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ABSTRACT

This collection of 20 articles from "The Science Teacher" and "Science and Children" is provided to assist teachers, students, and parents in preparing for science fairs. Four major questions about science fairs are addressed in the articles. They are: (1) Who should participate in a science fair? (2) How should a fair be organized? (3) What makes a science project successful? and (4) How should projects be judged? A position statement by the National Science Teachers Association (NSTA) on science fairs is included. (JN)

NSTA Position Statement on Science Fairs

The National Science Teachers Association recognizes that many kinds of learning experiences, both in and beyond the classroom and laboratory, can contribute significantly to the education of students of science.

With respect to science fair activities, the Association takes the position that participation should be guided by the following principles: (1) student participation in science fairs should be voluntary; (2) emphasis should be placed on the learning experience rather than on competition; (3) participation in science fairs should not be made the basis for a course grade; (4) science fair activities should supplement other educational experiences and not jeopardize them; (5) the emphasis should be on scientific content and method; (6) the scientific part of the project must be the work of the student; (7) teacher involvement in science fairs should be based upon teacher interest rather than on external pressures or administrative directives; and (8) if a science fair is to be undertaken, such an assignment should be a replacement for one of the teacher's current responsibilities, and not an additional duty.

The National Science Teachers Association's Position Statement on Science Fairs was approved by the NSTA Board of Directors in 1968. This position statement is intended as a guide, and does not reflect the whole range of interest of our members.

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Table of Contents

Introduction

In my neck of the woods (Room 107), there is a sure sign that spring is not far away. The fragrance of rubber cement exudes from nascent science projects. It's that time of the year again.

NSTA has assembled this collection of reprints to assist teachers, students, and parents through this science project season. These articles from *The Science Teacher* and *Science and Children* cover four major questions about science fairs: Who should participate in a science fair? How should a fair be organized? What makes a science project successful? How should projects be judged?

These projects are a valuable tool for science educators and for science students. In 1982 I heard Paul Brandwein tell an audience of science educators at the Iowa Curriculum Conference that the ultimate goal of any science program should be for each student to complete one independent project. I couldn't have agreed more. In the past 16 years, my experiences with student projects have been among the most rewarding aspects of my teaching.

In our system each student in second year biology does "major" research—a product of 6 or more months of study and experimentation. Not all or even most projects are competition quality. For many students, rediscovering the familiar is an adventure that leaves lasting memories. But each year there are just enough students in search of truly novel ideas that my teaching remains fresh and continuously challenging.

The word "research" in secondary schools has two very distinct meanings. For a few students each year, a junior partnership with a university or industry researcher leads to an exploration of not only a scientific problem but also a career. These experiences (usually during the summer), which have become quite expensive since the National Science Foundation jumped ship, usually produce impressive projects and symposium papers for the participants. But often the researcher or graduate students generate the problem, the procedure, and the conduct of the investigation.

Classroom or home research is another species entirely. The process of coming up with the problem is itself a major hurdle for most secondary students. In our district we spend some portion of each class for 2 months generating ideas, developing research designs, and tossing around sources of error.

Ideas come from magazines and journals (including *TST's* Science Briefs), from parents and friends, from experiences, and from adolescent curiosity. Most ideas must be discarded. As in many schools, our equipment is minimal, and our access to labs and industry is touch-and-go. We encourage creativity and scientific thought, as well as correspondence with generous professionals who often respond with suggestions, offprints, and words of support.

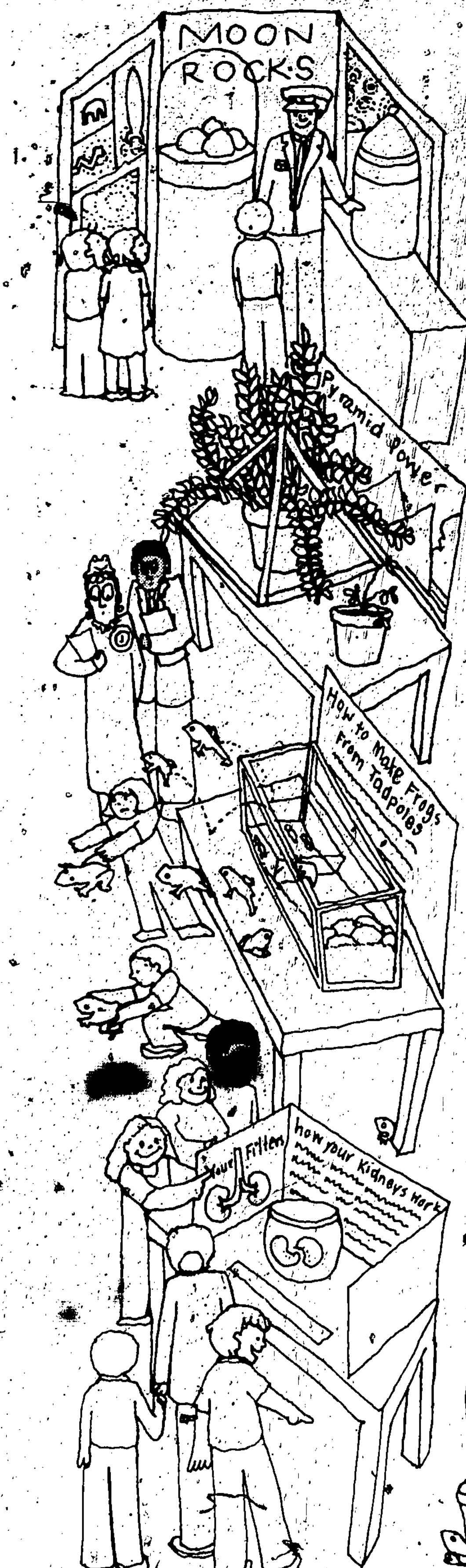
I often think that one of the major rewards of teaching this way is the opportunity to be eclectic, to explore areas that change from month to month, and never quite to know enough for the next class of researchers.

Home-grown projects often seem at a distinct disadvantage when the time comes for competition. I've heard many teachers struggle with this issue. Should we recognize the dichotomy and put the projects generated by university internships in a separate category? Or should we rely on the expertise of the judges and the evaluators to distinguish true creativity, whatever the product?

The question has been around for many years. For a few years, it seemed that teachers were so discouraged by inequities and the uncertainties of the judging process that th[illegible] students were losing in[illegible] fairs and competitions. [illegible] impetus of public support and professional enthusiasm—the trend has been reversed. While some school systems still opt out of the competitive circuit, most participate to some degree. Yet the issues remain.

For those who believe that science is as much an attitude—a state of mind—as it is a bod[illegible] knowledge, the science [illegible]n. Despite [illegible] problems of defining what [illegible] fair should be and how it should [illegible]d, we're certain to see even more projects this year. So pass the rubber cement.

Juliana Texley
Editor, *The Science Teacher*



Planning a Fair with a Flair

Brian E. Hansen

Though a successful science fair requires an enormous amount of time and energy, the payoffs are impressive: students get excited, parents become involved, and school-community relations are improved as the community is invited to take part in making the fair a success. That, anyway, is what we found when Sugarland Elementary School in Sterling, Virginia, held a fair last spring. More than 40 student science projects were exhibited, along with classroom science work from each class and seven professional and commercial science displays. Over 400 children and adults attended the fair. Planning, of course, was the key to its success.

First Steps

Sugarland's Science Fair Committee consisted of five volunteers—three parents and two teachers—who had expressed an interest in the school's science program. The committee began holding monthly meetings in October, about five months before the March date set for the fair. Working backward from that date, they established a schedule that allowed them to complete preliminary planning in about three months. (The two additional months would allow students time to work on their projects.) They began work by drafting the rules for the competition, the entry form, lists of suggested topics, and a cover letter. The rules included the entry and project completion dates, size/speci-

fications for the final display, and judging guidelines. An important part of the rules was a statement that distinguished between a scientific experiment and an encyclopedia report and encouraged students to stay away from the latter. The entry form asked that the student describe the hypothesis, methods, and equipment for the proposed project, and it also called for a parent's signature to indicate permission for the student to participate in the fair. Suggested topics were drawn from the students' science texts, with one list for first, second, and third grades and a second list for third, fourth, and fifth grades. When all the entries were in, the committee checked to make sure the forms were complete and the proposed projects practical and safe. (No bombs or erupting volcanoes, please.) Several students chose identical topics, but this caused no difficulty since the finished projects proved to be remarkably different.

On with the Projects

To make sure that students (rather than parents) did the projects, Sugarland's committee required that all work be done at school. To make this possible, they arranged to keep the cafeteria open after school two days a week for half an hour each day. A Science Fair Committee member and parent and teacher volunteers supervised the students and took attendance to find out which students needed reminding to work on their projects. (No matter what the hypothesis, if a student abandons his or her plants in the storage room for four weeks without water, they will die.) During the rest of the week the student projects were stored in an unused classroom. For the next science fair, the committee intends to add extra after-school work sessions during the crucial first and final weeks. It will also offer additional help for younger students. (One first grader cried when her project didn't work the way she thought it was supposed to.)

Getting the Word Out

The committee member in charge of publicity really had two [illegible] he needed to stir up school enthusiasm, and he needed to let the community know about the fair. The school menu and the parent/teacher newsletter were useful in publicizing the fair and its entry deadline among students and their parents. The committee also aroused interest in the fair by sponsoring a school-wide contest to pick a cover design for the program. Extramural publicity was provided by local newspapers, which were contacted both when the fair was originally announced and again a few weeks before Fair Night, with information about the date, time, and place and an invitation to send photographer-reporters to cover the fair.

The Community Participates

Sugarland encouraged community involvement in the fair by inviting scientists and science-related businesses in the area to set up displays of their work and products.

Brian E. Hanson is an associate professor of English at the Loudoun Campus of Northern Virginia Community College, Sterling, and he served as secretary of the Sugarland Elementary School Science Fair Committee in 1981-82. Photograph by Ruth Larsen, Loudoun Times-Mirror. *Artwork by Marilyn Kaufman.*

Science Fair Checklist

- ____ Recruit five to seven volunteers (teachers *and* parents) who have good organizational skills and an interest in science to serve on the Science Fair Committee.
- ____ Set time and date of fair about five months after first committee meeting. (Clear date with principal.)
- ____ Draft science fair rules (entry deadline, size limits for display, requirements for final report and log of observations, completion deadline, judging guidelines). Emphasize requirement that all work be done by students. Urge experiments rather than reports.
- ____ Design entry form (name, project title, hypothesis, method, materials, places for student and parent signatures).
- ____ Make up lists of suggested topics. Check with teachers, librarian, and science texts for ideas. Have separate lists for upper and lower grades.
- ____ Draft cover letter from principal introducing fair and explaining rules and schedule of after-school work sessions.
- ____ Design final report form (student number, project title, grade, hypothesis, method, summary of observations, conclusions). Don't leave space for student's name because projects are to be judged anonymously.
- ____ Design judges' evaluation form (number and title of project by grade, boxes for scores in each category).
- ____ Organize school-wide contest to select cover design for program.
- ____ Ask teachers to save their students' classroom science work to display.
- ____ Locate and reserve a vacant [illegible]dent[illegible] work on and [illegible] their projects. [illegible] to be [illegible] up between work sessions.
- ____ Schedule parent and teacher volunteers to supervise the after-school work sessions.
- ____ Publicize (1) application deadline, [illegible]ence [illegible] night, and, after the fai[illegible]as taken place, (3) th[illegible]nners.
- ____ Find judges (high school and college science teachers, district science supervisors, professional scientists).
- ____ Find commercial exhibitors and professional science demonstrators.
- ____ Solicit prizes or contributions to buy prizes.
- ____ Order ribbons and certificates for participating students. (Some companies will print the event and school's name on them.)
- ____ Arrange buffet for judges and demonstrators who may work through dinner before the fair opens.
- ____ Plan and type the science fair program.
- ____ Plan arrangement of booths to allow plenty of room for spectators.
- ____ After the fair is over, send thank-you notes to parent and teacher volunteers, judges, and demonstrators.

Who Needs the Competitive Edge?

Bob Burtch

Many science fairs are big, district-wide events and most are highly competitive. Such fairs can encourage and reward excellence, but they may not do much for students who are not particularly gifted—or competitive. The science fair at our school is designed as a teaching tool rather than a contest, and my aim is to involve and enrich *all* students in my fifth-grade class. Projects are judged on a 10-point scale by junior high school science and math teachers. The criteria include creativity, the quality of the display, and the student's ability to explain the principles involved to the judge. Although no prizes are awarded and an individual student's point score is not made public, I believe that our science fair achieves a number of important objectives. Here are some of the ones for which we strive:

1. Create science awareness among the students. Involving each student in a project which is to be on display generates far more interest in science than I, a single teacher, could ever do.
2. Encourage parental involvement. Many parents help their children with their projects. I invite this and ask only that, when the project is complete, students are able to explain what they have done.
3. Remove the element of competition I have seen elsewhere. Every student who participates in our fair receives a certificate with a gold seal bearing the school insignia.
4. Interest the younger children in science. Until this year when we outgrew our space, grades K–4 were able to visit the fair to see what the big kids did and to get a taste of science.
5. Give students experience in sharing work they've done with others. Students explain their projects in class, and many visit other classes to talk about their experiments and projects.

Our science fair has been going on for nine years now, and most people would agree that it's been fun. Many elementary school students have been turned on to science. (No one's ever been turned off because of losing.) Many parents have gotten involved. And this year we had to move to the junior high gym so we'd have enough room. What more could we ask?

To any teachers interested in starting a science fair, I offer a list of past topics that my students found enjoyable:

Bob Burtch is a fifth-grade teacher at J.B. Nelson Elementary School, Batavia, Illinois. Photographs by the author.

