Electrical Engineering Apprenticeship

Designed by Rosa Villastrigo, with aid from the DesignIt! Curriculum

Apprenticeship Overview

Apprentices will learn about electricity and power through a series of hands-on experiments wherein they will create circuits for flashlights and houses. Apprentices will learn about how electricity flows, what a circuit diagram is, how to wire a circuit in series and in parallel, and how to make an on/off switch. Apprentices will wire the lights in a 3D cardboard box to meet specifications (bright lights, dim lights, switches). In the end, they will design and build an electrical device of their choosing.

Goals

To teach apprentices about how electricity works, how current flows, and what it means to be an electrical engineer. Apprentices will gain more confidence in their motor skills by creating working apparatus by themselves. They will also build confidence in their ability to create by designing their own device.

Session 1: Introduction to Electricity

Overview

Apprentices will be introduced to each other, and to the concept of circuits and how they make things work. Apprentices will be challenged to create their own circuits and make a light bulb work.

Materials

- Flashlights
- Worksheets for apprentices to make circuit diagrams
- Pens/Pencils
- Coated Wire (approx ½ foot per student)
- Wire Strippers
- Batteries (9 volt), 1 per student
- Light bulbs (A string of Christmas lights can be cut so that each bulb has two one-inch wires coming from it)

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator

Content Step I: Team Intro Time: 15 min

Pass It Along: Apprentices and Staff will form a circle. The first person will say their name. The person to their left will say the last person's name and then their own. This pattern will continue until everyone has gone through and the last person says everyone else's name in order, and their name last. Then the initial person will say their name and make an identifying motion (hand claps, elephant noise, shout out), and again all of the names/motions will be passed along the circle until the last person can say all of them. When apprentices can do this successfully, the circuit will be "rewired" and all will be asked to find a new spot (no one can stand next to a person they were previously standing next to). The groups will be challenged to go back through the circle and remember the names and identifying motions.

Content Step II: Project Intro Time: 20 min

Expectations: Staff will explain what they expect out of the apprentices in regards to behavior, respect, and safety. Apprentices will be allowed to add when necessary.

Overview: Introduce the project to the apprentices in detail. Use this time to give the apprentices a clear picture of what the WOW! will be—to create a model house with lights and switches—and how you intend to work up to it in the following lessons.

Engineers: Staff will introduce the concept of an engineer. What do the apprentices think of when they hear that word? What does it mean to be an engineer? What does it mean to be an electrical engineer? What kinds of things do electrical engineers do? Record answers on a newsprint posted in the classroom.

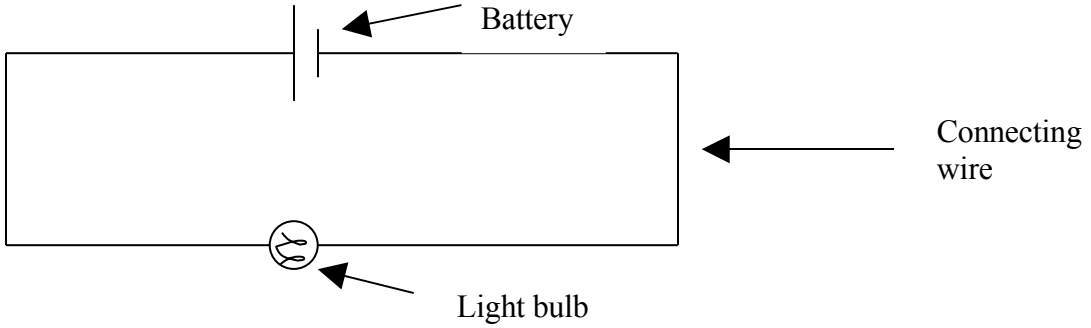
Content Step III: What makes a flashlight work? Time: 20 min

Apprentices receive pencil and paper. Staff explains that they will be handed flashlights, which they will be allowed to take apart and put back together. Apprentices will be challenged to make a drawing showing how they think the flashlight works. Pair students into teams to encourage teamwork, and hand out the flashlights—one per pair. Encourage groups to compare and contrast their drawings with others.

After all apprentices have made a diagram, discuss their results. When does the light work? Why doesn't it work when all the components are not together? Would it still work with only one battery? How could we make it work with only one battery?

