GOOD YEAR BOOKS

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YOUNG INVENTORS AT WORK!

LEARNING SCIENCE BY DOING SCIENCE

ED SOBEY, Ph.D.

GOOD YEAR BOOKS

DEDICATED TO

JERRY VALADEZ AND THE SCIENCE STAFF AT FRESNO UNIFIED SCHOOL DISTRICT AND TO THE TEACHERS AND KIDS AT CARVER ACADEMY AND STONE SOUP

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INTRODUCTION

Young Inventors at Work! challenges kids to exercise creative problem solving and critical thinking to design, build, and test model structures, games, and vehicles. Kids work in teams to solve technology-based problems. Their desire to find optimal solutions leads them to discover basic principles of science and engineering. Related science experiments or demonstrations accompany the activities. "Stories for Young Inventors" are intended to be interactive readings to provoke thinking and learning, and to be repeated at home.

These activities were developed for Fresno (California) Unified School District for use as an after-school informal science education program for children in grades 4 through 8. There are twenty-four active activities and twenty-six readings, consisting of original stories about inventors and inventions.

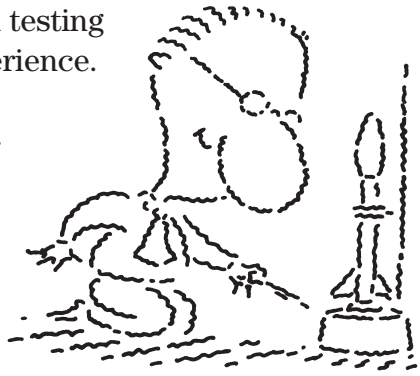
Young Inventors at Work! is suitable as an informal science program for school, youth groups, or home use, and as part of a formal science program at school.

The goals of *Young Inventors at Work!* are:

1. To fire each participant's enthusiasm for science (physics), engineering, mathematics, and technology
2. To get participants comfortable with technology and the tools of technology
3. To get them thinking, talking, and learning about science and technology
4. To have them learn about and think about role models in science and technology
5. To have them carry home their excitement for learning to share with siblings and other family and friends
6. To spark their creative energies and engage their problem-solving abilities

Young Inventors at Work! is predicated on the following axioms:

- To learn science and technology, kids need to think about science. Scientists and inventors think about their subjects and learn from testing their ideas. For them, learning is an enjoyable experience.
- The way to get kids to think about science is to challenge them to use their creativity and problem-solving abilities to solve realistic problems. Once they have invested their creativity in solving a problem, they will continue to think about and work on the problem, even after the lesson has finished. Once challenged, they become scientists and inventors solving problems and learning.



- Challenges that will engage kids are ones that are intrinsically fun, ones they can complete, ones that require their focused attention, and ones that allow them to

apply their knowledge and skills to get something done. Simple challenges and cookbook approaches don't excite a passion to explore.

- The more time a child spends thinking about science and technology, the more he or she will learn, so our challenge is to get kids to continue these experiences at home. If they engage their families in these activities, the learning will infect more people and they may build a family culture of learning.
- To get kids to work on projects at home, the projects must be designed to use tools and materials that are available to most kids. Exotic lab equipment is ruled out.

MANAGEMENT OF THE CREATIVE PROCESSES

Young Inventors at Work! provides a fundamentally different type of experience than the traditional classroom and, to be effective, requires a different style of management. These experiences beg to be led by a facilitator who outlines the challenges and ensures that materials and tools are available, and that safe working conditions exist. Laboratory workers—the participants—seek to solve problems by working in teams with their peers.

These activities encourage teams of kids to find better solutions to fun problems. *Young Inventors at Work!* doesn't offer rewards for meritorious work other than praise for a job well done. Creative failures are as valued as successes, and the facilitator/leader should direct discussions on the design elements that worked or didn't work in each design, as opposed to giving overall evaluations of one group's solution compared to another's. Each team will try to do a better job than the next team, but they should be encouraged to help the next team. Sharing information is an important part of the learning process.

