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Since receiving a federal grant in November 1985, 25 Keystone area educators have been working with AEA 1 consultants and University of Iowa science education specialists to expand the use of investigative activities in the science studies of Iowa students. The published results of their work, 27 units adaptable to upper elementary and junior high classes, are now available to other interested teachers.

The following article by the project leaders (1) explains the workshop plan and purposes employed by the project participants, (2) describes the focus and creation of their final products, a repertoire of new science units, and (3) lists the units now available and information on obtaining them.

The Keystone project became possible when in August 1985, Education for Economic Security Act of 1984 monies became available in Iowa (through the Board of Regents) for universities and colleges to develop in-service programs for teachers of math and science (Title II, 1985). One component of the Act suggested cooperative projects with Area Education Agencies. Representatives from The University of Iowa Science Education Center, Edward Pizzini and Sandra Abell, met with Keystone AEA Science and Talented and Gifted consultants, Joe Moore and Ann Boultinghouse, to assess needs and develop an action plan for a cooperative project emphasizing scientific investigation and TAG.

In November 1985, a grant was awarded to work with 25 Keystone AEA teachers. The project, "Implementing Appropriate Strategies in Science for the Talented and Gifted in Grades 5-9," aimed to expand the use of investigative activities in the science curriculum. Many of the problem solving strategies employed with TAG students were found to be appropriate for all students.

The final group of participants was composed of a TAG coordinator, an elementary principal, junior high science teachers and elementary teachers from self-contained classrooms. They averaged 15 years of teaching experience and had a wide range of formal science training. Their enthusiasm for teaching and

learning became apparent as the project developed.

The project officially began with an Awareness Conference in northeast Iowa on a Saturday in February 1986. The conference laid the foundation for the project by focusing on two major topics: "What is Science?" and "Who are the Talented and Gifted?" Through activity, readings and discussion, participants explored new ideas and generated questions that would guide further sessions. The day concluded with an "Invitation to Investigation" in which participants were asked to define criteria, design experiments, collect and analyze data and formulate conclusions based on the problem "Which paper towel is the best buy?" (USMES, 1974) Cooperative learning was employed as small groups went about solving the problem. Although strategies varied among the groups, results were generally quite similar (Tab. 1). This activity set the stage for the entire

Table 1
WHICH PAPER TOWEL IS THE BEST BUY?

VARIABLE	AVERAGE RANK*					TOTAL AVERAGE
Brand	Cost	Absorbancy	Attractiveness	Durability	Texture	RANK
Bolt	10	2	1	1	3	2
Bounty	7	3	9	5	3	4
Brawny	6	5	8	9	5	8
Gala	5	6	7	10	6	9
Generic	1	10	10	7	10	10
Hi-Dri	2	8	5	8	8	7
Job Squad	9	1	3	2	1	1
Mardi-Gras	4	7	6	6	7	6
Scot	3	9	4	3	9	5
Viva	8	4	2	4	2	3

*1 - highest, 10 - lowest

project which emphasized exploration, explanation and examination as key ingredients for any scientific investigation. As a result of this initial meeting, the participants were thereafter actively involved in "doing science."

The project then moved into its second phase, the Special Topics Seminars. On alternating Thursday evenings (and Saturdays in March and April), participants met to learn specific strategies for encouraging investigation in middle school science. Topics included problem finding, research types, creativity in science, as well as the identification of TAG students and their special needs. Each seminar was designed to be a 4-step process:

1. Experiencing a new topic through hands-on activity.
2. Explanation of the new activity by an instructional team.
3. Exploration of educational implications through discussion.
4. Discussion of strategies to be applied in the classroom.

The goal of this procedure was to make problem solving knowledge meaningful and personal for participants.

The often-ignored, yet most critical stage of problem solving is problem identification. The project attempted to ameliorate this weakness by concentrat-

ing first on problem finding. Using newspapers, magazines and everyday objects, participants searched for ideas that lent themselves to scientific investigation such as sports statistics, pollution problems, consumer information, polls and recent inventions. In a later session, brainstorming and webbing (techniques of problem solving) were utilized to expand upon such problem ideas. Finally, participants wrote problem statements that included operational definitions, and delineated dependent and independent variables. During each session participants were actively involved in the process, and after each session they employed the strategies in their own classrooms. Feedback from the participants confirmed the excitement that they and their students found implementing these and similar strategies in the classroom.