Content Step IV: Let There Be Light Time: 45 min

Move the class to the "work bench" area of the room in order to get some movement out of the apprentices as well as set clear divisions between the "working" area of the room and the "design" area of the room. Pull out supplies for making a light circuit: wire stripers, wires, bulbs, batteries, and electrical tape. As a group, identify each item and how it is used. Staff makes it clear how important it is to not short out a battery by connecting the leads. Apprentices are given the wire strippers and asked to practice cutting and stripping the wires.



Post a correct circuit diagram (shown above) and, as a class, go over each component. Give each apprentice the flashlight supplies and ask them to make the connection between the

diagram and the real components and make their bulb light. Encourage sharing ideas with other apprentices.

Many apprentices may have already done this activity before in an earlier grade. To avoid having these apprentices get bored and unfocused, have a few circuit diagrams on hand that are more complicated (with multiple bulbs in series and in parallel) and challenge the apprentices to complete these. However, this activity should only be introduced if the apprentice can teach back to you how the original circuit works and identify each component.

Content Step V: Closing Time: 20 min

Cleanup: All circuits should be taken apart and components placed in the supply box. All wire pieces and stripping should be cleaned up off the floor and desks and placed in the garbage.

When apprentices have finished cleaning up, staff should facilitate a discussion surrounding things that were covered during the day. Possible questions: What is a circuit? What happens when you break the circuit? What things around the house have circuits? How do the lights in the house work? What kinds of things connect the circuit? What is a conductor? What is an insulator?

Record answers (or have an apprentice record answers) on a newsprint posted in the room. This can be saved and brought out as a review during the next session. Preview what will happen during the next class.

Session 2: The Electrical Journey

Overview

Apprentices recap what they learned the day before about the basics behind circuitry, electricity, and engineering. Any apprentices that did not finish their flashlight circuits from the day before have the opportunity to finish them. The class will proceed to learn how electricity moves through mediums and what it means to wire "in series" and "in parallel".

Materials

- Pre-made circuit diagrams
- Insulated wires (approximately 1.5 feet per apprentice)
- Wire strippers
- Bulbs
- Electrical tape (to insulate all connections)
- 9V batteries

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator
- Series (new)
- Parallel (new)

Content Step I: Intro — Time: 15 min

Begin the session with a new game (since they all should be fairly familiar with each other by now). A good activity to keep them thinking about circuits and passing current is the Slap Game. Apprentices cross arms with the other apprentices, laying their hands flat on the table. A slap is passed along the circuit, one slap for pass two slaps for reverse. Any hand that lifts or slaps at the inappropriate time is out and must be taken off the table.

When the game is over and there is one or two clear winners, ask the apprentices to relate the game to things we learned last week—how was it like a circuit?

When the discussion has finished, regroup apprentices and focus their attention to the front, where the posters from last session should be posted. Spend a little time reviewing the vocabulary and reviewing what was learned during the last class.

Content Step II: Diverging Circuits Time: 50 min

Apprentices who were unable to make working circuits last session will have the opportunity now to get the lights to work. Apprentices who already had working circuits can help these students to get everything in running order. This should take no more than 5 minutes.

Once you are certain that everyone knows how to make one light bulb work, the class can begin to discuss how electricity "walks" through a circuit. Ask an apprentice to walk to the opposite side of the room. Instruct them to find a circular path from their "home" to you and back. They can't backtrack and they can't go anywhere if they can't find a path back. Ask the apprentices how many possible paths the walker can choose. Use this example as an analogy for how electricity flows—if it can't get "home" to its source, it can't go anywhere. If there is more than one path, it's free to move through both of them, as long as it can make it back home without backtracking.

The class can now begin to discuss how to make two light bulbs work. Apprentices will be given a worksheet that has illustration of batteries and bulbs and asked to draw two different ways to connect the two. Once they have done so, ask them how they think the bulbs in each configuration are going to work—will they be bright? Will they be dim? Will they be in the middle?

Hand the apprentices each a battery, wires and three bulbs and ask them to make as many different lighting configurations that they can. They must document each configuration with a drawing and write down how bright each of the bulbs are (they may use shorthand: B=Bright, M=Medium, D=Dim).

Content Step III: Series and Parallel Time: 30 min

Once apprentices have made all of the possible permutations (with 3 bulbs they can make a total of 3 different kinds), ask for volunteers to draw each one on the board. Discuss how to make each drawing into a circuit diagram so that we are being more professional (and so they can practice reading and drawing circuit diagrams).