Reprinted from *Science and Children*, January 1983, © NSTA

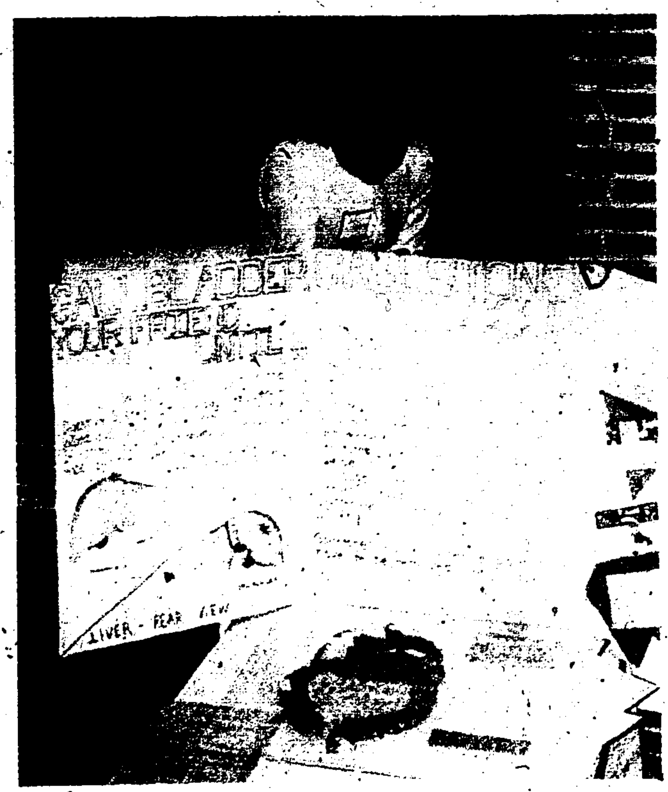
Comments on a science fair without prizes, together with some prized topics

The Human Body
Teeth
The Digestive System
Tissue of Life
How the Heart Works
Blood
Can You See How You Hear?
The Anatomy of the Lungs
A Comparative Study of Bone Joints
The Kidney
How Does Exercise Affect the Heart?
The Human Eye,
The Eye and Glasses: A Team for Better Vision
Orthodontia
Effects of Smoking
Drugs and You
The Human Body
Calcium, Iron, Vitamins A and C
Early Man

Animals and Plants
Flowers and Plants
Bacteria
Cheese
Sprouts
Herb Garden
Houseplants
Carnivorous Plants
Life Cycles of Plants and Animals
Bees
Dragonflies
Silk Moths
Seashells
Sharks and Teeth
Fish of Fox River
Amphibians
Frogs
Chameleons
Snakes
Dinosaurs
Birds
The Incredible Chicken
Beaver Lodge and Dam
Gerbil Training
Guinea Pigs
Horses

The Earth and the Universe
Crystals
Rocks, Minerals, and Their Uses
What is Inside Our Earth?
What Pollutes Our Water
Causes of Faulting
Volcanoes
Caves
Stalagmites
Glaciers Past and Present
Clouds
Local Weather
Weather—A Fact of Life

Involving each student in a project generates far more interest in science than an individual teacher could ever do:



Effects of the Earth's Atmosphere
What Are the Effects of Air on Earth?
Sidereal and Solar Days
The World Beyond Us
The Moon
Planets
Stars and Planets
The Solar System
Why Do the Planets Rotate Around the Sun?

Physical Principles, Machines, and Technology
Simple Machines
Bridges
How a Canal Lock Works
Paper Recycling
Natural Dyeing of Wool
Conductors
How Electricity Works
Insulation
Good Conductors of Electricity
Electricity in a House
Electrical Circuits
Uses of the Electromagnet
Electrical Robot
Electric Motor
The Electric Cell
What is a Photoelectric Cell?
Telephones—Past and Present
The Telegraph
The Speaking Telegraph, or Telespacen
Transistorized Rain Detector
Electrostatics
How a Doorbell Works
Burglar Alarm
Five-way Radio Transmitter
Building a Two-transistor Diode Radio
Teaching Machines
Light
Optical Illusions
Reflections of Light from a Mirror
Color and Light
Grinding a Mirror for a Reflecting Telescope
Photography
Solar Energy
Solar Water Heater
What is a Solar Furnace?
Wind Power
Hydroelectric Power
Physical Properties of Fluids
Fractional Distillation
Ph Factors
Hydraulic Press
Two-cycle Engines
Four-cycle Engines
Atomic Energy
Model Rockets
How an Airship Flies
Airplane Simulation
Apollo II
The Apollo-Saturn V Program
Piggyback in Space
Hot Dog Cooker
LED Communicator
A Home-built Geiger Counter

Miscellaneous
The Loch Ness Monster
Chewing Gum
Graphology
IFO's, UFO's, and Astronomy
Pyramid Power
Inside and Out of a King's Tomb

Science Fairs? Why? Who?

Evelyn Streng

"What's good for high school science is good for elementary science!" Is it? The attention given to science fairs at the junior and senior high school level has led to interest in and emphasis on holding fairs at the elementary school level. This trend has led elementary educators to consider the value of their use.

Opinions differ—as indicated by varying practices of "to have or not to have." Those who have not reached a conclusion would do well to recognize that the elementary science fair should (a) consider the nature and development of the elementary school child, and (b) should involve projects that serve the highest objectives of science education.

Child Development

Studies suggest that the elementary child is curious, and that natural curiosity can be directed to scientific investigation. Joseph H. Kraus, a noted science fair coordinator says: "Beginning science interests peak at age 12, with age 10 now coming a close second. Better than 10 percent of the nationally recognized students are launched toward a scientific future before they even enter kindergarten."

Although some childhood interests flower early, it is important to recognize the differences in developmental patterns. Also, perhaps only a few pupils in a grade-school class may be science oriented. Some creative, talented children may not have the patience or persistence demanded by "scientific investigation."

A fair amount of guidance and direction for the child-investigator is necessary, for the extent to which an elementary pupil can independently develop a project is questionable. The following criteria are desirable when deciding if participation of children in a science fair is appropriate:

1. Only children with a genuine interest in a science project and the initiative to see it to completion without undue adult prodding should be expected to participate in a science fair. A science project should never be a requirement for a class or a necessity for a good grade in science.

2. Any judging of a science fair project or display should consist of helpful comments and suggestions rather than comparative ratings or prizes. If projects are shown in one place, the emphasis should be on the stimulus of shared interests rather than on competition between classes or schools.

Suitable Science Projects

Suitable science projects are those which increase and direct a child's interest and competency in science. Worthwhile projects are those which are *problem-centered*, and in which the *process* is important—not those which center on showmanship or gadgetry. Some categories of appropriate problems for an elementary science fair are:

1. *Observation of the environment.*

- What kinds of trees seem to grow best in our area?
- What living things may be found in a cubic foot of garden soil?
- How do some insects change as they "grow up"?

These are the simplest types of problems, involving a study of the surroundings to classify and organize what is there.

2. *Demonstration of a basic principle of science.*

- How does electricity travel?
- What causes erosion?
- How does a machine make work easier?

These are not really "research problems," for the answer is known at the start. Their value is in enabling the student to clearly explain a basic idea.

3. *Collecting and analyzing data.*

- What is the average October weather like in our town?
- What is the rate at which a pet drinks water?
- How does the number of seeds produced by different plants compare?
- Is there a relationship between the phases of the moon and the weather?

In this type of problem there is no manipulation of nature by the student, but there are directed and recorded

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quantitative observations. This is more specific than simple observation, which is merely descriptive. Computation of averages, ratios, and rates; and performance of other analytic processes will be part of this type of project.

4. *Controlled experimentation.*

- What is the effect of temperature on the activity of mealworms?
- What is the effect of the moon phase on the germination of seeds?
- What difference does the kind of wire make in the resistance of an electric circuit?

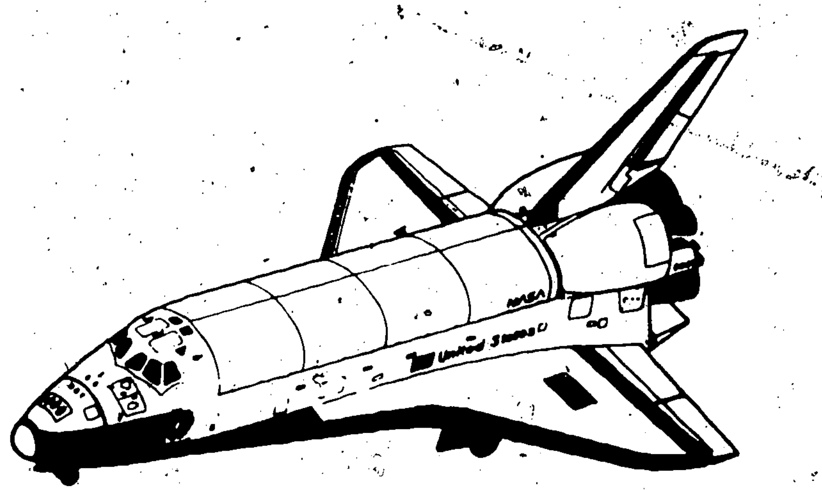
This is the most valuable type of problem from the viewpoint of understanding science. It involves the use of controls—situations identical except for the one variable under consideration. Quantitative aspects are surely implied. It is apparent that the "answers" to some problems (e.g., "What difference does the kind of wire make?") are known to scientists, but they will be unknown as far as the children are concerned.

It is quite possible that elementary children may come up with some original problems to which answers will *not* be found in the science text. In the execution of a project, children may make the valuable discovery that they do not have sufficient evidence for a valid conclusion. A science project which concludes: "This experiment does not show any relationship between A and B; more experiments are needed" may be as meaningful as one which comes to a remarkably demonstrable "answer."

Shall we have an elementary science fair? Only if careful consideration is given to the nature and the needs of students and to the objectives to be accomplished!

Evelyn Streng is an associate professor at Texas Lutheran College, Seguin.

Student Shuttle Projects



Student research can go a long way beyond the school science fair. The Space Shuttle Student Involvement Program, sponsored by the National Aeronautics and Space Administration and administered by the National Science Teachers Association, is an opportunity for secondary school students to propose experiments for possible flight on the space shuttle. Astronauts will conduct the experiments on board the shuttle if necessary.

NASA and NSTA began this program in 1980 to stimulate student interest in science and technology. Eight projects have already flown at this writing, ranging from "The Formation of Crystal in a Weightless Environment" to "Convection in Zero Gravity." Two hundred regional winners and ten national winners are selected each year.

This competition is open to all regularly enrolled students in grades 9 through 12 in all U.S. public, private, and overseas schools. The proposal must be the work of an individual student, though a teacher-advisor may guide the direction of the work. The project must be scientifically valid, it must take advantage of the unique conditions of the shuttle, and the proposal text can be no longer than 1000 words.

SSIP doesn't depend on elaborate facilities or sophisticated techniques. The emphasis is on inquiry and the premium is on creative thought. Students need to communicate their ideas in an organized way, however. David McKay is a teacher-advisor at Appleton (Wisconsin) High School, home of two national winners. He suggests "Proper format and good drawings are important, and so are good grammar, proper spelling, and word economy."

The annual deadline for submitting proposals is February 1. You can obtain entry materials by writing to Student Space Shuttle Program, National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, DC 20009.

Science Fairs in the Eighth, Seventh, or Sixth Grades?

JOHN KNAPP II

Associate Professor
Campus School
State University College
Oswego, New York

WHILE decrying some of the misuse of science fairs, such as an overemphasis on gadgetry and competition, Streng (1) [1] has presented a strong case for conducting science fairs for elementary students, and has observed that the developing of science projects can capitalize upon the natural curiosity of students aged 10-12.

The purposes of this article are to comment on some of the problems voiced by teachers about conducting science fairs with middle school children, cite some advantages of science fairs, and offer a list of simple experiments that are within the interests and intellectual range of many middle school children.

[1] See References.

Objections to Science Fairs

Some of the most frequent reservations to having a science fair include:

I don't know enough science to help my children with a wide variety of projects.

A good science background is helpful to a supervising teacher, however, science projects which emphasize *process* instead of content can be overseen by teachers who were nonscience majors.

I don't have enough time to help each child with a project, collect the materials, check on his progress, etc.

This can be a real problem for many teachers. However, individualizing science is not greatly unlike individualizing math or reading activities—areas in which many teachers have already found considerable success. It is helpful, though not essential, to have additional adult supervision when children work on science projects. Student teachers, teacher aides, or college student observers can be rallied for this purpose. Many of our college observer-participants have found this to be their most rewarding experience with children. Even with minimal or no extra adult help children can be led to develop meaningful projects with careful step-by-step planning on the part of the teacher.

Some of my children do not want to do projects.

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We give our children the options of working alone, in pairs, or sometimes in threes. This helps the child who may be a poor reader or writer and feels he cannot "make it alone." Very few children shrink from the opportunity of "doing an experiment of their own" if approached in the proper manner. When presented with project possibilities like those listed in this article we have never found a sixth grader, and rarely a seventh or eighth grader, who refused to participate in developing a science project. When asked at the end of the year to evaluate their science units our children have voted the Science Fair as an overwhelmingly favorite activity.

My children don't know enough to do a science project.

If teachers think of science projects in highly sophisticated terms, they are probably correct. But nearly all sixth-grade children "know enough" to set up and conduct simple experiments. Children will need help in establishing a consistent and reliable experimental design. With some teacher supervision, these tasks can become meaningful learning experiences.

If I conduct a science fair I won't have enough time to cover the rest of the year's work in science.

Some schools have more rigid requirements than others. However, if one views independent thinking, the process of stating a meaningful problem, drawing up a procedure to solve that problem, collecting data, and drawing conclusions to be important objectives of science teaching, then conducting a science fair is an outstanding way to meet these objectives.

I don't have enough science equipment.

Most meaningful science experiments that children can do may be done with very simple materials which the children can provide. Children delight in locating their own materials.

Children whose projects do not "win" may get turned off to science.

Do not award prizes for science projects, as Streng has recommended. Our children have enjoyed displaying their projects on a "Science Fair Night" when parents come to see their work, but children do not have to be provided with awards for science projects any more than for drawings and paintings in elementary art shows. We do, however, present a Certificate of Merit to every child who working alone, or in a group, completes his project.

I'm afraid the parents will get too involved and do the projects for their children.

This can be a problem, especially when the esprit de corps runs high. However, this can be averted by requiring children to do all, or most, of their work in school during regular classtime.

Advantages of Conducting a Science Fair

On the positive side, several advantages can be cited for conducting elementary science fairs.

Science fairs are popular with nearly all children.

This is true, providing of course, that a fair does not have rigid regulations for entrants, unrealistic requirements, and fierce competition.

Science projects are an effective means of stimulating a child's imagination and encouraging independent thinking.

Helping children with their science projects is a good way to get to know them.

I have learned fascinating things about my students—the way they work, their interests, etc.—that I would never have learned during regular science class activities. This is fun for them and fun for me.

Making science projects allows for expression of individual differences.

Faster workers can do more than slower ones, and are not held back by them. Children of below-average ability can effectively work on problems suited to their abilities. Bright children have the opportunity to do their utmost.

Science projects can be used to help children learn some of the processes of science.

While children work on their own projects they, at the same time, observe others at work. Some of the most important processes of science a child can learn may come from watching other children do experiments.

Working on science projects can cause genuine excitement in the classroom.

A classroom full of projects-in-progress looks, sounds, and smells like a very interesting place!

Working on science projects can be a profitable interdisciplinary activity.

In our middle school, where subject areas are compartmentalized, English teachers and librarians have

Children do not need to be provided with awards for science projects any more than for drawings and paintings in elementary art shows.

