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ABSTRACT

This teacher's guide was developed to assist teachers in supplementing junior high and high school science and social studies programs with a study of the relationships between science, technology, and society (STS). The program is intended to focus on the improvement of student knowledge about STS issues and the teaching of skills related to logical reasoning, critical thinking, problem solving and decision-making. The document contains major sections on: (1) science education for the 1980s and beyond; (2) preparing today's students for tomorrow's world; (3) the science-technology-society program (providing information on the audience, program usage, program objectives, theoretical basis, the development of mental structures, the development of thinking skills, the acquisition of knowledge and information, and the socio-scientific reasoning model); and (4) teaching approaches (including readings, development of critical thinking through reading, classroom discussion activities, questioning strategies, writing activities, dilemma discussions, and debates). (TW)

# SCIENCE-TECHNOLOGY-SOCIETY:



# SCIENCE-TECHNOLOGY-SOCIETY: PREPARING FOR TOMORROW'S WORLD

A Multidisciplinary Approach to
Problem-Solving and Critical-Thinking

## TEACHER'S GUIDE

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Science-Technology-Society

Preparing for Tomorrow's World



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## ABOUT THE AUTHOR . . .

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# INTRODUCTION

We live in an exciting, rapidly changing, and challenging world--a world highly dependent upon science and technology. In fact, our world is changing so rapidly that we sometimes fail to recognize that much of what we now take for granted as common, everyday occurrences existed only in the imaginations of people just a few short years ago. Advances in science and technology have brought many dreams to fruition and, long before our youth become senior citizens, much of today's science fiction will become reality. Recall just a few accomplishments that not too long ago were viewed merely as idle dreams:

- New biomedical advances make it possible to replace defective hearts, kidneys, and other organs.
- The first airplane flight lasted only a few seconds. Now, a little more than half a century later, space vehicles travel thousands of miles an hour to explore distant planets.
- Nuclear technology, of interest a few short years ago because of its destructive potential, could soon provide our planet with almost limitless supplies of energy for peacetime needs.
- Computer technology has made it possible to solve, in seconds, problems that only a decade ago required many human lifetimes.
- Science and technology have brought us to the brink of controlling weather and other natural phenomena.

Moreover, the changes that we have been experiencing and to which we have become accustomed are occurring at an increasing rate. Most futurists forecast that these changes will continue and even accelerate as we move into the twenty-first century and beyond.

Recently, the authors discovered the following quotation:

> *At the rate at which knowledge is growing, by the time a child born today graduates from college, the amount of knowledge in the world will be four times as great. By the time that child is fifty years old, it will be 32 times as great and 98% of everything known in the world will have been learned since the time he was born.*
>
> *Dr. Robert Helliard*
> *U.S. Federal Communications Commission*

Dr. Helliard's statement, made during the late 1970's, provides an important clue about the rate at which knowledge is expanding as a result of changes and advances in science and technology. His statement also raises some interesting questions for education.

More recently, John Naisbitt, in his book *Megatrends* (1984) revised upward Dr. Helliard's prediction. Naisbitt noted that

- 6,000 - 7,000 scientific articles are written every day,
- the doubling time for information is currently 5 years, and
- because of advances in science and technology, within the next few years the doubling time for information will be reduced to approximately 20 months.

Even if Naisbitt is only "near correct" in his estimates and predictions regarding the growth of knowledge, what does that tell us about the information commonly contained in the textbooks used in our nation's schools? If the textbook of today is the major source of information for our students, are we really sure that teachers of science and social science are actually teaching those subjects or are they, more accurately, teaching history?

If textbooks are outdated by the time they reach our nation's schools, then perhaps the best sources of up-to-date scientific information are the journals. Well...let's look at this point a bit closer. An article appearing in a scientific journal published this month was probably accepted for publication between 9 and 12 months ago. Prior to being accepted for publication, the article had to be reviewed by several readers, revised, and then resubmitted to the journal again. This process took anywhere from 4 to 8 months or more. If we consider that it might have taken 3 to 4 months to analyze the data collected and then to write the first draft of the article, this additional time must be added to the total process of having an article published in a professional journal. Thus, excluding the time needed to actually conduct the study, the complete process from data collection to the actual publication of the article in a scientific journal can easily take 2 or more years. If, as Naisbitt points out, the doubling time for information will shortly be a mere 20 months, it seems reasonable to expect that a good deal of the information published in professional journals in the not too distant future will be outdated before it reaches the reader. Today, scholars are increasingly relying on computers and computer networking to interact with their colleagues and to share information quickly.

A recent study conducted at Rutgers University (1983) has revised still upward the phenomenal rate at which scientific knowledge is growing. This study revealed that throughout the world

- there are currently 100,000 journals published in 110 scientific fields of specialization,
- 6 to 8 million articles are written each year, and
- 18 to 21 thousand articles are written each working day.

One must remember that as advances take place they also impact on the rate at which further advances occur and thus compound the information generation problem. Is there any wonder then, why it is becoming almost impossible to "cover" all the material you must include in the courses you teach within the time allowed?

While science and technology have given us tremendous power, we have also been charged with awesome responsibilities: to use that power and ability wisely; to make equitable decisions, and to make valid and just choices when there are no absolutely correct alternatives. Since many of our recent advances have forced us to pay a heavy price, we must question if we are using our new powers wisely. We are only now beginning to experience some of the adverse effects of our techno-scientific accomplishments:

- The world's natural resources are being rapidly depleted.
- Our planet's water and air are no longer pure and clean.
- Thousands of plant and animal species are threatened with extinction.

This in no way implies that we should try to halt the advancement of scientific and technological progress. However, we must remember, as Barry Commoner has stated, "There is no such thing as a free lunch."

Considering that today's youth will soon become society's decision-makers, the following questions become critical.

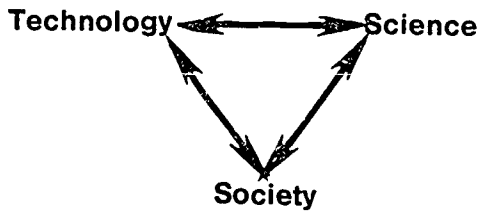
- Will they be capable of improving upon the decision-making of the past?
- Will they possess the skills and abilities needed to make effective, equitable, and long-range decisions to create a better world?
- How can we prepare youth **now** to deal effectively with the issues and challenges of the future?