Why are some of the bulbs bright when others are dim? How does the electricity get from one place to another? What would happen if another battery were added? Introduce some scenarios where certain lights are not properly hooked up and ask the apprentices what would happen—which scenarios would cause all of the lights to turn off, and which would cause only some to turn off?

Content Step IV: Closing Time: 25 min

Cleanup: apprentices help make sure that all circuits are taken apart and placed in the proper places. All wire pieces are picked up off the floor and tables and thrown away.

Discussion: Have apprentices share back what they've learned throughout this session. Ask one apprentice to be scribe for the new words: series and parallel. Finally, ask the apprentices how many configurations they could come up with if they were given four bulbs instead of three.

Session 3: Wiring a 2D House

Overview

Apprentices will use their knowledge of series and parallel circuits to wire a practice house. They will be given different scenarios that require the lights to be wired in different manners and asked to wire them, creating circuit diagrams for each scenario.

Materials

- Paper
- Pens/Pencils
- Insulated wires (approximately 1.5 feet per apprentice)
- Wire strippers
- Bulbs
- Electrical tape (to insulate all connections)
- 9V batteries
- 2D House Worksheet

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator
- Series
- Parallel

Content Step I: Intro Time: 15 min

Apprentices sit around table for the opening circuit game ritual—the Slap Game.

After the ritual, open the session with a review of yesterday's class—vocabulary, circuit diagram drawing process, and how to wire in series and in parallel. Discuss what the plan for the day is, including reminders about safety, teamwork, and the importance of documentation (every time a circuit is made, be sure to write down how you did it so that it can be reproduced at a later time).

Content Step II: The Challenge Time: 25 min

Hand out "Wiring a 2D House" worksheet (found in the DesignIt "Wiring a House" curriculum). Read over the instructions carefully as a class and have someone teach back what it is asking. A scribe can be appointed to write instructions on the board (for example, they can write D = Dim, B = Bright and/or 6pm=2 Dim, 2 Bright lights) for all to see. Make sure apprentices know what is expected of them before asking them to begin.

Ask apprentices to draw circuit diagrams of what they think their circuit for each scenario should look like. Have them team up and compare their diagrams with their partners. When they feel that they are ready, they should raise their hands to have all of their diagrams checked over by the staff member.

Content Step III: Engineering Time: 35 min

After the staff has checked over each of the apprentices' circuit diagrams and made sure they are correct, hand out the necessary supplies (batteries, wires, wire strippers, bulbs, and electrical tape) and allow the apprentice to take charge. Instruct them to alert you upon every successful configuration. If they find that it is different than their circuit diagram, have the apprentice redraw the diagram correctly.

If apprentices are having trouble, ask a more advanced student to aide them in their wiring. If an apprentice finishes extra early and cannot help other students, give them extra bulbs and ask them how many different circuits they can make. Each circuit should be documented.

Content Step IV: Showing Off Time: 20 min

Have volunteers go up to the board one at a time and draw one of the circuit diagrams. Then have them show their circuit and light the bulbs to show that they actually work in the correct manner. One volunteer should show each scenario given. Be sure to ask apprentices questions to make sure they know why and how each situation works.

Content Step V: Closing Time: 25 min

Have apprentices clean up their desk area. Have them first take apart their circuits and put the components in designated receptacles. Then ask them to make sure that all wire strippings are picked up off the floor and desks and thrown away. Be sure to keep all paperwork.

Debrief: ask apprentices what they learned today. What were new words that we used? How confident are they that they can read circuit diagrams? Facilitate discussion about the day's work and preview what will happen the next program day. Be sure to keep notes of things we learned.

Session 4: Switches and Battery Packs

Overview

Apprentices are introduced to a new symbol that will be used in their circuit diagrams: the switch. They will learn the role of the switch and why it turns things on. Apprentices will also make battery packs by connecting three batteries which will be used to power the lights in their model homes, which they will begin drawing diagrams for at the end of the session.

Materials

- Brass fasteners (brads)
- Cardboard pieces (for battery packs and squares for switches)
- Paper clips (plain metal)
- Pens/Pencils
- Insulated wires (approximately 1.5 feet per apprentice)
- Wire strippers
- Bulbs
- Electrical tape (to insulate all connections)
- 9V batteries (3 per apprentice)

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator
- Series
- Parallel
- Switch (new)

Content Step I: Intro — Time: 15 min

Begin with Slap Game ritual.

