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ABSTRACT

The purpose of this project was to develop, conduct, and evaluate a K-6 science inservice program for elementary school teachers. This program was conducted in six 3-hour workshop sessions and consisted of hands-on activities, problem-solving exercises, and large and small group discussions. The individual workshop sessions focused on incorporation of the process skills in elementary science lessons, the use of effective questioning techniques, and the use of the learning cycle approa~ in teaching science. Eighteen elementary school teachers from a midwestern school district participated in this project. Qualitative and quantitative procedures were used to evaluate the extent to which these teachers incorporated the information presented in this inservice program into their science teaching. Both measures indicated that the information presented in this program did influence the participants' science instruction. Materials used in the workshops, including two modules and a workshop journal, are appended. Lists 4 references. (Author/YP)

State of Indiana -- Commission for Higher Education
FY 1987-88, Title II-A Program
FINAL PROJECT REPORT
Oct. 1, 1989

Project Title:	A Science Inservice Program for K-6 Teachers
Project Director:	Charles R. Barman, Indiana University School of Education, 902 W. New York St., Indianapolis, IN 46202-5155
Instructional Assistant:	Natalie S. Barman, Park Tudor School, 7200 N. College, Indianapolis, IN 46240-3016
Project Evaluator:	Jill D. Shedd, Indiana University School of Education, Indianapolis, IN
Sponsoring Institution:	Indiana University School of Edcation 902 W. New York St., Indianapolis, IN 46202-5155
Cooperating School Corporation:	Eagle-Union Community School Corporation
Other Cooperating Bodies:	Eagle-Pleasant View & Union Parent Teacher Organizations

Abstract

A Science Inservice Program for K-6 Teachers

The purpose of this project was to develop, conduct, and evaluate a K-6 science inservice program for elementary school teachers. This program was conducted in six three-hour workshop sessions and consisted of hands-on activities, problem-solving exercises, and large and small group discussons. The individual workshop sessions focused on incorporating the process skills in elementary science lessons, the use of effective questioning techniques, and the use of the learning cycle approach in teaching science.

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SECTION I -- PROJECT DEMOGRAPHICS

Type of Award:	Competitive Program
Project Focus:	Elementary (K-6) Science
Individuals Served by Project:	Public School Teachers (K-6)
Project Location & Duration:	Pleasant View Elementary School, 4800 South 975E., Zionsville, IN 46077 October 1, 1988 to August 1, 1989
Geographical Areas Served by the Project:	Suburban; Zionsville
Major Project Activities:	Pre-inservice Evaluation - 10/1-88 to 11/30/88 Workshop Sessions - 1/17/89; 1/31/89; 2/14/89; 2/28/89; 3/14/89; 3/28/89 Post-inservice Evaluation - 5/1/89 to 5/30/89
Media & Publicity Used:	None
Historic Background of Project:	Modification of Inservice Program Developed in 1986
Will the Project Continue Without Title II-A Funds?	Yes; In-Kind Contribution of Project Director & Inservice Assistant

Project Matching Funds:

Indiana University School of Education (inservice manuals)	-	$250.00
Eagle-Pleasant View/ Union PTO (meals & child care)	-	$300.00
Total Matching Funds	-	$550.00
Federal Grant Award	-	$16,029.00
Total Project Cost	-	$16,579.00

Participant Demographics: Public School Teachers - 2 males; 16 females

Type of Institution: State University

Section II -- PROJECT NARRATIVE REPORT

The project narrative report follows the format suggested by the Indiana Commission for Higher Education. Each of the questions posed by the Commission will be stated before the response to that question.

1. Please describe the specific objectives of the project. What was the project intended to do and what results did you hope to achieve?

The overall goal of this project was to provide K-6 teachers in Eagle-Union Community School Corporation with an effective science inservice program designed to impact their methods of teaching science. Specifically, this project was designed to:

a. provide teachers with a rationale for teaching activity-based science,

b. introduce teachers to the learning cycle approach to teaching science and demonstrate how this approach can be incorporated into their existing science materials,

c. assess the effects of teachers' participating in the inservice program with respect to their science teaching activities, and

d. facilitate the development of a science teaching network in each Eagle-Union elementary school.

2. Please describe the general characteristics of the individuals who participated in your project; and the processes and procedures used to select them.

The project participants were made-up of K-6 teachers from the Eagle-Union Communinity School Corporation. These participants included members of the Science Curriculum Advisory Committee, the elementary science resource teacher, and a group of K-6 teachers that were identified by their building principals as having demonstrated peer leadership qualities. The participation of this latter group was voluntary.

3. Did the project actually attract the number and type of participants anticipated? Was the selection procedure used, appropriate? Please explain. Was there a difference in the level of participation and responsiveness of public school versus private school personnel? Please explain.

Although the workshop had space for twenty five (25) participants, a total of eighteen (18) teachers participated in this project. However, the type of individual that did participate was the kind of person that the workshop was intended to serve.

I believe that the selection procedure was appropriate. The workshop was designed to facilitate the development of a science teaching network in each Eagle-Union elementary school. The individuals that participated in the project were the type of teachers that had demonstrated the willingness to share new teaching ideas with their colleagues.

Because there are no private schools in Boone County, the workshop only served public school personnel.

4. Please describe the instruction/service(s) that were delivered to project participants; and list each project activity, its location, session leader(s), and the number of participants at each session/activity.

The inservice program consisted of six individual workshop sessions that were three hours each. All six sessions were conducted in the science resource room at Pleasant View Elementary School, Zionsville, Indiana. All eighteen participants attended each workshop session.

The content of each sesion, the workshop leaders, and the date of each session is listed below.

Session Number		Session Topic(s)
Session 1 (Jan. 17, 1989) Leaders - Charles R. Barman Natalie S. Barman	-	An introduction of science process skills; Effective questioning techniques.
Session 2 (Jan. 31, 1989) Leaders - Charles R. Barman Natalie S. Barman	-	How to incorporate process skills into the elementary science curriculum.
Session 3 (Feb. 14, 1989) Leaders - Charles R. Barman Natalie S. Barman	-	An examination of current learning theories and how they can be applied to science teaching.
Session 4 (Feb. 28, 1989) Leaders - Charles R. Barman Natalie S. Barman	-	An introduction to the learning cycle approach; Examination of how this teaching strategy is related to current learning theories.
Session 5 (March 14, 1989) Leaders - Charles R. Barman Natalie S. Barman	-	Application of the learning cycle to elementary science teaching materials.
Session 6 (March 28, 1989) Leaders - Charles R. Barman Natalie S. Barman	-	Incorporation of the learning cycle into the participants science materials.

Please note: Session 4 introduced a teaching approach called the learning cycle. Sessions 5 and 6 demonstrated how this approach can be applied to science teaching and incorporated into current teaching materials. The learning cycle consists of three phases. The first phase, EXPLORATION, involves students in hands-on manipulation of materials to gain familiarity with the materials, to provide a common cognitive experience, to raise questions, and to promote cognitive dissonance. The second phase, CONCEPT INTRODUCTION, involves the teacher and student in developing the concept through operational definitions and experiences gained during the exploration. The final phase, CONCEPT APPLICATION; is an opportunity for teachers to provide their students with additional examples of the concept, especially as that concept relates to the student's everyday experiences.

5. Please describe participant reactions to your project sessions and activities, noting any significant differences among types of participants and other findings that you deem important.