What does a mouse prefer to drink?

assisted in some of the reading and writing activity associated with the production of projects. Working on projects can, and should, include periodic "write-ups" or "progress reports." This gives a child a practical opportunity to develop and apply reading and writing skills. In addition, many projects have "social studies" implications and may profit from the aid of certain social studies teachers or materials. (Our plans for next year in our middle school—grades 6, 7 and 8—include expanding our Science Fair into a Learning Fair to focus on social science as well as natural science projects.)

Science Fairs make for good public relations.

Science fairs are an excellent way to draw adults into the school. A PTA meeting, Parents' Night, or a special "Science Fair" Night that is centered around student science projects can bring out large numbers of parents, grandparents, and other family. Many parents like to see something "tangible" that seems to indicate their children are learning in school.

Types of Projects for Children

Many types of observation, demonstration, and collecting activities can be made into science projects. Examples of these are mapping and naming trees in a particular area, examining organisms in a unit of soil, illustrating how erosion works, or comparing the number of seeds produced by different plants. (1)

While these activities may make fine projects for young children, we have encouraged most of our middle school children (including many sixth graders) to develop experimental projects. This involves a four-step process.

Identifying a Problem

Children are encouraged to identify a "bite-sized" problem for which they don't have an answer. To do this, a teacher may provide several examples of possible "problems." Emphasis is made upon the fact that this is the way many scientists work. One person cannot do everything; he must narrow down to one specific thing. Help children avoid undertaking an unmanageable task. The child is asked to state the problem in the form of a question that can be answered. Hence the child who wants to do a project on water pollution may, through guidance, arrive at a question like, "What is the effect of a detergent on the germination of radish seeds?" That question is within reach of an answer by a young scientist conducting a simple, planned experiment.[2]

Identifying a problem and putting it in question form is usually the *most difficult* part of doing an experiment for a science project. As much as one-half of your contact time with a child during the Science Fair unit may be spent in helping him pose his question.

Determining a Procedure

How does the child plan to answer the question? The described process must be specific and include making measurements of one kind or another. Example: "I am going to take six babyfood jars and put ten radish seeds in each one. Then I am going to fill each half-way with water. Then I am going to add varying amounts of detergent. . . . The sixth jar will have no detergent and will serve as a *control*. Each day for ten days I will count the number of seeds that have germinated. . . ." The procedure, written out, serves as a map for the child and a useful record for the teacher who must keep track of what is going on.

Collecting the Data

"Data" are the results of what you can count or measure. The child is encouraged to collect and *record* his data according to his procedure. Dates, times, lengths, volumes, things counted, etc. are all important. Children can keep usable records if they are shown why they are important.

Drawing a Conclusion

After the experiment is finished, what has been learned? Is the question answered? If not, what else needs to be done? Conclusions can usually be stated in one or two simple sentences. Encourage the children to be cautious in making conclusions. Example: "In the jars with more detergent, fewer seeds germinated. It seems that the detergent is responsible for causing this because this is the only thing that varied in the jars. . . ."

One of the big problems that children have with science experiments is experiencing so-called negative results. "Nothing happened . . ." "My experiment didn't work . . ." "The detergent didn't have any effect." Children usually have to be led to understand that results of this kind are often perfectly acceptable, and in no way indicate failure.

Possible Experimental Projects

The following is a list of experimental projects, written in question form, that many children between 10 and 13 can successfully investigate.

[2] Note that little mention is made of "library research." With some exceptions, extensive library work to provide background for a specific project (as is required in many high school projects) is counter productive to a sixth grader's impulse to "do." (Less so for seventh and eighth graders.) As a readiness activity before attempting a science fair, we have found that sixth graders generally profit from "looking through" books of science experiments to get a feel for possibilities for projects. Seventh and eighth grade students may be directed to specific books by their science teacher or librarian.
Note also that no mention is made of the word "hypothesis." We avoid "terminology" when simpler words do as well, or better. We ask a child to "ask a question" that he can "answer" with an experiment.

Note in the list that blanks appear in places where specific information such as a "type" of plant (such as "bean") or brand name is required, according to materials a child selects to use.

1. What is the effect of __________ detergent on the germination of __________ seeds?

2. What are the effects of different kinds of detergent on the germination of __________ seeds?

3. What are the effects of __________ detergent on different kinds of seeds?

4. What are the effects of different temperatures on the germination of __________ seeds? (Wrap different kinds of seeds in moist paper towels and put them in a freezer, refrigerator, oven, etc. for varying periods of time.)

5. What are the effects of __________ oil on the germination of __________ seeds?

6. Under which color of light do __________ plants grow best? (Use fast-growing plants such as bean or pea, put them in containers and cover with different colors of cellophane, but allow for circulation of air.)

7. What are the effects of certain household chemicals (baking soda, sugar, salt, etc.) on the growth of __________ plants? (Mix the "chemicals" with the soil, or put in watering solutions.)

8. What is the effect of salt on __________ plants? (Use bean or pea plants, or varieties of grass. This has implication for the winter salting of roads.)

9. In what type of material (sand, clay, vermiculite, cotton, etc.) do __________ plants grow best?

10. What are the effects of chlorine water on __________ plants? (Use chlorine tablets. Make water solutions of various strengths.)

11. What is the effect of __________ insecticide on __________ plant growth? ("Paint" plant with insecticide solution in various strengths or add insecticide to watering solution.)

12. [illegible] different fabrics burn? (A surpris[illegible] experi[illegible]

13. [illegible] really most absorbent [illegible]

14. [illegible] really the strong-[illegible]

15. [illegible] detergent breaks up __________ oil b[illegible]

16. What are the effects of growing __________ plants in varying amounts of fertilizer?

17. What are the effects of different kinds fertilizers on __________ plants?

18. In what liquids can __________ seeds be germinated besides water?

19. How does homemade organic fertilizer compare to commercial fertilizer in growing __________ plants?

20. What is the best amount of fertilizer to give to __________ plants?

21. Can mice distinguish between colors? (One way of trying to test for this is to make curtains of different solid colors and put them above openings to separate compartments in an experimental box. One of these openings leads to food. Through trial and error the mouse may begin to associate food with a particular color. Rotate the curtains and food so that the mouse does not learn to associate food with "place," etc.)

22. Can mice distinguish between shapes? (Similar to above but have different shapes—square, circle, triangle—painted in the same color on the curtains. One shape is associated with food. As above, many trials may be required.)

23. Which food do mealworms prefer? (Many experiments can be done with mealworms which are cheap, clean, and convenient laboratory animals. Place about a dozen mealworms in the center of a circle of different kinds of food such as dry cereal, bread, a piece of damp towel, etc. After a period of time count the number of mealworms at each food. Repeat several times.)

24. Can a child's vision be better than 20/20, and if so, by how much? (Use the nurse's eye chart.)

25. Can people identify different kinds of Kool Aid by taste alone? (Test many people while blindfolded.)

26. What does a mouse prefer to drink if given the choices? (Use milk, water, coffee, alcohol, etc.)

27. What are the effects of detergent on the growth of algae? (Put equal weights of algae collected from a pond or lake in small containers filled with pond water and left in the sun.)

28. What are the effects of oil (detergent, etc.) on microorganisms found in pond water?

29. Can children tell the difference between dog food and human food? Which do they prefer? (Grind up several dry cereals and dry dog foods and have blindfolded children attempt to decide which is which, and which foods taste best.)

30. Do adults and children agree on what is the world's greatest problem? (Have children make up a list, show them some common sense ways of collecting survey data, and have them ask their subjects to rank the problems.)

31. What characteristic do children and adults consider to be most important in order to be popular? (Use similar procedure as in #30.)

32. Which chewing gum holds its flavor longest? (Use small unmarked pieces of the same size. Drinks of water between trials. Have students rank pieces from best to worst.)

We consider the nurturing of a child's "reverence for life" to be an important goal of science teaching. We attempt, at some length, to discourage cruelty to animals both in and out of the classroom. To that end we usually have many animals such as mice, rats, gerbils, mealworms, and fish in our science class to encourage proper handling of pets by children. Projects which involve the diets, climates, etc. should be done only by serious students, and under close supervision by the teacher if at all.

These ideas are examples of questions which can lead children through some of the various activities of science process.

Some Guidelines

We have found the following to be important guidelines in conducting science fairs with children:

Insofar as possible, let each child select his own topic, or pose his own question. Children resist having to make forced choices from lists.

Have the children make "progress reports" of one kind or another on a periodic basis. This may be no more than a couple of sentences, but it provides a ready check for the teacher as to what a child is doing (or thinking), and a gentle reminder to the child of his responsibility.

As children design their own projects, accentuate the positive and minimize the negative. Children who can surprise teachers with flashes of originality can also be weak in carrying out processes which we consider logical. Encourage children to work up to the limits, realizing what those limits are for each child.

Stress the importance of carefully recording data in a usable form. Stress also the need for clarity in the visual presentation of a child's project, pointing out that visitors to the science fair must quickly be able to read and understand things that may be unfamiliar to them.

Give children enough time for their work—perhaps four to six weeks in class—depending upon how much time is available each day for work in science.

Do not grade the projects but give the children recognition and praise for their completion.

Do not lose sight of your main objectives as a teacher. The purpose of the projects is not to discover unknown scientific truths, but rather to lead children to independently use some of the processes by which scientific information is obtained.

Reference

1. Streng, Evelyn. "Science Fairs? Why? Who?" *Science and Children* 3: 104-105; February 1966.

A Science Fair For Younger Children

Priscilla D. Kesting

Hands-on science fairs are nothing new to the American scene; but consider a science fair designed especially to involve young children (pre-school to kindergarten). Our science fair for young children offered individual learning activities in which university students interacted with young children to help them discover the world of science.

Our Early Childhood Education science curriculum class undertook the project somewhat apprehensively. We had never seen such a fair carried out. But as we worked through obstacles and solved problems, our enthusiasm mounted. The final product was deemed highly successful by community and students alike.

Here is one way to create a science fair for young children:

WHERE: A shopping mall, both accessible and inviting to parents and children, is a good choice.

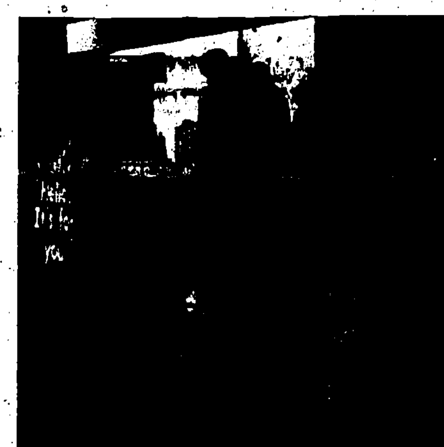
WHEN: We contacted the promotions manager at the mall about two months ahead of time to select a mutually convenient date. Choose a time when parents can be with their children. We selected a Sunday afternoon from 1:30 to 4:00.

WHAT TO OFFER: Each activity selected for the fair met the following criteria: (1) children would be directly involved, (2) the activity would take five minutes or less, and (3) the materials needed were inexpensive and plentiful so that all children could participate. All in all, we offered about 25 different activities. (See list.) We reserved long folding tables on which to display experiments. A supermarket loaned us the square containers used for delivering milk; these we inverted and placed in front of the tables for young children to stand on.

HOW TO ADVERTISE: Submit a description of the fair to local newspapers and radio stations. Duplicate fliers for posting on public bulletin boards. We advertised in grocery stores and all around the mall about a week in advance. In addition, we provided fliers for every kindergarten student in our area. (Packets were made up, taken to the public school administration office, and distributed through the district's regular delivery system to the schools.) We also supplied fliers to some nursery-school and day-care students, including those who attended our school's Child and Family Study Center.

THE DAY OF THE FAIR: Our students arrived about 45 minutes early to set up the fair. Tables were placed in a rectangular shape so that children could move easily from one activity to the next. Large "day-glo" letters spelling "Science Fair!" decorated the mall wall. Colorful posters made by the students hung in front of the tables to advertise the activities. Strolling among the tables, children carried the results of their experiments on styrofoam trays and paper plates.

RESULTS: Young children, parents, grandparents, and students made exciting discoveries about our world.



Priscilla D. Kesting is Associate Professor in Early Childhood Education, University of Wisconsin-Stout, Menomonie. Photo by Kathie Behrs.

Science Fair Activities

- Mixing colors
- Fingerprinting
- Planting grass in egg shells
- Sink 'n float
- Will it roll or slide? (fun with rolling and sliding objects)
- Planting marigold seeds
- Feely box (matching shapes)
- Balloons which stick without glue (fun with static electricity)
- Making peanut butter
- Popping popcorn
- Shadow fun
- Sounds of water (water of various levels in soda bottles)
- Chemical garden
- Water changing the way things look
- The clever clip (games with magnets)
- Optical illusions
- Keeping paper dry under water using air pressure (paper in inverted glass lowered into water)
- Telling raw from hardcooked eggs without breaking them
- Smell and guess (identifying substances by smelling)
- Weighing air (experiments with a scale)
- Shake and match (matching and identifying objects by their sounds)
- Sandpaper fun
- Making heat through friction

A SPECIAL SCIENCE FAIR

LD Children Learn What They Can Do

Jeannie Rae Rice

It had been at least seven years since my school had had a science fair. Late in the fall I asked my principal if I could organize and sponsor a school science fair for my class and the other students in grades four through six. My main concern would be to get as many students as possible to follow a project through to completion so they could experience the reward of displaying their work. She immediately gave her permission a[illegible] pport.

All of this sounds fairly routine—it's the way special activities usually get started in an elementary school. However, my students are learning disabled.

Profile of an LD Class

My 16 boys and 1 girl, aged 11 to 13, have reading abilities ranging from beginning first grade to high third grade. Their math skills are somewhat higher, while handwriting and spelling skills vary but are generally low. According to intelligence test scores, these students have at least average potential, but they have not achieved at the same rate as most of their peers. They have been placed in my class in order to receive special and individualized instruction.

The behavior and attitudes of children with learning disabilities have been described as impulsive, distractible, frustrated, stubborn, disruptive, defiant, obstinate, and extremely disorganized. One word I would never use to characterize my students, though, is "unmotivated." Of course their motivation varies according to the activity at hand, but when their interest has been roused, they really get into gear. Fortunately, my explanation of a science fair induced every member of the class to decide to enter a project.

Jeannie Rae Rice teaches learning-disabled students in the Metropolitan School District of Wayne Township, Indianapolis, Indiana.

Shifting Attitudes

During the three months our school was involved in the science fair, I noticed some important change[illegible] own students and in other students and the faculty.