After ritual, begin by reviewing things apprentices learned last session (words, circuits), as well as activities from last session. Go on to preview the objectives for the day: to learn about switches, make working model switches to be used in our houses, to make battery packs to power all of the lights we will need in our houses, and to begin designing our houses.

Content Step II: Which Switch? Time: 55 min

Begin by asking apprentices, "What kinds of things need switches?" Why do they need switches? What does a switch do?

Explain to them that we are going to be making our own switches today—and like the lights that we've been making they will be made of bare essentials, but will serve their purpose. Apprentices should, through prior discussion, understand how the switches work. Show them the pieces they will be given: two pieces of wire, a brad, a square of cardboard, and a paper clip, and ask them how they would use these pieces to make a switch. At this point most apprentices will know what to do, but some may need a little help, which can be given by asking pointed questions.

Allow apprentices to put together their switches. Let them begin with one, attach it to a bulb and make sure that it works. Let the apprentices know that, even though this is a simple activity, it gives them immense control over their circuits and the flow of power. Once they have mastered the simple switch, they can move on to a dial switch. Some apprentices may be familiar with devices that are similar to a dial switch. They may have seen a light dimmer, which makes a light bright or dim, depending on how far the switch is turned. This function is regulated by a potentiometer, which is an electrical component which allows varying amounts of power to pass through it. The dial switch that apprentices will be making is similar in that it will make the lights go through different brightness, but the difference here is that they will be telling the electricity which pathway to take.

Apprentices need to use another cardboard square, but this time they will hookup four brads instead of two. One will be attached to the paper clip switch (whose other end should be hooked up to one side of the battery), and the other three will be hooked up in different ways to a four bulb system. The system will have four bulbs in series, but wires that will put two of the bulbs in parallel when the switch is in the right place. A circuit diagram will need to be drawn in order for the apprentices to get it right. The dial switch should make three things happen: the first connection will make one bright light and three dim lights, the second connection will make all four lights dim, and the third connection will make a different bright light accompanied by three dim lights. This new switch will allow their house to be lit in different manners at the turn of a dial!

Content Step III: Battery Pack Time: 20 min

Students will have some "down time" in order to connect three batteries and their "home". The batteries will need to be hooked up positive to negative in a series and then placed in a cardboard carrier of the apprentices making. Use electrical tape to connect wire leads that originate from both the positive and negative sides. Apprentices can check to see if they work by attaching a bulb.

Content Step IV: Closing Time: 25 min

Cleanup: Disconnect all wires (apprentices may keep switches and battery packs in tact, but make sure their names are clearly marked on their items) and clean desktops and floors.

Discuss what was learned today and give the apprentices an opportunity to teach back important aspects.

Preview the next lesson, which will be to begin wiring the 3D house. Let them know what you expect them to accomplish in the end: how big the house will be, where you would like them to put the lights in, how bright you would like each of the lights, what kinds of switches they will need (or what kinds of lighting configurations, and allow them to think of what kind of switches they will need). See if there are any questions and ask them to think over the days in between classes how they will accomplish these tasks.

Session 5: Planning a House & Beginning Construction

Overview

Now that they know all of the basics, apprentices will be asked to plan out how they will build their houses. The shells will have the same basic design, but the wiring between apprentices may vary. They will have cardboard boxes (which will be the houses) in front of them to get a better special feel, but need to come up with a concrete plan before any wiring commences.

Materials

- Cardboard boxes (1 ft x 1 ft x 1 ft)
- Cardboard slots to make up "walls" and "floors" of house
- Pre-made, working house to show as model
- Circuit diagrams for pre-made houses
- Brass fasteners (brads)
- Cardboard pieces (for battery packs and squares for switches)
- Paper clips (plain metal)
- Pens/Pencils
- Insulated wires (approximately 1.5 feet per apprentice)
- Wire strippers
- Bulbs
- Electrical tape (to insulate all connections)
- Battery packs

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator
- Series
- Parallel
- Switch (new)

Content Step I: Intro — Time: 15 min

Begin with Slap Game ritual.

Recap what was learned the previous day by having apprentices share what they remember. Ask which of the things that they've learned so far might be most useful for building their houses.
Introduce what the plan for the day is by showing them some "blueprints" that you have made up for your own house, and a working house. Do not allow them to look too closely so as to avoid copying. Let apprentices know that today they will begin designing the lighting of their house. Each apprentice will be allowed to first construct their house, then to get a feel for it and how they can put the wiring in. make it clear that they may not get any wiring today, and might spend most of their time planning and making diagrams (they may even draw on the houses if that helps them think).