The participants' reactions to the inservice program indicate success. The participants came to the program with few expectations, yet from interviews that were conducted before and after the inservice the participants suggested that they gained useful information, information which they immediately applied to their teaching in some way. The evaluative measures used for this project suggest that the program had a positive impact on the participants' science teaching. The pre- and post-classroom observations that were conducted indicated changes in the teachers' science classes. In comparisons of the individual pairs of classroom observations, changes were noted in more participants using the learning cycle. For example, three of the eight teachers observed changed their lessons from focusing on identifying the "right" answer to identifying multiple answers. Two of the teachers' post-program lessons included student generation of the concept introduction, whereas in their pre-program lessons, the teachers introduced the concept. An analysis of the participants' pre- and post-inservice lesson plans indicated a significant difference in their plans. The participants incoporated more elements of the learning cycle approach in their science lessons at the end of the inservice as compared to the ones they deveeloped at the beginning of the program.

6. Please describe the materials produced for and by the project; the particpant responses to using the materials; your assessment of their usefulness to participants; and their availability for dissemination. Attach examples as may be appropriate.

Two sets of materials were used for this project. The first set of materials was produced specifically for this project. These materials consisted of two modules that introduced the nature of science and effective questioning techniques and a "workshop journal" for participants to reflect on their workshop and classroom experiences during the inservice program. The modules on the nature of science and effective questioning were used during the first workshop session, while the journal was used throughout the inservice program. Please refer to the Appendix for a copy of these materials.

The second set of materials used in this inservice program was a set of materials titled LEARNING ABOUT THINKING & THINKING ABOUT LEARKNING (Barman, Cooney, & Leyden, 1986). These materials were developed with funding from the National Science Foundation (grant number - MDR - 855034) and are modeled after the components of an effective inservice program identified by Orlich (1987), Bowyer, Ponzio, and Lundholm (1987), and Joyce and Showers (1980). (A set of thes materials is attached to this final report.)

Based upon responses received during the post-inservice evaluation, it appears that the workshop participants felt that the materials were helpful in developing a rationale and a practical strategy for presenting activity-oriented science. For a more detailed description of the overall feelings of the participants, please refer to items 9 and 10.

The LEARNING ABOUT THINKING & THINKING ABOUT LEARNING materials are available for dissemination and have been used in several states in the United States. The materials that were developed specifically for the workshop (Appendix) still need to undergo additional field-testing before they are ready for dissemination.

7. Please describe the administrative/management activities of the project; identify the personnel (faculty, student assistants and other individuals) who were involved in the project, the amount of time they devoted to the project and their project role/responsibility.

This project was directed by Charles R. Barman, Associate Professor of Science Education at Indiana University - Purdue University at Indianapolis (IUPUI). Dr. Barman organized and delivered the six workshop sessions. Assisting Dr. Barman in organizing and conducting the workshop sessions were Natalie S. Barman, 5th grade science teacher at Park Tudor School, Indianapolis, IN, and James McAdams, graduate student at IUPUI.

Dr. Jill D. Shedd, Assistant Director for Academic Affairs at IUPUI, served as the evalualtion specialist for the project. Dr. Shedd conducted pre and post-inservice interviews and classroom observations. She was assisted by Mr. McAdams in compiling and organizing the evaluation data.

Mr. McAdams was also instrumental in assisting the project director in specific clerical tasks (e.g. developing purchase orders, and distributing supplies to the participants).

The time devoted to this project by each of the above individuals was:

Charles R. Barman (Project Director) - .25% of second semester 1988-89

Natalie S. Barman (Instructional Assistant) - 6 days

Jill D. Shedd (Evaluation Specialist) - 20 days

James McAdams (Graduate Assistant) - 180 hours

8. Please identify any cooperative efforts or assistance provided by public or private school staff or administrators, community organizations, groups, state and local government, the sponsoring institution, and others.

Two individuals from the Eagle-Union Community School Corporation assisted in organizing the workshop sessions. G. William Anderson, Assistant Superintendent, helped coordinate the selection of the workshop participants, helped communicate information to the participants throughout the project, led several discussions during the inservice sessions, and assisted in securing access of the science resource room at Pleasant View Elementary School.

Mr. Michael Garis, elementary science resource teacher and inservice participant, assisted the project staff in obtaining specific science equipment for the inservice sessions. In addition, Mr. Garis helped lead several discussions during the inservice sessions.

The Eagle-Pleasant View and Union Parent Teacher Organizations assisted the project staff during the three evening workshop sessions (Jan. 17th, Feb. 14th, and March 14th). These Organizations provided evening meals for the participants and project staff and child care for any of the participants requiring this service.

The LEARNING ABOUT THINKING & THINKING ABOUT LEARNING inservice manuals were provided as an in-kind contribution of the host institution.

9. Please indicate the impact that you feel your project has had on project participants. Is there any evidence that participants are using project concepts, techniques, materials, activities or imformation in their classrooms? Is there any evidence that there is an impact of teacher performance in the classroom or on students? Provide illustrations, examples, or evidence as may be necessary.

10. Discuss the nature and findings of the project evaluation. Describe the evaluation procedure used, who administered it and the findings of the evaluation. Please comment on the degree to which you feel your project achieved the results that you intended in your project proposal.

Based on the way the evaluation was conducted for this project, it seemed appropriate to combine the responses to items 9 and 10. Therefore, the following information is a response to both of these items.

Evaluation Procedures

The objectives of this project evaluation were three: (1) to learn about the participants' initial perceptions and attitudes toward the inservice program and teaching science in general, (2) to assess the impact of the program on the participants' teaching of science, and (3) to document the participants' reaction to the program at its conclusion. To meet these objectives both qualitative and quantitative methods were used including interviews, classroom observations, and lesson plans.

The first component of the evaluation was to identify a foundation of information, to be able to begin the program with an initial assessment of the participants' attitudes, expectations, and teaching practices. To understand the participants' intitial perceptions and attitudes, three different activities were used First, each participant was interviewed soon after the 1988-89 school year began and prior to the first workshop session. They were asked to describe what they knew about the inservice program, what the issues surrounding science teaching were, what expectations they had of the program, their attitudes toward teaching science, and where science presently fit in their teaching. The intent of these interviews was to gain baseline information about the participants' attitude toward teaching science and what they hoped to gain from the program. Secondly, at the end of the interview each participant was a given a science topic for which they were to outline a lesson plan and explain how they would present the topic to their classes. An analysis of these lesson plans was to provide information as to how the participants typically approach teaching science. The final element of the evaluation baseline were observations of a science lesson in classrooms of randomly selected participants. Eight of the 18 participants were observed.

The second component of the evaluation was to assess the impact of the program on the participants' teaching of science. Three different evaluative instruments were used. To provide quantitative measure of any changes in the participants' science teaching, they were asked to complete two more lesson plans, one at the midpoint of the program and another once the program was over. Each lesson plan was scored as to its inclusion of the characteristics of the learning cycle approach (e.g., exploration, concept introduction, and concept application). The set of three lessons plans' scores was statistically analyzed to identify any significant differences those prepared initially, midway through the program, and at the program's conclusion. As one qualitative measure of the programs' impact, each participant was interviewed following the program's conclusion. In the interviews the participants were asked to describe the value of the learning cycle approach to teaching, any changes they had made in their teaching and the extent to which the participants discussed ideas for science teaching with their colleagues. Additionally, observations of teaching a science lesson were conducted of the same participants as observed earlier.

The final component of the evaluation was to assess the participant's overall reaction to the program. As part of the final interviews the participants were also asked questions as to their evaluation of the inservice program.

Results of Evaluation

Prior to the start of the inservice program, each of the participants was interviewed. The purpose of these interviews was to gain a foundtion of information about the participants, their science teaching, and their expectations of the program. The participants were asked five questions:

a. What do you know about the upcoming science inservice program?

b. What expectations do you have of the program?

c. What would be the "ideal" science inservice workshop for you?

d. How do you feel about teaching science?

e. When is science taught in your classroom?