Another important focus of the workshops was discussion of types of research and how they can be utilized in middle school science classes. Through active involvement in investigation, participants learned about descriptive, correlational and experimental research. Using member characteristics (such as years of teaching experience, male/female ratios and health facts), the group was described in a number of ways. Two-thirds of the group was identified as male, 95 percent were nonsmokers and over one-half were involved in a regular exercise program. Exploring physical characteristics such as height, arm span, lung volume and foot length revealed correlations that were positive (height and arm span), negative (age and lung capacity) and zero (foot length and age). By utilizing experimental and control groups, reaction time and pulse rate were examined. One group showed that fatigue can cause a decrease in reaction speed. All of these activities required participants to design experiments, collect and analyze data and draw conclusions. Subsequently, these same processes were employed with students in science classrooms. The techniques used, including scatter diagrams and graphing, enabled students to understand the relationship between and among variables.

A final teaching technique examined was a systematic problem solving process called Creative Problem Solving (Osborn, 1963). Synthesizing previous workshop experiences, participants brainstormed problems associated with a situation, found facts, thought of solutions, evaluated alternatives and gained acceptance for their solutions. Later they utilized the process with their students to examine topics such as energy use, school lunches and newspaper buying.

Throughout the Special Topics Seminars, feedback from participants indicated the value of the applications component: using the strategies with their students increased understanding of the problem solving process and improved their skills as facilitators. The workshop succeeded in changing science teaching behaviors among participants as evidenced by their written comments:

> "Since the very first class meeting, our science room has changed. We have investigated popcorn varieties for the best buy, monitored noise levels on rainy days as opposed to sunny days . . . We have even identified the 'average' male and female students in our school."
>
> "If I have learned anything from this class, it is that science is an action verb. It involves the real world — not a book. These active definitions have changed the scope of my teaching. I have learned that sciencing does

not just take place in science class but in all subject areas."

"As a principal and curriculum coordinator, I feel we have a real need for change in our science curriculum. This workshop and the importance placed on research, brainstorming, problem solving and other processes has certainly opened my eyes to suggestions for curriculum change."

"I felt the things that helped me the most were the hands-on activities in class [project workshop] and in my classroom."

Their comments also indicated a change in student attitudes toward science:

"I have noticed that my students are enthused any time we use an inquiry approach to solving a problem. I think they feel more ownership of what they are learning; it makes it seem more personal."

"I've been pleased with the quality of responses made by my lower achievers. They, many times, are the most enthused."

"Students have enjoyed the sciencing they have done in connection with my workshop assignments."

"It has been fun, exhausting, educational, loud, delicious and stimulating. I know the students would agree. They are working on identifying our next problem. I wonder..."

Summer Curriculum Writing Project

The final phase of the project, a two-week Summer Curriculum Writing Project, took place in June 1986. Through an alternating series of training sessions and writing periods, participants created investigative science lessons and learning units to extend their existing science curriculum. A brief description of two such units, "Weather Correlations" and "Scrape, Scrape, Scrape," will illustrate the problem solving and investigative techniques utilized.

"Weather Correlations," by John Zietlow of West Delaware Middle School, Manchester, asks students to investigate the correlations that might exist between their collected data, their predictions of future weather and the information presented to the public by local media meteorologists. Students learn to read weather instruments, make a weather forecast and determine the correlation between forecast and actual weather. In this unit, the computer is utilized to store data, graph data and analyze correlations. Higher order skills such as synthesis and application are required of participating students.

"Scrape, Scrape, Scrape" develops "real" thinking in a "real world" setting — the school cafeteria. Written by Jill VanderWilt of Lambert Elementary School, Manchester, the unit has as its major goal the involvement of students in a "real-world" investigative problem. Related goals are to develop an awareness of the waste in a hot lunch program, to increase knowledge of the history of hot lunch programs in the United States and to develop an understanding of the necessity of a healthful balanced diet. These activities are ideally integrated into a nutrition unit. Students are involved in determining the parameters of the investigation such as securing permission, determining methods of collecting waste, deciding upon methods of presenting the data, analyzing data and making correlations. These higher order skills are interwoven with basic information about the hot lunch program and the basic nutritional needs for good health. A number of

suggested extensions give ideas for development of further units or writing a longer project.

Summary

Considering that only one year has elapsed since the announcement of project funding to the writing of this article, a great deal has been accomplished. In addition to the preliminary planning, preparation and submission of a proposal, the implementation has been successfully carried out. Without the cooperation among university staff, Keystone Area Education Agency personnel and educators from local school districts, the project would not have been possible. The outcomes include not only quality in-service experiences for a select group of teachers, but curriculum projects which can be of benefit to others.

Further details regarding the topic areas listed below and, for a nominal fee, sets of the problem solving units can be obtained from Joe Moore, Keystone AEA 1, Elkader, IA 52403 or by calling 1-800-632-5918.

References

Unified Science and Mathematics for Elementary Schools. 1974. Education Development Center, Newton, Massachusetts.

Osborn, A.F. 1963. *Applied Imagination.* Scribners, New York, New York.