Learning-disabled children have difficulty getting along with one another in group situations. They are easily frustrated and tend to argue and become angry. Much to my surprise, however, this did not occur when my students worked on their science fair projects. I must stress the significance of this change in behavior. Naturally it improved the quality of their work for the science fair, but it also demonstrated to me—and to them—that they could control themselves and cooperate to solve difficult problems.

While my students' perceptions of what they could do were changing, the attitudes of other students towards my class were also shifting. At the beginning, most of the other students in the school had little information about learning-disabled children. They only knew that my students were somehow different, and they usually called ours the "dummy class." I, of course, was the "dummies' teacher." But during preparations for the science fair, the perceptions of some of these other students began to change. They found it difficult to understand how a "dummy teacher" could run a science fair and why she'd

By taking part in a science fair, some students may be able to excel for the first time.

want to. The fact that I seemed to be doing a good job created a halo effect that was important: as my image began to improve among students throughout the school, so did the image of my students. For the first time, members of my class began to develop friendships with other students.

Many teachers were as uninformed as their students about the limitations and the capabilities of learning-disabled children. These colleagues often viewed students in my class simply as behavior problems. This misapprehension is not necessarily the fault of the teachers, since many of them finished college before courses in special education and learning disabilities had become part of the curriculum. Today, inservice programs are gradually helping to inform teachers about the nature and the causes of learning disabilities. Our school science fair was an important step in showing my colleagues how much such children can accomplish.

A Sense of Accomplishment

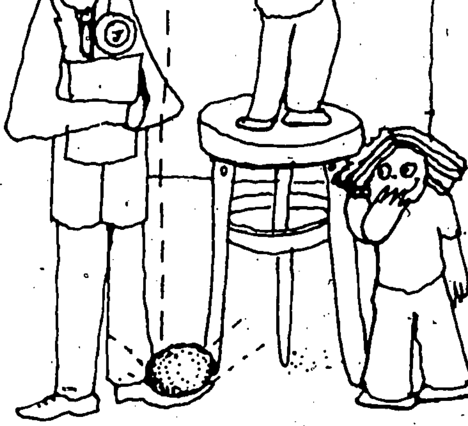
I initiated our science fair with one goal—to have my students complete and display science projects. However, as preparations for the fair progressed, it became clear that my students were learning more than I had originally imagined possible. I was curious about their perceptions of what they were accomplishing, so I asked them. Here (in their words) are some of their replies:

- learned how to make things
- learned how to work together
- learned about electricity
- met deadlines
- had to be responsible (if you mess up, it's your own fault)
- made stuff and did things usually too lazy to do
- helped others
- did things you didn't know you could do
- found out what you could do and could not do.
- writing reports about your project helped you learn things

My students had no doubt that they'd learned some valuable lessons by participating in the science fair and neither had I. In fact, it seems to me that several important academic and personal goals can be accomplished by involving learning-disabled children in a science fair.

- LD children spend most of their school day developing language arts and math skills. Science, health, and social studies are taught when materials are available and when there is time left in the day. A science fair gives these students the opportunity to become actively involved in learning science without struggling through textbooks too difficult for them to read.
- A science fair also allows the teacher readily to combine science with other subject areas. Even though science concepts are stressed, language arts and math skills are naturally involved and are easily integrated into the part of the school day devoted to preparations for the fair.
- It is vital for all students—whether enrolled in regular or special education classes—to learn to work together in groups. Science fair projects provide a good opportunity for learning-disabled children to develop a variety of social skills.
- By taking part in a science fair, some students may be able to excel for the first time. The first-prize winner in our fair was a sixth-grade, learning-disabled boy who reads at the middle first-grade level. After many years of failure, he proved to himself, and to others, that he can win.
- Having regular and special education students share in the same activity gives teachers a chance to understand the strengths, weaknesses, and learning styles of all children. Since P.L.94-142 (the Education of All Handicapped Act) has mandated that special students be educated in the environment that is most appropriate for them, it is important that teachers in regular classes come to understand the learning-disabled students who might be mainstreamed into their classrooms. But, even if a teacher never has an LD student in class, an understanding of the real nature of the problem can have a positive effect on the attitudes of students in the class.

For me and my students, the school science fair was an extremely satisfying experience. Of the nine winners chosen by outside judges, four were from my learning-disabled class. And, while getting prizes was exciting, equally important for my students were the intangible rewards of embarking on a joint enterprise with others, seeing a task through to completion, and discovering within themselves capabilities of which they had not been aware.



JIM EBERT

Planning a Science Fair

IS YOUR district planning a science fair for students? Are you wondering what to do and how to go about it? Five elementary schools in the Elk River District, Elk River, Minnesota, faced the same situation and all involved survived in excellent shape! The science fair will be a popular item on the annual activities list as a result.

Planning the Fair

Bruce Pearson, district coordinator, 1975-76
Elk River science fair

My enthusiasm for our fair began with a positive experience. When my son Scott entered the science fair in the Anoka District adjacent to Elk River, and I saw what that fair did for my child, I could not resist sharing such an involving activity with the intermediate students of our own district, where I teach.

The planning stages involved advice and expertise from the Anoka District people. I convinced the Elk River director of elementary education and elementary advisory council that the expenses and work for the fair were worth the anticipated benefits. Once the plan was accepted, the search began for a coordinator at each school to lead a local science fair and help organize the district fair. Each coordinator and a representative from the administration joined me frequently for meetings during the several months involved.

It was crucial to give students an early start on their projects, as much as three months before their school fairs, we first believed. This time span was too long; interest waned. A month prior to the fair is probably sufficient.

We used the official entry forms and permission slips to alert parents to the upcoming event and the desire to keep it a student's fair. The intent was to have students participate on a volunteer basis, but when so few entered, several schools made entering a requirement, a recommended technique for others trying the science fair idea for the first time.

Schools used the lunchroom, gym, or library areas for their school fairs. Senior high science students served as judges. Their science teachers selected them to provide a judge-to-project ratio of about 1:8, which was adequate. The judging criteria emphasized "doing science" with fewer points for the "art" aspects of a project. All students were recognized with awards of some kind. Certificates of achievement were presented to every student who entered. Discipline problems were kept to a minimum as students were required to remain seated during the judging.

Superior projects were invited to the district fair and their creators received patches to sew on a jacket or shirt. Grades four, five, and six were separate classifications as the students advanced to the district competition.

At the district fair, honorable mention, excellent, and superior ribbons were presented at each grade level. Each project was judged by three separate judges, assigning points. Enough calculators to tabulate results are a necessity! (See accompanying chart for judging criteria.)

There need to be more ways to help teachers turn student ideas into projects, guiding students toward scientific experiments rather than "book report" projects.

An awards ceremony was held where winners were called up to the stage to receive their ribbons. Even with a major snowstorm brewing outside, a number of parents made time enough to watch the "grand finale!" We had a large number of photographs taken to be used for

compiled from several viewpoints by
JIM EBERT
Science Teacher
Rogers Elementary School
Elk River District
Rogers, Minnesota

SCIENCE FAIR QUESTIONS

A project is usually begun by asking oneself a question to which an answer is pursued. One keeps records of all the experiences and experiments encountered in securing an answer to the question. Some examples of project questions are listed below.

1. What causes mold to grow on bread?
2. Where can we find molds?
3. How is sound obtained from a phonograph record?
4. How can electricity create magnetism?
5. Why are coastal cities warmer in winter and cooler in summer than inland cities at the same latitude and elevation?
6. How does one read a weather map?
7. How are we affected by dust and smoke in the air?
8. How do large balloons differ from blimps and dirigibles?
9. How does a jet engine work?
10. How does burning gasoline make a car move?
11. What keeps an airplane in the air?
12. Why are rockets used in space flight?
13. Why are multi-stage rockets used to launch satellites?
14. What causes a satellite to stay in orbit?
15. Why are mirrors such good reflectors of light?
16. How much better do some common materials reflect light than others?
17. Where does the motion in motion pictures come from?
18. How can the developing of films and the printing of pictures be done at home?
19. How do thermometers work?
20. What is the basic composition of water?
21. How can we measure the altitude of stars and planets?
22. How can we measure the amount of moisture in the air?
23. To what extent can the behavior of white rats be modified?
24. How can a tomato plant be grafted to a potato plant?
25. What does a nuclear reactor look like and what is its function?

publicity and for motivating students next year. The local weekly newspaper gave a full page to a story and photo coverage of the event.

The last step was a debriefing meeting with the committee, to make a final report and discuss ways to improve the next fair.

Getting Projects Started

Marcia Krech, science teacher, Elk River district

During the first year, students were required to enter a project. This requirement acted as a great advertiser to parents. In larger schools, however, it would proceed more smoothly if the fair were on a voluntary basis. Enthusiasm was undiminished, even in these cases where there was less than 100 percent involvement.

We started working on the projects in December and worked through January. Of course, it involved hard work . . . but everyone thoroughly enjoyed themselves. The students who complained most about the project being required seemed to be the most enthused at the end. Now a group of students takes me aside to discuss next year's science fair. Sixth graders feel cheated because they won't be doing another project.

Getting Ready

Each student was asked to fill out a form detailing the project to be developed, something that required a "basic question" such as "Can a rat learn?"

Once a student found his or her question and planned how to answer it, the rest was relatively easy. Some students worked with partners, others alone.

"What are the parts of the eye and how do they function?" The girls who chose this project researched the eye parts and functions. Their project consisted of enlarged drawings of each eye part with a short paragraph about its function. They made an eye model by painting on a large plastic foam ball, using flags to label the parts. The project won a blue ribbon at the science fair.

"Can a rat learn?" Several groups from different schools researched this question using hamsters, white rats, or mice. The animals were timed from beginning to end of a maze and each trial graphed. The entire sequence of trials was analyzed to see if the animal shortened its "travel time" and therefore "learned" something.

Information-only questions can be taken on by students not yet ready to conduct full-scale experiments. Fourth-graders did more library work and children in each successive grade did more demonstration projects. The first year was a trial and error time to both teacher and students.

A three-panel board connected with hinges or tape works well for displaying a project. Heavy duty packing tape was used with success. The panels had to be self-supporting. Most of the students could scrounge large cardboard boxes from the local furniture or appliance stores. White or colored butcher paper or construction paper was fastened on for backgrounds,

A SUGGESTED READING LIST

Barr, George. *Research Ideas for Young Scientists.* Whittlesey House, McGraw-Hill Book Company, New York City. 1958.

Moorman, Thomas. *How To Make Your Science Project Scientific.* Atheneum, New York City. 1975.

Stepp, Ann. *Setting Up a Science Project.* Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1966.

Webster, David. *How to Do a Science Project.* Franklin Watts, Inc., New York City. 1974.

and the question was lettered on the center panel either in writing or in cutout letters. The panels on either side were used for charts, graphs, drawing conclusions, and reports. There are a lot of books available to help inspire questions leading to original science projects.

A Word From the Students

Jeff Sebeck

Joel Goergen

We intended to build a project together, but the first attempt didn't work. The next day we both came back to school with a telegraph. We didn't want to build that either, but we discovered that we could only put one project in the fair.

We both liked the idea of building a radio, and started to work on it at once, but no matter how much we tried it wouldn't work. Joel stumbled over a transistor projects book and decided to build a battery charger for his project, and also give it to his family for Christmas. It took him three days to make it.

JOEL: I brought all the parts and soldered them together. Then I made out my reports and printed a couple of photographs. It was fun, but there was a lot of competition and I wished that I would win. I even pulled a wishbone. Jeff was using an oscilloscope for his half of the project and soon we were jealous of each other.

JEFF: Things were unfriendly for a while. Soon we made up and were friends again. We both made it to the district fair, and we took first place.

Debbie Loftus

I was going to do a science fair project on cars and how they move. Then I got some inspiration from my dad to do something on elevators.

First I read all the books I could find on elevators, then drew a picture of one, made reports, and took photographs.

On the day of the fair I was very nervous, but I was glad I had decided to do a project. Then it was time for judging. The first judge came and I told her how elevators work. When the second one came I was so nervous I could hardly talk. Then came the third. He wasn't so hard to talk to.

I even received enough points to go to the district fair! Science fair night there was another ordeal, but I got most of my same judges, so it wasn't as scary. I think that the science fair was really good and you learn a lot from everyone.

Chris Larison

I watched all the people making radios and lots of other things. At first I was designing a radio station, but that did not work out.

As the science fair came closer, I was in the darkroom printing some pictures, and thought, "If I'm so good in photography, why don't I do my project on photography?" That was a week before the school science fair. I took pictures, made my display, and wrote a report. I was selected to go to the district fair, and in spite of the long afternoon and the snowstorm, it was a blast!

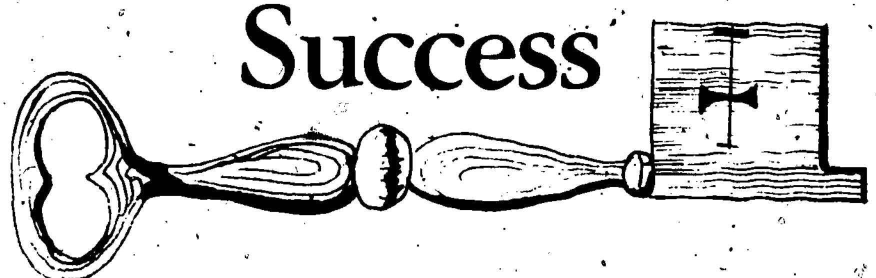
SCIENCE FAIR JUDGING CRITERIA

STUDENT'S NO. ______________________ JUDGE ______________

CATEGORY (Circle the proper rating)	Fair		Average		Superior	
1. Is the project attractive, with readable lettering, etc.?	1	2	3	4	5	____
2. Are student's data expressed in a scientific way? (Charts, graphs, & photographs)	1 2	3 4	5 6	7 8	9 10	____
3. Does the student have one or more explanations accompanying project or can he explain procedures for collecting data?	1 2	3 4	5 6	7 8	9 10	____
4. How well does the student understand his project?	1 2	3 4	5 6	7 8	9 10	____
5. Did the student actually answer his basic question?	1 2	3 4	5 6	7 8	9 10	____
			GRAND TOTAL (45 points)			____

JUDGE'S COMMENTS: ______________________

Organization: the Key to Success



Arthur G. Rundle

After observing and working with numerous science fairs in the past five years, I have discovered that the success of the fair depends upon how well the chairman has planned the operation. Although science fairs are held in the spring, planning must begin early in the school year. How well this early work is handled can determine the success or failure of the entire fair.

The Chairman

A science fair chairman usually is chosen by the principal at the beginning of the school year. He or she is normally a person with experience in conducting the activity and is familiar with the hazards of last-minute planning. But, too often the coordinator waits until the last month to implement the plans—thus jeopardizing the chances for a successful fair. This pitfall can be avoided if the chairman will give consideration to the planning immediately after his or her assignment to the post. This article lists details and procedures to help the chairman insure a smoothly operating activity with less work from start to finish.