If we are going to prepare today's youth to deal with the future, perhaps a good starting point would be to try to determine, to the best of our ability, what the future might be like. While no one has a crystal ball or the ability to predict with 100% accuracy what the next quarter century will bring about, there are strategies and methodologies for identifying trends and determining probable conditions that will most likely exist in the not too distant future.

In a recent review of the literature in future studies, highly respected futurists, such as the late Herman Kahn, Willis Harmon, Harold Shane, and others provide important clues as to what the next quarter century will be like. The following is a partial listing of their forecasts for the next twenty-five or so years:

- A continued acceleration in the rate of change.
- Greater complexities of life because of new technologies.
- An end to the hydrocarbon age.
- Continued overcrowding, overpopulation, and food shortages.
- Increased pressure for human equity in all areas.
- An increased demand from less developed countries for their share of the world's resources.
- Increased international disagreement and conflict.

Even a brief examination of this list reveals that the dominant issues of the future will focus on science, technology, and society. Moreover, the list indicates that science, technology, and society must now be viewed as a total interdependent system.




We are at last beginning to recognize that science cannot exist **solely** to advance scientific knowledge; technology cannot exist merely to advance technology. Rather, science and technology also have a major responsibility to society.

## SCIENCE EDUCATION FOR THE EIGHTIES AND BEYOND

During the latter part of 1982, the *National Science Teacher's Association (NSTA)* issued a major position statement: "Science-Technology-Society. Science Education for the 1980's." This proclamation, issued by our nation's largest and most influential professional organization in the field of science education, acknowledged the significant relationships among science, technology, and society, and stressed the importance of including science-technology-society issues in science curricula at all levels.

The *NSTA* position statement, which was endorsed unanimously by the *NSTA* Board of Directors, described the "scientifically and technologically literate" person as one who

- *uses science concepts, process skills, and values in making responsible everyday decisions;*
- *understands how society influences science and technology, as well as how science and technology influence society;*
- *understands that society controls science and technology through the allocation of resources;*
- *recognizes the limitations as well as the usefulness of science and technology in advancing human welfare;*

- *distinguishes between scientific evidence and personal opinion;*
- *recognizes the origin of science and understands that scientific knowledge is tentative and subject to change as evidence accumulates;*
- *understands the application of technology and the decisions entailed in the use of technology;*
- *has a richer and more exciting view of the world as a result of science education; and*
- *knows reliable sources of scientific and technological information and uses these sources in the process of decision-making.*

Then, in a bold and extremely important statement, the *NSTA* went on to recommend that, at the

- *senior high school level; a minimum of 20 % of science instruction should be directed toward science-related societal issues; and at the*
- *middle/junior high school levels; a minimum of 15 % of science instruction should be directed toward science-related societal issues.*

In other words, no less than one class period per week at the senior high school level, and nearly one class period per week at the middle/junior high school level, should be directed towards science instruction related to societal issues!

## PREPARING TODAY'S STUDENT FOR TOMORROW'S WORLD

In view of all that has been said thus far, what can be done to effectively prepare our students to function fully in **their** world - the world of the future?

The Swiss psychologist, Jean Piaget, spoke eloquently to this question when he stated his goals for education:

> *The principal goal of education is to create men who are capable of doing new things, not simply repeating what other generations have done - men who are creative, inventive, and discoverers. (Duckworth, 1964, pp. 1-5)*

In commenting on Piaget's first goal of education, Ed Labinowicz, in his informative volume, *The Piaget Primer. Thinking, Learning, Teaching* (1980, pp. 265-266), noted

> *Piaget's first goal for education is not to perpetuate the existing culture but to change it. Since the world is already changing rapidly, why be interested in more change? The changes to date have been largely technological advances. These, however, have been accompanied by an unprecedented number of problems such as pollution, overpopulation, depletion of non-renewable energy sources... Each of these problems is immersed in a complex web of social, political, and economic forces that cross natural boundary lines, and defy solutions. In turn these problems seem to be embedded in other larger ones.*
>
> *Piaget's first goal for education is to create men and women of vision, who can foresee problems and consider long term effects of their decisions, who are capable of considering abstractions and multiple variables at the same time that they exercise social responsibility in their decision-making. His goals focus on an alternative set of three R's that are basic to the human potential and essential to the quality of our survival:* ***reason,*** *self and mutual* ***respect,*** *and self and social* ***responsibility.***

Piaget's second goal for education provides still more important clues for preparing our students for the so-called "high-tech" world of tomorrow. In this goal, he speaks to the need for critical minds in the survival of a free society:

> *The second goal of education is to form minds that can be critical, can verify, and not accept everything they are offered. The great danger today is of slogans, collective opinions, ready made trends of thought. We have to be able to resist individually, to criticize, to distinguish between what is proven and what is not. So we need people who are active, who learn early to find out by themselves, who learn early to tell what is verifiable and what is simply the first idea to come to them. (Duckworth, 1964, pp.1-5).*

Clearly, information transfer, the dominant goal of instruction in secondary education for centuries, cannot meet the challenges of a modern, rapidly changing world. With the amount of knowledge in the world today, and the increased rate at which knowledge is accumulating, teachers cannot hope to give their students all the current information needed as quickly as it is needed. As we will see later in this guide, while transfer of knowledge is still important, it is pure folly to continue to attempt to simply give students all the information they will need. Information is becoming old and obsolete too quickly while, at the same time, new information and knowledge are being generated at an unprecedented rate.

Thus, to prepare youth to function as the future leaders of society, efforts must begin now to develop more enduring skills in our students - skills that can be applied to a variety of ever-changing conditions and situations in a world dominated by science and technology. These, we submit, include the increased development of the following.

- **logical reasoning** skills in dealing with problems containing multiple interacting variables (cognition),
- **critical-thinking** skills in the evaluation of consequences and implications of alternative actions (analytical/critical thinking),
- **problem-solving/decision-making** skills incorporating socio- ethical considerations and a wider societal perspective (social/ethical reasoning), and
- **knowledge** of the issues (both emerging and projected) at the interfaces of science technology-society (information and knowledge).

# SCIENCE-TECHNOLOGY-SOCIETY

## Audience and Program Usage

*Issues in Science-Technology-Society* (S-T-S) was designed for the junior/senior high school level as a supplement to existing programs in the areas of science and social studies education. Depending upon the students involved, the program can also be used with more capable younger students, as well as students well beyond the senior high school grades. Each of the modules included in the program is complete and independent and most of the chapters in the modules are independent and can, therefore, be taught or studied in any sequence selected by the teacher. This feature is particularly helpful when coordinating this supplementary program with an existing program of study. Of course, this program can stand on its own and be taught as a separate and distinct S-T-S program if so desired.