All of the participants had no or little information about the inservice program. For the most part, the participants had volunteered to attend the program out of their interest in teaching science. In discussing their expectations of the program, the participants noted most often a feeling of inadequacy of not being well prepared to teach science. In describing what would constitute an "ideal" science workshop, two themes came across in their comments. Noted most frequently were references to activities, "hands-on activities." These participants indicated a high interest and need for good ideas for activities to "make science more meaningful for kids", to "integrate (science) with other subjects", and to "go with the curriculum." In addition to a focus on activities, the participants commented on a need for "practical information." The participants wanted easy to use information and information about a variety of projects and resources.

From the interviews, it appears that the participants' attitude about science influenced when science was taught in their classroom. Generally, the participants ranked science third or fourth, after reading and mathematics and on a par with social studies. Oftentimes, science was taught as the last subject of the day, sharing the time slot with social studies and health.

In addition to information presented above, important issues were identified which were useful to know prior to the start of the inservice program. By far the greatest issue in the minds of participants was the amount of supplies and/or money available for science and science activities. The participants did not feel there was adequate equipment or financial support to provide students with activities in science. Noted next in frequency was that the teachers did not feel they had the time to prepare activities for science nor did the teaching day provide time for science. Another issue that was raised during these intitial interviews was that science was non-graded in the primary grades, and consequently, teachers did not place a similiar level of importance to science as they did to the graded subjects. Several participants also shared a concern regarding their ability to teach science. Individuals noted a need to feel at ease with the material to feel confident about the topics discussed.

At the end of the interview, each participant was given a topic from an elementary science textbook for which they were asked to outline how they would teach the topic to their students. The intent of this exercise was to learn at the start of the program how the participants approached teaching science. The lesson plans were analyzed for their inclusion of the three phases of the learning cycle (exploration, concept introduction, concept application). Of the 18 lessons, only one included all three phases in the correct order. Eight had two of three phases (exploration and concept introduction), while the remaining nine had only one (concept introduction).

After the second workshop session, classroom observations of a selective set of teachers were conducted. Observations of science teaching were completed in randomly selected classrooms in each of the three Eagle-Union elementary schools. The observations focused on the emphasis of the lesson, the activities used, and the form of interaction between the teacher and students. Among these initial observations, the majority of lessons emphasized concepts and the development of concept understanding based on some form of activity. The types of activities used in the classroom were individual or small group activities. Yet the direction or purpose of the activities varied. In three classrooms, the activities appeared to be directed to the students' learning the "correct" answer, while in two classrooms the activities seemed to be directed to the students' reaching multiple answers. Yet in the last three classrooms observed there appeared to be no specific purpose for the activities. As to the interaction between the teachers and students during the science lessons observed, the teachers tended to dominate the lesson. In each of the classes, they selected the activities and most of the teachers generated the questions during the lesson. There was more diversity among the classrooms regarding how concepts were introduced. In three classrooms the students discovered the concept, while in two the teachers introduced the concept. In the remaining classrooms, the introduction of a concept was not observed as part of the lesson.

Following the inservice program, the same three evaluation processes were completed; participant interviews, lesson plan analysis, and classroom observations. During the final interview, the participants were asked five questions:

a. Describe the inservice program. What did you like and dislike about it?

b. How do you feel about the learning cycle approach to teaching science?

c. What changes have you made in your teaching as a result of participation in the inservice program?

d. Describe the extent to which you have discussed the program and/or teaching science with your colleagues.

e. What does the ideal science program require?

Overwhelmingly, the participants liked the inservice program. As one person shared, "There was something useful in each workshop session." Individuals cited a variety of reasons for their enthusiasm about the program. The positive feature noted most frequently by the participants was the opportunity to work and share with colleagues, particularly teachers from other buildings. Individuals noted that the program was one of the best they had attended. The other facets of the program which participants liked were varied and individually related. Several noted that a positive element of the program was that they learned more than science. For example, one participant stated the program provided another way of looking at things. Another one shared that she liked the general philosophy that she gained from the program; "Don't provide so much information. Let the students discover first hand." The participants indicated that they liked learning about children's cognitive development and and playing the role of a student during the inservice.

The participants shared very few dislikes. Several felt that the workshop sessions at the end of the program could have been shortened, however, they were unable to point to a specific activity or topic that could have been deleted. Other individuals noted that they would have liked to have been advised that there were going to be assignments, and they would have liked feedback about the lesson plans they developed.

As to the learning cycle, each of the participants understood it and found it useful. In the interviews, they suggested that they have applied it in some form of their teaching. For example, one noted that she tries to keep the learning cycle in mind as she starts new units. Another stated that the learning cycle material has led her to think about her classes more. Yet another participant stated, "the students like it and that's all that matters."

Many of the participants commented that the learning cycle applies to many topics and not just science. As one teacher remarked, "it's a philosophy of teaching, to provide an opportunity for students to explore, before presenting the content. You can do it with every subject." Individuals cited examples of the use of the learning cycle, e.g., using more exploration, asking more open-ended questions, not only in science but other subjects, such as reading and social studies.

Several participants did point out some difficulties with the learning cycle. One issue raised was the level of change required. To implement the learning cycle several noted that they had to make a conscientious change in their teaching, and they admitted that habits are hard to break. Others commented that this teaching approach did not apply to everything and some indicated that using the learning cycle approach takes more time. As one participant shared, "time dictates if I use it (the learning cycle) or not."

Every participant was able to cite specific changes in their teaching as a result of attending the inservice program. The majority of participants commented that they are providing their students with more exploration and more involvement in their science lessons. Several noted that their classes contain more constructive questioning, e.g. using more open-ended questions, more wait-time. Individuals suggested they had made significant changes in their teaching. One commented that she had made a major change in her teaching, in that she now uses activities as the focus of her teaching and the textbook as a support instead of vice versa. Another participant shared that she "feels learning is taking place and I'm really teaching."

With respect to interaction with their colleagues about the program and/or teaching science, the majority of participants cited little interaction, noting they simply did not have time. Yet several did share that they worked with their building colleagues to prepare their supply requests. In one school, the teachers even found science equipment no one knew they had.

For the majority of participants, the ideal science program requires more money and supplies. Other responses to this question were more individual. References were made to requiring grades in science, the quality of the textbook, the availability of science lab class periods. Other individuals noted that an ideal science program needed to focus on students' thinking and teachers learning the learning cycle approach.

Following the inservice program, observations of science teaching were conducted in the same set of participants' classrooms as observed earlier. During these observed lessons there was a more equitable emphasis on content and concept development than in the lessons observed earlier. In all of the classrooms as in the first observations, the activities were conducted by the students individually or in small groups. The vast majority of the lessons focused on multiple answers than on one answer, in contrast to the first observations. As to the interactions between the teacher and students, the teachers continued to select the activities although three classes included student-generated questioning compared to none earlier. The lessons observed included a similiar distribution of concept introduction generation as the ones observed earlier.

In addition to these qualitative evaluation measures, a more quantitative measure of the impact of the inservice program was made. As mentioned previously, toward the beginning of the workshop sessions each participant was asked to complete a lesson plan for a specific science topic. The participants were asked to complete two more such lessons, one midway through the program and another after the programs's completion. Each lesson was scored as to its inclusion of the three phases of the learning cycle. An analysis of variance (one way ANOVA repeated measures) was conducted on the participants' set of three lessons. The analysis resulted in a significant difference at the .000 level. With these results, a post hoc analysis was conducted using the Tukey-HSD procedure. Using this procedure, the first, second, and third sets of lessons were compared to each other. The results indicated that the sets of lessons were significantly different from each other at the .05 level. These analyses suggest that each set of lessons was significantly different in terms of their reflection of the learning cycle approach than the previous set of lessons. In reviewing the scores of each set of lessons, it is apparent that the second set of lessons incorporated more elements of the learning cycle than the first, and the third set included more than the first and second sets. The results suggest that the participants' attendance in the inservice program did impact their science teaching. Also, these results suggest that the participants' teaching re.lected the learning cycle approach more having participated in the program than prior to their program attendance.