Early Organization

• *Staff Meeting:* A general briefing early in the year for the benefit of new faculty members is needed. Survey critically the science fair of the previous year and consider possible changes to create an improved fair.

• *Application Forms:* Prepare a form listing the requirements to enter the fair. The form should include such items as category of entry (biology, chemistry, physics, earth science, and general science), number of electrical outlets needed, and table space needed (dimensions).

• *Publicity:* Plan the posters and flyers for school use, and plan on distributing public announcements to local newspapers and radio stations. A series of flyers should be sent out by the publicity committee. The first flyer should include details about dates, rules, and prejudging instructions.

• *Judging:* Prepare standards for judging and provide tallies. Recruit judges and instruct them in their duties and responsibilities. Some judges are lenient and others quite strict; therefore, they should be instructed to judge consistently.

• *Exhibit Area:* Be sure to arrange sufficient space and provide equipment for each exhibit according to subject classification. Plan a committee to clear the area after the exhibition. (This is often done by Science Club members.)

• *Programs:* The subject cards can be printed and arranged according to category, grade level, number, and name of applicant. List the industrial displays alphabetically.

• *Guide Service:* Plan to have guides greet visitors at the door, give them programs, and lead them into the exhibition area. (Again, the Science Club members can help.)

• *Refreshments:* Provide refreshments for judges and faculty members on all days of the fair. Selling soft drinks can provide an income to offset the cost of the fair.

• *Awards:* Purchase these *before* the fair. Have evaluation forms for each project.

• *Floor Plan:* Draw up a tentative floor plan when the number of projects and industrial displays is known. Some fairs are in one large exhibit area; others use several rooms. A large school may want to confine the industrial displays to the gymnasium and use the classrooms for the various categories, e.g., chemistry projects in the chemistry room.

Project Selection

Teachers should be sure that students choose projects within their capacity and that they submit outlines for the construction of their projects. Submit a list of possible projects to students to give them an idea of what is expected.

Most chairmen find that some screening of projects is necessary to insure

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that science activities are adequately represented. The number of projects in the fair will depend upon school enrollment, size of exhibit area, and space required by the industrial displays.

Industrial Displays

Most chairmen find that a good industrial display will encourage interest in the fair. Industries that welcome the chance to display their education activities include telephone companies and local manufacturers.

Early planning and communication are the keys to good industrial participation. Prepare a form letter with the following information: (1) dates and time of the fair, (2) educational objectives and purpose of the fair, (3) regulations on the amount of space or type of display, (4) name of the school co-ordinator and telephone number, (5) time to set up and take down displays. Include a postcard for exhibitors to indicate the amount of space and number of outlets they need.

Calendar of Events

- *The Week Before:* The week preceding the fair is naturally an active one. During this time call a final meeting to make last-minute assignments. Most chairmen find that a two day fair is enough time. Weekends are usually ideal, because the fair can be set up Friday in time for the entire student body to view the projects and displays before going home. On Saturday morning, the judging can take place, and the exhibits can remain open Saturday afternoon and evening.
- *Operations During the Fair:* Assign at least one teacher per exhibit room for each hour the fair is in progress. Teacher supervision is needed because of the value of most exhibits and, more important, as a source of information for students, industrial personnel, and visitors.
- *Close of the Fair:* A well-organized work crew should make sure that all equipment is put away and the exhibit area is clean.
- *Follow-up Recognition:* Photographs and write-ups should be made available for local newspapers and the school publication. Arrangements for press coverage should be made before the fair opens. A description of the top projects and the more interesting industrial displays may make the best report.

Arthur G. Rundle is a science instructor for the Stongsville (Ohio) City School System.

Preparing for the Fair

Nancy Cramer

A science fair project is an excellent way to get students involved in hands-on science, but success lies in careful planning and preparation. If the 15 suggestions listed here are followed, a successful fair is guaranteed.

Fifteen Suggestions

1. Start with materials and ideas on hand. A lot of time and energy can be wasted looking for hard-to-get materials. Use parents as resource persons for how-to ideas and everyday objects. Other sources of ideas include *Science and Children,* basic science texts, experiment idea kits, trade books, TV and radio commercials; food and soft drink labels, cleaning agents, newspaper articles, and—of course—questions and ideas from students.

2. Getting started is the hardest part. Decide which branch of science to emphasize. Look through the suggested sources for ideas that interest all of you. Then search out more specific sources of information.

3. If this is your first science fair project, begin with an investigation already planned. Expand it by adding variables. Repeat the investigation several times to see if the same results occur.

4. Outline the project on the board; have students record the schedule and brainstorm ideas. Then have students meet in groups of four to pursue the projects. Don't assign students to work in pairs; if one is absent, delays result. More than four in a group tends to be too many to keep all students involved.

5. If you begin the project in January or early February, allow at least eight weeks for completion. Set a target date at least two weeks before the actual science fair or completion of the projects. Offering a sneak preview of the projects at a parents night or other event stimulates useful comments.

6. If this is your first fair, limit yourself to one or two class projects. After experiencing success with a few, you can set up more projects. A maximum of 12 projects per class is desirable. Better to do more with fewer projects than spread yourself and students too thin.

7. Keep all notes and papers in large folders or envelopes, marked appropriately. It is better to collect too much data than too little. Don't throw any information away until after the event. Once the fair is over, important papers can be saved, and the rest discarded.

8. From the start, keep parents informed about the project. Parents are pleased to learn that their children are involved and usually enjoy helping with the activity. Parents can supply special materials, take students to the library, or serve as resource persons. You may need parents to transport projects to the fair and remove them when the fair is over.

9. Be certain students do all of the printing and drawing. Before final copies are made, go over everything, checking spelling, grammar, punctuation, content, and clarity. Always involve students in this process; it serves to reinforce language arts skills.

10. Avoid using fancy lettering, borders, or elaborate pictures. *Do* have neat, accurate charts and graphs. Be sure the backboards are large enough

Nancy Cramer is a Sixth Grade Teacher at Wes- [illegible] Elementary School in Kansas City, Missouri. Over the last 15 years, she has sponsored nearly 90 science projects, many of them award winners. She also teaches a graduate class on Science Fair Construction at the University of Missouri-Kansas City. Photo by the author.

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to display necessary materials. Large, empty cardboard boxes used for television sets or washing machines can serve as backboards and are lighter and easier to carry than wooden backboards.

11. Decorate the backboards using complimentary colors with accent colors for borders and lettering. Avoid too many colors or too much decoration. If it is appropriate, give the project a catchy title. Otherwise, restate the hypothesis as a short, simple title. For accent, cut paper strips and frame each title. This is neater than printing onto the background paper. Also strips are easy to remove if an error has been made. Use rubber cement instead of glue for the same reason. Be certain charts, graphs, and titles are lined up straight. Crooked lines look messy and detract from the display.

12. If possible, schedule work on projects during the part of the day you feel best. Stop work when pupils are tired, bored, or creating problems. If all is going well, extend the work period. Always remember: science fair projects require hard work and commitment, but they should also give students feelings of enjoyment, satisfaction, and accomplishment.

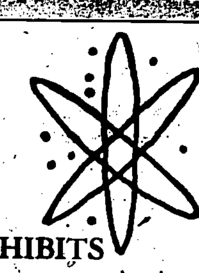
13. If an experiment fails, don't give up. Find out why. These are sometimes the most interesting projects for students.

14. I permit students to do only experimental projects, not research, collections, or models. Setting up experiments, collecting data, interpreting results, and assembling it into a project is the purest form of science. During such study, each child is truly a scientist.

15. Begin preparing for a fair now. Motivate pupils early, talk about a number of ideas, and then get busy. The rewards will truly outweigh all the hard work, frayed nerves, and messy classrooms.

SCIENCE FAIR BULLETIN BOARD

THE BALTIMORE SCIENCE FAIR



RULES ENTRY AND EXHIBITS

1. Interested students must enter proposed projects for preliminary selections by individual schools. Schools will arrange judgings for competition in their respective areas.

2. Contestants chosen to represent their individual school in the Baltimore Science Fair must submit a Special Entry Blank to Mr. R.J. Weiss, 1927 York Road, Timonium MD 21093 (561-1055), on or before March 10, 1983. If entry blanks are not received by this date, exhibit entries will not be accepted. Entry blanks will be supplied to science teachers not later than January 24, 1983.

3. Only the contestant may work on his exhibit, which must be submitted in his name. No one may enter more than one exhibit.

4. All exhibits must be durable and safe. Movable parts must be firmly attached. Where electrical equipment is used, the display must operate on 110-volt alternating current, single phase. Each such exhibit must be provided with at least ten (10) feet of extension cord with popular style parallel, or male plug. Battery operated circuits need not be so treated. Plants must also be watered by the exhibitor. The University will not provide outlets or facilities for running water, gas, or compressed air for exhibit positions.

5. *Live, warm-blooded animals, dangerous chemicals, open flames, explosives, poisonous reptiles and arachnids* may not be exhibited. If your exhibit involves any type of animal experiment, your application will be reviewed by a Science Fair special committee. This special committee is charged with the responsibility to ensure that all animal experiments have been conducted in accordance with International Science and Engineering Fair Rules and Regulations, all with a view toward humane care and treatment of animals. Should this special committee determine that your animal experiment violates ISEF rules, you may be disqualified and asked to withdraw your exhibit.

6. Exhibits may consist of a demonstration model, an experiment, a working mechanism, or of charts, diagrams, or collections with a scientific objective. These must be no larger than 30 inches deep (front to back) by 48 inches wide (side to side) and no higher than 12 feet (floor to ceiling)—thus meeting National Science Fair specifications. No backing or rear display board of any kind will be provided for the exhibits. Tables at the local fair are slightly less than 3 feet deep, and it is suggested—though not required—that exhibitors construct displays like a miniature stage with three sides and a floor.

7. Neither name of exhibitor nor name of school shall appear on the exhibit before or during the judging. A number will be assigned each exhibit for identification prior to the judging.

8. An official label for name of exhibitor, age, home address, school, and name of teacher will be mailed to each exhibitor upon receipt of entry blank.

9. Each exhibit must include a completed Summary of Exhibit form prominently displayed with the exhibit. This form is a single page containing 1. Title of the exhibit; 2. What the exhibitor intended to accomplish by the project; 3. Steps taken in the preparation of the project; and 4. Conclusions reached. This form must be typewritten and may not contain the student's name or the name of his or her school.

10. Exhibitors will be responsible for setting up and removing their displays.

11. A student who has previously won Division I first place and attended the International Science and Engineering Fair will not be eligible again to win first place. However, he or she may exhibit and be eligible for other awards.

Did Billy Gene Do This Project Himself?

Stephen A. Henderson, director of the Model Laboratory School, Eastern Kentucky University, Richmond, recently wrote S&C *with comments on a big science fair question.—ED.*

Having supervised hundreds of projects, directed many fairs, and judged scores of others, I'm very familiar with the question, "How much of this work did the student do?" It's not hard to see why teachers ask it, but the importance given this question may cause us to ignore one of the greatest benefits a science project can offer—the opportunity for child and parent (or other adult) to work together to produce a project in which both can take pride. This message was made even clearer to me when one of our elementary teachers received the following letter:

> This is to certify that Billy Gene performed all workmanship on his Solar Water Heater project himself, with advice but no other assistance except that noted. The measuring, sawing, drilling, painting, soldering, screwing, and hammering are all his handiwork. Throughout the project he has been required to explain the basic principles involved. While he articulates them poorly, I am positive his understanding is thorough. (We didn't discuss finer points such as refraction, wave lengths.)
>
> If his project merits an award it might encourage him in further study. However, my greater motivation in the several projects we have worked on is not blue ribbons but promotion of his already keen thirst for knowledge. Close scrutiny will reveal many imperfections, but the project is still darn good for an eleven-year-old. Without this letter I feared you might think the project done for him, instead of by him. A lesser project would not have challenged him.
>
> Granddad bent the tubing (he tried first), drove one stubborn nail, cut the plexiglass, and soldered one tube to the bucket (to demonstrate technique). Billy Gene did the rest.
>
> I confess to too much advice in helping him condense his volumes of poster material. He had accumulated enough pages of drawings, tool and material lists, data, principles, and conclusions to nearly paper a wall of your classroom instead of make one poster. If time were not running out, I would have advised less.
>
> Sincerely,
> Eugene Spurlock (Granddad)

The letter reinforces my feelings about adults' helping with science projects. This eleven year old probably learned more science as he worked with his grandfather than anyone could have taught him in the classroom. Perhaps more important, the experience deepened a family relationship that will last a lifetime. Hurrah for science projects, willing kids, and granddads!

More Science Fair Info from S&C

1. Ebert, Jim. "Planning a Science Fair." *Science and Children* 14:30-32, November 1976.
2. Kesting, Priscilla D. "A Science Fair for Younger Children." *Science and Children* 18:11, April 1981.
3. Knapp, John. "Science Fairs in the Eighth, Seventh, or Sixth Grades?" *Science and Children* 12:9-12, May 1975.
4. Rundle, Arthur G. "Organization—Key to a Successful Science Fair." *Science and Children* 3:13-14, February 1966.
5. Streng, Evelyn. "Science Fairs? Why? Who?" *Science and Children* 3:11-12, February 1966.

"OH NO! A SCIENCE PROJECT!"

Gail C. Foster

Mention the words "science project" to a teacher, student, or parent, and you'll probably provoke reactions ranging from delight to aversion. More than one elementary science teacher has been confronted with wails of "Oh, no, a project!" when the assignment was introduced. And more than one (if he or she is honest) will admit to harboring occasional doubts about the value of doing science projects.

The problem may be that people involved in working with science projects sometimes forget what the projects are supposed to accomplish. The primary purpose is to encourage students to think critically and to investigate. A successful project has given its creator a chance to observe, infer, measure, identify, classify, hypothesize, experiment, manipulate variables, and interpret data. It has helped the student learn how to learn.

Guess What?

Science projects often cause difficulty because they appear out of nowhere, like a rabbit out of a hat. And children are supposed to be able to do a project just because the school is having a fair or because the teacher says that a certain percentage of their science grade depends on it. It's not that easy. Children may not have the process skills needed to do such a project. They lack extensive practice in observing and making inferences, and they may not even have participated in any simple group projects. Requiring a child to do an individual project without this experience is like introducing the alphabet and then expecting the child to write a novel.

Just Pick a Topic

Selecting a topic and identifying a problem are undoubtedly the most difficult parts of doing a science project. Common approaches include having children write down several "areas of interest" or pick topics from a list of time-honored favorites. If these methods don't work, children may be sent off to the library or media center, where they find "cookbook" experiments and then organize them into the form the teacher has specified. At best these approaches are artificial; at worst they cause children to work on topics in which they have no real interest.

