Iowa Science Teachers Journal

Volume 27 | Number 1 Article 2

1990

Instructional Outcomes Change with STS

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INSTRUCTIONAL OUTCOMES CHANGE WITH STS

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Ideas and approaches central to Science/Technology/Society (STS) have been introduced via the Chautauqua program in classrooms of nearly 1,000 Iowa teachers of grades 4 through 9 since 1985-86. Assessment of the results of STS instruction has been central to the effort supported by the National Science Teachers Association, the Iowa Utility Association, the National Science Foundation (NSF) and the University of Iowa. Some of the emerging results demonstrate the advantages of an STS focus for school science.

Currently, STS is a major focus in science education. The NSTA STS Initiatives Task Force has described distinguishing features of STS and traditional programs and the differences between the students in them (Yager, 1990). Differences between students involved in an STS program and those in a traditional science program include:

Traditional	**STS**
Connections and applications	
Students see no value and/or use for their studies.	Students can relate their studies to their daily lives.
Students see no value in their studies for resolving current societal problems.	Students become involved in resolving social issues and see science as a way of fulfilling their responsibilities as citizens.
Students can recite information/concepts studied.	Students seek out information and use it.
Students cannot relate the science they study to any current technology.	Students are engrossed in current technological developments and, through them, see the importance and relevance of scientific concepts.

Creativity

Students decline in their ability to question; the questions they do raise are often ignored because they do not conform to the course outline.	Students ask more questions, and these questions are used to develop STS activities and materials.
Students rarely ask unique questions.	Students frequently ask unique questions that excite their own interests, that of other students and that of the teacher.
Students are ineffective in identifying possible causes and effects in specific situations.	Students are skilled in identifying possible causes and effects of certain observations and actions.

Attitude

Students have few original ideas.	Students continually offer ideas.
Student interest in science declines at all grade levels.	Student interest increases from grade level to grade level and in specific courses.
Science seems to decrease curiosity.	Students become more curious about the material world.
Students see their teacher as a purveyor of information.	Students see their teacher as a facilitator/guide.
Students see science as information to learn.	Students see science as a way of dealing with problems.

Process

Students see science processes as skills scientists possess.	Students see science processes as skills they can use.
Students see processes as something to practice as a course requirement.	Students see processes as skills they need to refine and develop more fully for themselves.
Teacher concerns for process are not understood by students, especially since they rarely affect the course grade.	Students readily see the relationship of science processes to their own actions.

Students see science processes as abstract, glorified, unattainable skills that are unapproachable.	Students see process as vital part of what they do in science class.

Knowledge

Knowledge is really information mastered for a teacher test.	Students see science knowledge as personally useful.
Knowledge is seen as an outcome itself.	Knowledge is seen as a needed commodity for dealing with problems.
"Learning" is principally for testing.	Learning occurs because of activity; it is an important happening but not a focus in and of itself.
Retention is very short lived.	Students who learn by experience retain information and can often relate it to new situations.

The situation described as "traditional" is based on the extensive studies sponsored by NSF in 1977 (NAEP, 1978; Heuftle, Rakow & Welch, 1983; ETS, 1988) and verified in 1987 by a second study by Weiss (1987).

Assessment strategies have focused on the five domains of science education as defined by Yager and McCormack (1989) for all teachers involved in the Chautauqua program. Although 1,000 teachers have developed and tested STS modules in their own classrooms during the past six years, only 40 teachers were able to conduct an experiment to compare student performance in two class sections that they taught: one incorporating STS and one using a traditional (textbook) approach. Other assessments were undertaken by individual teachers and schools. Since there were no common instruments, information from such assessments could not be compared from school to school. To some extent this problem existed in two areas reported here, namely concept mastery and applications of such concepts. The science concepts considered were the same for a given teacher and his/her two sections of students. However, because every module was different, no standard set of concepts and applications of concepts could be used across grade levels, disciplines and schools.

The five assessment areas which all Chautauqua teachers are asked to assess include concepts, processes, creativity, attitudes and applications. Information from these five domains was collected in the form of pretest and posttest scores from each of the teachers who identified an STS and a parallel traditional class for this comparison study. Standard hypotheses that no differences in performance would occur between STS and traditional sections were tested. Except for the concept domain, all such hypotheses were rejected. STS sections performed significantly better than textbook sections in use of process and creativity skills, attitudes and ability to apply concepts to new situations.

Assessment instruments in the concept, process, creativity and attitude domains are appended. All have been developed over a seven-year period within the Chautauqua program. An assessment package is available with rationale and directions for administration (McComas & Yager, 1988). Standard statistical information is included with each sample instrument.