Content Step II: The Blueprint Time: 80 min

Apprentices should be given boxes and slots and instructed on how to make their house. Ask them to put their names on the boxes so that they can identify them later. Hand out a worksheet detailing what is expected of each room—which ones you want dim, which ones you want bright, which ones you want to be capable of being both dim and bright. Allow them to ask questions, but see if another apprentice can answer before you give a response.

From now on, the apprentices are basically free to make circuit diagrams and drawings on the box to show what they plan on doing. Emphasize the fact that you want to see a circuit diagram from everyone before they begin any type of wiring. Let the apprentices know what materials they will be given (how many bulbs, their battery packs, which supplies for switches, how much wire) so that they can incorporate all of their resources into their plan. Then step back and let them work their magic.

If apprentices complete their diagram and plan before time is up, check it over to make sure it is correct. If it is not, have them go through it and make it right instead of telling them where the flaws are. If apprentices pass all inspections, have them help younger or struggling apprentices. They may also be allowed to begin prepping wires (by cutting to specific lengths and stripping the ends) and switches.

Content Step III: Closing Time: 25 min

Cleanup: houses are all put in a safe place in the classroom. All documentation created by the apprentices should be given to staff unless apprentices wish to work on them at home (this should only be allowed if staff trusts students to bring it the next day). Any materials prepped by apprentices can be stored in their boxes.

Have some apprentices share their designs and plans for construction. Let them know that it may be useful for others to get new perspectives into how to solve a problem and in no way will they be "giving away secrets". Go around the room and check in with each apprentice as to how much more they need to do before they are ready to construct.

Session 6: Wiring a 3D House

Overview

Apprentices will continue their planning from the day before and begin to wire their house. If their plans are concrete enough, they may be able to finish wiring today.

Materials

- Cardboard boxes (1 ft x 1 ft x 1 ft)
- Cardboard slots to make up "walls" and "floors" of house
- Pre-made, working house to show as model
- Circuit diagrams for pre-made houses
- Brass fasteners (brads)
- Cardboard pieces (for battery packs and squares for switches)
- Paper clips (plain metal)
- Pens/Pencils
- Insulated wires
- Wire strippers
- Bulbs
- Electrical tape (to insulate all connections)
- Battery packs

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator
- Series
- Parallel
- Switch

Content Step I: Intro — Time: 15 min

Begin with Slap Game ritual.

Apprentices will be eager to continue working on their houses and will likely be too impatient to sit through too long of an intro. Try to be brief and to the point, but not rushed in explaining that today we will begin construction, but only if they have complete plans.

Let them know that they may not finish today, and that's okay—it takes professional electrical engineers many hours and days to make sure that they've made the right circuits and there are no faulty connections.

Content Step II: Construction Time: 90 min

Allow apprentices to finish their plans or begin construction (whichever stage they may be at). Be sure to tell them that they should never make connections while the battery is plugged in. they can use extra wires to quickly make connections to the batteries to see if their circuit connections are in working order, but they should wait until they have the switches in place and can control the power flow before they plug the batteries in. this way they won't wear their batteries out from too much use.

This portion of the lesson requires very little instruction from the team leader. Apprentices will be busy with their construction. Staff should float around and make sure problems are worked out.

If the students begin to lose focus from working so long, have a game prepared to split the time and get them out of their seats.

Again, if apprentices finish early, have them aide others. Also, challenge them to do different wiring configurations.

Content Step III: Closing Time: 15 min

Cleanup: pick up all unused components and place them in the proper place. Make sure the houses are stored so that the wiring does not come undone.

Breakdown the day and discuss successes, failures, and plans for making things work.

Session 7: Debriefing the House and Designing a Project

Overview

Apprentices will finish their houses and then discuss how each one works. They will share what they've learned so far and what other applications they think these things would be useful for. Apprentices will then be shown a number of supplies and challenged to design some electrical device.

Materials

- Household items
- Various recycle shop materials
- Brass fasteners (brads)
- Cardboard pieces (for battery packs and squares for switches)
- Paper clips (plain metal)
- Pens/Pencils
- Insulated wires (approximately 1.5 feet per apprentice)
- Wire strippers
- Bulbs
- Electrical tape (to insulate all connections)
- Battery packs

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator
- Series
- Parallel
- Switch (new)

Content Step I: Intro — Time: 15 min

Begin with Slap Game ritual.