A more productive approach is to introduce students—early in the school year—to the idea of asking questions about the world around them. Asking questions shouldn't be too hard, should it? Consider children's natural curiosity: "Why do balls bounce?" "What makes a radio work?" "Why are leaves green?" "What do spiders eat?" Unfortunately, as Lazer Goldberg notes, children seldom ask such questions at school, so you'll need to get them going.(1)* Set the stage for questioning by taking your class outside or gathering them around an aquarium, an insect zoo, or a learning center. A bulletin board with a new display could serve as a focus for questions. Talk about things you might have wondered about. Do ant lions turn into anything else? Will spiders eat dead insects? Does salt water boil as rapidly as fresh water? How does soap clean things? Will certain fish react to seeing themselves in a mirror?

Children respond quickly to this approach and begin contributing questions of their own. Explain that some questions can be answered by investigating while others cannot, and give some examples of both. Select some questions and have the children tell how they could find the answers. If time permits, groups could design simple investigations to answer simple

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*See References.

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questions. And be prepared for additional questions that arise from observation. For example, if children have experimented and found that they can lower the temperature of water by adding baking soda, they may have new questions that need answering: Will the water freeze if they continue to add baking soda? Will the temperature of hot water drop the same number of degrees as that of cold water? Will adding baking powder lower the temperature? How about yeast?

Creating Excitement

Once students are accustomed to posing their own questions, you can set the stage for selecting a topic and identifying a problem using the same approach you employed earlier to stimulate students' curiosity.

First, assess your class's attitude toward science projects. If students seem less than enthusiastic, blitz them with attention-capturing activities: try optical illusions, "eyeball benders," mystery boxes, mixtures and fluids, puzzles, tangrams, and magic tricks. Contests that pose problems with many possible solutions can be particularly stimulating. (Who can figure out the best method for floating an egg?) You can find suggestions for such contests or activities in Joe Abruscato and Jack Hassard's *The Whole Cosmos Catalog of Science Activities* (Santa Monica, Calif.: Goodyear Publishing Co., 1977).

You can also arouse curiosity by having students contribute to a classroom resource center. This resource center might include

- a mini-museum of interesting items such as shells, galls, lichens, seeds, magnets, magnifying glasses, a thermometer, batteries, wire, bulbs, a stethoscope, a tuning fork, balloons, candles, a funnel, a compass, pulleys, balls of various sizes, a gyroscope, a prism, a paper airplane, convex and concave lenses, marbles, a stopwatch
- a bulletin board with a word-and-picture collage depicting subjects that might spark ideas
- a display of advertisements for competing products and the containers the products come in to encourage comparisons
- interesting books and magazines like *Insects, Optical Illusions, Ranger Rick's Nature Magazine, National Geographic World, 3-2-1 Contact*
- lists of familiar places, people, and things that might inspire your students' investigations:

  personal interests—hobbies, pets, or leisure-time activities

  home—under the sink; in the refrigerator, pantry, garage, or yard

  neighborhood—school grounds, parks, vacant lots

  stores—grocery stores, drugstores, bookstores, malls

  people—family, friends, classmates

  media—television, movies, radio, newspapers, books, magazines.

Help for the Perplexed

In spite of all this, some children will need additional suggestions. Help them arrive at topics by staging brainstorming sessions, where class members contribute ideas and post the results for pondering. Or organize a Student Advisory Committee for Perplexed Individuals.

If a few children are *still* without a problem to investigate, you can fall back on teacher-child conferences, lists of specific projects, or a collection of experiments.

What Now?

When a child is ready to state the problem for the science project, he or she needs a brief conference with the teacher. In most cases you only need to help the child narrow the problem to a question that can be answered by experimentation. Let the child tell you what he wants to find out. You may need to help him simplify or reword the problem, but resist the impulse to tell the child what he wants to know. Simply ask: "What do you want to know?" and "How will you find out?"

Before beginning an experiment, the child should be able to express exactly what he is trying to find out (the problem) and how he plans to find out (the method of investigation). Theoretically, the child should find out as much as possible about the problem through observation and research. However, if the child actually researched the problem thoroughly, there would be few investigations because most answers to simple questions can be found in books. For an elementary school child, then, research should be highly specific and brief. (One side of one page will suffice for most projects.) Sources may include audiovisual materials, interviews, and brochures, as well as encyclopedias and magazines.

Table Talk

When your students are about ready to settle on their topics, use the chart above to give them practice in narrowing broad topics to specific problem statements and verifiable hypotheses. Work through the first four topics on the chart with the whole class. After each problem statement, ask students to design a simple experiment that would answer the question.

By the time you have presented the fifth topic, students should be able to proceed with the rest of the chart individually or in pairs. After students have completed the chart, present them with a blank chart and ask them to fill in the whole thing. (They might do this individually, in pairs, or as a group.) Stress simplification. The simpler (and therefore more manageable) the problem statement and hypothesis, the less difficulty the student will have completing the project.

A successful science project should begin with wonder and foster wonder. As Cornell professor Verne Rockcastle says, "After all, science is not a subject; it is a way of looking at the world around us. Good science teaching helps children develop ways of finding out what makes things happen, and what will happen if . . . ."(2)

Trying Things Out

With a little practice, your students can become accustomed to locating topics, posing questions, and formulating hypotheses. Discuss the first four examples below as a class. Then, have students work together to fill in the blank columns in the last six items.

Topic	Problem Statement	Hypothesis
1. Conserving water	Do showers take less water than tub baths?	Showers take more water than tub baths.
2. Heating things	Do thick liquids boil as fast as thin liquids?	The thinner the liquid, the faster it will boil.
3. Balls that bounce	Will more air make a basketball bounce higher?	If air is added to a basketball, then it will bounce higher.
4. Ant lions	Do ant lions only eat ants?	If a worm or small insect other than an ant is dropped into an ant lion's hole, the ant lion will eat it.
5. Vision	Does eye color have an effect on pupil dilation?	
6. Rusting		Iron nails rust more quickly in salt water than in fresh water.
7. Soil	Does water soak into some kinds of soil faster than others?	
8. Plants		
9. Solar heat and color		
10. Hearing		

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1. Goldberg, Lazer. "I Know the Answer, But What's the Question?" *Science and Children* 11:8–11, February 1979.
2. Rockcastle, Verne N. *Some Basic Philosophy of Good Science Teaching in Elementary Schools*. Atlanta: Addison-Wesley Publishing Company, n.d.

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Smith, Norman F. "Why Science Fairs Don't Exhibit the Goals of Science Teaching." *The Science Teacher* 47:22–24, January 1980.

Ukens, Leon. "Inquiry with Toys." *Science and Children* 15:20, October 1977.

SCIENCE FAIRS:
A Primer for Parents

Last month Science and Children *presented a series of science fair articles for teachers and science fair committees. This month we are following up on the topic with an article aimed at another group interested in the ins-and-outs of science projects—parents. You might want to send this article, or a letter of your own, home with students the next time they are assigned a science project.*

Linda Hamrick
Harold Harty

Odds are that sometime during your child's elementary or middle school years, he or she will be involved in some type of science fair project. And, if fair guidelines permit, you're probably going to be involved too. But don't panic, because you know more than you think you do. Common sense—and the recollection of your own experiences—tell you that doing the project over a reasonable period of time, instead of cramming it into one or two frantic nights, is essential to its success and your sanity. You also probably know that working on a project with your child can be a source of immense satisfaction to both of you.

Naturally, some questions about logistics remain, but we hope the guidelines that follow will answer many of them.

Getting Acquainted with the Project

First, be sure you are familiar with any guidelines for the project that have been set by the teacher or fair committee. Usually this type of information is sent home as a bulletin to parents, and you might tape the bulletin to a wall or refrigerator door so it doesn't get lost.

Help your child to allow plenty of time to do the project. Begin at least four weeks before the deadline, and, if the school allows more time, take advantage of it. Try to set aside time every other day or so for work sessions. It's a good idea to make the sessions fairly short (about 20 minutes). This will allow for slow but steady progress. It will also accommodate the limited attention span that children usually have and ensure that each encounter is pleasant rather than tiring.

Don't get hung up on details. Children often become very worried about small points, like choosing a paint color, and spend a disproportionate amount of time trying to make up their minds. Usually the decision is so hard to make because there is no right or wrong answer. On the other hand, if your child is puzzled about what seems to be an issue of substance or of size limita-

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tions, for example, a quick call or note to the school can probably take care of things.

Scientific Approaches

Science projects, whether constructed for classroom display or for competition, share certain basic characteristics. This is the case because all seek to follow the scientific method in the way they approach a problem, and all make use of inductive reasoning.

Inductive reasoning is a tool used by scientists and means simply that the investigator bases conclusions on an examination of the data that he or she has gathered. A simple example would be an inductive investigation of whether mammal hairs are all alike or whether they differ from animal to animal. The inductive approach would require gathering hairs from mammals that were handy—family members, pets, cooperative friends—and looking at them with a microscope and perhaps drawing pictures of them before coming to a conclusion.

The scientific method involves four steps: forming a hypothesis, designing and describing the method of investigation, gathering and analyzing data, and drawing conclusions. The hypothesis is a statement that will either be proven or challenged. Teachers sometimes urge children to ask a question instead of stating a hypothesis, but answering a question does not always require scientific investigation. At any rate, by defining the purpose first, the child can see what information he or she must seek in order to draw conclusions.

Next comes the description of the method, a statement of how the investigation is to be carried out. It paves the way for the actual investigation and forces the child to think ahead of time about the investigative plan of attack. The information gathered during the investigation is called data. After the data are collected, they need to be tabulated or diagrammed to facilitate their analysis. From the data, the child will confirm or challenge the hypothesis or answer the question asked. Thus, the project comes full circle to the question that started the adventure.

Setting Up the Display

Once the project is completed, the next step is to set up a display to show the course of the investigation and explain its outcome. Three-panel displays are the most common, both because they are free-standing and because they accommodate themselves nicely to the divisions of the child's investigations. Three sides of a cardboard box will do the job well. Suggest that everything be blocked in first with pencil. Then, when the display is in its final form, a felt pen can be used. The top of the left section is a good place to write in the hypotheses or scientific questions the investigation sought to answer. The lower half might carry a description of the methods used in carrying out the project. The right-hand panel can show the investigator's name, grade, and any other required information. (Perhaps this is an appropriate time for you to consult the school bulletin you posted on the refrigerator.) On the same panel, your child might put his or her conclusions—but only those based on the data. Opinions just do not count, no matter how sure the investigator may be. The body of the data or a model can be put on the center panel of the display. Try not to get possessive about the project at this point. (Or at any other, for that matter.) Let it end up looking like exactly what it is: the beginning work of a youngster investigating the use of inductive reasoning and the scientific method.

Finally

Both of you will probably feel considerable satisfaction when the project is completed. But, if the project is to be entered in competition, your child may also be wondering how successful it's going to be. This depends, of course, on the criteria on which it's to be judged. Some fairs publish their criteria, and, in this case, you'll probably find them on the refrigerator with your other science fair information. Otherwise, try checking the project against the general criteria we offer. (See Box.) They will give

How Does the Project Measure Up?

Scientific Thought

- **Does the project follow the scientific method? (hypothesis, method, data, conclusion)**
- **Does the project illustrate controlled experimentation?**
- **Does it represent real study and effort?**
- **Does it make appropriate comparisons?**
- **Does it form conclusions based only on the data gathered?**
- **Does the project show that the child is familiar with the topic?**

Originality

- **Does the project demonstrate some ideas arrived at by the child?**
- **[illegible] ject [illegible] a high degree [illegible] complishme[illegible] is the degree of accomplishment consistent with the student's age level?**
- **Is the project primarily the work of the child? Does it give that impression?**

Thoroughness

- **Does the project tell a complete story?**
- **Are all the parts of the project well done, including the visual display and the oral presentation?**

Technical Skill

- **Is the project physically sound and durably constructed? Will it stand normal wear and tear?**
- **Does the project show effort and craftsmanship by the student?**

Clarity

- **Are the labels clear, correct, and easy to read?**
- **Is the objective likely to be understood by one not technically trained in the subject area?**
- **Does the project attract attention?**
- **Is attention sustained by the project?**
- **Is attention focused on the objective?**

you and your child an idea of what modifications, if any, ought to be made in the project.

As part of the judging process, your child may be asked to explain the project to the judges or to present it to the class. Those in charge usually try hard to make the presenter feel comfortable in this situation, but a dress rehearsal might be a wise move. Simply encourage your child to go through the project as if explaining it to someone totally unfamiliar with its purpose and development. Start with his or her name. Then give the title of the project and explain how interest in it was first aroused. The child might then simply talk his or her way through the project, step by step. The more comfortable your child is, the easier it will be not simply to read from the project write-up.

Undertaking a project for a school show or competition can be a daunting prospect for young children, especially if they are expected to work without the teacher's constant guidance. A little preparation, however, can assist a parent in reassuming the role of guide. We hear much today about the value of individualizing education, and it's important to recognize the part a parent can play in this process. There simply is no match for the parent-as-teacher in working with youngsters, and there can be no more fitting place for learning to occur and no more loving individualization to be found than at the hands of a concerned parent. Not only does learning occur, but the opportunity for sharing is enhanced, as parent and child set out on the road of inquiry together.

34

Science Fairs: Do Your Students Measure Up?

Bernard W. Benson
Joy A. Kerby
Barbara A. Wofford
Kathryn B. Biggs

The importance of accurate measurement in science cannot be overemphasized. We decided to investigate whether this principle is being adequately stressed in science teaching. In particular, we felt that science fair projects would provide a reasonably accurate reflection of current science-teaching practice and a good "yardstick" with which to assess the extent to which metrication, in particular the International System of units (SI), is being adopted in our schools.

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In his list of criteria for judging science projects, Stedman [3] states that the science student should attempt, as much as possible, to quantify data by measuring, timing, determining mass, and recording changes. The judging guide for the 30th International Science and Engineering Fair [1] stipulates that accurate data collection is of primary concern in evaluating projects. Many science fair projects, however, are non-investigatory in nature; they stress the construction of physical models, hobbies, laboratory demonstrations, or report-and-poster projects. [2] Even so, there are elements within these non-investigatory projects that are capable of being measured, and science fair judges can properly expect such measurements to be made and recorded.