Application

To compare applications, each teacher was asked to identify an STS module to coincide with a textbook chapter or unit from the district course of study. For example, Joan McShane's toilet-paper testing provided a setting for comparison to the content of a month-long ecology unit from her typical course of study. Twelve teachers were able to identify such a parallel situation and randomly selected at least one section for the standard unit and one for an STS focus. The teachers wrote-test items designed to permit observations of student ability to use information in new settings, to relate two happenings in a new situation, to identify related but divergent practices from a given situation, to choose relevant information for solving a specific new problem and to choose appropriate action based on new information provided. This was necessary because the standard topics or units chosen for study varied from school to school and grade level to grade level. All teachers used the 50-item samples provided in the Chautauqua Assessment Package as a model for developing items to fit their teaching model. This did introduce the problem of uniform item quality and teacher ability to write such items. Each of the 12 teachers gave the same test to his/her section(s) of students who studied science in the traditional manner as well as to those who worked on problems where information was needed in order to resolve particular questions (the STS focus).

The percentage of students from each of the 12 teachers was averaged in each of the five categories to present a general contrast of results. Class sizes varied from 18 to 32. No observable differences in class sizes were noted between the traditional and the STS sections for a given teacher or school, a situation which also existed throughout the study and for all categories where data was collected. Also, no significant differences in abilities, male-female mixes, interest levels, grade averages and socio-economic differences between the sections were taught by the teachers. Figure 1 provides the information from the 12 teachers regarding the percentages of students successfully performing in the five application areas.

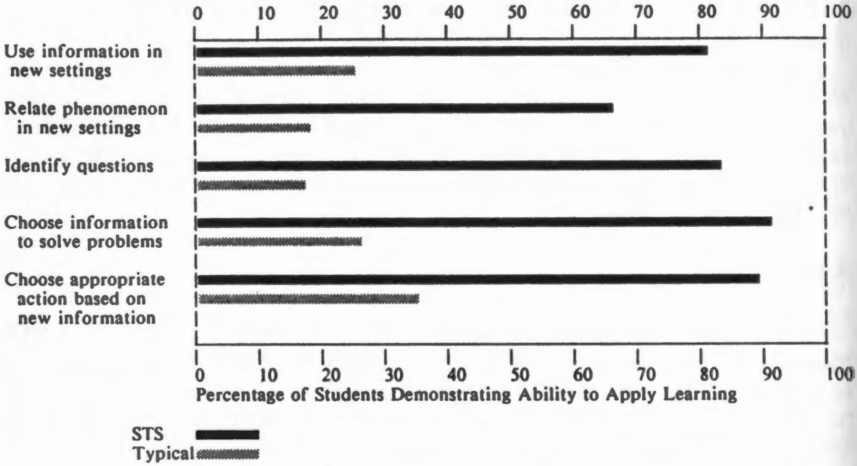

Figure 1
DIFFERENCES IN PERCENTAGES OF STUDENTS ABLE TO APPLY SCIENCE CONCEPTS TO NEW SITUATIONS AFTER BEING TAUGHT IN AN STS FRAMEWORK AND IN A TRADITIONAL MANNER

Attitude

One area regarding which all teachers were asked to provide information was the affective domain. Items for attention have been extracted from the *1978 Third Assessment of Science* by the National Assessment of Educational Programs. Nine items from the Preferences and Understanding Instrument were identified as important concerning student attitude.

Several studies have indicated that positive attitudes decline with the typical study of science. Generally, student attitudes are lower following a year's study of science than they were when students began a given science class (NAEP, 1978; Yager and Penick, 1986; Yager and Bonnstetter, 1984; Yager and Wick, 1966).

Twelve teachers who expressed interest in studying their own students' attitudes agreed to assess students after a month-long study of a textbook unit and to compare the results with another section studying similar topics in an STS format. Appropriate t-tests were computed between each section (traditional and STS) taught by a given teacher. No statistically significant differences were found between the mean scores of the STS group and the traditional group. And, these student attitudes and the class averages for attitude categories compared very favorably with those reported by NAEP (NAEP, 1978; Hueftle, Rakow & Welch, 1983; ETS, 1988). After one month of either STS or traditional instruction, students completed the attitude assessment. Results from the 12 teachers were again averaged. Figure 2 includes information indicating the average number of students involved with each approach who replied to nine attitude indicators.