Young Inventors at Work! begs for the services of volunteers to assist the facilitator/leader. There is simply too much to do for one person with 15 to 20 kids. We suggest enlisting older students, high school or college age, or adult volunteers (for example, Telephone Pioneers or other organizations of retired people) to assist as Inventing Guides. Guides can prepare and give demonstrations, read readings, and help teams with their activities. They can also help clean up. You want Guides who will bond well with the teams and help the teams without solving the problems for them. The Guides will become role models, and as such they must exemplify the spirit of *Young Inventors at Work!:* encouraging teams with positive feedback and being helpful, friendly, inquisitive, creative, and industrious. The best training for Guides is to have them perform the activities while you act as their guide, modeling the approach you want them to take.

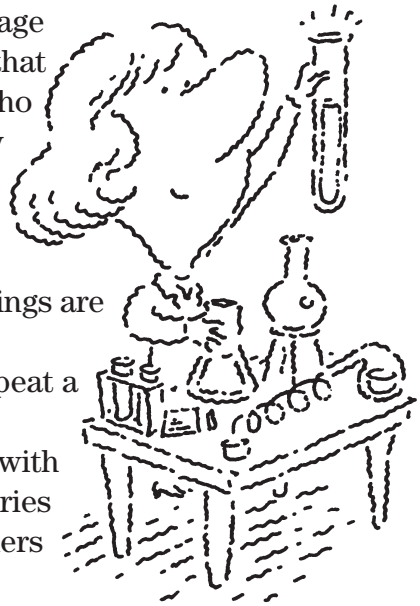
LESSON MAKEUP

Each lesson description consists of seven components:

1. **OVERVIEW.** This is a short description of the main activity.
2. **OPENING.** Recognizing that not all the kids will arrive at the same time, the Openings provide learning activities for early arrivers. The intention is threefold: one, to get early arrivers engaged in meaningful and fun learning; two, to encourage all the kids to arrive on time since late arrivers will miss the fun of engaging in the opening activity; and three, to introduce the topic for the day.

   The opening of the lesson is also a time to invite anyone who worked on a previous project at home to show what they developed. Please remember to ask if anybody did more work at home. Since *Young Inventors at Work!* is built on the premise that kids will replicate fun activities at home and with their friends, we want to encourage and reward this behavior.
3. **DEMONSTRATION.** Given by a guest, a Guide or the Leader, demonstrations relate to the lesson and often provide concepts helpful for finding a solution. For home or small-group use, demonstrations could be presented as science experiments for the Leader and participants to undertake together.
4. **READING.** The "Stories for Young Inventors" in Section II of this book are intended to be interactive elements of the lesson where questions and statements written in italics are directed to the listeners to engage their responses. The readings emphasize the notion that inventors are people of both genders and all races who overcome adversity to solve problems and that they take advantage of mistakes and opportunities. In most cases, the readings tie in with the activity.