This program can be used in many ways. It could be used as a basal text for a course in S-T-S at any appropriate grade level. In this case, one would use the program in the same way that any other textbook is used. Hence, one would typically start with chapter one and move sequentially through the book chapter by chapter.

Another approach is to supplement existing courses in social studies and science by emphasizing those sections that apply directly to the course being used in the classroom and then moving more quickly - or even eliminating - those chapters that are not specifically related to the existing course of study. Still another method might be to teach the course in the way one might deal with current events in the classroom. That is, set aside one day per week to cover a current event dealing with S-T-S. One week the students could do most of the reading and in subsequent weeks they can do the activities. While this approach tends to result in somewhat of a disjointed approach, it can be effective when there is little other choice.

Highly capable students or highly motivated students enjoy using the program for science or social science enrichment. In these cases, the student(s) can work pretty much on their own with minimal help from you, the teacher. The text and activities stand on their own and work well in a variety of settings and with infinite variations. These are only a few of the typical configurations in which the program is used. There are many other arrangements as well. Use your imagination, creativity, and resourcefulness. As you come up with your own great ideas, let us know. This way we can share your ideas with others, too.

Teachers of specific disciplines (e.g., science, social studies, etc.) will probably want to slant the discussions and activities so as to focus more heavily on the content and skills considered important to their discipline. Thus, teachers of science might want to supplement the program with other readings focusing on the science concerns of the issue being studied. Likewise, teachers of social studies/science might want to focus more on the social concerns by supplementing the text with additional appropriate readings or articles. Of course, all teachers should strive to relate the S-T-S issues included in the student text to the existing curriculum and regular classroom textbooks in science and social science. Another exciting, challenging, but highly rewarding, approach is to "team teach" the course in which this program is used.

## Program Objectives

While the basic purpose of this program is to help students develop more mature mental structures, higher-order thinking skills, and a knowledge of present and emerging issues in S-T-S, specific objectives include the following:

— To increase student's knowledge about issues that interface science, technology, and society now and in the future.

- To increase student's ability to analyze issues that arise in our technological society.
- To increase the socio-scientific reasoning ability of students.
- To develop student's higher-order thinking skills, including problem-solving, decision-making, and critical analysis/thinking.
- To develop student's awareness of his/her role in the process of technological change.
- To help students recognize the complexity of decision-making in our high-tech world.
- To provide opportunities for students to examine possible future technologies brought about by advances in science, engineering, and societal changes.
- To increase student's ability to communicate more effectively orally and in writing.
- To increase student's ability to develop and present effective arguments in a logical, consistent, and comprehensive manner.
- To increase student's ability to read analytically and critically

## Theoretical Basis

The Socio-Scientific Reasoning Model was developed in response to the concerns noted in the introductory section of this guide. The model has served as a basic framework for the production of all of the curricular materials. It combines our philosophy, ideas, and research with the theories of Jean Piaget, Lawrence Kohlberg, Robert Sternberg, Robert Selman, Barry Beyer, and others. Basic to these theories is the idea that education should help an individual to grow intellectually, socially, and morally. Therefore, the Socio-Scientific Reasoning model approaches education from a developmental perspective and consists of three interacting components:

- Development of Mental Structures,
- Development of Thinking Skills, and
- Acquisition of Knowledge and Information.

The components of the model and the basic tenets of the theories upon which it has been built are summarized below.

### THE DEVELOPMENT OF MENTAL STRUCTURES

This component consists of three interacting sub-units. logical reasoning, socio-moral reasoning, and social role-taking.

#### Logical Reasoning

Jean Piaget has made important contributions in the area of cognitive development that are pertinent to our efforts (Piaget, 1958, Lickona, 1970, Gruber and Voneche, 1979). Piaget views the development of logical reasoning as the gradual progression through the series of stages indicated in Figure 1. At each successive stage of logical reasoning, individuals are capable of taking a broader perspective and incorporating an increased ability to deal with greater numbers of interacting variables of increasing intellectual complexity. Each stage of thinking builds upon the previous one, but takes on a new structural form. We have documented that growth in cognition can be facilitated and nurtured through appropriate educational experiences (Iozzi, 1982). It should be noted, however, that progression from one stage to the next does not occur in leaps and bounds, as the step-like portrayal of growth shown in Figure 1 might lead one to believe. Rather, growth from one stage to the next takes many years and then progress is a more gradual blending and smooth upward transition from stage to stage. Perhaps a more accurate representation of stage growth according to developmental theorists is represented in Figure 2.