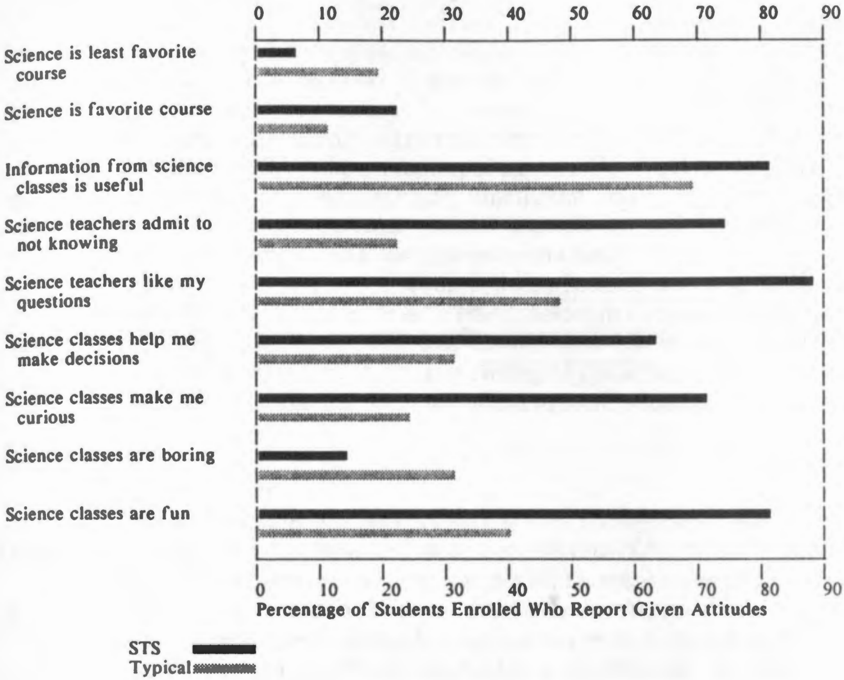

Figure 2
PERCENTAGE OF STUDENTS WITH POSITIVE ATTITUDES CONCERNING THEIR SCIENCE CLASSES AND SCIENCE TEACHERS FOR THE STS GROUP AND THE TRADITIONAL GROUP

Creativity

Many instruments have been developed to assess the numerous facets of creativity. One aspect that has received attention in Iowa concerns the quantity and quality of student questions. Other areas of concern are quantity and quality of student ability to identify causes for given phenomena and the ability to predict various consequences of given actions. Some of the differences in abilities of seventh and eighth grade students in this domain illustrate additional differences between the two modes of science teaching.

Again, 12 teachers agreed to collect information regarding questions, identification of causes and prediction of consequences from students enrolled in a standard textbook course versus those enrolled in a nine-week STS module(s). Each teacher devised a situation related to his/her science classes (both traditional and STS sections). Students were asked to suggest questions, to offer possible causes and to predict possible consequences. Each teacher reported the average number of questions, causes and consequences generated by the students enrolled in each class. Using descriptions offered by Torrance (1966), they also reported the number of unique responses identified by students from the two treatment groups. Generally, unique responses are those which are offered infrequently and/or show complex relationships to the original situation. Uniqueness is also related to the usefulness of the questions, causes and/or effect of the student response. Figure 3 shows the average number of responses for students enrolled in a traditional science course (textbook dominated) and for students experiencing science with an STS focus. Comparisons of tests administered to the traditional and STS sections before instruction revealed no statistically significant differences. Figure 3 reveals significant differences between the two groups after instruction.

Process

For over 50 years, process has received major attention in science education in the United States. Unfortunately, most of the attention has been lip-service with little research evidence to demonstrate that science teaching produced students with better science process skills than they had without instruction. Items for each of the processes-of-science areas identified by AAAS for its *Science: A Process Approach* (1963) program for K-6 have been developed over a five year period. Teachers choose skill items appropriate to their students and their content focus. Or, they create new items more appropriate to their own students. Results from cooperating teachers compared the skills of students after instruction in a traditional section (or two) to those taught with an STS focus. The scores were averaged to produce a generalized picture contrasting the two approaches to middle-school science. Figure 4 shows the results averaged from reports provided by the 15 teachers.