Check in with apprentices to see what they have finished and how much they need to do in order to finish their house. This will allow you to know how much time you will have for the other projects.

Content Step II: Finishing Up Time: 30 min

Allow apprentices time to finish their houses. If some apprentices have already finished, have them help others or get them started on the "Design Your Own Device" project. If all apprentices are finished, this step can be skipped and more time given to the others.

Content Step III: Debriefing Time: 30 min

Discussion topics: How did this project work out for everyone? Was it too easy? Too hard? What did you lean? What do you wish you learned? What is still a little unclear? Are there projects you wish we would have done in addition to making the house? Based on the skills that you've learned so far, which are the most important? What other types of things can you use these skills for?

Content Step IV: Engineering Challenge Time: 30 min

The apprentices have worked very hard so far, and are inches away from becoming electrical engineers. In order to make that leap, challenge them to design something on their own.

Lay out some supplies on the table: lights, LED's, wires, various random articles. Let them know that they can use all of these supplies and any that they wish to bring from home to make some type of electrical device. Suggestions include: lighted jewelry, flashlights, or just wacky lamps. Their imagination will be the limit.

Have the apprentices think about what they would like to make, and have them begin making blueprints and circuit diagrams. They may all decide to do different things, or a group project. Let them begin planning, and float around to see if there are any circuit diagram kinks that you can work out.

Content Step V: Closing Time: 15 min

Compliment everyone on a job well done. Have them do the usual cleanup. Discuss plans for their project. Encourage apprentices to bring in any supplies from home (that have their parents' approval) that they may wish to use.

Session 8: Electrical Engineers

Overview

Apprentices will continue their design projects, experimenting to tailor their device to their liking.

Materials

- All leftover building supplies
- Student plans for construction
- Any recycle shop supplies purchased ahead of time

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator
- Series
- Parallel
- Switch

Content Step I: Intro Time: 15 min

Begin with Slap Game ritual.

Have each apprentice share what they will be working on today and what their plans for success are. Encourage a good start to the day, and a strong finish to the apprenticeship next session.

Content Step II: Engineering Time: 90 min

Go over apprentices plans to make sure that they are solid and plausible. If they are not, ask the apprentice what changes they could make so that their goal is more obtainable.

Give apprentices freedom to build their devices. If they are having a problem, ask them to present it to the class and ask for advice from their peers.

If some apprentices are having difficulty thinking of something to build (perhaps they are still a little shaky on circuits), scaffold a project for them. Suggest making a lamp of some sorts, or partner them with another apprentice and have them make the same device.

Content Step III: Closing Time: 15 min

Cleanup. Be sure apprentices put all of their supplies in an identifiable place so that they are not mixed up with other apprentices' supplies.

Ask how each apprentices' project is coming along.

Session 9: Prepping for WOW!

Overview

Apprentices present their device to the rest of the class, sharing what it does, how they made it, any problems they encountered and how those problems were solved. They will also show their blueprints and original circuit diagrams. Afterwards, apprentices will play a circuits themed "Jeopardy" game to review things they have learned, and finally, they will prepare what they will be presenting during their WOW!.

Materials

- Newsprint for making posters
- Jeopardy game with vocabulary, circuit diagrams, and other review trivia
- Apprentice projects
- Apprentice houses

Vocabulary

- Circuit
- Circuit Diagram
- Engineer
- Electrical Engineer
- Conductor
- Insulator
- Series
- Parallel
- Switch

Content Step I: Intro Time: 15 min

Begin with Slap Game ritual.

Explain to apprentices that they will be making presentations to each other about what their device is, how it works, and the process they went through to get everything in working order. They need to be able to explain all parts of the device. This presentation is practice for the larger presentation they will do during their WOW!.

Content Step II: Prep for Presentations Time: 20 min

Write on the board the things that you wish to see in apprentices presentations: What their project was, why they chose that, whether that was their first choice, what were some of the problems they ran into, how the device works, how they knew what to do to make it work,

and what they would like to learn how to make and make in the future if money were no object (optional).

Have them practice with a partner if they finish early.

Content Step III: Presentations Time: 25 min

Have apprentices draw numbers to find out what order they will be presenting in. Go over expectations of other apprentices while a speaker is presenting. If a student sorely wants to go first/last have them give you a compelling reason before allowing it.