Figure 1

PIAGET'S STAGES OF COGNITIVE DEVELOPMENT

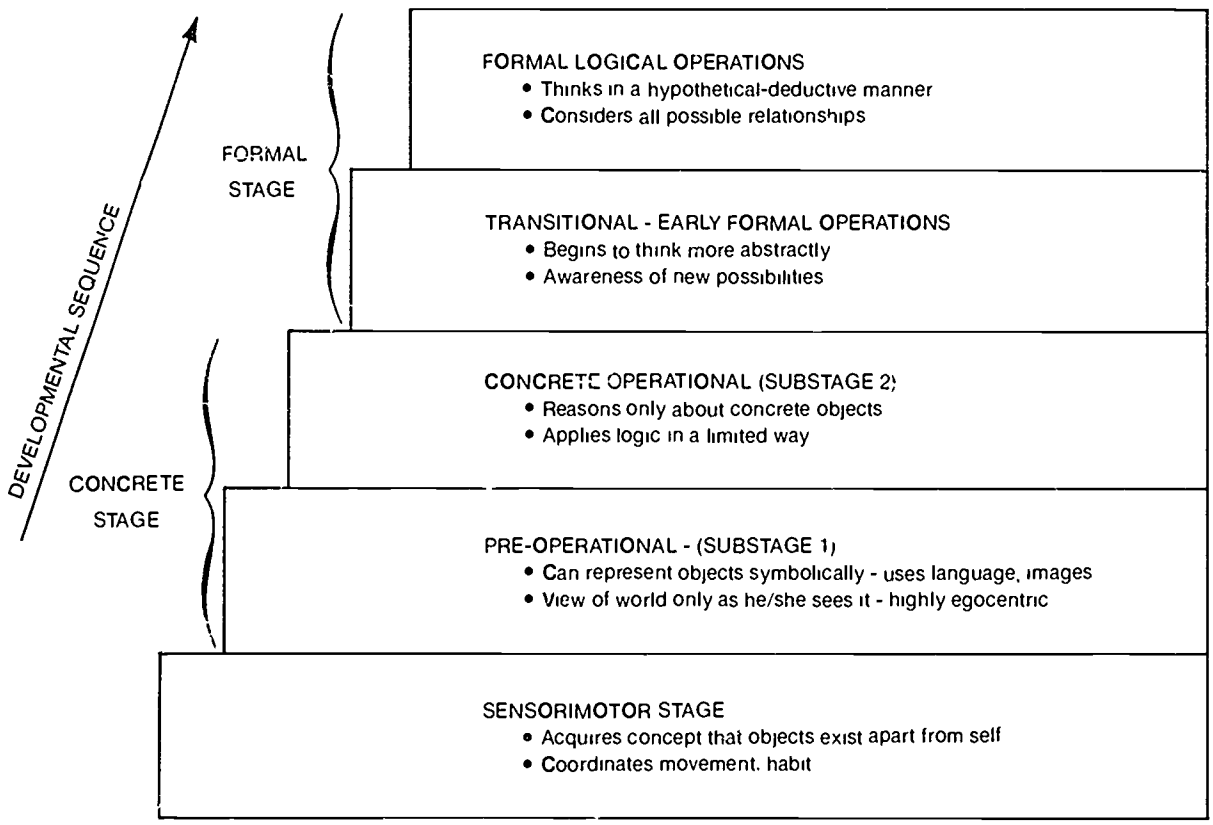
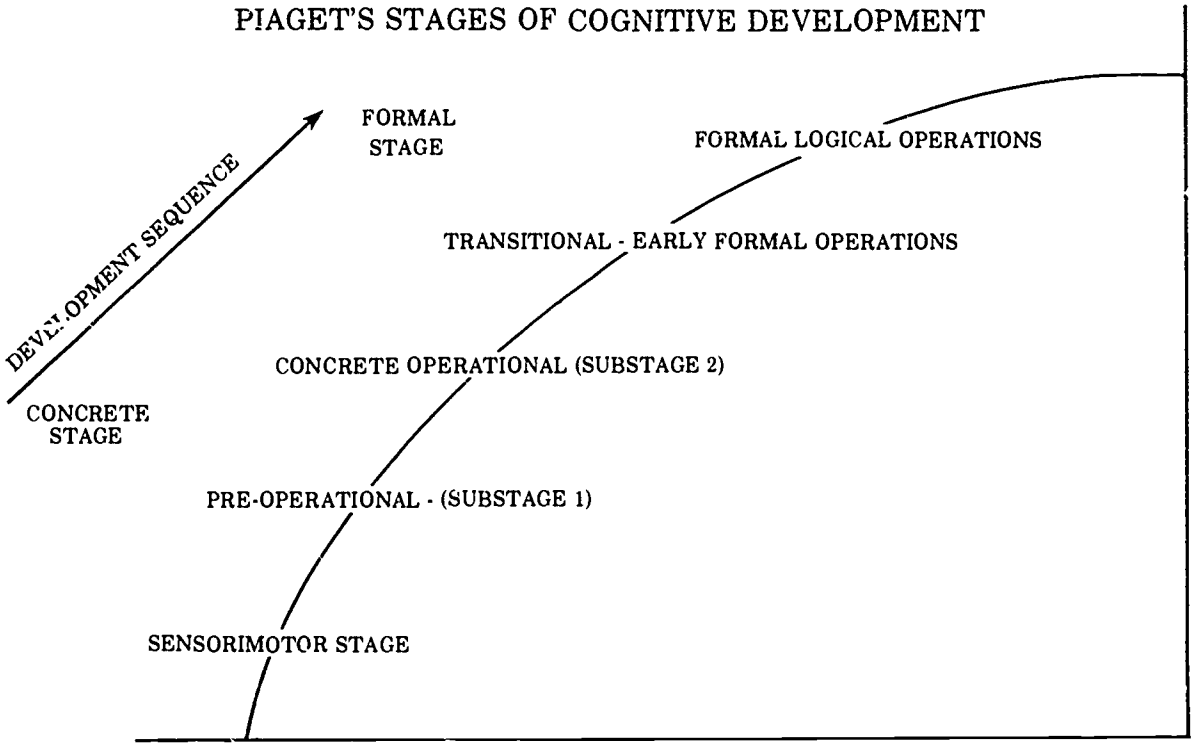



Figure 2

PIAGET'S STAGES OF COGNITIVE DEVELOPMENT



In explaining growth in logical reasoning ability, Piaget refers to the processes of assimilation, accommodation, and equilibration. **Assimilation** occurs when the child incorporates new ideas and situations into his or her existing thought structures. On the other hand, the child also encounters objects and events that do not fit into his/her existing thought structures. In these contradictory situations, the child has essentially two options: either enlarge his/her existing structures or create a new category or structure. Piaget defines this as the process of **accommodation.**

Intellectual growth, Piaget postulates, occurs when the individual attempts to resolve the tension between the interactive processes of assimilation and accommodation by developing new thoughts and responses that are more suitable or adequate. Equilibrium is re-established when thought structures are altered, producing new accommodations that enable the individual to assimilate the new situations. Intellectual growth, then, occurs through internal self-regulation processes that lead to new, higher levels of **equilibration.**

### Socio-moral Reasoning

While there are several approaches to values education, the more encompassing one is the cognitive developmental approach offered by Lawrence Kohlberg (Lickona, 1976, Gibbs, Kohlberg, Colby, and Speicher-Duben, 1976). Kohlberg's ideas are derived from the philosophic positions of Dewey and Piaget. The emphasis here is to help individuals grow intellectually, socially, and morally. The authors feel this is a more functional approach than arbitrary indoctrination of values as used in "character development" or "socialization" education or taking a "values relativity" stance, typically employed in the more common values clarification approach.

Kohlberg's moral/ethical development theory is an extension of Piaget's cognitive development theory. Like Piaget, Kohlberg views moral development from childhood to adulthood as the gradual progression through a series of stages (Figure 3). Each stage is characterized by a very different way of perceiving and interpreting one's experiences. At Kohlberg's stage 2, for example, "right" and "wrong" are judged in terms of satisfying one's own needs and sometimes the needs of others if it is convenient to do so. Stage 3 reasoning centers around maintenance of approval in one's own social group. The orientation is towards conformity to group expectations. At the higher principled stages, reasoning takes into account concerns for the welfare of others in a broader context, and includes such constitutional principles as human dignity, liberty, justice, and equality.

