WEEKS 16-20: WRITE FINAL DRAFT

The student revises the rough draft for punctuation, word usage, and format errors. The rough draft and the final draft are submitted to the science teacher for evaluation.

WEEK 21: PROJECT DISPLAY AND PRESENTATION

Before the actual science fair, students present their projects during science class. A complete explanation of purpose, methods of investigation, and conclusions is required. Frequently a question and answer period follows the students' oral presentations.

Students are evaluated on creativity, scientific value, depth of knowledge, technical expertise, and communication skills. The evaluation of the projects is done by classmates as well as the teacher.

The students use their evaluations to pick the top three or four projects to represent the class at the school fair. A similar process of presentation is followed at the school-wide science fair. Each student is given an appointment to present his or her project to a team of judges. The evaluation process that was used in the classroom is used once again. Projects are displayed and viewed during an awards ceremony.

Advantages to the science fair plan explained here are that students of vastly different abilities can experience success. Artistic qualities, computer capabilities, imagination, mechanical aptitude, and writing skills are enhanced through the project-research and written reports.

Lorraine F. Gowen is a science teacher at Lacey Township High School, Lanoka Harbor, NJ 08734. Edmund A. Marek is director of the Science Education Center at The University of Oklahoma, Norman, OK 73019–0260.

A Fair Proposition?

by Arnold Grobman

Science is a cooperative enterprise in which scientists routinely refer to the works of their predecessors and colleagues. In the process, the works are extended, corrected, and modified as scientists strive to increase our understanding of the natural world in which we live. Science is a tremendous body of knowledge accumulated through the diligent efforts of investigators worldwide who are building on the data, theories, and conclusions of other scientists. In its broadest sense, science is a vast, continuing collaboration that has its roots in pre-Aristotelian days.

Furthermore, it is also a contemporary collaborative enterprise. For example, of 71 articles reporting on research developments in five recent issues of *Science,* 93 percent were jointly authored. And of the articles written by single authors, each acknowledged the help of three or four other scientists.

Cooperation in science is so pervasive and so widespread that it is not newsworthy and is rarely mentioned. Competition for prizes, on the other hand, is so rare that it becomes newsworthy. The popular media announce the awarding of Nobel prizes and professional and technical journals report on the election of new members to the National Academy of Science. The media rarely comment on the vast cooperative endeavors, however, that have produced our current body of scientific knowledge.

In the way we currently conduct science fairs we give our students exactly the reverse impression of science. Students generally work independently on their projects and prizes are awarded in wholesale numbers. In St. Louis, for example, it took two full pages of small print in the local newspaper to list all of the science fair prize winners. For example, blue, red, and green ribbons were awarded to 104 first grade students and 172 sixth grade students.

The wholesale awarding of prizes requires the participation of a large number of judges from outside of the school system. A project with graphs and complicated formulas, expertly and attractively mounted, was, with clear delight, being displayed by a young high school student at a state science fair where I was a judge.

I asked her to tell me a little about it; to explain the relationship between the graphs and the formulas and to describe how she had become interested in the project. She began rather hesitantly and then said, quite directly, that she did not know much about the project. She explained that her father, who was an engineer, had made the exhibit for her and that it had won a first place at the district fair. Why had the judges at that district fair not recognized the deception?

At another state science fair, a young man exhibited an aquarium in which a dozen small fish were swimming. He explained, with enthusiasm, that the aquarium originally had held 20 guppies. At his request the family physician had taken the aquarium to the local hospital where it had been exposed to X-rays. Since then, eight of the fish had died.

Obviously, he continued in his explanation, the radiation had caused the death of the fish. I asked him if, perhaps, some of the fish might have died without exposure to radiation. Well, possibly, he thought, but certainly not eight out of twenty. Would it be helpful, in estimating the effects of the radiation, I asked, if he had had two aquaria, each with 20 fish, and had exposed one to radiation and not the other, and then compared the number of fish remaining in each aquarium? He stared at me for a long moment, his eyes opened widely, and then he exclaimed, "Wow! What a great idea."

Here was a bright young man who had had at least one science course in high school; had won prizes at local and dis-