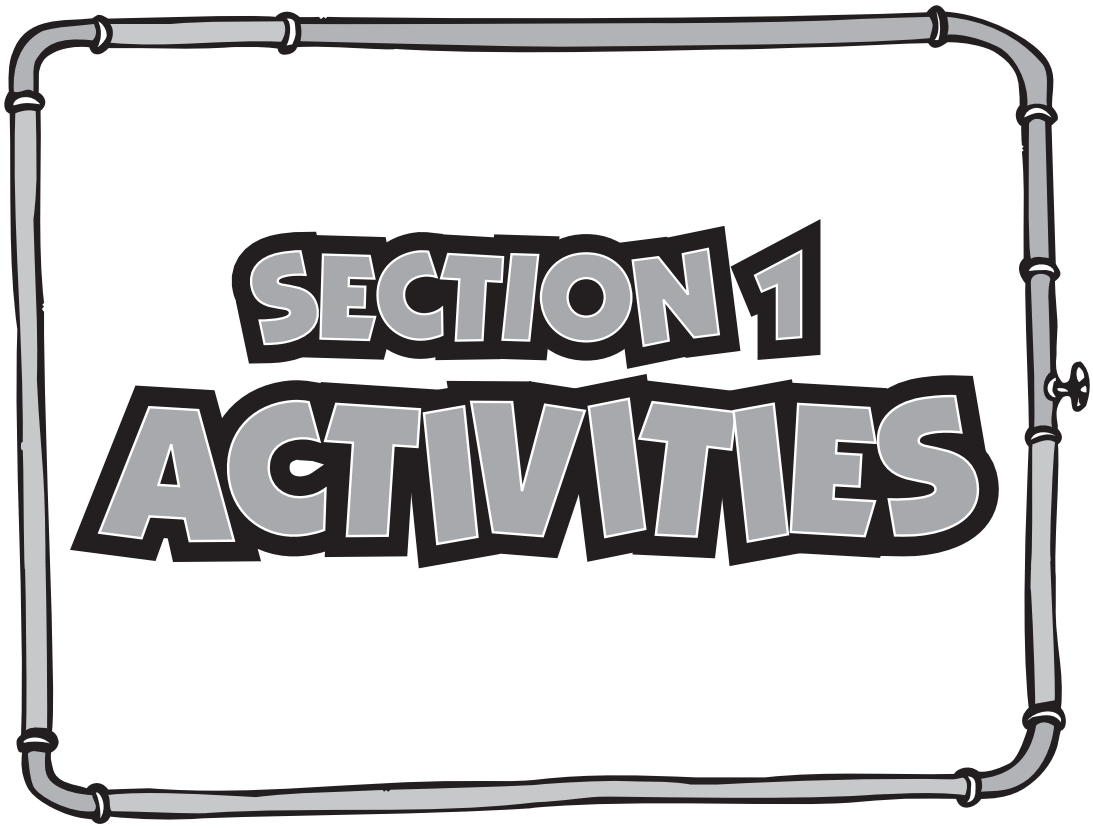
   Copies of the readings can be made available for kids to take home to read to their families. Readings are included in Section II of this book. There are more readings than activities since you may choose to repeat a lesson (for example, you could use Take Apart several times with different materials to take apart, or with different activities built around it). Several of the stories mention specific geographic locations to afford readers the opportunity to use an atlas.



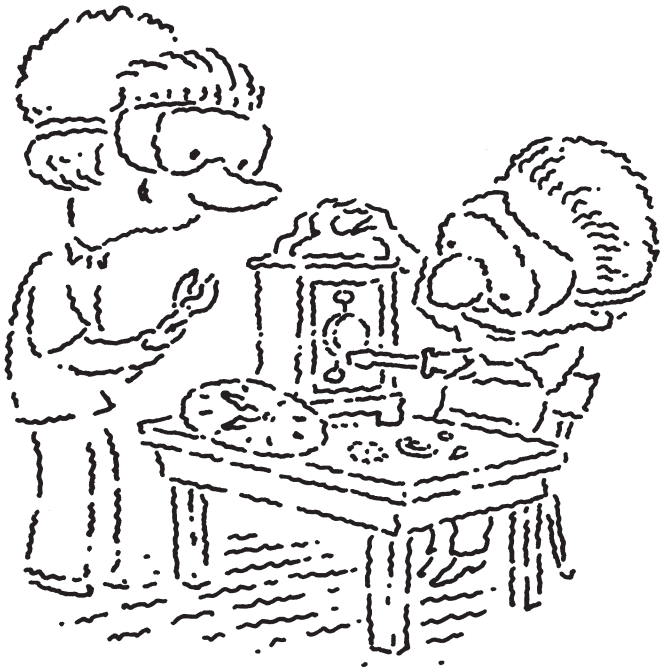
5. **ACTIVITY.** This is the principal component of each part of the lesson. The Leader specifies a problem to be solved and any constraints on the solution. Kids break into teams of two to four, depending on the activity. In most cases, before they are allowed to start constructing a solution, teams must first show a thoughtful design on paper to one of the Guides. The requirement for a design is to force them to think as a team and agree on what they are going to do, rather than having the dominant personality say, "Oh, I know what to do, I'll . . . " to the exclusion of other members of the team. Everyone participates or the team doesn't proceed.
   It also forces abstract thinking and the comparison of an object with its design on paper.
6. **DEPARTURE.** This is the opportunity for Leaders and Guides to transform home behavior into learning activities. The longer a child works on a problem, the more he or she is likely to learn. By encouraging kids to keep working on the activity at home, Leaders will extend the learning environment and greatly facilitate real learning.
7. **REFERENCES.** Books and articles are listed that may be helpful to you in extending the activities.

