrate the concept of capacitance. I will also work on incorporating a simulation of the circuit. A student could look at nodes in the circuit to see the voltage and current levels. This is important because it provides information as needed by a student to comprehend and learn the overall concepts of electrical/computer engineering. The interactive approach allows for learning at the student's level of understanding. This effective teaching style is more flexible and based on the student rather than conforming to a set curriculum.

## Interactive Software – Electronic Components – Computer Logic



Here is an example of the Logisim software that is incorporated in Joe Zachary's Introduction to Computing course. Electronic logic gates can be selected and placed in the workspace. They can interact with each other and an output can be examined. My software will be similar to this; selecting electronic components to place on a circuit board.



The graphic design of my project will be based on these images in Professor Cotter's High School Outreach Project.

### Java Application

Java Applets will be incorporated into the interactive software to illustrate various concepts. Java was chosen because of its widespread use online and across computer platforms. It also has extensive, tested and well-documented features to choose from in coding. Additionally, there is a wealth of applets specifically used for interactive learning from academic sources that could be incorporated into the high school outreach software that I am working on. Here are a few examples of Java applets involving electronic circuits that could be incorporated:

How a Capacitor Works

<http://micro.magnet.fsu.edu/electromag/electricity/capacitance.html>

Voltage Divider

<http://people.clarkson.edu/~svoboda/eta/designLab/VoltageDividerDesign.html>

Many More Electronics Java Applications

<http://www.educyclopedia.be/electronics/javacollectors.htm>

### **Thesis Tasks Ordered by Priority**

Here I have outlined the tasks for my thesis based on priority. The tasks in level 1 are the top priority and will be accomplished. Level 2 and particularly level 3 tasks will be completed as time permits.

#### Level 1

Graphics Layout

- Circuit board
- Electronic components in box to choose from
- Place electronic component objects on circuit board
- Ability to rotate components on board

Learning - Interactive

- Explanation of each component
- Overview of a few projects + how the parts fit together

#### Level 2

Simulation

- Basic output waveforms at each node – voltage, current levels
- Graphic representation of short circuit/higher values than a component can handle (ie smoking/exploding component).
- Applied math variable illustrations

Learning

- Java applets incorporated

#### Level 3

## Simulation

- Basic oscilloscope simulator
- Schematic diagram based on circuit created with components

## Learning

- Apply concepts to specific areas in classes  
Work with high school teachers for each learning application based on their lesson plans.

## **Timeline**

- Weekly meetings with Professors Cotter and Zachary for duration of thesis
- March/April – preliminary thesis proposal (This class)
- August/September – setup design layout and pseudo code, components as picture objects
- October/November - finish coding and obtain all materials from other sources
- January/February/March - work through bugs, interactivity with user, incorporate material and software from outside sources
- Done by April 1 ( 1 month before graduation )

## **Electronic Components and Concepts in the Software**

Each electronic component will be treated as an object in Java. The object will have an associated picture that can be placed on a virtual proto-board. Each object will also have associated characteristic data that will be provided to the back-end circuit simulation. Additionally, each component can be clicked on to continue to a page with more information explaining the fundamental concepts behind it. The following is a list of the electronic components and concepts that will be incorporated in my interactive software:

- Resistors, LED's, Op-amps, Switches, Inductors, Capacitors, Transistors, LF353 OpAmp Chip, 4011 NAND Gate Chip

The main concepts of electronics can be described using these components within a circuit. For example resistors in a circuit are necessary to have a functioning system that will not short circuit. A short circuit animation may be incorporated to illustrate this concept. Each component will have its associated value further explained, such as resistance measured in ohms units. The LF353 OpAmp chip will be used to explain amplification within a circuit. The NAND gate chip will be used in the Introduction to Digital Electronics Project. It will illustrate, through a working circuit, the use of digital logic gates. These gates will show their utility by controlling the flow of electricity that turn on or off an LED.

- Voltage, Power, Current, Resistance, Ohm's Law, Kirchhoff's Laws

Concepts will be taught when occurred within a circuit. For example, when a student clicks on a node in a circuit; voltage, current and resistance values will be shown. These values will then be related to Ohm's Law, showing and calculating the equation that manipulates and relates the measurements to each other. Illustrations on Kirchhoff's Laws will also relate the electric circuit and component measurements to algebraic

equations that represent a mathematical model of the circuit. The associated unit with these values could then be selected to obtain an information/demonstration page that describes the concept.

### **Circuit Simulation**

There will be a back-end circuit simulator that will give a voltage waveform at any node that is clicked on. Each component will have a unit value that can be used in calculations by the simulator. Those variable values could be adjusted by the student to see the direct causes and effects of their input. It may also contain other circuit simulations that will aid in understanding the circuit concepts. For example, if feasible in the allotted time, the circuit illustration could be translated into an electronic schematic diagram and visa versa. There may also be an animation to illustrate blowing a fuse or burning component parts based on their specifications if power values set are too high for them to physically handle.

The simulator will be implemented using software such as PSpice that has open source code. If possible, Java source code will be used to enable different server platforms and a more streamlined integration with the rest of the software. Here are a few examples of software that are good candidates for this back-end simulation:

Chile Spice

<http://www.cs.sandia.gov/esimtools/chilecad/overview.html>

PSpice Java Applet

<http://www.geocities.com/reli73/Vred.html>

MultiSim

<http://sine.ni.com/nips/cds/view/p/lang/en/nid/202313>

They are all based on the PSpice circuit calculation engine. Chile Spice uses schematics as inputs to produce mathematical models of electronic circuits. The PSpice Java Applet was created by developers as an input/output port using electronic components and measurement tools via a web interface. MultiSim is an excellent program that precisely simulates electronic equipment such as those we have in the electrical/computer engineering labs here on campus. All of these examples provide aspects of the simulation that are desired for my interactive software.