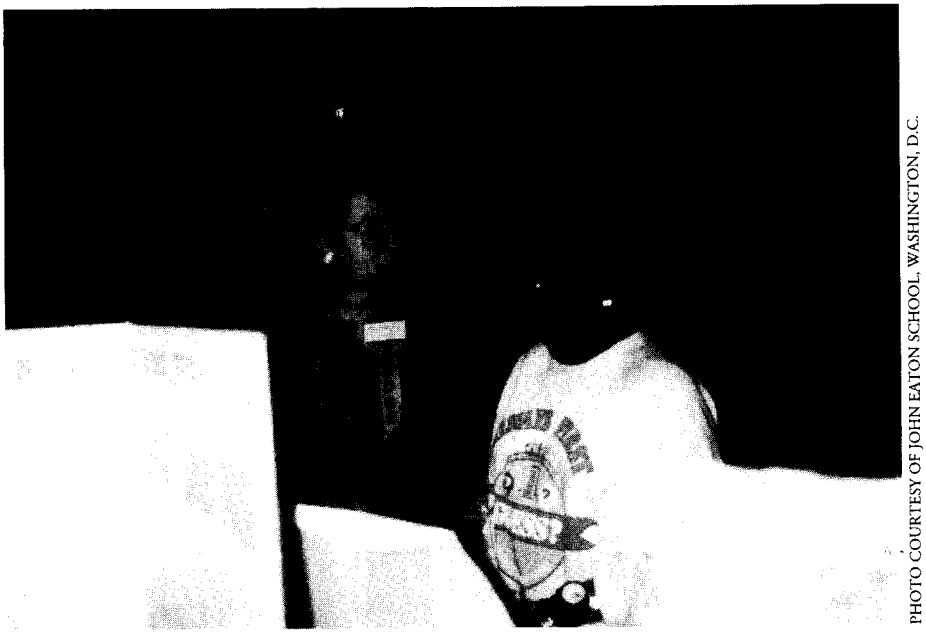

PHOTO COURTESY OF JOHN EATON SCHOOL, WASHINGTON, D.C.

trict science fairs; was a strong competitor for state-wide honors in science; and who, until that moment, was not acquainted with the concept of a controlled experiment. Why did he have to wait to learn, at a state science fair, a basic procedure in experimental science that should have been taught in his science classroom? And why had the judges at the school, local, and district levels failed to ask him about controls for his experiment? Did the judges understand no more about a controlled experiment than had the student?

During some phase the evaluation of projects at many fairs, the judges inspect the exhibits in the absence of the student participants. On such an occasion, at yet another state science fair, the five finalist judges were conferring about the awarding of the top prizes. Besides me, the judges were three high school teachers and a professor of physiology at the U.S. Air Force Academy. Under discussion was a student's exhibit with the explanation that she had discovered a new species of bacterium and would be writing to Washington to have a scientific name assigned to it.

Since my own professional specialty is biological systematics, I felt a special responsibility to mention to the other judges that the student was giving no indication of understanding the procedures used in describing new species. I explained that an investigator must publish an article, with a proposed name, in an appropriate journal that is available to other specialists and they may, over time, accept or reject the conclusions and the proposed name.

"No!" said the Air Force Academy professor. "What the student said is correct. She should write to the Smithsonian Institution and they will tell her if she has a new species and they will assign a name to it." Whether awed by the sky-blue uniform with its brace of medals or the stentorian voice of authority, the three teachers agreed with the Air Force professor. As a result, a student was awarded a top prize at a state science fair by four judges whose knowledge of standard procedures in the area of her project was as minimal, and as faulty, as the student's.

The science fair movement is about 50 years old and has been regarded by some as a valuable contributor to science education. One of the original goals was to try to insure that the academic achievements of school children in science would receive as much public recognition as their athletic accomplishments.

Over the years, major newspapers and corporations have joined to support the effort and science fairs have become widespread nationally and internationally. They are now a standard feature of most school systems. Unfortunately, not all of the generous awards to students, and the accompanying transient notoriety, necessarily reflect educational accomplishments. Also, in a very important respect, by emphasizing prizes and not cooperation, science fairs are misrepresenting the nature of science.

Part of the responsibility of a critic is to propose a solution to a problem that has been identified and I attempt to do so below.

- I believe science fairs should be continued. Students should be encouraged to work in pairs or in teams whenever feasible.
- Completed projects should be displayed solely in the classroom. District, regional, state, and national fairs should be phased out. Student projects should be evaluated by classroom teachers and science supervisors without the participation of judges from outside of the school system.
- Parents and friends of students at each grade level should be invited to view the exhibits in the classroom. Students at one grade level should be invited to study the projects of students in the next higher and lower grade levels. Students at a particular grade level should be invited to see the exhibits of students at the same grade level in a nearby school, if possible.
- Since there would be no prizes and no publicity about "winners," newspaper sponsorship would be unnecessary.

Science fair programs based on this series of proposals would more accurately reflect the way science is conducted. Such programs would emphasize cooperation and greatly reduce, if not eliminate, prize winning. They would place the evaluation of students' efforts in the hands of their teachers and other school supervisors and eliminate the sometimes confused judgments of persons not familiar with the instructional background of the students.

Science education is too important for the obfuscation that accompanies today's science fair programs. Good intentions do not necessarily make good education.

Arnold Grobman was formerly Chancellor of the University of Missouri–St. Louis. He now resides in The Valley, Virgin Gorda, British Virgin Islands.