As a final note, from the evaluation results it is apparent that there are several persistent issues which the participants raised about science that the program did not impact, nor was it designed to address. A major continuing concern that the partcipants noted was the lack of money and/or supplies available for activities to include in teaching science. The participants were appreciative of the money provided through the program for the purchase of materials, but this was a one time only opportunity. The issue of non-grading of science in the primary grades was a persistent concern noted. With no requirement for grades, teachers were less compelled to find the time to plan and to teach science. Though their enthusiasm for teaching science may have been increased through their participation in the inservice program, in the crunch to cover all the curricular topics in the teaching day it is unclear that the amount of science taught will increase or that the time required to change science teaching habits or incorporate more activities in science teaching will be found. It is not clear that science will receive increased time in preparation or actual teaching or move from its lower priority behind readi~ and mathematics simply due to increased enthusiasm and recognition of different, more positive wavs to teach science. It is uncertain that science will change from being the last topic taught in the day, if time permits.

11. If you were asked to conduct your project again next year with a new set of participants, what changes/modifications would you make in the project that would enhance its effectiveness?

There would be no changes made in the content or format of the inservice sessions. However, if this program was again offered during the spring semester, a fall follow-up meeting would be included as part of the project. In addition, a different feedback mechanism would be incorporated into the evaluation plan to provide teachers with more detailed information about the project staff's evaluation of the project.

12. The purpose of the Title II-A program is to improve the quality of classroom teaching of math and science and to better understand the problems, concerns and realities that elementary, middle and high school teachers face in teaching science. What insights have you gained through your project that would increase our understanding of the issues, concerns and realities that teachers face? What recommendations would you make to federal, state and local officials who are looking for ways to improve teacher performance and student

performance in math and science?

Generally, elementary school teachers feel that they are held mainly accountable for the success of their students in learning how to read and to perform mathematical calculations. As a result, teachers take this as a message that science is not a major component of the school's curriculum. In addition, teachers feel that their science textbook dictates to them how and what science should be taught.

After conducting this inservice program and obtaining the evaluation data, the following recommendations are being made to individuals responsible for improving science education in their school districts.

a. To improve science instruction, faculty inservice must be planned and conducted on a long-term basis. One shot inservice sessions are ineffective. Plus, school districts must make a financial and philosphical commitment to the improvement of science instruction.

b. Teachers need to be given permission to allow students to "discover" science content. Students need ample time to explore and "mess about" in science.

c. Inservice programs should be targeted at providing teachers with a philosophy of teaching rather than just providing them with individual activities. (Inservice should provide a mechanism that will help teachers continue to improve their instruction.)

d. As part of any inservice, time should be built into the program for teachers to share with their peers new ideas and techniques that they have learned and used in their classroom instruction.

References

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APPENDIX

MATERIALS USED IN WORKSHOP

MODULE 1

WHAT IS SCIENCE?

INTRODUCTION

A convenient way to view science is to visualize it as containing three distinct components, which include: (1) a number of process skills, (2) a body of knowledge resulting from these process skills, and (3) cultural implications of this knowledge. This module will examine each of these components individually and will also demonstrate how they interrelate with one another to comprise the scientific enterprise.

PROCESS SKILLS

The first part of this module will acquaint you with the process skills used by scientists.

Activity I - Alka-Seltzer in Water

Materials Needed:

1 - 50 ml graduated cylinder
1 - 250 ml beaker
1 - Alka-Seltzer tablet
1 - Celsius thermometer

General Directions:

1. Pour 100 ml of water at room temperature (about 21 degrees C) into a 250 ml beaker.

2. Place one tablet of Alka-Seltzer into the water.

3. Observe the phenomenon until you can see the bottom of the beaker clearly while looking down into the beaker. List at least three observations of the phenomenon:

a.

b.

c.

d.

e.

f.

A. *Observation* is a process skill used by scientists. Observations can be made in a variety of ways using all of the senses. Where direct sense experience is not adequate for making needed observations indirect methods are used. For example, through the use of such instruments as the microscope, the thermometer, a balance and a clock, a scientist may extend his/her senses and probe deeper into the unknown. Some other process skills include the following:

B. Inference, while based on observations, requires evaluation and judgment. Inferences based upon one set of observation may suggest further observation which in turn requires modification of original inferences. Inference leads to prediction.

C. *Prediction* is the formulation of an expected result based on past experience. The reliability of prediction depends upon the accuracy of past observations and upon the nature of the event being predicted. Prediction is based upon inference. A progressive series of observations and, in particular, graphs are important tools of prediction in science.

D. *Classifying* is the grouping of phenomena according to an established schema. Objects and events may be classifed on the basis of observations. Classificational schemes are based on observable similarities and differences in arbitrarily selected properties.

E. *Measuring* properties of objects and events can be accomplished by direct comparison or by indirect comparison with arbitrary units which, for purposes of communication, may be standardized. Identifiable characteristics which can be measured may be interrelated to provide other quantitative values that are valuable in the description of physical phenomena.

F. In order to *communicate* observations, accurate records must be kept which can be submitted for checking and rechecking by others. Accumulated records and their analysis may be represented in many ways. Graphical representations are often used since they are clear, concise and meaningful. Complete and understandable experimental reports are essential to the scientific enterprise.

Which other process skills, besides observation, did you use in Activity I?

Formulating Questions and *Hypotheses* are also process skills used by scientists. Questions are formed on the basis of observations made and usually precede an attempt to evaluate a situation or event. Questions, when precisely stated, are skills of science. For three of the observations you listed in Activity I (page 3), write a question about that observation.

After scientists ask certain questions and have examined their data, they will usually formulate a *hypothesis* to be tested. (A hypothesis is an explanation of something that occurs in nature. A scientist will test this hypothesis to determine if the explanation is correct.) The formulation depends directly upon questions, inferences and predictions.

Forming hypotheses consists of devising a statement which can be tested by experimentation. When more than one hypothesis is suggested by a set of observations, each must be stated separately. A workable hypothesis is stated in such a way that, upon testing, its credibility may be established. It can be stated positively or negatively. The following are examples of each:

1. A hypothesis stated in positive terms.

   Example: A gas is produced when Alka-Seltzer reacts with water.

2. A hypothesis stated in negative terms.

   Example: A gas is not produced when Alka-Seltzer reacts with water.

In the space below, formulate a hypothesis for this question: Is the rate of reaction between Alka-Seltzer and water affected by the temperature of the water?

Experimentation is a process skill used by scientists to gather certain information and to test the accuracy of an hypothesis. For example:

1 A scientist may ask the question: Is the rate of reaction of Alka-Seltzer with water affected by the temperature of water?

2. From this question the scientist may formulate a hypothesis: The rate of reaction of Alka-Seltzer with water is affected by the temperature of the water.

3. Then, the scientist will design an experiment to test this hypothesis. This experiment must contain the following components:

a. manipulated variable - thing in the experiment that changed or varied.

b. variables held constant - things in the experiment that are not changed.

c. responding variable - thing to be observed or measured to see if they change when you modify the manipulated variable.

d. materials or apparatus necessary to carry out the experiment.

e. an awareness of the limitations of the apparatus and the design of the experiment.

