Microprocessors

Supplemental Lesson Ideas

Students learn the importance of writing clear programming instructions in an activity that asks them to describe, step-by-step, how to make a sandwich. Discussion ideas help students understand the fetch, decode, execute sequence. Activities give students the opportunity to apply what they have learned about debugging programming instructions to correct errors. A simulation activity helps students think about the manufacturing process.

1. **Give students the High-Tech Sandwiches handout and ask them to complete the first activity on the sheet. This can be done individually or in groups.**
   When everyone has completed the task, collect their instructions. Select one of the sets of instructions and complete the directions exactly as they are written. Exaggerate any problems you encounter in the instructions. Help the students see why the set of instructions is inadequate. Remember, the sandwich maker—you, playing the role of robot—is a non-thinking machine. (Note that you can do this activity without the mess by pantomiming the making of a sandwich, but it is much more fun to use the real ingredients.)

   An alternate way to complete this activity is by having the students exchange instruction sets, and then have them carry out the directions prepared by another student.

2. **Discuss whether the human brain uses a fetch, decode, and execute cycle.**
   If students think this is true, ask them to explain where and how the instructions are received and stored. If they answer no, then ask why not. Have students consider a comparison of the rate at which information is processed in a computer compared to the rate at which the brain processes similar information.

3. **Distribute the Fetch, Decode, and Execute handout.**
   Discuss the assignment expectations. Set out the box of instructions you have created and have your students complete the activities. Provide discussion time for students to share their experiences with the fetch, decode, and execute cycle.

4. **Have students discuss the experience of knowing something so well that you can do it without thinking.**
   The example of traveling home from school works well. Discuss how people can walk or ride a route they frequently use without really being aware of the features of the route. Have students think about how they would describe in detail what they see as they travel home or to a favorite store or park. How many features can they actually describe? Help students understand the difficulty of breaking complex actions into small, isolated steps so that the actions can be easily taught to someone else.

   Make sure students understand that a microprocessor does not think, it merely follows instructions. Humans—the programmers—do the thinking. The smallest error on the part of the person writing the instruction set can lead to unexpected and incorrect results.

5. **Complete the Taking Command handout in small groups.**
   Divide students into small groups. Provide at least one copy of the handout to each group. Working together, students develop a series of instructions to move a robot from a chair to the wall and back again.

   When all of the groups have finished, select four volunteers from the class. One student representing computer memory holds the list of instructions. A second student representing fetch gets the instructions one at a time. A third student representing decode reads the instruction. The fourth student plays the part of the robot and executes the instruction. The robot must follow the instructions exactly as they are read.

After one set of instructions is tested, allow time for all the groups to debug their programs. Then repeat the activity with a different group's program.

Debrief the exercise with the students. Ask them to list some of the most important ideas that were illustrated. Examples include the difficulty of writing programs with no bugs and the limitations of the robot.

6. **Pass out copies of the Bugs and Debugging handout.**
   Have students continue the activity described in the Taking Command handout, but this time with two new commands (Wall?, Chair?) that simulate conditionals in computer language. Have students experiment with writing instructions and debugging them for the described tasks.

7. **Have the students look closely at a human hair or a piece of fabric such as an old sheet.**
   Indicate that the transistors in a chip are so small that it would take 500 to 1,000 transistors to cover the intersection of two threads in the fabric of a 500-count sheet (500 threads per inch). If the sheet is of poorer quality and only 200-count, you would need six times this number of transistors. It would take 500 transistors in a chain to go around the human hair. Have students consider that the connections between transistors on a chip are less than 1/1000 the size of a human hair.

8. **Give students the handout How Clean Is Clean?**
   Provide time to work through the handout and then discuss their answers.

9. **Have students consider why the fabrication process of a chip might be expensive when the main ingredient in the chip is common sand and silicon.**

10. **Discuss the idea of masks used in fabricating chips.**
    Have students brainstorm similar or related ideas. For example, think about stencils, silk screening, patterns used for painting lines and symbols on streets, patterns made when light comes through a patterned curtain or venetian blind, shadow pictures made with a flashlight, etc.

11. **Provide students with the "pizza perspective" of layering.**
    Toppings are placed on a pizza one at a time until several layers are in place. However, when the pizza is removed from the oven, the layers are no longer identifiable. The layers of cheese have melted around the other layers until all the layers are a single delightful topping. You cannot reverse the layering process by removing the toppings of the pizza one at a time. The same is true of the layers of a computer chip. The layers are placed one at a time, but they are not independent of each other. Parts of one layer may extend through several adjoining layers and removing layers one at a time is impossible.

12. **Complete the handout Fabrication Art.**
    After students have had time to browse through the handout, ask if there are questions. Note that you may want to do this activity in small groups. Ask students to discuss their work. How long did it take them to complete their "artwork"? What worked well and what didn't? Did some students throw away some of their products? Why? What kinds of problems did they have? How might their problems be similar to those encountered in the chip manufacturing process?

13. **Engage the class in a brief discussion about seconds—products somewhat defective, but still good enough to use.**
    Have students give examples of seconds that are available in stores. Point out that the fabrication and testing standards for computer chips must be much higher than are used for the consumer items that they are discussing. Hand out the student materials on Making a Complex Product. This class activity simulates the making of parts and assembling them into a product. Have students read the activity and then ask them to guess how many acceptable products will result. Number your students and tell them that their number is also their part number. That is, each number represents a different part of the final product. The final product created by the class will be made up of one part from each student. In this activity, about 2-4 percent of the parts that each student supplies are defective.

When the simulation is complete, record and discuss the results. Have students compare their initial estimates with the actual results of the activity.

If time permits, carry out the product-manufacturing simulation exercise again. Then compare the results from the two simulations. The results from the two simulations may be somewhat different. Discuss the implications of this in the manufacturing process. This activity should give you and your students some insight into the type of thinking and the steps used by people engaged in formal statistical quality control to maintain high standards in manufacturing a particular product.