Following Piaget, Kohlberg views development not as mere accumulation of information, but changes in thinking capabilities (the structures of thought processes). In the course of development, higher-level thought structures are attained and result in the extension of an individual's social perspective and reasoning capabilities. Applying higher levels of thinking to problems results in problem solutions that have greater consistency and are more easily generalized.

### Social Role-taking

The research of Robert Selman (1976) indicates that social role-taking ability is a developed capacity that also progresses in a series of stages from early childhood through adolescence. Role-taking is viewed by Selman in terms of qualitative changes in the manner a child structures his/her understanding of the relationship between the perspectives of self and others.

Using the open-ended clinical method of inquiry first applied by Piaget and then later by Kohlberg, Selman has identified and defined Stages 0 through 4 (age range is approximately 3 years to 15 years). These stages are identified in Figure 4. Each of Selman's role taking stages relates closely to and parallels Kohlberg's moral reasoning stages.

Figure 3

KOHLBERG'S STAGES OF MORAL DEVELOPMENT

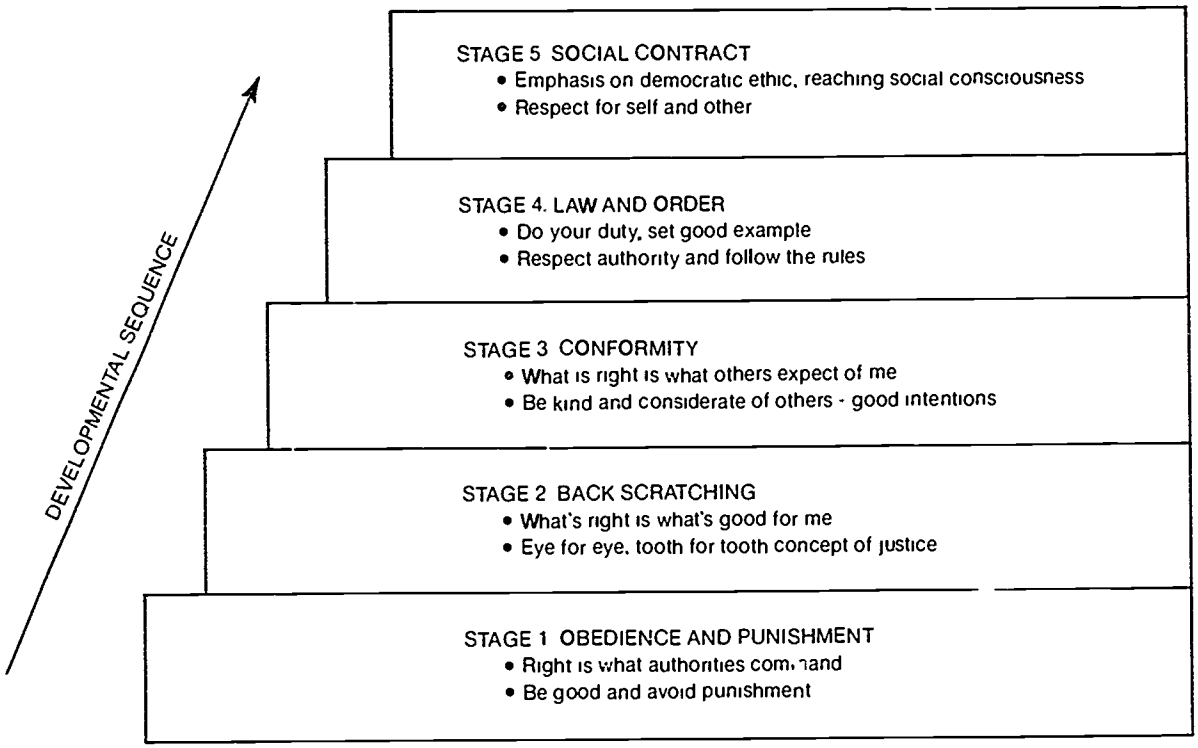
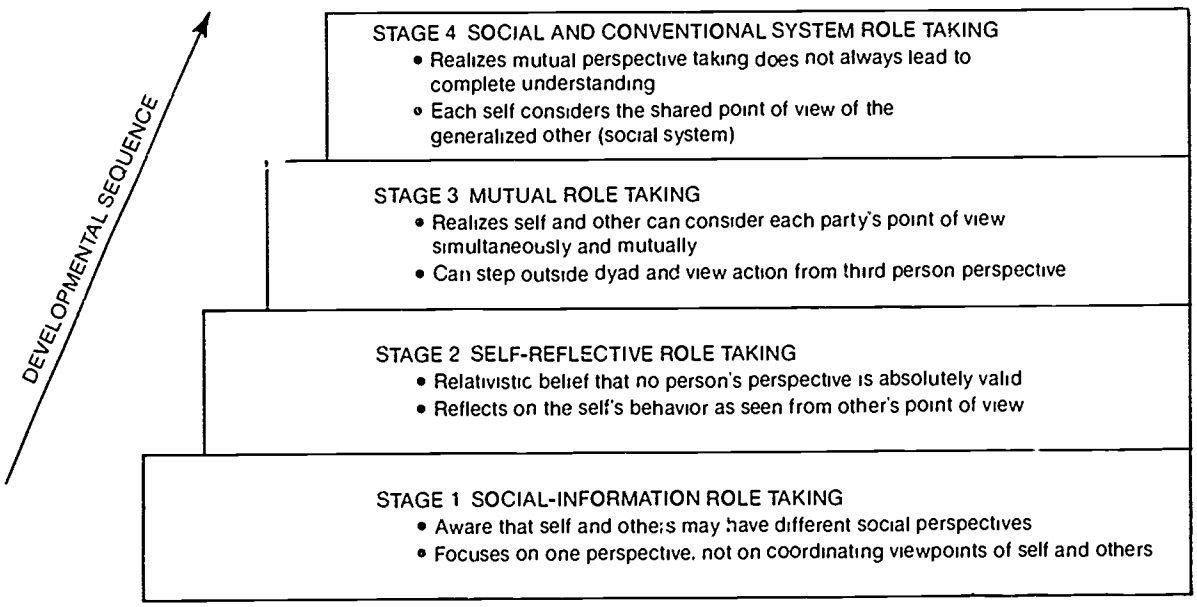



Figure 4

SELMAN'S ROLE-TAKING STAGES



Selman views the social role-taking stages as a link between Piaget's logical reasoning stages and Kohlberg's moral reasoning stages. Just as Piaget's logical reasoning stages are necessary but not sufficient for attaining the parallel moral reasoning stages, a similarly necessary but not sufficient relationship appears to exist between the social role-taking stages and parallel moral reasoning stages. As Selman has pointed out,

> *... the child's cognitive stage indicates his level of understanding of physical and logical problems, while his role-taking stage indicates his level of understanding of the nature of social relations, and his moral judgment stage indicates the manner in which he decides how to resolve social conflicts between people with different points of view.*

## THE DEVELOPMENT OF THINKING SKILLS

The second major component of the Socio-Scientific Reasoning Model deals with the development of thinking skills. For the most part, our concept of thinking skills and thinking skill development follows the ideas of Barry Beyer, Robert Sternberg, and Robert Ennis.