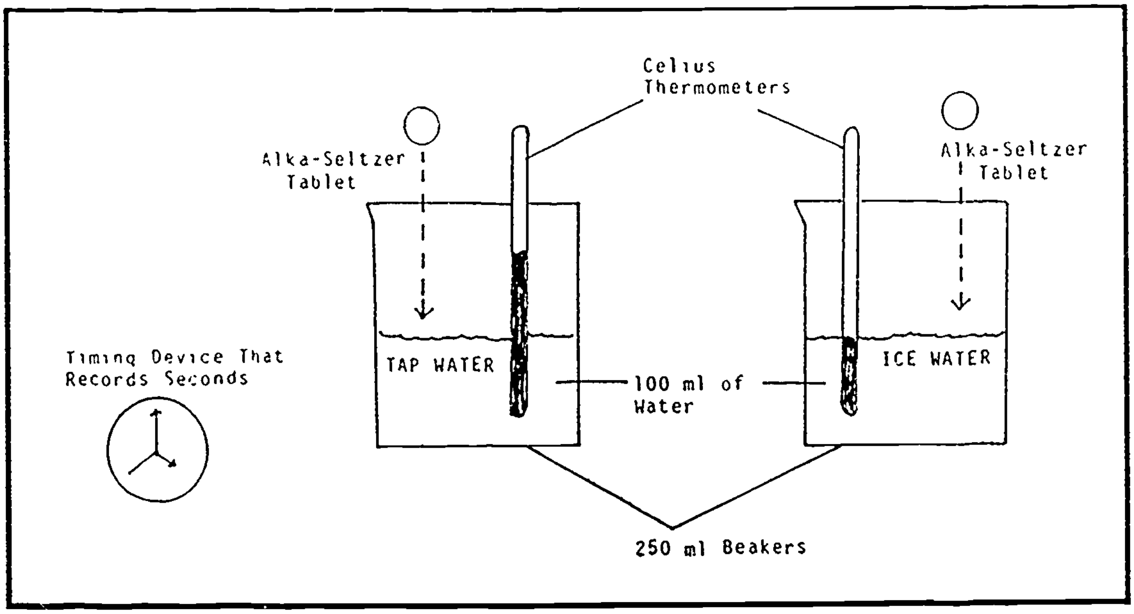
4. **Activity II - Conducting an Experiment**

Hypothesis: The rate of reaction of Alka-Seltzer with water is affected by the temperature of the water.

The materials required to conduct the following experiment are:

2 - Celsius Thermometers
water at room temperature (about 21 degrees Celsius)
1 - timing device (watch or clock)
2 - 250 ml beakers
1 - 50 ml graduated cylinder
2 - Alka-Seltzer tablets

The experimental design should be set up as follows:



Define operationally the manipulated variable, variable(s) held constant and responding variable in this experiment? What might be the limitation(s) of this experiment?

Manipulated Variable -

Variable(s) Held Constant -

Responding Variable -

Limitation(s) of experiment -

Now, go ahead and conduct this experiment....

After completing this experiment, do you feel the original hypothesis has been verified? (The rate of Alka-Seltzer with water is affected by the temperature of the water.)

If the results of your experiment support your hypothesis, then:

- you may be satisfied that you have solved the problem (which may or may not be true), and there is no further need to pursue

the phenomenon, or
- you may wish to state a more specific hypothesis from which you can make a prediction and design a new experiment to test.

Or, if the results of your experiment do not support your hypothesis, you might then decide to propose a new hypothesis and design a new experiment to test your new idea.

By now it may appear that experimenting is a laborious task. You're right! However, by having a set of rules or procedures, anyone can duplicate an original experiment. This allows other scientists to check the work of their colleagues.

When a hypothesis has been checked and rechecked and it continues to be verified, it can be called a *theory* . A theory is an idea that is generally accepted by the scientific community. However, it is subject to be changed or modified as new information becomes available through new experimentation.

Therefore, scientific theories and hypotheses are continually being tested. If, due to this testing or experimenting, some problems are identified with a theory or hypothesis, they may be altered, modified, or possibly disregarded. For example, organic evolution is now a biological theory. It has been tested and modified for many years. However, because the basic idea appears sound and no major information has been identified to cause evolution to be disregarded as scientific theory, it is still accepted by most scientists.

SCIENTIFIC KNOWLEDGE

As indicted earlier, all scientific knowledge is subject to very careful analysis by the scientific community. Therefore, it could be viewed as being "certified knowledge." In other words, when a scientist publishes the results of an experiment or formulates a hypothesis, he/she expects his/her colleagues to check and recheck the accuracy of his/her claims. This type of scrutiny tests the validity of scientific knowledge.

Even though "pure science" and applied science (technology) are closely related, it should be noted that there is distinction between the two. Pure science refers to the accumulation of knowledge about natural phenomena. It includes the knowledge itself, but also the interpretation of the knowledge and the process by which such information is gained. *Applied science* or technology, on the other hand, refers to the activities that result in the production of materials and services. Science and technology often are interrelated, but they are not synonymous.

CULTURAL IMPLICATIONS *

Man lives in a world in which his activities and his ways of life are profoundly influenced by science, Science in turn influences technological development. It is not possible to discuss science outside of its relationship with human beings, since science, both as a body of knowledge and as a process of the human intellect. The main interrelationships between science and human activities on both intellectual and physical grounds may be expressed as follows:

1. Science is a significant part of our culture, having aesthetic and humanistic as well as practical value.

2. Scientific and technological structures of a society have a strong influence on the level of economic development.

3. Governmental policies affect the growth of science and are in turn affected by scientific activities. Society's wisdom in the support and application of science is related to the level of understanding of the purposes, strengths and limitations of science.

4. The rapid accumulation of scientific and technological knowledge and the decrease in the time lag between development and sociological application create serious problems when societ accepts the new developments without taking time to anticipate the consequence.

---

*This section has been adapted from *A Guide To Science Curriculum Development*, a publication of the Wisconsin Dept. of Public Instruction, Bulletin No. 161.

For the purposes of simplification, these four statements will be referred to hereafter by the following adjectives:

1. *Aesthetic*

2. *Economic*

3. *Political*

4. *Sociological*

Aesthetic

> *Science is the creation of scientists and every scientific advance bears somehow the mark of the man who made it. . . The Creative scientist, whatever his field, is very deeply involved emotionally and personally in his work, and. . . he himself is his own most essential tool.*
>
> *Anna Roe 1961*

The word "art" can be used to describe fine paintings, pieces of sculpture and great works of music and literature. The word may also be used to describe the process of developing these accomplishments. The word "artist" denotes a person who uses his/her materials, whether they be oil and canvas, clay and bronze or pen and paper, to create a product of his/her investigations and contemplations. The words "science" and "scientist" are very similiar to "art" and "artist". The scientist finds the same creative satisfaction in formulating models, explanations and predictions of natural phenomena as the poet finds in creating memorable verse or the artist finds in developing new relationships between his/her materials. A scientific investigation of nature is a creative activity which has enormous intellectual challenges and satisfactions. Just as the artist is limited by the nature of his/her materials, so the scientist is limited by the behavior of the materials of nature.

The aesthetic nature of science is apparant at all levels -- from the most elementary observations of the young child to the sophisticated investigations of the professional scientist. Aesthetic satisfaction can be found in the simple observation of the color of flowers, the patterns of butterflies, the green of the landscape, the blue of the sky, the form of seashells and the complexity of crystals. At a higher level, the professional scientist sees beauty in his/her physical and mathematical models of theoretical constructs.

Economic

> *"The basic institution upon which everything else depends is the scientific department of the university . . . "*
>
> *C. E. K. Mees, Vice Pres.*
> *Eastman Kodak Co. 1950*

Pure science has been developing for centuries. However, it was not until the middle of the 19th Century that scientific developments began to have practical and therefore economic consequences. Prior to this time, most of the technological developments which resulted in important inventions, such as the steam engine, the printing press and many others so important to bringing about economic revolution, were based upon trial-and-error development designed to produce a specific product, and not upon the results of scientific investigation. However, in the past 100 years, the dependence of economic development upon the outcomes of scientific research has increased sharply.