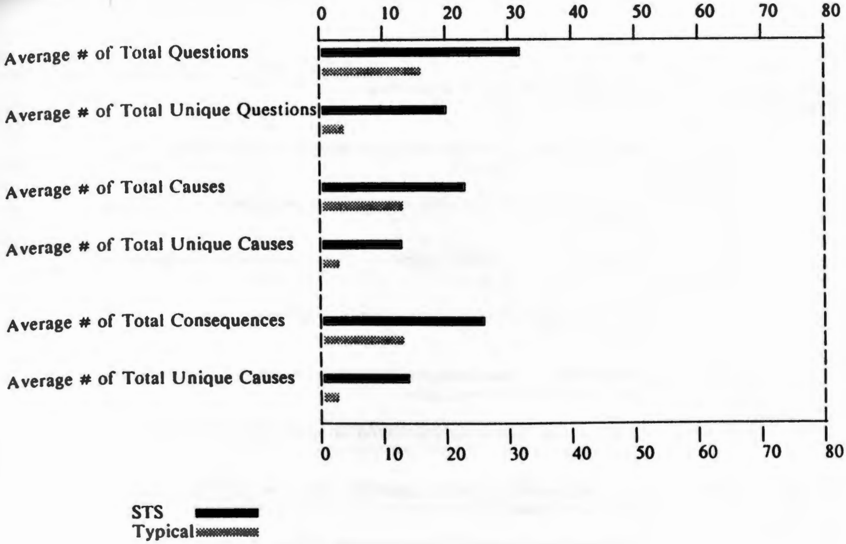

Figure 3
AVERAGE NUMBER OF RESPONSES GIVEN BY STUDENTS IN THE STS GROUP AND IN THE TRADITIONAL GROUP IN THE CREATIVITY INSTRUMENT

Concept

Acquisition of information has been a primary focus for school science as well as a means of assessing successful teaching and learning. Some critics have feared that an STS approach would result in less information acquired by students since fewer concepts are presented for mastery. Miller selected key concepts for his national studies of science attentiveness (Miller et al, 1980). Other science concepts were chosen from third grade science textbooks for use in a series of follow-up studies in Iowa (Yager & Yager, 1985). Eight concepts have been used extensively for follow-up studies of student mastery from grades three through twelve. These concepts/terms are: Volume, Organism, Motion, Energy, Molecule, Cell, Enzyme and Fossil. These terms are included in the Preferences and Understanding (1988) assessment instrument administered to all teachers enrolled in the Iowa Chautauqua Program.

Information was extracted from the assessment data provided by the teachers concerning applications (Figure 1), attitude (Figure 2), creativity (Figure 3) and processes (Figure 4). Figure 5 is a report of the percentages of students who, after middle school science instruction,