To measure or not

In this study, we surveyed the extent to which measurement in general and the SI System in particular are being taught, as reflected in the use of measurement in exhibits at two consecutive regional science fairs. (We appreciate that the samples were small and drawn from a limited locality, but some of the observations seem to be of interest nevertheless.) Three judges collected data independently using the same method. In the junior high school exhibits (grades 6–9), an 86.8 percent level of agreement was obtained among the judges; agreement in the senior division was 81 percent. The judges evaluated exhibits according to the criteria specified in Tables 1 and 2. Junior and senior high school exhibits were evaluated separately.

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Table 1. Measurement in science fair projects—Junior Division		
Description of measurements used	1978	1979
	percent	percent
1. Project not quantifiable	32	15
2. Project not quantified	8	42
3. Customary units only	37	33
4. Metric units only		
A. SI conventions primarily	15	0
B. Not SI conventions	1	4
5. Metric and customary mixed	4	2
6. Metric plus customary equivalents	3	4

Note: The number of projects in 1978 was 75; in 1979, 52.

Table 2. Measurement in science fair projects—Senior Division		
Description of measurements used	1978	1979
	percent	percent
1. Project not quantifiable	18	15
2. Project not quantified	11	24
3. Customary units only	32	24
4. Metric units only		
A. SI conventions primarily	37	19
B. Not SI conventions	2	6
5. Metric and customary mixed	0	6
6. Metric plus customary equivalents	0	6

Note: The number of projects in 1978 was 44; in 1979, 34.

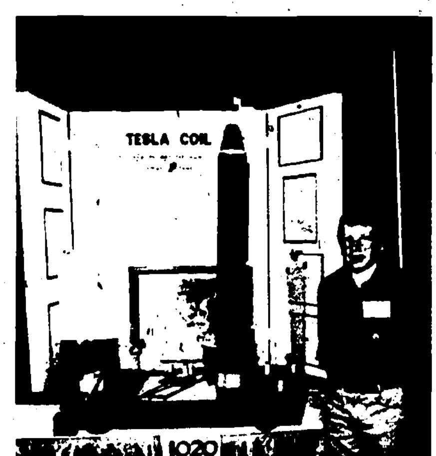
The first two categories in the tables ("project not quantifiable" and "project not quantified") identify the percentage of exhibits that were qualitative in nature and the percentage of exhibits where quantification *should* have been used, but was not. Ideally, of course, no projects should have been classified in category 2 ("project not quantified").

Projects were classified in the category where they seemed to fit best; no project was classified in more than one category. The remaining categories are self-explanatory. Some customary and non-SI practices observed appear in Table 3. Excluded are the most common customary measurements, such as inches, feet, and ounces, or the quasi-quantitative terms, such as a pinch or a small amount.

As Table 1 shows, the number of non-quantifiable projects in the junior high schools we studied decreased by 17 percent from 1978 to 1979. However, there was a concomitant 34 percent increase in the number of projects that *could* have applied measurement practices, but did not. Although fewer projects used only customary units in 1979, none used primarily SI conventions. The trend in junior high schools was toward some improvement in topic selection; a sharp decline in the use of SI conventions; and a dramatic increase in ignoring quantification of *any* sort in both project methodology and data enumeration.

During the same 2-year period, we saw a 13 percent increase in the number of projects in the senior high schools where quantification was not used, even though appropriate. Similarly, the exclusive use of SI conventions declined. In general, senior high schools exhibited the same trends that the junior high schools did. The only positive tendency at the senior high level was an increase in the number of investigative-type projects that require process skills, including measuring.

Smith [2] reports a dominance of non-investigative projects in science fairs. He asserts that such projects run counter to science teaching's primary goals, which focus on critical thinking, inquiry, and investigative skills. For this scarcity of projects reflecting the dynamic nature of science, Smith blames the judges' fallibility. Judges, he says, are often impressed by encyclopedic knowledge in a subject, or by a neat and well-organized presentation of a tried-and-true scientific principle. He further suggests that the preponderance of non-investigative projects in science fairs is, in part, a direct result of judging biases.



New trends

Two of the authors of this article have served as judges in local and regional science fairs where they have found that the importance of investigative project design has been emphasized. Furthermore, it has been their experience that 30 percent of the emphasis in judging criteria is on scientific thought. Local officials have repeatedly encouraged judges to be aware of sound experimental design rather than of a flamboyancy of presentation.

Apparently, this emphasis has positively affected project design. As demonstrated in Tables 1 and 2, projects in the regional fairs studied have become more investigative in nature. Students are using experimental-type designs more frequently; generating hypotheses; recording observations; and drawing inferences. Student use of quantification, however, is often conspicuous by its absence. "Plants grow taller when fertilized with 'XXX' rather than with 'YYY'" is an acceptable generalization, but it should be based on an enumeration and analysis of quantitative data expressing the concentrations of 'XXX' and 'YYY'; the amount and frequency of 'XXX' and 'YYY' applications to each plant; and the plant's growth per unit of time.

Table 3. Some customary and non-SI practices

Observed practice	SI convention
Centigrade	Celsius
BTU	Joule
Weight (ref. amount substance)	Mass
62½c	62.5° C
50° F	10° C
1½ cm	1.5 cm
cc or cu. cm.	cm^3
721,632.06	721 632.06
21 ml.	21 mL

What we found most revealing in this study is not the anticipated lack of metric usage but the total failure of many students to quantify data collection at all.

The trend toward metrication in the United States, sparked by the Metric Conversion Act of 1975, has not become reality and is not likely to do so soon. [4] Unfortunately, the lack of popular support for metric conversion in consumer matters has not helped promote standard SI usage in science teaching. Clearly, the science teachers or the students whose projects we assessed—and who are, therefore, indirectly involved in this study—either do not support the exclusive use of SI standards in science fair projects or are unaware of these standards. Furthermore, students do not appear to have a clear understanding of the role of quantification in investigative science activities.

Photos courtesy ISEF

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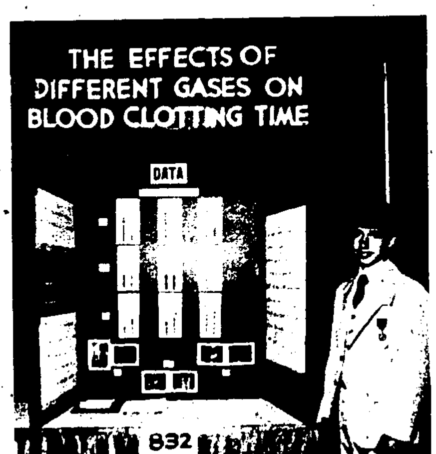

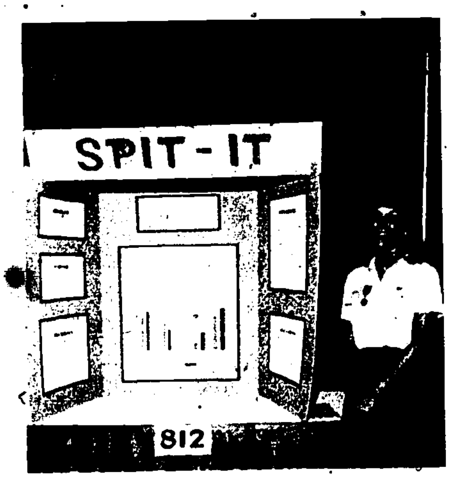

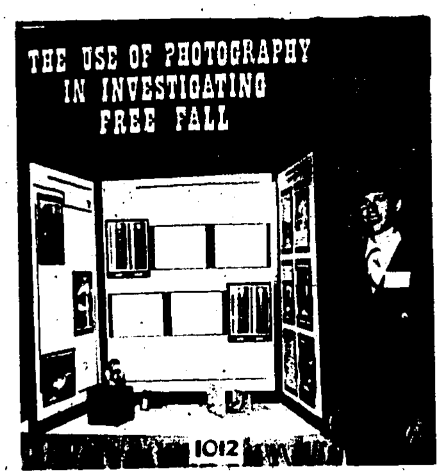

INJECTING OBJECTIVITY INTO SCIENCE FAIR JUDGING

Use of a standard evaluation form reflecting specific criteria may help to clarify science fair goals for both students and judges.

Harvey Goodman

Many science fair evaluators have suffered at one time or another from the nagging feeling that judging is, at best, subjective and, at worst, borders on the arbitrary—a sad commentary in light of the tremendous amount of effort that students put into their projects.

A major part of the problem undoubtedly lies in the fact that we have not well defined the goals of science fairs, nor evaluated how these coincide with the broader goals of science teaching. In a recent article in *TST*, for example, author Norman F. Smith pointed out how few projects are investigative, involving students in critical thinking and science processes.[1] Most awards, he observes, still go to traditional "library research and poster" projects.

Another factor that may account for the subjectivity of the judging process is the lack of availability of objective criteria—criteria so designed that a judge evaluating a project in a specialty other than his own could arrive at a conclusion that is at least comparable with that of other members of the judging team.

Traditionally, judges are asked to evaluate students' projects according to a scheme that looks something like the following:

Creativity (30 points)
Logical Thought (25 points)
Thoroughness (10 points)
Skill (15 points)
Clarity of Presentation (15 points)

What is the likelihood that two judges using this scheme could arrive even approximately at the same point value for a project? How helpful are these criteria to a student planning a project? How is creativity to be evaluated?

Usually, when one evaluates a project, one has (or should have) some criteria of a different sort in mind. What one really is looking to see is, for example: whether the project really reflects the problem statement; whether the hypothesis arose from adequate background reading; whether the procedures used were appropriate for the problem; whether the observations were accurately recorded and appropriately displayed; whether the apparatus was appropriate for the experiment; and whether further research problems were suggested by the project.

How can one get judges to focus on these criteria (or whatever standards are decided on)? I would suggest that we begin by drawing up standard evaluation forms which reflect the values of each fair and which direct the evaluator's attention to specific elements of the project. The format might look something like the following:

Science Fair Project Evaluation Form

0 = Cannot make a judgment
1 = Poor
2 = Fair
3 = Satisfactory
4 = Good
5 = Excellent

Rank each of the following based on the rating system given above:

The problem was clearly stated. *(Problem formulation.)*
Appreciable time was evidently spent searching for and reading scientific articles. *(Background reading.)*
Background reading was appropriate both in quality and scope. *(Background reading.)*
The hypothesis was stated clearly and reflected the background readings. *(Hypothesis formation.)*
The experimental design demonstrated understanding of the scientific method. *(Methodology.)*
Apparatus and equipment were appropriately designed and/or used. *(Materials.)*
Observations were clearly summarized. *(Observations.)*
Interpretation of data conformed with observations. *(Observation.)*
Tables, graphs, and illustrations were used effectively in interpreting data. *(Observation.)*
Conclusions and summary remarks were justified on the basis of experimental data. *(Conclusion.)*
The experiment was repeated several times to establish validity of results. *(Validity.)*
A log book was used to record experimental data, ideas, interpretations, and conclusions. *(Record keeping.)*
The bibliography contained a significant number of relevant and timely references. *(Background reading.)*
Limits of accuracy of measurements were stated. *(Measurement.)*
Work on the project suggested new problems for future research. *(Future research.)*
Oral presentation was made in the time allotted, with all phases of the project discussed. *(Interview.)*
The researcher answered questions effectively and accurately. *(Interview.)*
The oral presentation made good use of visual aids. *(Interview.)*
The student initiated his or her own research project. *(Initiative.)*
The display board was effective in presenting the project. *(Display board.)*

The maximum number of points that a candidate may obtain is 100 percent; awards may be granted in accordance with the following scores:

60 - 69—Honorable Mention
70 - 79—Third Prize
80 - 89—Second Prize
90 - 100—First Prize

In the event that a judging team consists of two or more members, the final score is the team average.

...

If the goals of each science fair were adequately described to judges, if judges were given evaluation forms reflecting specific criteria by which projects could be evaluated in a more objective way, we would all benefit—students, teachers, and judges. ■

[1] "Why Science Fairs Don't Exhibit the Goals of Science Teaching," by Norman F. Smith, *The Science Teacher* 47:22; January 1980.

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Lawrence J. Bellipanni
Donald R. Cotten
Jan Marion Kirkwood

You have just hung up the telephone after a brief conversation with the science teacher at a local junior high school, and somewhere along the line you've "volunteered" to be a judge for the school's science fair. Suddenly you are responsible for evaluating projects that students may have spent months working on and for deciding which projects are best. Making these decisions is no easy task, but if you keep a few points in mind, you can turn your judging duties into a rewarding experience for both you and the students.

Regardless of the grade level you're working with, you should note the quality of the work the students have done and determine how well they understand their projects. The project should include research, experimentation, and application—not simply library work. But as you apply these standards, always consider the grade level of the student whose project you're judging and the general level of expectation for that particular fair.

Here are some specific criteria to use:

1. *Creative ability*. Has the student shown intelligence and imagination both in asking the question and arriving at the answer? Is the student original in deriving and applying data? Did he or she build or invent any equipment to use in the project?

Remember, anyone can spend some money, but it takes a creative person to devise the equipment needed for a particular project. Ask students where they got their ideas. Creative students are always coming up with new twists to old ideas; such ingenuity indicates that you're dealing with an interested young scientist. Collections may show diligence, but they seldom show creativity. So don't be tempted into giving them high marks unless they have some true scientific merit.

2. *Scientific thought*. Is the problem stated clearly and unambiguously? Did the student think through the problem and pursue his or her original question

Suddenly you are responsible for evaluating projects that students have spent months working on and for deciding which ones are best.

without wandering? Was the experimental procedure well defined and did the student follow each step toward the expected outcome?