Science/TAG Curriculum Units

Acid Rain by John Hearn.

Students learn the basis for acid rain and conduct experiments to see the affect of acid on various materials — living and non-living.

Activities to Improve Observation Skills by Sue Kiel.

A number of activities help students improve their ability to communicate observations.

Animal Behavior — Live Crickets by Larry Stott.

Students observe the behavior of an organism - crickets.

Archeology Dig by Larry Stott.

Students excavate a "dig" to determine the "culture" of the "people" who lived at this site.

Asexual Reproduction of Plants by Shirley Kellogg.

Students learn about asexual reproduction and develop experiments to determine the affect of environmental factors.

Bubbles, Bubbles, Bubbles: An Investigation of a Common Gas by Jamie Ann Thomas.

Students develop a procedure for determining the percentage of an Alka-Seltzer tablets' mass lost in bubbles when placed in water.

Cleared for Take-Off: Investigation into Aerodynamics by Colleen Willard.

Students learn the basic principles of flight as well as a historical perspective in the development of aviation. Students participate in a simulation of a cross-country flight.

Comparison Study of Candy Bars by Roger Hoekstra.
Students investigate candy bars for nutritional and calorie value and theorize the ingredients of the "perfect" candy bar.

Computer-Aided Classification by Mel Butikofer.
Students learn the concept of a data base and how to establish a classification system.

Construction by Thomas Carroll.
Students investigate the principles of construction of towers of clay and straws.

Culturing Bacteria Found in the Classroom by Shirley Kellogg.
Students learn about common bacteria and their environmental factors. Students gather evidence of the variability of bacteria.

Doing Science by Gary Crawford.
Students are introduced to short term investigation.

Energy Dilemma by Leon Mindham.
Students examine the current utility of electrical appliances and consider alternative activities to deal with electrical storage.

Energy Misers by Esther Adams.
Students examine sources of energy and the problems related to each source of energy.

Environmental Studies by Bruce Evans.
A field guide to aquatic sampling and testing.

Environmental Studies: Plant Succession Hotels in the Forest by Bruce Evans.
Students learn some skills in plant identification and explore a deciduous forest ecosystem.

Fossils of Dubuque by John Hearn.
Students learn to identify fossil types found in the Dubuque area.

Incorporating Problem Solving into Any Unit by Roger A. Beane.
Students learn skills in problem solving.

Investigating Terrestrial Diversity by John Zietlow.
Students investigate and compare two diverse study areas.

Investigation into the Laws that Govern the Protection and/or Reclamation of Streams in Iowa by Hank Bramman.
Students become acquainted with legal statutes regarding Iowa streams and how to go about solving problems.

Investigation of the Diversity of Plant and Animal Life Found in a Cold Water Stream Ecosystem by Hank Bramman.
Students investigate the influence of grazing upon the flora and fauna of a coldwater stream.

Measuring Stem Growth on Trees in the Spring of the Year by Roger Hoekstra.
Students investigate stem growth for a period of weeks to predict future growth.

Miracles under the Microscope by Colleen Willard.
Students become acquainted with magnifying properties of lenses and become familiar with using the microscope.

Paper Towels by Thomas Carroll.
Students determine the quality of paper towels and make a decision on a "best buy."

Plant Census by Esther Adams.
Students determine a population and its diversity.

Plant Problems by Sue Kiel.
Students investigate the affect of environmental conditions on plant growth.

Pollution by Mark Levin.
Students investigate causes and concerns of pollution.

Popcorn — A Problem-Solving Activity by Robert G. Wilson.
Students learn problem-solving technique via determining the "best buy" in popcorn.

Scrape, Scrape, Scrape by Jill Vander Wilt.
Students investigate waste in the local lunch program.

Sealed Aquatic Ecosystem by Roger A. Beane.
Students investigate closed aquatic environments.

Study and Experiments to Be Used with Mealworms by Mark Levin.
Students learn the life cycle of mealworms and conduct various experiments to determine the behavior of mealworms to various stimuli.

Surveying Smoking Attitudes by Mel Butikofer.
Students learn the techniques of surveying and the risks of smoking.

Test Questions to be Used with a Junior High Life Science Course by Mary E. Reuland.
A life science test requires students to solve problems and determine an answer from data presented.

Throw Away Society by Jill Vander Wilt.
Students investigate the impact of Iowa's bottle return law.

Use of Corn (*Zea mays*) in a Middle School Science Curriculum by Mary E. Reuland.
Students investigate growth in plants by studying corn growth.

Weather Correlations by John Zietlow.
Students learn to use weather predicting instruments and predict weather for a local area.

Which Mouthwash Is Best? by Leon Mindham.
Students investigate mouthwash to determine an effective, economical product.