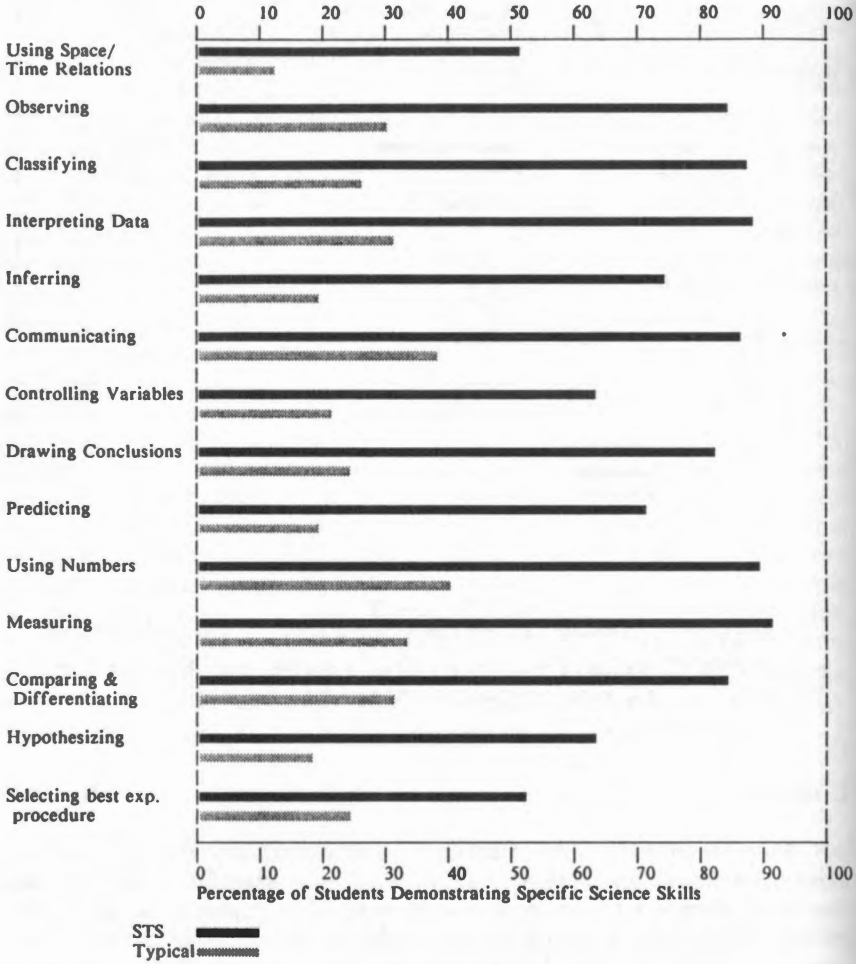

Figure 4
PERCENTAGE OF MIDDLE SCHOOL STUDENTS DEMONSTRATING ABILITY TO PERFORM IN FOURTEEN PROCESSES OF SCIENCE AREAS WHILE ENROLLED IN STS SECTIONS VERSUS STUDENTS ENROLLED IN TRADITIONAL CLASS SECTIONS

were able to identify the meaning of the eight concepts. Each teacher provided other data concerning specific information assimilated by students after traditional and STS instruction. These data cannot easily be generalized and/or reported since the concepts and units varied from school to school and teacher to teacher. McComas (1989) has reported on the general results from STS instruction. However, no contrast group was available to permit direct comparisons. The problem with the results reported in Figure 5 is that neither the traditional nor the STS instruction may have been concerned with the particular concepts included in the test. Perhaps the lack of major differences between the two groups is cause for optimism. An increase in student ability to apply, to develop positive attitudes, to exhibit more creativity and to improve in process skills are impressive enough without the claim that information acquisition *per se* is improved with STS instruction.

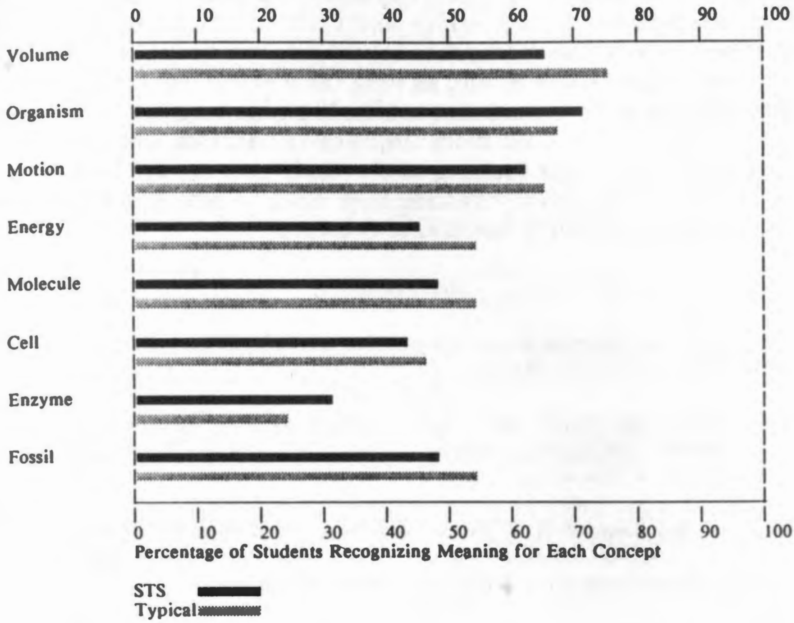

Figure 5
PERCENTAGE OF STUDENTS SELECTING CORRECT DEFINITIONS FOR EIGHT SCIENCE CONCEPTS AFTER INSTRUCTION IN STS COURSES AND TRADITIONAL COURSES

Studies of student retention of science information have not been conducted in individual schools in a systematic manner. However, everyone willingly concedes that much of what students learn for examinations is forgotten soon after. Some of the STS efforts have been too new to permit follow-up studies over a span of several years. However, since STS students are so much better at making applications and connecting experiences, indications are that the information students possess is indeed knowledge, i.e. information that is useful. If mastered information can be used and has real meaning for the learner, there is every reason to believe that STS instruction is providing a much better experience in the information domain.

Critics have argued that STS efforts in schools will fail because they do not affect standard test scores--or their claimed advantages cannot be measured. The evaluation of Iowa students seems to refute these concerns. To date, no significant gains have been found with respect to students' acquisition of information. However, the improvements in student attitude, the increased ability to use process skills, growth in some features of creativity and the ability to use information in new situations are impressive and positive advantages of STS instruction. As more teachers are involved, as more time is spent in given courses over grade levels, and as long-term studies give students the opportunity to show even more results, the advantages of STS instruction are likely to be even more impressive. In fact, the assessment information may be as exciting as the early positive student, teacher and parent testimonies. Testimonies tend to wane; however, real evidence exists for all to see and to interpret.