During the last half of the 19th century, the electrical industry, which could hardly have developed from random invention, began to thrive from the input of scientific knowledge. This industry was based upon fundamental knowledge of magnetism and electricity which had been developing for several hundred years, but which had come to fruition only through the important scientific investigations of of Volta, Ampere, Oersted, Faraday and Maxwell. The contributions of these men led to the development of practical electrical generators and motors about 1870. It became possible to generate electricity in sufficient quantities for such large scale use as the operation of streetcars and industrial motors. About 1890, electricity made possible the preparation of various chemicals through the use of electrolytic cells. In the 1880's, the work of Hertz led to the concept of electromagnetic waves transmitted through space. Application of this knowledge led to the development of radio and ultimately radar and television.

The dye industry is another industry based on application of theoretical chemical knowledge. Although the first synthetic dyes were discovered on empirical grounds, the German chemical profession successfully investigated the processes by which the synthesis of organic compounds having good dyeing properties could be accomplished. These chemists learned the nature of the chemical groups responsible for color and described those chemical groups which had mordant properties. By 1880, the close relationship between the German dye industry and the chemical profession led the dye industry to branch out into the fields of drugs and photographic chemicals.

The close tie between science and national economics which proved so important in the 19th century developed on a massive scale during the 20th century, particularly in the western world. Many industrial companies now maintain extensive research and development laboratories in order to discover new products for introduction to the consumer market and new processes to more efficiently manufacture these products. Plastics, synthetic textiles, synthetic rubber, modern drugs and pesticides are largely products of the 20th century scientific research and the resulting technological innovation.

The most prosperous countries of the world are those which have an economic system solidly based on the application of scientific discovery to technology. However, it is equally important to point out that the development of science is favored in a country which already has a strong economy. Science first flourished in England, France and the parts of western Europe where a strong economic structure already existed. Scientific activity is fundamentally expensive since many investigations lead to other investigations. Although new knowledge may result from such investigations, there is no assurance that this knowledge will lead to technological application within a predictable period of time. For this reason, a strong financial backing is needed in order to foster research to the point where it can become profitable. The scientific discoveries which have resulted from such research without having any direct technological application are invaluable in the further development of pure science. It is impossible to know which scientific discoveries will eventually lead to practical application and which will ultimately represent contributions to man's knowledge. However, that small portion of scientific knowledge which has economic value will ultimately feed into technology and therefore into national and world economies. An economic structure which is too weak to support a sizeable scientific population shows little promise of developing, or even borrowing from other countries, the kind of science which will become important in technoloy.

Political

> *It is clear that science occupies a conspicuous place in national policy making . . . And the reasons are impressive: science provides new and fast routes to economic growth, international bridgebuilding, national defense. technological advance, and such human values as overcoming want and disease.*
>
> *William D. Carey*
> *U. S. Budget Bureau 1967*

A sympathetic governmental policy toward science is important to developing and maintaining forceful scientific activities in any country. This first became evident in Germany during the period of Bismark when political strength was built upon science and the resulting technology. It is also evident in the present century in the United States and the U.S.S.R., where a significant amount of governmental encouragement toward the pursuit of science has been available for a number of decades. However, this does not automatically mean that strong nations should enthusiastically appropriate money for scientific activities simply for the sake of scientific activity, nor does it mean that support of scientific endeavors will automatically guarantee increased strength for the supporting government. In a democratic political structure, the society which supports the government should understand the nature of science, its strengths and its limitations. When such understanding is lacking or when the society does not exert control over government, government policy could very easily support scientific ventures of little significance for the society.

Just as government-supported science is effective in meeting the internal needs of a country, it is also of utmost importance in establishing the international position of the country. No other field of intellectual activity has a comparable effect on the power struggle which goes on between nations, whether in direct conflict or in negotiation. It is essential to national prestige.

In the present era, scientific research is almost always supported by some institution, either private industry or a privately funded research institution. To a large degree, funds for this kind of work come through tax policies from some level in the political structure. This is often true even in colleges and universities where academic freedom is prevelant, but where research is dependent upon grants.

Because of this dependence on governmental financing, there is a tendency toward political determination of the direction of scientific research. If the political policies governing this determination of direction are well advised, the purposes of science, society and the government can be advanced. The source of advice in scientific matters often comes for the practicing scientists themselves. However, in a democracy, an informed citizenry has the responsibility not to submit to the control of a limited number of scientific experts. Social techniques are needed to insure that decisions made by politicians, with the advice of scientists, concerning scientific research will truly reflect the needs of all citizens.

Sociological

> *An entirely new character has been given to the whole of our modern civilization, not only by our astounding theoretical progress in sound knowledge of Nature, but also by the remarkably fertile practical application of that knowledge in technical science, industry, commerce, and so forth. On the other hand, however, we have made little or no progress in moral and social life, in comparison with earlier centuries; at times there has been serious reaction. And from this obvious conflict there have arisen, not only an uneasy sense of dismemberment and falseness, but even the danger of grave catastrophes in the political and social world. It is, then, not merely the right, the sacred duty, of every honorable and humanitarian thinker to devote himself conscientiously to the settlement of the conflict and to warding off the dangers*

that it brings in its train.

Ernest Heinrich Haeckel 1900

Until the latter part of the 19th century, scientists were pretty much independent of society; in turn, society was not influenced to any great extent by the application of scientific discoveries. Then, in the 1870's technological development based upon the products of pure science began to affect the lives of people. While the changes were profound, they tended to be adopted slowly, allowing time for the adaptive process. However, as the scientific climate changed, the almost exponential rise in the rate of scientific discovery and the corresponding decrease in the time lapse between discovery and sociological application reached into the physical and emotional lives of large numbers of people simultaneously. This snowballing of technological advances has completely changed the attitude of the non-scientist toward the scientist.

The use of new scientific knowledge by applied scientists and technicians requires the lapse of a variable period of time. Basic knowledge cannot be technologically applied until it is available and understood and until the practicality of the knowledge is appreciated. Once these critera are met, it is only a matter of time before application occurs. An additional time lag occurs between development and actual availability of the product to society. Within this total time period, society must make its adjustment to the changes resulting from the new development. These changes may or may not be easily predictable.

The early application of fundamental knowledge to social uses took place very slowly. Faraday's discovery of electromagnetic induction was basic to the invention of the electric generator. However, while Faraday's discovery was made early in the 1830's, a practical electrical generator was not invented until 1870, a lapse of approximately 40 years between discovery and application. Today the period between discovery and application has collapsed to a small fraction of that time. The transistor principle was discovered in the 1940's and transistorized appliances were manufactured by the mid-1950's. In the present decade, space research is followed almost immediately by application.

While the shortening of this time lag may seem valuable, it is not without its problems. The fast rate of technological development creates corresponding needs which the pure scientist sometimes finds difficult to meet. For example, the rapid development of the space program created a need for special materials that could withstand the stresses of re-entry into the earth's atmosphere without being prohibitively heavy. When this problem was first recognized, the basic knowledge concerning such materials was not available to the materials engineers. It is, of course. in this kind of situation that scientific research receives pressure and therefore direction from society.

