

ACHIEVEMENT #6:

Integrated Circuit

Teacher's Guide

Introduction

Integrated circuits are tiny chips with all the instructions needed to run electronic games, video cameras, touch-tone phones, calculators, microwave ovens and much more.

Jack Kilby and Robert Noyce independently invented the integrated circuit. Once people realized how important it would be, engineers had to find a way to mass-produce it. They experimented with different materials – always searching for the best material, and the most economical methods.

Mass production made the microchip affordable. Once, you could only find machines for writing and calculating in an office. You had to go to the library to research a report for school. Now most people can do all of this work from home or school on a computer.

Microchips also made products smaller. Compare this CD Player to the radios of the 30s. This calculator to an old adding machine. This laptop to an early computer which would be the size of room. The smaller things get, the more power they have. All of this from this little chip.

Lesson Focus: Smart Appliances

Lesson Synopsis: Students brainstorm microchip-containing products in their home, review the history of the invention and application of microchips, and design and create an ad for a new smart appliance.



Teacher's Guide (Continued)

Related National Science Education Standards:

Content Standard E (Science and Technology):

As a result of activities in grades 5-8, all students should develop Abilities of Technological Design, including the ability to

- ◆ Identify Appropriate Problems for Technological Design,
- ◆ Design a Solution or Product,
- ◆ Implement a Proposed Design,
- ◆ Evaluate Completed Technological Designs and Products, and
- ◆ Communicate the Process of Technological Design.

Related Benchmarks from Benchmarks for Science Literacy:

Section 3C (Issues in Technology):

By the end of 5th grade, students should know that:

- ◆ Once an invention exists, people are likely to think up ways of using it that were never imagined at first.
- ◆ Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems.

By the end of 8th grade, students should know that:

- ◆ Technology ... is largely responsible for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, and communications that have radically changed how people live.

Related Standards for Technological Literacy:

Standard 1 (Characteristics and Scope of Technology):

In order to comprehend the scope of technology, students in grades 6-8 should learn that:

- ◆ New products and systems can be developed to solve problems or to do things that could not be done without the help of technology.
- ◆ The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.
- ◆ Technology is closely linked to creativity, which has resulted in innovation.
- ◆ Corporations can often create demand for a product by bringing it onto the market and advertising it.

Teacher's Guide (Continued)

Glossary:

integrated circuit An electronic circuit of transistors etched onto a small piece of silicon. Commonly referred to as a **microchip**, a **chip**, or a **silicon chip**.

transistors Invented to replace vacuum tubes, can now be etched onto small chips of silicon to create integrated circuits.

microprocessor An integrated circuit that contains thousands, or even millions, of transistors that work together to store and manipulate data so that the microprocessor can perform a wide variety of useful functions.

semiconductor A substance that conducts electricity better than an insulator but not as well as a conductor. Silicon is a semiconductor used to make microchips.

Important Concepts:

- ◆ The invention and mass production of integrated circuits has allowed the invention of numerous small, relatively inexpensive, energy efficient electronic devices.
- ◆ Appliances containing embedded microchips can react to stimuli, communicate with other such appliances, or connect to the Internet.

Materials for Each Design Team:

- ◆ Posterboard
- ◆ Markers
- ◆ Pens

Safety Precautions: no special precautions are needed

Procedure:

Engagement: Pass out the Student Handout and have them brainstorm all the microchip-containing products in their homes.

Exploration and Explanation: Have students read the handout and explore the Timeline.

Extension: Divide the class into design teams and have each design a new smart appliance. Provide them with materials to create an ad for the product.

Evaluation: Have students give examples of how home appliances that were available before 1958 are different from those available today and relate these differences to the invention of integrated circuits.

Ideas for Further Exploration:

- ◆ Have students research the biographies of key figures listed on the Timeline.
- ◆ Have students research how microchips are manufactured.

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Student Handout

How Many Microchips Do You Own?

In 1958, Jack Kilby and Robert Noyce independently invented the integrated circuit, now commonly called the microchip. How many microchips do you have in your home? You may think that you don't have any unless you own a PC, but it is estimated that there are 40-50 microchips in the average American home in addition to the 10 or so in a typical PC!

Microchips are the "brains" of electronic gadgets ranging from smoke detectors to VCRs to garage-door openers to cordless phones. They are even being implanted in dogs as an electronic ID. Brainstorm a list of the microchip-containing products in your home. Don't forget your digital watch, your calculator, or your electronic games.