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Sample Test Items

Science Concepts

The terms below were selected from standard science textbooks for grades 3-12. Students are asked to select the most complete definition or understanding of these terms from the list provided for each.

1. Volume
   A. the space occupied by matter
   B. the energy needed to produce movement
   C. the size of an object expressed in numbers
   D. the amount of matter present
   E. the speed of a moving object
   F. I don't know

2. Organism
   A. organic materials
   B. any living object
   C. the part of the human body that controls actions
   D. a very small form that is alive
   E. a form of chemistry
   F. I don't know

3. Motion
   A. the action that occurs during exercise
   B. a feature of animals
   C. a change in the position of an object
   D. the action that occurs in a human
   E. the movement of the earth in space
   F. I don't know

4. Energy
   A. the force which makes objects in a system interact
   B. the material in a system that has substance
   C. the force responsible for growth
   D. chemical changes in a living thing
   E. factor which controls the weather
   F. I don't know

5. Molecule
   A. a form of energy that holds the world together
   B. a kind of organism that lives underground in the dark
   C. a chemical change that can produce new kinds of materials
   D. the smallest living part of any organism
   E. the smallest unit of material that has the original features of the material
   F. I don't know

Reliability: $r = 0.89$
Content Validity.
Population: a total of 1250 students, grades 4 through 9

Science Processes

Grades 4-6

1. Which of the following could be observed with the sense of sight?
   A. The temperature of the air
   B. The change in height of plants
   C. The sweetness of a new chemical
   D. The sound made by an engine

Process: Making Observations Difficulty: 0.61

2. What object has six equal sides, volume, 8 corners and 12 edges?
   A. cube
   B. square
   C. sphere
   D. cone
   E. hexagon

Process: Communicating Difficulty: 0.59

3. Recently, Beth heard sirens roaring on a nearby street. The next day, when she went to school, she saw a house covered with wide black spots and smoke. The most reasonable inference that she could make when describing what she saw was that:
   A. the house was destroyed by a tornado.
   B. the house was destroyed by a wild animal.
   C. the house was destroyed by a fire.
   D. the house was destroyed by a hurricane.

Process: Making inferences Difficulty: 0.55

4. A group of students conducted an experiment to determine the effect of heating on the germination (sprouting) of sunflower seeds. Which of the variables listed below is LEAST important to control in this experiment?
   A. The temperature to which the seeds are heated.
   B. The length of time the seeds are heated.
   C. The type of soil used.
   D. The amount of moisture in the soil.
   E. The size of the container used for growing each seed.

Process: Controlling variables Difficulty: 0.63

Grades 7-8

1. A tennis ball was dropped from several different heights, and the height the ball bounced was recorded each time the ball was dropped. Which of the following would be the best method to report the data collected?
   A. A written paragraph
   B. A tally of the number of bounces
   C. A frequency distribution
   D. A bar graph
   E. A pie chart

Process: Communicating Difficulty: 0.58

2. During the night, Steve was awakened by a thunderstorm. Walking to school the next day, he saw a large tree blocking the street. The best inference that he could make is that the tree was:

A. hit by a bulldozer.
B. bombed by an airplane.
C. knocked down by the storm.
D. destroyed by a fire.

Process: Making inferences Difficulty: 0.51

3. Dan and Dawn want to know if there is any difference between the mileage expected from bicycle tires from two different manufacturers. Dan will put one brand on his bike and Dawn will put the other brand on her bicycle. Which of the following variables would be MOST important to control in an experiment?

A. The time of day the test is made.
B. The number of miles traveled by each type of tire.
C. The physical condition of the cyclist.
D. The weather condition.
E. The weight of the bicycle used.

Process: Controlling variables Difficulty: 0.59

4. Bob set up two identical bowls which both contained sugar water and both were open to the air. One was put in the dark while the other was put in the light. What is the one item that is different from one set-up to the other?

A. The exposure to light.
B. The shape of the bowl.
C. The exposure to air.
D. The amount of sugar in each.

Process: Formulating a hypothesis Difficulty: 0.61

Grades 9-12

1. A student wants to know the level of effect of acid rain upon a fish population. She takes two jars and fills each of the jars with the same amount of water. She adds fifty drops of vinegar (acid) to one jar and adds nothing extra to the other. She then puts 10 similar fish in each jar. Both groups of fish are cared for (oxygen, food, etc.) in an identical fashion. After observing the behavior of the fish for a week, she makes her conclusions. What could you suggest to improve this experiment?