OBSERVATIONS

1. Everyone—kids and volunteers—walks into the room and asks, "What are we doing today?" Once people know that fun, creative activities usually transpire, they want to know what's next. We suggest having a "coming events" sign outside the classroom listing today's activity and tomorrow's.
2. We have found that some kids need to see a concrete model of a solution before they can come up with their own solution. When teams are stumped, one of the inventing guides will make a mock-up to show them. Once the participants see it, they can start designing improvements to it.
3. Many of the activities provide wonderful photo opportunities for the media or your own community relations people. Published stories and photos could open up funding opportunities, so you might consider inviting the media.



TAKE APART



OVERVIEW

Kids love to take things apart, and they can learn a lot in the process. There are at least three types of learning that occur: learning to work with tools, learning to work with each other, and learning about technology. All three types of learning instill confidence and empower kids to ask questions and explore further. A major focus for Inventing Guides is to help kids know where to go to seek answers to their questions and to make sure they know how to do Take Apart safely at home.

A challenge of offering Take Apart is to slow down the process of equipment destruction and get kids to think. Since you might want to offer this activity several times, there are several different activities suggested under the umbrella of Take Apart.

TOOLS AND MATERIALS

Safety goggles (1 pair for each participant), newsprint, pencils. Flat and Phillips' screwdrivers, and pliers for each team. Additional tools to keep in a central location: jeweler's screwdrivers, Allen wrenches, vice grips, needle-nose pliers, and an adjustable wrench.
For the Opening: shoe boxes taped shut with common objects (a ball, a large paper clip, a pencil) inside.

OPENING

As kids come in, have several shoe boxes set out on tables. Each one should be sealed to prevent casual opening and each one should have a common object or objects inside.

Challenge the kids to figure out what is inside each box and write down their answers on a piece of paper. They can rattle or shake the boxes, smell them, and feel the weight, but they can't see or come in contact with the contents.

At the appointed start time, ask the kids if they were able to identify what was in each box. Ask them for their ideas before opening each box. Explain that scientists and inventors make educated guesses about things they don't know and then test them (like opening the box) to find out. Many times they are wrong, but that doesn't matter as long as they learn in the process. Science and inventing are processes of finding out.

DEMONSTRATION

Demonstrate the tools for this activity: brainstorming and hand tools. Brainstorming is a technique for individuals or groups to come up with creative solutions to problems. People use brainstorming any time they need to solve a problem. There are only a few rules to follow:

1. Everyone participates. You want different ideas because they can lead to some of the best solutions. Different is good.
2. During the "idea phase," you want to generate as many ideas as possible. They can be silly, bad, or great ideas. Someone writes them all down and no one comments on the ideas (no one says, "That's dumb," or even "That's good").
3. When everyone has run out of ideas, you go to the "deciding phase" in which you look critically at each idea to decide if it will help you solve the problem. You select only a small number to try. You can add to the list if more ideas come along, and you can go back to the list to try more ideas if you want. Coming up with ideas and deciding which are best use different thought processes. To get the best results, the two different activities should be done separately.

Have a Guide show the participants the tools and materials, provide names for the tools, and show the participants how to use the tools and of what they should be careful.

READING

Take-apart King (Charles Kettering), page 110

ACTIVITY

Each time you offer Take Apart, follow this outline:

1. Describe the activity. Identify the pieces of equipment to be taken apart. Stress that nothing else should be taken apart. Describe the specific things you want the participants to be aware of, or to do.
2. Show them the tools they will need. Make sure they know the names of the tools and how they are to use them. You might have one of the Inventing Guides demonstrate the safe use of each tool.
3. Review the rules of Take Apart. Although we encourage kids to break thought-constraining rules (that is, to think outside the box) while they invent, they are not to break Take Apart rules.