According to Beyer (1984) there are essentially three kinds of thinking skills:

- **discrete micro operations** - essentially those skills identified by Benjamin Bloom et al. in their *Taxonomy of Educational Objectives. The Cognitive Domain*;
- **broad general processes** - problem-solving and decision- making; and
- **critical thinking** - combination of discrete micro operations and broad general processes

The specific micro operations, general processes, and critical thinking skills emphasized can vary considerably, depending upon the topics (information) involved, grade levels, and other considerations related to the target audience for which the particular program or text is developed.

For us, critical thinking can be most simply defined as "rationally deciding what to do or what to believe" (Ennis). More specifically, some of the critical thinking skills we consider important in the area of science-technology-society, and therefore emphasize in this program, include the following:

- distinguishing between verifiable facts and values claims;
- determining the reliability of claims and sources of information;
- distinguishing between relevant and irrelevant information, claims, and reasoning,
- detecting biases; and
- recognizing logical inconsistencies in a line of reasoning.

Robert Sternberg (1985a, 1985b) has provided appreciable guidance regarding the types of educational activities important to developing thinking skills. These include, among others, an emphasis on problem identification/recognition (often an elusive task for students), real vs contrived problems, the nature of real problems, and various types of problem-solving experiences.

## THE AQUISITION OF KNOWLEDGE/INFORMATION

Acquiring knowledge and information about issues at the interfaces of science-technology-society comprises the third major component of the Socio-Scientific Reasoning model.

Our research has shown that information and knowledge about issues are critical for maximum growth in developing mental structures and thinking skills. The research and recommen-

dations of Beyer and Sternberg also underscore the importance of this component for maximum growth in problem-solving, decision-making, and in critical thinking. We have found that information

- helps one to relate more easily to the scenario or conditions surrounding a problem;
- helps clarify the problem situation;
- promotes rational, rather than emotional, decision-making;
- reduces biases in problem-solving and decision-making;
- helps the student to critically examine all aspects and elements of the problem situation, and
- makes one more aware of, and sensitive to, long- and short-term consequences of decisions.

In our work, we have chosen to include issues at the interfaces of science-technology-society for the knowledge and information component. Of course, one could just as easily utilize any other topics or issues one chooses.

## PUTTING IT ALL TOGETHER

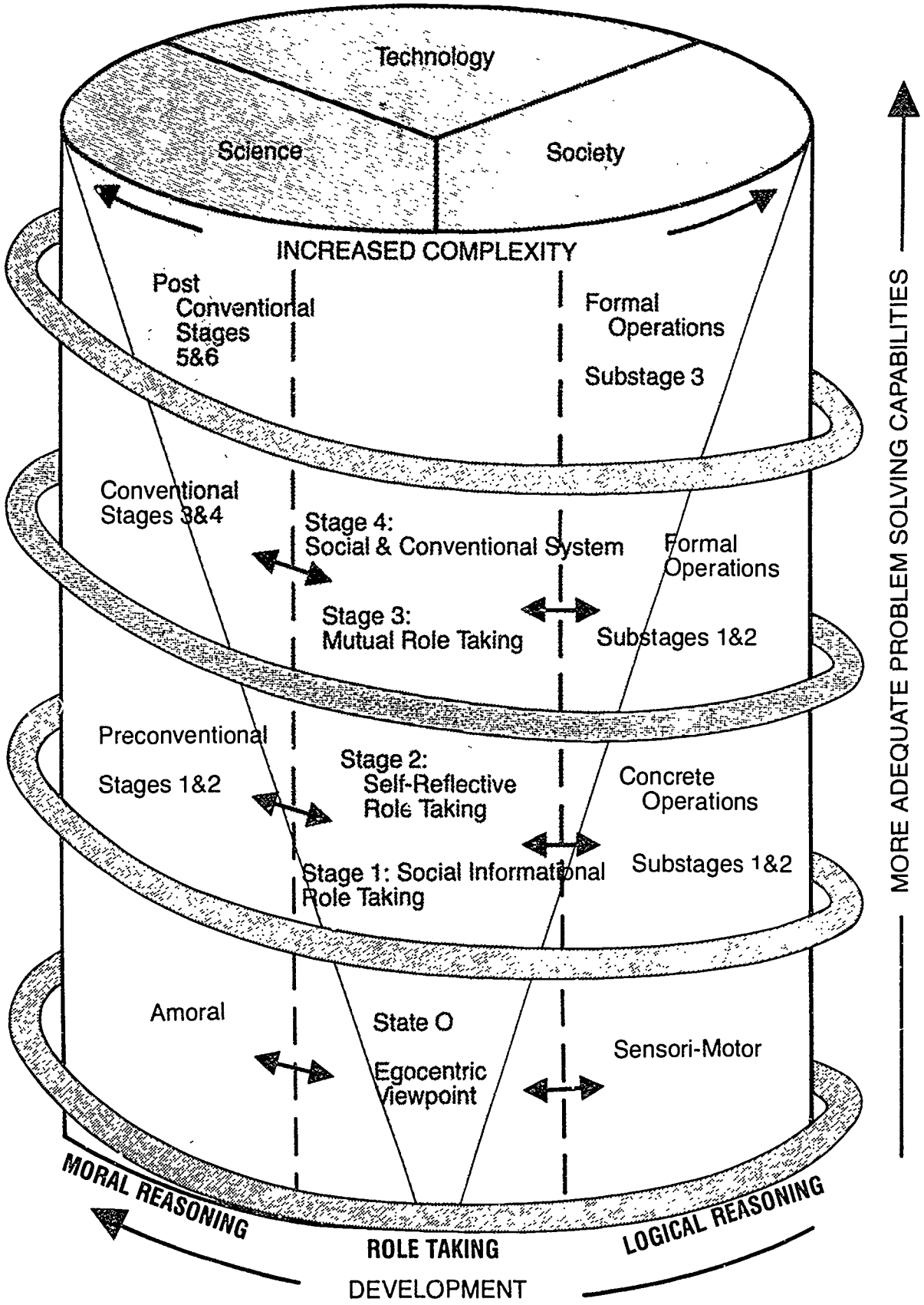
The basic assumption of the Socio-Scientific Reasoning Model is that effective problem-solving requires the simultaneous development of mental structures, thinking skills, and a content (knowledge and information) base. Purely objective scientific thinking cannot always be applied in the resolution of problems society will likely face in the future. Resolution of these problems requires a regard for the impact of those decisions on human needs and on human goals. Our schools need to prepare students for the real world with its "messy" problems, not just for the neatly packaged world so often presented as examples in textbooks. For example, a technological solution may be scientifically feasible and logically consistent. From a societal perspective, however, we must question whether that solution should be applied. Prioritizing our needs and evaluating trade-offs with a concern for the needs of future generations involves not only logical reasoning, knowledge of the issue or problem, and analytical and/or critical thinking, but also the inclusion of a values dimension.