A. Prepare more jars with different amounts of vinegar (acid).
B. Add more fish to the two jars already in use.
C. Add more jars with different kinds of fish and different amounts of vinegar (acid) in each jar.
D. Add more vinegar (acid) to the two jars already in use.

Process: Controlling variables Difficulty: 0.58

2. Which one of the following IS written as an operational definition?

A. Since the density of oil is lower than water, when water is mixed with oil, the oil will float on the surface of the water.
B. The speed of a supersonic jet is similar to the speed of sound waves.
C. When you drive your car at a speed of 30 miles per hour, you have to push the brake pedal 300 feet before the line or point at which you are planning to stop.
D. The speed of a car will decrease when it has to turn right or left.

Process: Defining operationally Difficulty: 0.61

3. Eight bean seeds were germinated, then divided into four groups of two seeds each. One group of two seeds was grown under red light, another under yellow light, another under blue light and the fourth under ordinary white light. At the end of two weeks, the growth of each group of plants was measured to see which group of plants had grown the most. This experiment could *best* be improved by:

A. giving more water to the plants grown under the red light.
B. increasing the number of seeds grown in *each* of the four groups.
C. growing just the plants under white light in sandy soil, but growing all the others in humus soil.
D. adding one more group of two seeds to the experiment and growing them under purple light.

Process: Experimenting Difficulty: 0.62

4. What shape of shadow could not be formed by a cylinder?

A. a circle
B. a square
C. a rectangle
D. a triangle

Process: Using space/time relationships Difficulty: 0.49

Reliability: r = 0.72 (K-R.20) for 5th grade;
r = 0.81 for 7th grade;
r = 0.79 for 9th grade
Content Validity
Population: students in fifth grade N = 846;
students in seventh grade N = 546;
students in ninth grade N = 391

Creative Thinking

The rationale behind this measure is to provide a thought-provoking situation appropriate to the ability and experiences of the students to be assessed and have students write as many pertinent and imaginative responses to the situation as possible. The number of such responses provide clues to their overall creativity. This test is designed to assess creativity by examining two factors, namely the **number of questions asked and statements made** by the student and the **quality (and/or uniqueness) of those questions and statements**. There are three activities which together will help assess student creativity. Students will be instructed to **ask questions, guess causes** and **predict consequences** relative to the situation statement.

Sample situation statements used in the past have included the following:

1st grade: "Bobby woke up yesterday and found dinosaurs in his yard."
3rd grade: "Suppose we lived in a world without insects."
5th grade: "Pretend that there was no more pollution."
7th grade: "Suppose there was no more disease in the world."
General: "Jane stopped at the gas station to obtain fuel for her car. To her dismay, she was not able to get any."

It is recommended that the situation statement be related to the unit of instruction so that the students can see the relationship between the assessment and what they are studying. Care should be taken, however, to ensure that the unit of instruction does not center on the situation statement to such an extent that this measure of creativity becomes a test of knowledge.

Five minutes should be allowed for each of the three activities. A signal should be given to end each activity, after which students are requested to proceed to the next activity.

Evaluation of Student Responses:

There is certainly a great deal of judgment involved in the scoring, but since the same teacher ordinarily will be evaluating other pretests and posttests, this factor should remain constant. Information regarding inter-rater reliability, reliability in scoring by a single teacher and student reliability in responding are given below.

Quality of Questions:

Scoring in terms of quality or uniqueness refers to the **creative strength** expressed in a particular response based on a teacher's experience with children. Uniqueness can also be determined after reading the responses for an entire class.

Each statement the student makes is evaluated by entering **I**, **P** or **U** in the space marked *score code*. Several examples of students' responses with the appropriate scores are shown below:

Statement: Suppose you got up one morning and found that there was no gravity.

I =	Irrelevant:	The student's response is not related to the question (ex. "Dogs will chase cats.")
P =	Pertinent:	The student's response is related to the question, but is not particularly creative (ex. "We would float away.")
U =	Unique:	The student's response is related to the question and is very creative (ex. "We would be able to jump very high and pick fruit from trees.")

Population: 575 students from grades 4-9
Inter-rater reliability: r = 0.91
Same teacher reliability in scoring: r = 0.93
Student response reliability: r = 0.85
Content Validity.