History of Microchips

In electronic devices, components called **transistors** are connected into circuits. Before the microchip, transistors were no smaller than the eraser on the end of a pencil. The more transistors used, the bigger the size of the completed circuits. This limited how small and how inexpensive electronic products could be.

In 1958, Kilby and Noyce both invented a way to etch transistors onto the surface of a chip of **semiconductor** material. (A semiconductor conducts electricity better than an insulator does, but not as well as a conductor.) Kilby used germanium and Noyce used silicon. The first microchips were made individually. Mass production and the development of precision manufacturing techniques were needed to make the microchip affordable. Soon, microchip-manufacturing plants sprang up in an area of California near the Intel Corporation that became known as the **Silicon Valley**.

Microchips are a great invention, but they can only do what they were designed to do. In 1971, a young (34 years old) scientist at Intel, Ted Hoff, created a chip that was actually a mini-computer. It was only a 1/8" by 1/16" piece of silicon, but it had 2300 transistors etched into it and was more powerful than the first computer ever built. Hoff's invention is now called a **microprocessor**.

Today, nearly 5 billion chips are manufactured in the US each year. Because they are so small, they must be manufactured in special Clean Rooms, where even tiny particles are filtered out of the air, and where workers wear special suits that make them look like astronauts.

Examine the Timeline to discover how quickly and in how many different ways these inventions have had an impact on our lives.

Student Handout (continued)

Timeline of Events Related to Achievement #6:

- 1934** Electronic hearing aid invented (connected to a unit worn on your belt).
- 1947** Researchers at Bell Telephone Laboratories invent the transistor.
- 1954** The transistor radio is introduced and becomes the largest selling item of the time.
- 1958** Jack Kilby of Texas Instruments and Robert Noyce (who later founds Intel) invent the integrated circuit.
- 1958** Seymour Cray at Control Data Corp. develops a transistorized computer.
- 1967** First handheld calculator using an integrated circuit is designed by Jack Kilby and made by Texas Instruments.
- 1970** The bar code system is created.
- 1971** Ted Hoff of Intel invents the microprocessor. Beginning of Intel's famous line of 386, 486, and Pentium processors.
- 1971** First video game and videodisc introduced.
- 1974** The Altair, first desktop computer designed for personal use, sold as a kit.
- 1979** Mattel Toy Company receives its 1 millionth chip for electronic games.
- 1980s** Integrated circuits applied to computers.
- 1984** Compact disc (CD) player introduced.
- 1984** First CD-ROM (compact-disc read-only memory) is available.
- 1995** GE releases its first “smart dishwasher”, which senses dirtiness of dishes.
- 2000** Sunbeam, General Electric, Maytag announce plans to work with Microsoft to develop “smart appliances”.
- 2000** GE unveils plans for a “smart microwave” that will read the UPC on a product and set its timing accordingly.
- 2001** Carrier and IBM create program that allows people to adjust their home air conditioner settings via their cell phone or their computer at work.

Student Handout (continued)

Smart Appliances

Although nearly 5 billion microchips are sold each year, only about 2 percent of these end up in computers. The rest are used in other products, including home appliances.

How smart are your home appliances? Do you have a breadmaker that signals you when the bread is done? What about a smoke detector that beeps to remind you when its batteries need to be changed? What about an iron that shuts itself off after several minutes if you forget to?

According to appliance manufacturers, consumers can expect that appliances will be getting smarter and smarter, being designed to react to stimuli, to communicate with each other, and even to connect to the Internet. Carrier already has a program in some places in Europe that allows users to communicate via their cell phones or office computers with their home air conditioning system. Imagine being able to call your air conditioner and tell it to raise or lower the temperature in your home!

What does the future hold in store? What would you like your refrigerator to be able to do? Call a serviceman when it needs repair? Order more eggs and milk when you run low? Offer you recipes downloaded from the Internet? The technology exists to create a refrigerator with any or all of these features.

Design Challenge: Design a New Smart Appliance

Select a home appliance, other than a refrigerator. Imagine all the things you might like for that appliance to be able to do. Create an ad to advertise your newly designed smart appliance and be prepared to share your creation with the rest of the class.

Materials for Each Design Team:

- ◆ Posterboard
- ◆ Markers
- ◆ Pens