Because of the complexities of illustrating the three interacting components and the several sub-components of the Socio-Scientific Reasoning Model, only two of the three components are shown in Figure 5 -- Mental Structures and Knowledge. From this illustration it can be seen that the Mental Structures component is comprised of three parts: logical reasoning, social role-taking, and socio-moral reasoning. The knowledge component also consists of three interacting subunits. Just as in the real world, these subunits - science, technology, and society - are interdependent and rely on each other for their very existence. While each of the subunits is dependent upon the others, their individual underlying value structures create a high potential for discord since the concerns of one subunit often conflict with those of the others. This paradox - dependence and simultaneous conflict among the subunits - presents a unique opportunity and context for curriculum developers employing the Socio- Scientific Reasoning Model to develop educational experiences and to prepare educational materials.

Referring to Figure 5, the content cone representing the information/knowledge component is small at the lower end because at earlier stages of development the number of concepts entertained is smaller and the concepts are simple in nature. As one moves higher, the cone broadens as does the complexity of content or information included. Thus, individuals operating at the stages of development depicted at the lower end of the cone can deal with fewer and simpler issues and concepts, while individuals at the upper end with higher levels of maturity have the capacity for dealing with multiple issues of greater complexity. Thus development is both vertical and horizontal. Vertical development is from lower to higher stages, whereas,

Figure 5

THE SOCIO-SCIENTIFIC REASONING MODEL



horizontal development relates to the "necessary but not sufficient" requirements that must be satisfied as one moves from logical reasoning, through social role-taking, to socio-moral reasoning capabilities (see Selman in previous section).

While each stage reflects a distinctly unique capability for problem-solving in a science-technology-society context, we view development or progress as a conti. sly spiraling process. In this process there are no leaps, and a fixation at any stage is possible. Levels of logical reasoning, socio-moral reasoning, and socio-role-taking maturity seem to vary with the issues addressed. These apparent inconsistencies in reasoning - even when dealing with the same or similar mental and moral constructs - seem to be related to the degree of emotionality, familiarity with, interest in, and/or knowledge about the issues under consideration (Iozzi, 1976, Rosenbaum, 1987).

The goal is to help each individual spiral upwards through the Socio-Scientific Reasoning cone and synchronously achieve "more adequate" reasoning ability. Higher stages of reasoning ability allow students to generate more encompassing and more easily generalized solutions to problems of higher complexity.

Another way of looking at the components of the Socio-Scientific Reasoning Model is represented by Figure 6. This figure includes the third component of the model - the development of thinking skills. It should also be noted that this figure illustrates how the Socio-Scientific Reasoning Model was used to guide the development of this curriculum. Because of the difficulties in trying to represent a "cone within a cube", the knowledge component has been represented, in this illustration, as the top face of the cube, while the side represents the thinking skills component. The "front face" of the cube represents the development of mental structures and reasoning exactly as it does in Figure 5.

In examining Figure 6, it should be noted that only the stages dealt with in this program (e.g., concrete operations, substage 1, social information, and pre-conventional moral reasoning) are represented. Lower stages are more appropriate for young children and, therefore, are not included here. Similarly, all of the thinking skills one could include are not represented in the figure. Rather, only those that are emphasized in this specific program (skills most appropriate for grades 9 through 12) are represented. The knowledge component identifies some of the specific topics included in the study of issues in Science-Technology-Society.

It should be remembered that even though the "conical" representation of the knowledge component illustrated in Figure 5 is here represented by t. "top of the cube", the goal is still to help each individual "spiral" upwards through the stages.