Content Step IV: Circuit Jeopardy Time: 20 min

Separate the apprentices into teams—2 or 3, depending on how many apprentices there are. Each team will get the opportunity to answer questions that should be review for them, and earn points for their team. Questions should include vocabulary words, circuit diagrams for them to produce, circuits for them to wire, and possibly random trivia questions.

Content Step V: Preparing for WOW! Time: 35 min

Ask the apprentices what they would like to present to the public about what they've learned. Which are the most important concepts? How do they want to present them? Whose house should be shown?

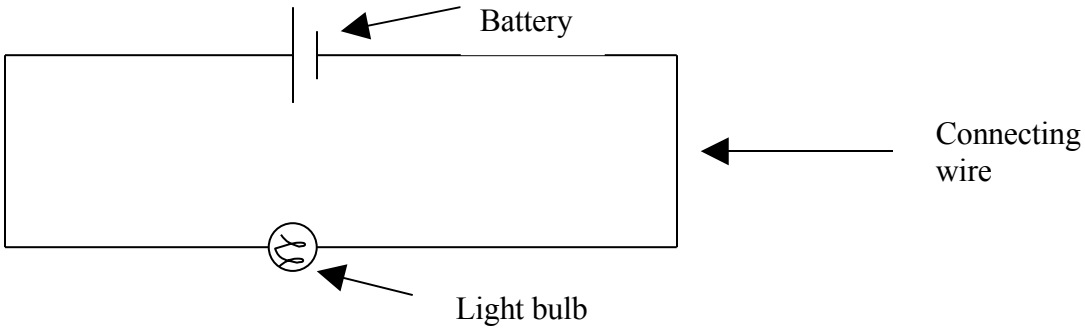
Assign roles to apprentices regarding who will be presenting what and have them make visuals and prepare what they will say to their audience.

Content Step VI: Closing Time: 5 min

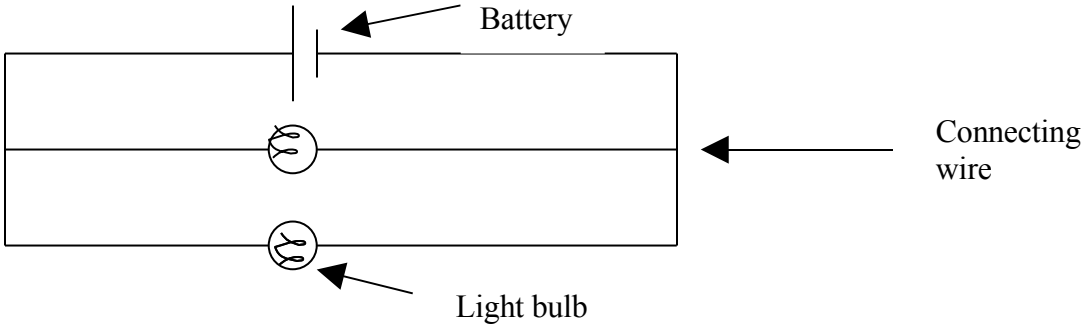
Do final cleanup and wrap up everything we've learned to this point. Congratulate the class on a job well done, and let them all know that they are now officially electrical engineers.

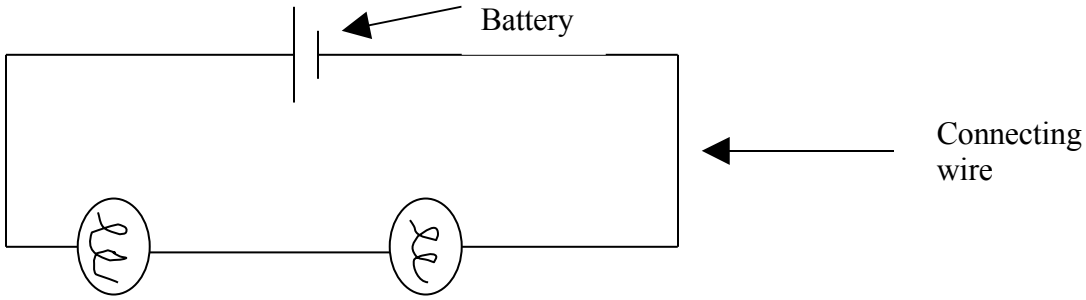
Sample Circuit Diagrams

1. Simple circuit:



2. Light bulbs in parallel





4. Circuit with switch