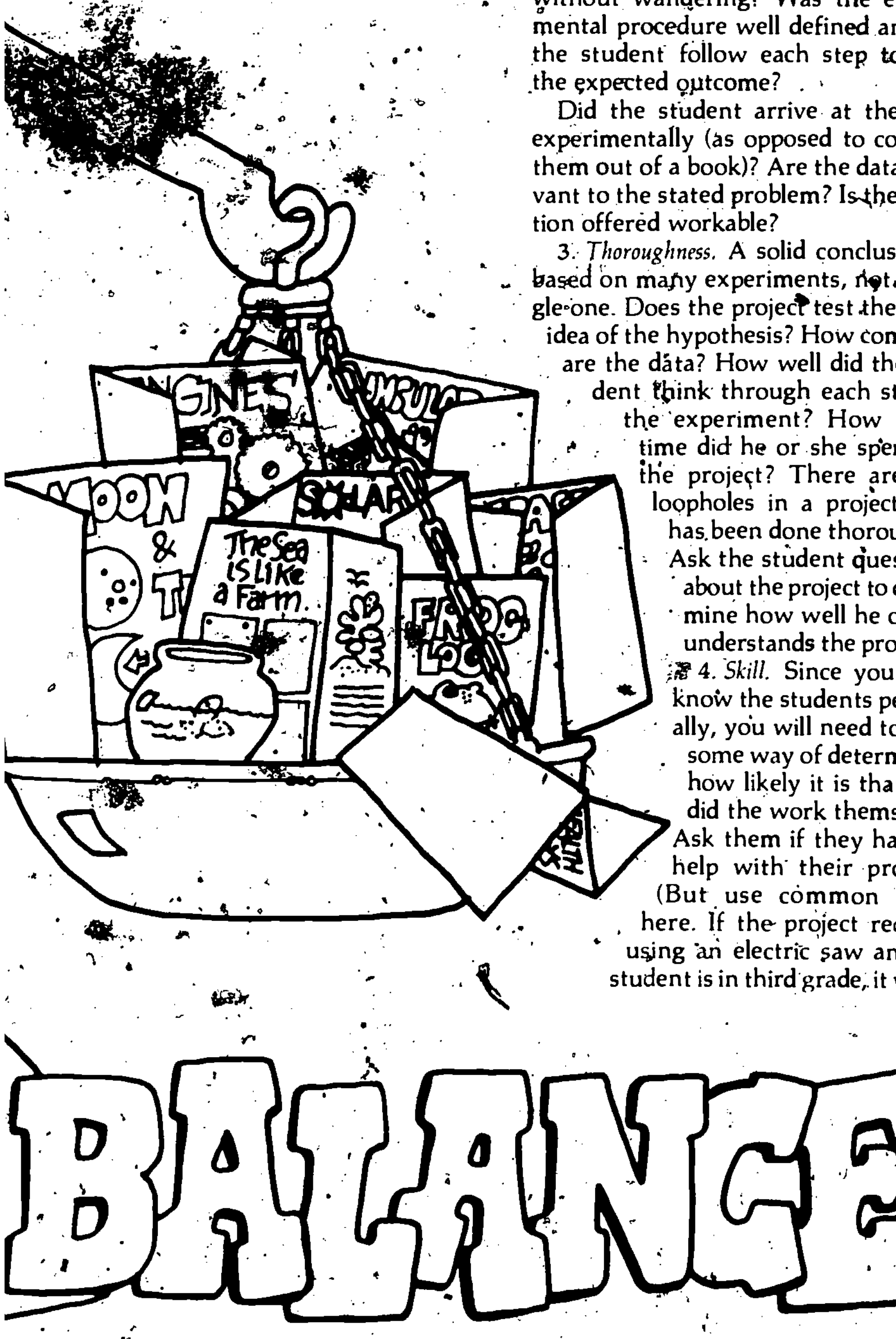
Did the student arrive at the data experimentally (as opposed to copying them out of a book)? Are the data relevant to the stated problem? Is the solution offered workable?

3. *Thoroughness.* A solid conclusion is based on many experiments, not a single one. Does the project test the main idea of the hypothesis? How complete are the data? How well did the student think through each step of the experiment? How much time did he or she spend on the project? There are few loopholes in a project that has been done thoroughly. Ask the student questions about the project to determine how well he or she understands the problem.

4. *Skill.* Since you don't know the students personally, you will need to have some way of determining how likely it is that they did the work themselves. Ask them if they had any help with their projects. (But use common sense here. If the project requires using an electric saw and the student is in third grade, it would be permissible—indeed advisable—for an adult to perform this task.) You can usually tell how much of the actual work students have done by observing them while they demonstrate or explain the project.

5. *Clarity.* The project should be set up so that the judge can follow the procedure and understand the data without getting confused. Students should have written the data clearly, using their own words, and they should be able to discuss any portion of the project. The main purpose of the project is to show that students can formulate, test, and present research.

Though these five criteria are basic, the standards for judging particular science fairs may vary, depending on the grade level of the participants or the types of projects involved. The teacher supervising the science fair should make certain that each judge has a judging sheet, indicating not only the criteria to be used but the points that each item is worth. If you do not understand one of the criteria, ask the teacher or coordinating judge for clarification before judging begins. Your responsibility to the children is to be as fair and objective as possible, and that can happen only if all the judges use the same criteria in the same way. And remember: each child's project is very important to that student. So whether the project merits a blue ribbon or not, be sure to provide proper encouragement so that students will continue to investigate their own ideas.



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Why is it that models, posters, show-and-tell, and laboratory demonstrations are so predominant at science fairs, while projects dealing with discovery and investigation are decidedly scarce?

Norman F. Smith

Why Science Fairs Don't Exhibit The Goals Of Science Teaching

One need attend only a few elementary- and intermediate-level science fairs to discover that they are all more or less alike. A second discovery will follow close behind: most of the projects in these fairs have little relevance to the goals of science teaching. From my long experience as a scientist, plus many assignments as a science-fair advisor and judge, I suggest that the cause of this situation lies where no one may have thought to look—in the way science fairs are operated and judged.

An analysis of the kinds of science-fair projects we see time after time at the elementary and intermediate levels clearly shows a disparity between the goals of science fairs and those of science teaching. Nearly all fair projects can be placed in one of the following five categories:

1. Model building (for example, the solar system, volcanoes, clay models of frog organs);
2. Hobby or pet show-and-tell (for example, arrowheads, slot cars, dogs, baby chicks);
3. Laboratory demonstrations right out of the textbook or laboratory manual (for example, distillation, electrolysis, seed germination);

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"... the first-in-class was awarded, for at least the thousandth time in the history of science fairs, to the students who crushed the cans with air pressure."

4. Report-and-poster projects from literature research (for example, fossils, birds, bees, the astronauts, the ear);

5. Investigative projects that involve the student in critical thinking and science processes, such as measuring, reducing data, and drawing conclusions (for example, tests of reaction time, effectiveness of various detergents, comparison of the performance of vacuum bottles with insulated jugs).

If the goal of science teaching is to improve skills in model building, library research, poster making, or following laboratory-manual directions, then projects from the first four categories are appropriate. Such projects may indeed stimulate students' interest in science and increase their knowledge of science, in addition to contributing to social and communication skills. But if one of the primary goals in science teaching is to teach critical thinking, inquiry, and investigative skills, then projects in the first four categories simply do not match this goal, or are, at best, ineffective approaches to it. The essence of science is found only in category 5, in which the student must conceive and plan a project, perform an investigation, and analyze data to arrive at some conclusions or some new understanding.

Problems worth investigating

This being the case, why is it that projects in the first four categories (models, posters, show-and-tell, and laboratory demonstrations) are predominant at science fairs, while projects dealing with discovery and investigation are decidedly scarce? This is a question long overdue for investigation; it applies as well to extra-credit projects and normal laboratory activities.

Discussing this question with science teachers yields a number of viewpoints. Some teachers blame the poor science backgrounds of those in their own profession, especially among elementary teachers. Because elementary teachers may be neither highly skilled in science, nor entirely certain about the goals of science teaching, they tend to be more comfortable with activity closely allied with bookwork. Students, too, are more comfortable with projects that can be lifted from books than with less familiar and more original projects that probe the unknown.

Other teachers point out that the kinds of projects currently popular represent a "point of entry" into science for the younger student. This viewpoint has validity, and some use of these kinds of projects is undoubtedly justified.

As it turns out, however, most students remain stuck with these projects year after year, repeating selections from the first four categories until they move into high school. Then the rules suddenly change, and only original experimental or technical projects generally are accepted, at least at major competitions. What are missing or at least underemphasized in the present system are *transition* projects, in which the student moves from the easy poster project to a deeper look at the science aspects of his topic, and finally to sampling the process of investigation. (Indeed, some of the exotic projects in high-school science fairs are more oriented to technology than to science; consequently, one wonders whether these students have *ever* had the experience of designing a simple experimental project.)

Many teachers are aware that the question of what kinds of projects might or should be done in science fairs is almost never discussed. In particular, there is little or no discussion or agreement beforehand among teachers, students, and science-fair judges as to the *purposes* of the endeavor and the *criteria* by which entries will be judged. As a result, teachers find themselves coaching students in the execution of projects that will be judged by persons unknown to them, and according to criteria that are not carefully considered by those making the rules.[1]

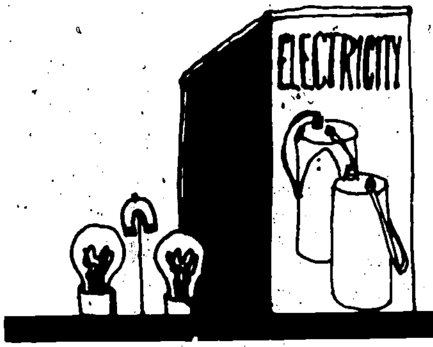
In my view, the most startling reason for the present emphasis on non-investigative projects is the orientation of the judges themselves, which causes them to reinforce projects in the first four categories and to discourage investigative projects. While this orientation may seem contrary to the interests and instincts of scientists, it is really quite understandable, given the usual conditions of scientists' involvement in science fairs.

View from the scientist

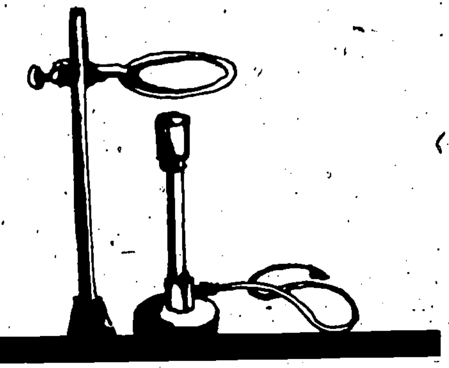
The lot of the scientist asked to judge a science fair is not a happy one. Armed with a specialty in some branch of science, but often with little or no knowledge of science *education*, he surveys, clipboard in hand, a scene that is quite foreign to his professional world—a vast arena of eager students of widely varying competencies, who are presiding over projects that vary even more widely in quality and science content. The casual observer may marvel at the diversity of projects he sees, but the judge has the grim job of sorting out these projects and finding some basis for declaring a few of them the "winners."

How "winners" are often chosen is best illustrated by true examples from a junior-high science fair. On one table the judge finds a project labeled "Air Pressure," with a Bunsen burner and three or four gallon cans that have been crushed by air pressure. There are also

[1] Judging criteria usually consist of items like: originality, thoroughness, accuracy, clarity, organization, neatness, creativity and skill, dramatic effect, technical skill and workmanship, social implications; communicative skills, science content, and scientific approach. Such criteria are usually vaguely defined for the judges, if at all, and are weighted very differently from one science fair to another. It is amazing that items such as "science content" and "scientific approach" are sometimes omitted or are weighted as little as 10 percent.



". . . in the dazzle of textbook competence from the next booth, the spark of inquiry glowing among the eggshells was unnoticed by the scientist . . ."



two other gadgets right out of the lab manual neatly hung on ringstands so that people can blow into them to demonstrate "air pressure" for themselves. The posters are adequate; the students are responsive to the questions of the judge and impress him with their understanding of the topic.

A few tables away is a project in which two students have compared the ability of a thermos bottle, a plastic jug, and two or three other kinds of containers to keep liquids hot. They have described on posters their purpose and test procedures. Their equipment is on display, and other posters show tables of data and graphs of the variations of temperature with time that the students stayed up half the night to measure. The graphs are neatly made and the data, though a bit rough, look good. Under questioning, the students show that they have drawn some conclusions, but their understanding of the science principles behind what they have done seems somewhat shaky to the judge. He finds that they don't know a great deal about heat, how heat is transmitted, or about insulation.

As the reader by now has guessed, the first-in-class was awarded, for at least the thousandth time in the history of science fairs, to the students who crushed the cans with air pressure. Second and third awards went to excellent library-research-and-poster projects on fish and birds, respectively. The investigation of thermos bottles and insulated jugs did not place or receive any recognition.

The process by which the judge had arrived at his decision later became clear from discussions with him. With only general criteria to guide him and a sketchy, at best, understanding of children and science teaching, he had relied on his best instincts as a scientist. The questionable understanding of science principles shown by the thermos investigators troubled him—perhaps "repelled" would be a better word—and kept him from seriously considering their project, whereas he was drawn toward the apparent competence shown in the demonstration-and-poster project. A "good" understanding of some concepts of air pressure and a "good" laboratory *demonstration* were more worthy, according to his standards, than a "fair" ability to conduct an *investigation* backed by only a "fair" understanding of the concepts involved.

But what could be wrong with that? We all know that competence is vital in science, don't we? And don't we also try to teach proper understanding of science concepts and principles?

"Investigation" rebuffed

The consequences of such decisions by science-fair judges, however, are obvious. The students who made earnest—and perhaps fruitful—attempts to explore the unknown with an investigative project have been rebuffed. If they try at all next year, they will probably seek a project along the safer lines of library research or laboratory demonstration in which they may, through book learning and practice, acquire the aura of competence for which the "system" has shown clear preference.

Lest anyone think this an isolated event, I cite two other projects from the same fair. One is a demonstration of refraction, well-executed by a pair of confident students. They know the principle of refraction and demonstrate it in half a dozen ways using a slide projector and an aquarium, along with several drawings. Their competence in this topic is impressive.

On the next table is a project on chickens and eggs, an interest the student brought from home. With some guidance from the teacher, the student undertook to measure the thickness of eggshells from different kinds of chickens. At first, she couldn't locate a micrometer, but did have a feeler gauge. She used an old automobile spark plug, gapping it by trial and error to fit each shell, then measuring the gap with the feeler gauge. Later she was able to locate a micrometer and used it to check and refine her earlier measurements. Her display was unimpressive, her manner shy; but from her data one could learn about the range of thickness of eggshells, and—a most interesting item—the dimensional tolerance within which the chicken manufactures the shell. (Anybody out there know that?) She also showed a comparison between the thickness of a standard shell and a "soft-shell"—a defective egg occasionally laid by some chickens. She understood well the dietary deficiency that causes soft-shelled eggs and what to do about it.

But in the dazzle of textbook competence from the next booth, the spark of inquiry glowing among the eggshells was unnoticed by the scientist—indeed, may have been snuffed out by his lack of interest and his final decision. First place went to the demonstration of refraction, second place to the familiar "How Seeds Grow," and third place to the ever-popular "How The Ear Functions." Should the student who struggled with eggshells be brave enough to do another project on chickens—or any other topic—next year, she will put curiosity aside and generate instead the most elaborate library-research, poster, show-and-tell project she can muster. Who could blame her?

The dominance of non-investigative projects in today's science fairs suggests that fairs have drifted far from the avowed goals of science teaching. A fresh examination is needed to bring the goals of science fairs and science teaching back together.

Here's one modest proposal: if fair sponsors were to set up a separate judging category for investigative projects, they would immediately motivate students and teachers to move in this direction by guaranteeing recognition of such projects. Over a period of a few years the present monotonous fairs might begin to evolve into new "discovery fairs" in which students, teachers, and the public would discover the adventure of investigation and experience the true meaning of science. ■

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