Rules for Take Apart:

A. Always cut off the electrical plug on any device you are taking apart. Inventing Guides will help do this. Throw these plugs away where kids can't get to them, or bend the plugs so they can't be inserted into an outlet. Never try to reconnect the devices or fool around with AC electricity.
B. Wear eye protection while taking anything apart.
C. Never point a screwdriver or other sharp tool at yourself or at anyone else. Always point it away from people.
D. You don't need a hammer. The idea is not to destroy the components, but to get them out. Maybe you'll find a part you can use.
E. Never take anything apart unless the owner says it's okay. It's unlikely that you will get it back together again, so if it works, leave it alone. Even if it doesn't work, ask the owner first.

ACTIVITY I

Ask questions about each piece of equipment: What does it do? How does it operate? Where does it get the energy it needs? Where does the energy loss manifest itself? (Does it get hot?) What do you expect to see inside? A motor, a series of electrical components, switches—what else?

Divide kids into teams of two to four, depending on the availability of stuff to take apart. Ask them how their team will function: Will everyone take turns using the tools and asking questions? Will everyone get a chance to help?

Assign teams to particular pieces of equipment and have them send one person to get the tools they need from one of the Inventing Guides.

As each team gets started, have the Inventing Guides wander about to:

1. Make sure the safety rules are being followed.
2. Help, but only where help is absolutely needed. This is not an activity for the Inventing Guides to perform and the kids to watch.
3. Ask questions to get kids thinking. "What is this for?" "Why do you suppose the engineers put this piece in there?" "Isn't this a neat way to do . . . ?" "How could you use this part in your own inventions?"
4. Slow down the urge to hurry. Make sure the activity is Take Apart, not rip apart. The best way to do this is by asking questions. Also, if there is pushing and shoving going on regarding whose turn it is to use a tool, the Inventing Guides should take the tools away until the team can come up with an agreed-upon plan for how to share the workload.

Devote about ten minutes at the end to have a group discussion on how the activity went. You might see whose team learned the most about the machine they were taking apart, and let each team explain what they learned. Encourage participants to take safe components home, but first check for sharp edges, glass that could break, and other dangers. Remind them that although they can do Take Apart at home, they must still follow the rules (review the rules), especially the rule about asking the owner's permission before taking anything apart.

ACTIVITY II

This activity provides a bit more structure to the general Take Apart and is recommended for the second time you offer Take Apart. Ask each team to create a classification system (use brainstorming to come up with the system) for the parts they take out. Their system can have no more than ten classes and no fewer than six. Have them take some newsprint and create large squares for each class. They can pile up the parts in the appropriate squares. They can change their classification system as they proceed. You might suggest that an effective system is one in which there is some equivalency between the numbers of parts in the classes. Teams might classify parts by color, shape, size, material, function (gears, springs, etc.), or perceived cost.

When a team has concluded, ask them to talk about the piece of equipment, how it worked, and the parts they found. They can describe their classification system and show examples of parts in each class.

If there is time, challenge them to come up with an entirely different classification scheme. For example, if they used a functional classification scheme (gears, electronic components, buttons, . . .), they could reclassify parts by size, color, shape, and so on.

ACTIVITY III

The challenge is to make something from the parts they extract. This is a good time to use brainstorming. You could limit them to using only those parts, or allow them to use tape or other materials in addition to the parts they find. They can trade with other teams for parts they want. The results will be fantasy inventions that they can describe to the rest of the group.

DEPARTURE

Challenge them to look at devices (a toaster oven, binoculars, slide projector) and try to figure out what's on the inside. Suggest that they also look for discarded devices for Take Apart, and that they can bring them in for the Inventing Guides to check out before taking apart. Tell them what the activity for the next session will be and ask them to think about it.

REFERENCES

David Macaulay, *The Way Things Work.* Boston: Houghton Mifflin, 1988. This is a wonderful resource.

Robert Gardner, *This Is the Way It Works: A Collection of Machines.* Garden City, NY: Doubleday, 1980.