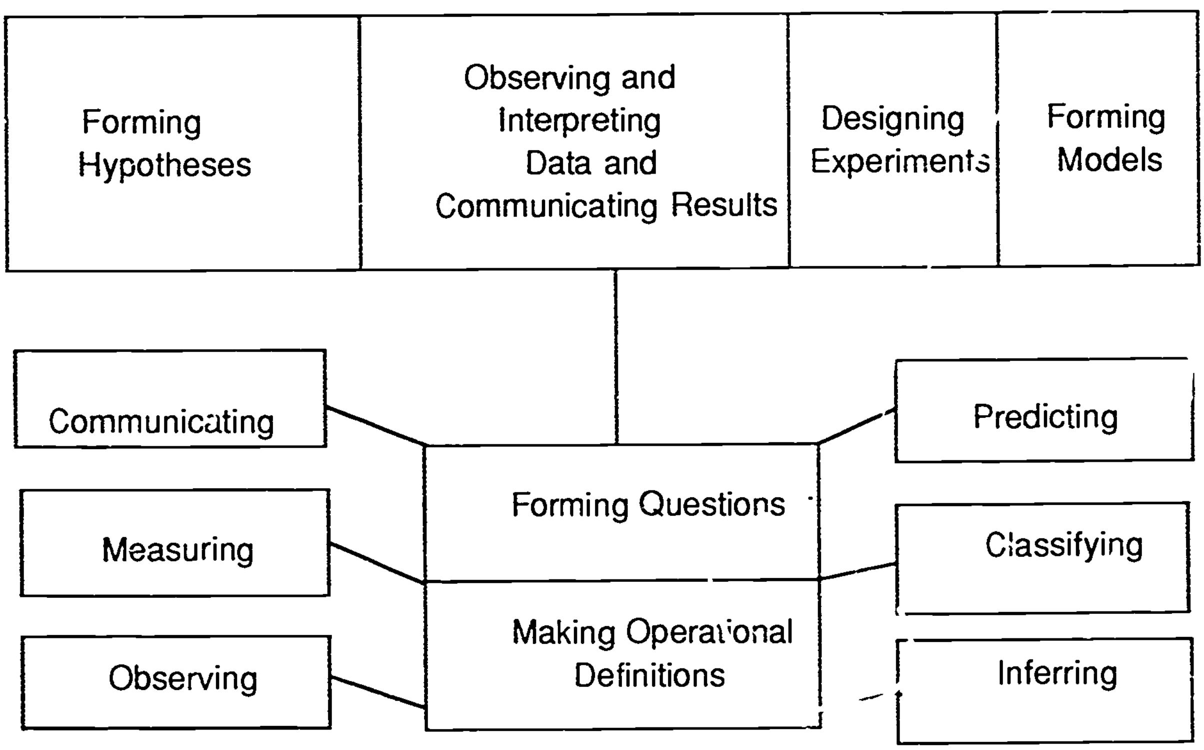
On the other hand, science depends upon technology for the development of new and better tools to make possible better techniques for scientific investigation. The development of the computer, an important example, has greatly enhanced scientific research since calculations can be made much more rapidly that before, and more importantly, since previously unsolvable problems can now be solved or approximated through computer technology. Computer usage has also greatly reduced the problems of further technological development and sociological application.

One of the greatest problems resulting from the use of scientific knowledge in technology arises when application follows discovery in such short order that there is little time to anticipate possible adverse consequences. An example of this is evident in the indiscriminate use of persistent pesticides such as DDT. This insecticide came into use during World War II and within a decade was being applied to insect control problems on a world-wide basis. The insecticide was prized because of its persistence. Yet, because of that very persistence, the accumulation of DDT in the environment has created a hazard to many desirable animal species unable to tolerate the level of pesticide to which they are exposed. Sometimes such adverse reaction can be more subtle. When detergents were first used to solve hard-water problems, the resulting pollution was not anticipated. Similiarly, the invention of the internal combustion engine did not carry with it a warning about air pollution or traffic dangers. Not so subtly, the adverse social effect of the atomic and nuclear bombs was well known even before development began, but immediate needs were met without finding solutions to the related problems. In this respect, technology becomes involved in moral issues, whether such involvement is desirable or not. Unfortunately, moral issues are often set aside without complete solutions.

SUMMARY

In this module you have investigated the process skills by which scientific knowledge is obtained. The following diagram illustrates the hierarchical structure of these processes and some of their interrelationships.

THE PROCESS SKILLS OF SCIENCE



It is through these processes that scientific knowledge is gained. This knowledge has historically had a great impact on our society and conversely, our society has also influenced some of the discoveries of science. Therefore, the scientific enterprise is comprised of three major components: (1) process skills, (2) a body of knowledge, and (3) the cultural implications of this knowledge.

MODULE 2

QUESTIONING TECHNIQUES

INTRODUCTION

In Module 1, you were provided with examples of how scientists use the skill of questioning to help them solve problems and gather information about the natural world. In this module, you will examine the importance of questioning in teaching. To begin this module, read the article "Ask the Right Questions." Then respond to these items.

1. Why should teachers use both open and closed questions?

2. What are some student and teacher benefits of using good wait -time during a classroom discussion? (The answers to these questions will be discussed during the next class session.)

Questioning Activity

Materials:
- 60 ml water
- 1 beaker or glass
- 1 teaspoon of baking soda
- graduate cylinder
- 4 raisins
- cassette tape recorder
- 30 ml vinegar - cassette tapes

Procedure:

1. Obtain a group of four to five students.

2. With these students, conduct the "Bouncing Raisins" activity. Encourage the children to manipulate the variables in this activity and to discuss the events that occur during the exercise. (If you feel your students could not successfully conduct this activity, refer to the "Alternate Activity for Questioning Techniques.)

3. After a period of about 20 minutes, you should conduct a 10-15 minute discussion of the activity. The purpose of the discussion is to help the students discover the possible causes of the phenomena. Valid explanation of many phenomena can be discovered by making careful observations of the event and drawing conclusions based on evidence. Students can test their hypotheses by manipulating variables one at a time.

4. During the inquiry session, you should keep the students focused on the observations (inferences). Do not tell the students why the raisins bounce. Instead, guide their discussions so that they may discover the reasons for themselves.

"Bouncing Raisins Activity"*

Procedure:

1. Dissolve a teaspoon of baking soda in approximately 60 milliliters (ml) of water.

2. Drop 4 raisins into the system of water and baking soda.

3. Gradually add vinegar, possible as much as 30 ml.

4. Observe the system of soda solution, vinegar and raisins.

5. Wait, some interactions are slow. The basic question you are trying to answer is *HOW DO YOU EXPLAIN WHAT HAPPENS TO THE RAISINS?*

Tell the students not to rush into an explanation -- there are many possible theories. Have them list their observations and their inferences in a chart similar to the one below. Encourage the students to discuss their ideas.

OBSERVATIONS	INFERENCES

WHAT TO EXPECT IN THE ACTIVITY

As the students begin the activity, they will observe about a teaspoon of baking soda being dissolved in a glass of water. Four raisins are dropped into the solution. After observing for several minutes, some or perhaps all of the raisins will bounce to the top and some will sink and rise again. Others may float or remain on the bottom. If no raisins bounce after about 3 minutes, give the students a different set of raisins.

CONDUCTING THE DISCUSSION

After the students have performed this activity, discuss (for about 10-15 minutes) their observations, and their explanations of what took place. Make an audio tape of the discussion. The audio tape will be used to analyze your questioning techniques.

DISCUSSION SUGGESTIONS

While talking with the students, you should help them to define a variable as some part of an experiment that may vary or change. Some possible variables in this task are: 1) the amounts of water, soda, vinegar, raisins; and 2) the kinds of materials, old raisins, juicy raisins, other kinds of reaction agents. (These are a few examples but the students may think of others.) After closely observing the raisins, you might discuss how manipulating or controlling one of the variables would alter the outcome. You could ask the students to infer the effect of cutting the raisins in half. You could ask them to predict what would happen if another object was substituted for the raisins. Examples of objects that are similar in size are peanuts, paper wads, moth balls, or buttons. You could discuss the effect of decreasing or increasing the amount of soda, vinegar, or water. Try to get students to recall their observations. Help them to distinguish between observations and inferences. Ask if they noticed if and where the bubbles collected. Try to develop the relationship between the raisins and the bubbles in eliciting an explanation. The students will want you to tell them the answer; avoid that temptation. Instead encourage them to rely on the evidence and their own judgement. Try to ask open-ended, probing questions and let the explanation come from group consensus.