Current Attitudes Concerning School Science

A. What is your favorite school subject?
Choose from: reading, language arts, social studies, mathematics, science, art, physical education, music, foreign languages

B. What is your least favorite school subject?
Choose from: reading, language arts, social studies, mathematics, science, art, physical education, music, foreign languages

C. After each sentence, circle the number which indicates your current feeling.

A = Always **B** = Frequently **C** = Sometimes **D** = Rarely **E** = Never

	A	B	C	D	E
1. Science classes are fun.	5	4	3	2	1
2. Science classes increase my curiosity.	5	4	3	2	1
3. The things studied in science classes are useful to me in daily living.	5	4	3	2	1
4. Science classes help me test ideas I have.	5	4	3	2	1
5. Science classes are boring.	5	4	3	2	1

6.	My science teacher frequently admits to not having answers to my questions.	5	4	3	2	1
7.	Science classes provide me with skills to use outside of school.	5	4	3	2	1
8.	My science class deals with the information produced by scientists.	5	4	3	2	1
9.	Science classes are exciting.	5	4	3	2	1
10.	Science classes provide a chance for me to follow-up on questions I have.	5	4	3	2	1
11.	Science teachers encourage me to question.	5	4	3	2	1
12.	All people can do/practice basic science.	5	4	3	2	1
13.	Scientists discover information that is difficult to understand.	5	4	3	2	1
14.	Being a scientist would be fun.	5	4	3	2	1
15.	Being a scientist would be lonely.	5	4	3	2	1
16.	Being a scientist would make a person rich.	5	4	3	2	1
17.	Being a scientist would make a person feel important.	5	4	3	2	1
18.	Being a scientist would mean giving up some of the things of interest.	5	4	3	2	1

Reliability: Alpha measure of internal consistency = 0.82
Perceptions of science teachers = 0.63
Perceptions of science classes = 0.81
Perceptions of what it would be like to be a scientist = 0.73
Content Validity.
Population: Students in grades K-9, N = 456

Applying Science Concepts

The samples included here will serve to illustrate the types of questions which may be constructed to assess students in the application of the concepts communicated to them. In each case, the fundamental concept taught during the unit is followed by a question which asks students to apply what they have learned. In an actual test of applications, the concept itself would not be part of the examination since the students are expected to have learned this as part of the unit and use it as they respond to the question.

1. **Concept**: When water freezes, its volume increases.

   Application Question: Which one of the following is the main reason that water should not be stored in the freezer in a container which is totally filled and sealed?
   A. The taste of the water will change.
   B. The container might break as the water expands.
   C. The water reacts with the glass at very low temperatures.
   D. The water will not freeze because there is not enough space available for it to convert into ice.

2. **Concept**: The time it takes to warm an object which is in a boiling liquid depends on the amount of material making up the object and how much of its surface is exposed to the boiling liquid.

Application Question: In which of the following situations will the potatoes cook most slowly in boiling water?

A. A single one-pound potato.
B. One pound of small potatoes.
C. One pound of medium potatoes.
D. One pound of potatoes cut into small pieces.

3. **Concept**: Most bird identification guides are based on knowledge of a bird's shape, size, color and patterns of markings.

   Application Question: While sitting at the breakfast table on a winter morning, you notice a species of bird that you have never seen before. What steps would you recommend to best guarantee that you will be able to identify it?

   A. Make a note of the bird's favorite food.
   B. Observe the behavior of the bird.
   C. Carefully study the bird's size and coloration.
   D. Determine the sex of the bird.

4. **Concepts**: The temperature at which water boils decreases with altitude; therefore, water boiling at high altitudes will not be as hot as water boiling on the normal kitchen stove. A pressure cooker is a kitchen appliance where high pressure and high temperature are maintained inside the cooker despite the altitude.

   Application Question: Where would it be more useful to have a pressure cooker for cooking food?

   A. At sea level.
   B. In the high mountains.
   C. Below sea level.
   D. When it is very cold outside.

5. **Concept**: It takes a large amount of heat energy to evaporate water; therefore, evaporation is used as a cooling process.

   Application Question: Out on a camping trip, which of the following situations would result in providing the coldest drinking water if the water in each case started out at the same temperature?

   A. Metal canteen filled with water and kept in the shade.
   B. Metal canteen with wet cloth-covered sides, filled with water and kept in the shade.
   C. Metal canteen filled with water immersed in a bucket of water at the same temperature as the interior water and kept in the shade.
   D. Metal canteen filled with water and kept in direct sunlight.

6. **Concept**: Light colored objects reflect sunlight better than dark colored objects.

   Application Question: During a sunny winter day, which vehicle would be warmest to the touch?

   A. A blue car.
   B. A red car.
   C. A white car.
   D. A black car.

Reliability: r = 0.85-0.91 (KR-20)
Content Validity.
Population: 475 students in grades 4-9

Sample test difficulty: 0.63 (grade 4)
0.58 (grade 6)
0.51 (grade 8)