ACTIVITY EXPLANATION

Baking soda ($NaHCO_3$) dissolves in water. When vinegar is added, a chemical reaction occurs between the baking soda and the vinegar releasing a gas, carbon dioxide (CO_2). Tiny carbon dioxide bubbles float to the surface and escape but many adhere to the surface of objects as observed by the bubbles collecting on the side of the glass. The raisins, being wrinkled, have a large surface area and many crevices where the bubbles may collect. If enough bubbles collect around the raisins, they become buoyant and rise to the surface. Upon hitting the surface, many bubbles pop and escape causing the raisins to flip over, bounce around or fall back to the bottom. The variability of the raisins account for the differences in the way the raisins behave. Density, size and surface area will vary from raisin to raisin. For example, a very dense raisin may not bounce at all, while a light, convoluted one may float instead of bouncing. Each raisin acts individually thwarting an easy explanation of the phenomena.

ASSIGNMENT:

Using the audio tape, analyze the amount of wait-time and the type of questions that were characteristics of your discussion (You may want to conduct this analysis with a partner). After your analysis, complete a similar set of data tables to those shown on the following pages. Hand in a a copy of your data tables and a written summary containing a discussion of your experience and an analysis of your questioning techniques. For example, your analysis should include the following:

-What were the ages of the students in your discussion?

-What was the average number of seconds of wait-time I and II (Table I) during your discussion? Was this wait-time adequate to provide enough time for the students to think critically about the activity?

-Did you use appropriate types of questions (Table 2) to encourage the students to think critically about the activity?

You are encouraged to conduct this entire activity more than once. "Effective questioning" only develops through practice! (Refer to the definitions at the end of this module to assist you in conducting this analysis. Also review the "Ask the Right Questions" article before you begin your analysis.)

OBSERVATION ANALYSIS

Table 1 - WAIT-TIME

	0	1	2	3
WAIT-TIME I				
WAIT-TIME II				

AVERAGE Wait-Time I - Total seconds/number

Wait-Time II - Total seconds/number

1. Listen to the audio tape of your discussion. As you listen to the to the tape, perform the following steps:

   a. Tally the number of seconds of wait-time I & II in Table I.

   b. Calculate the average Wait-Time I and Wait-Time II, by by using the following procedure:

      -Multiply the total tallies in each category by the number displayed above each box (number of seconds of wait-time).

      -Find the sum of the products for each category (total seconds).

      -Divide the total number of seconds by the total number of tallies in all four boxes.

Table 2 - TYPES OF QUESTIONS USED

	Tallies	Total No. of each Question	% of each type of Question
Managerial			
Rhetorical			
Closed			
Open			

c. Tally the number of different types of questions used in the discussion in Table 2. Enter this value in the column titled "Total No. of each Question."

d. Calculate the percentage of each type of question by using the following procedure.

-Add the tallies for each type of question (total number of questions).

-Divide the total number of questions by the total tallies for each type of question.

-Multiply the quotient by 100 to obtain the percentage of each type of question you used during the discussion. Record this value in the second column of Taole 2.

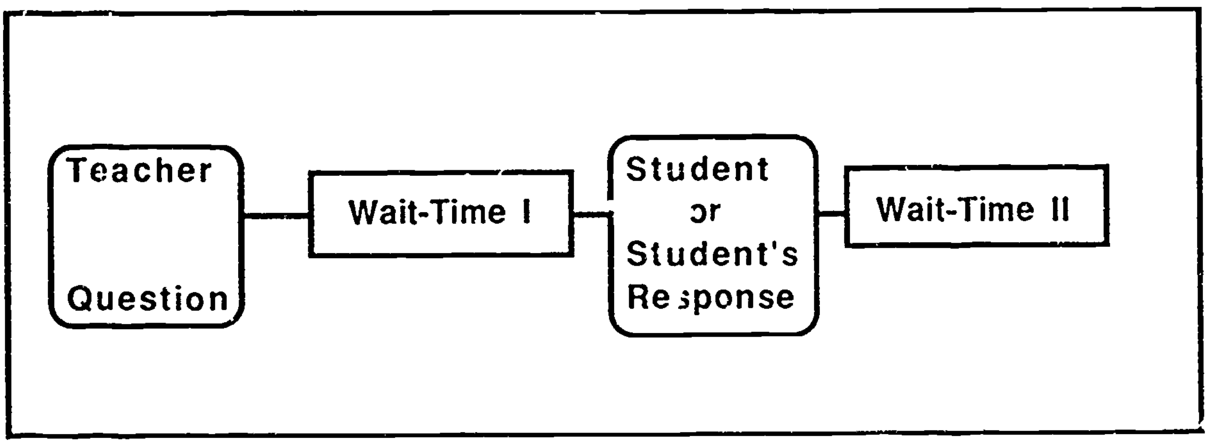
$$\frac{\text{Total tallies of each type of question}}{\text{Total No. of Questions}} \times 100 = \_\_\_\_\_\_ \quad \text{\% of each Question Used}$$

DEFINITIONS

Wait-Time I: The amount of time a teacher waits in silence after asking a question

Wait-Time II: The amount of time a teacher waits after receiving a student's response. Wait-time ends when the teacher comments or asks another question.

Conversational Set: One complete teacher-student exchange, e.g.



QUESTION CATEGORY SYSTEM*

Question Type	Question Function
Managerial	To keep the classroom operations moving.
Rhetorical	To emphasize a point, to reinforce an idea or statement.
Closed	To check the retention of previously learned information, to focus thinking on a particular point or commonly-held set of ideas.
Open	To promote discussion or student interaction; to stimulate student thinking; to allow freedom to hypothesize, speculate, share ideas about possible activities, etc.

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* This classification is taken from Blosser, P. 1978, "*Ask the Right Questions*," NSTA, Washington, D.C. Stock Number 500800.

Alternate Activity for Questioning Techniques

"Classifying Objects"

Materials:

-Each child should have a set of about 25 different objects (they should have at least three different characteristics; e.g. color, size shape)

Procedure:

l. Distribute a set of materials to each child.

2. Ask the children to examine the materials and to explain how they are alike and how they are different. Have them them share their observations.

3. Then have ask the children to put the materials in piles according to specific properties they identified. Have them share their reasons for separating the materials.

Extension

You may want to ask the children if they could make more piles or less than they have. Or, you could ask: Are there other ways to put the objects into piles?

WORKSHOP

JOURNAL

Science Inservice - January 17 - March 28, 1989

This is your teaching journal. Please use this journal to record the results of specific assignments from each workshop session. In addition, use this journal to record any special events that occur in your classes. At the beginning of each workshop session, time will be provided to share information from your journal.

Session 1 (January 17th)

Make a list of the different process skills your children used in science or other subject areas (e.g. oberservation, inference, prediction, classifying, measuring, communicating, forming hypotheses, designing experiments, recording and collecting data).

Please summarize the results of the questioning activity (bouncing raisins).

Session 2 (January 31st)

Please list your class results from the conservation of water problem.

Please record any other information about your classes.

Session 3 (February 14th)

Please share the results of your Piagetian tasks.

1. What tasks did you present to your students?

2. What responses did receive from each task?

Session 4 (February 28th)

Please describe which learning cycle lesson you presented to your students.

Do you feel the lesson was successful? Why or why not?

Please list any comments or questions you have about the reading assignment.

Session 5 (March 14th)

Please outline the learning cycle lesson you presented to your class.

List any comments you have about the lesson. Would you use this lesson again? Would you make any modifications in this lesson?

Post Script

Please complete and return this page in the self-addressed and stamped envelope by April I, 1989.

Do you feel tha the inservice program was a worthwhile experience? Please explain your answer.

What changes, if any, have you made in your science teaching as a result of this inservice program? Please explain your answer.

Use the following space and/or the back side to share any additional information that you feel would help us evaluate the inservice program.

Thank You!