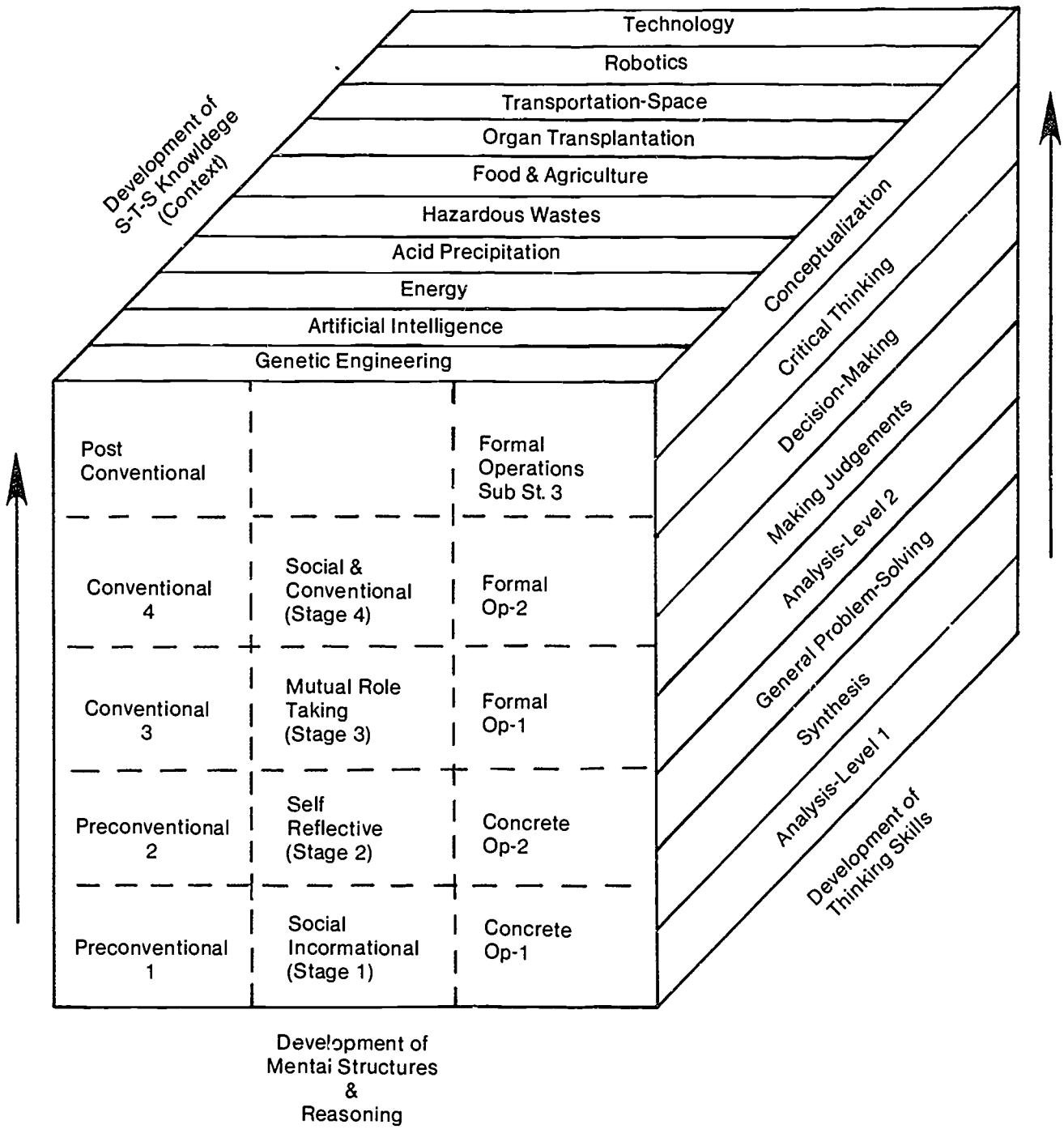
## Using the Socio-Scientific Reasoning Model to Guide Educational Experiences

In order that students may grow intellectually, the Socio-Scientific Reasoning Model serves as the basis for identifying and/or guiding the development of learning and identifying the appropriate type and level of skill development experience. It recognizes that learning capabilities differ with age, grade level, interest, and learning needs. Implicit in the model and in accord with stage theory is the idea that at each stage there is a characteristic form of thinking capability that determines how experiences and information are integrated and acted upon.

The main strategy underlying all of these activities is based on Piaget's concept of **equilibration**. It is only when **disequilibrium** is created that active restructuring of thought takes place. This active restructuring leads to growth in logical reasoning, in social role-taking, and in socio-moral reasoning capabilities. It is also very important for developing higher-order thinking skills.

Restructuring of existing cognitive structures occurs when internal disequilibrium is felt by the

Figure 6
THE SOCIO SCIENTIFIC REASONING MODULE (Cont'd)



individual. New experiences and inputs that are not readily comprehensible to the individual challenge their existing mode of thought by revealing inadequacies or inconsistencies in their problem-solving strategies. Arrestment at a given stage is partially explained by the developmental theorists as the lack of opportunities that create conflict or dissonance, which places the individual in a position where he/she needs to assess his/her particular mode of thinking. Perhaps, as Clive Beck points out, the reason why people do not progress to higher stages morally is because they have not had the opportunity to entertain alternatives - their imaginations have not been extended (Beck, 1972). We additionally contend that the reason people do not advance in logical reasoning nor develop higher-order thinking skills is also attributable, to a large degree, to a similar lack of opportunities.

We have identified several basic elements needed to provide experiential opportunities that promote development of problem- solving, decision-making, and critical-thinking skills. A partial list includes providing opportunities for students to

- encounter a variety of viewpoints,
- experience higher-level reasoning and thinking,
- take the perspective of others,
- examine and clarify one's own ideas,
- examine the consequences and implications of one's decisions,
- defend one's own position,
- evaluate possible alternatives,
- consider and recognize the role of the self to society,
- reflect on one's own value system, and
- test one's own ideas and those of others.

These, as well as many others, are included in the activities throughout the program. For example, we have taken simulations, debates, problem-solving activities, and decision-making activities and developed variations and extensions to more systematically encompass critical analysis and evaluation of information and data. We have also included role-taking, futures forecasting strategies, scenario-writing, and other analytical methodologies in the program.

Effective discussion cannot take place in a vacuum. Needed also is a data base or context from which students can begin to analyze and evaluate information. Using information which they have extracted and synthesized from the program, additional ideas and rational arguments can be developed for discussion and/or debate. For curriculum activities, we have created problem situations in a variety of contexts which will be prominent in the next quarter century and beyond (Shane, 1977). This adds a futuristic perspective to the approach and serves as mechanisms for students to put some of the ideas and judgments that have emanated from the discussion into larger structural frameworks. Activities also provide students with opportunities to project into the future, to think beyond their own immediate experiences, and to consider the impact of different decisions on future society.

# APPROACH

Consistent with the Socio-Scientific Reasoning Model, each activity seeks to develop

- knowledge/information about S-T-S issues,
- mental structures, and
- thinking skills.

The program includes readings to help develop a knowledge or information base and, to some extent, reasoning and thinking skills. The various activities provide opportunities for students to develop mental structures and reasoning thinking skills, and to use the knowledge acquired in meaningful situations.

Even though today's students were born into a world of rapid change, most do not realize the breadth and depth of the change and the consequent impact on their lives. In order to assist students in dealing with the complexities of rapid change, employs a variety of strategies to transform complex issues into concrete situations. These strategies include scenario writing, simulations, role-play and a variety of problem-solving techniques.

In concrete and frequently in real life situations, students can actively participate in the exploration of the various concepts. Activities begin at a level students can readily comprehend; then, as the issues are pursued in greater depth, more sophisticated concepts are entertained. The ultimate levels of complexity attained depend solely upon the student's ability, maturity, degree of involvement and interest.

Students need experiences that challenge their existing ideas in order to develop higher-order mental structures. Such experiences are gained through dynamic dialogue with other classmates. Several of the activities place the students in adversarial positions or in role positions that do not necessarily reflect their personal perceptions and feelings. This creates opportunities for students to constructively argue with one another and with themselves. In each case, the student should be able to grasp the problem at hand and investigate it at a level of complexity consistent with his/her level of cognitive, moral, and social development.

If the students have had few experiences with open-ended activities and discussions characteristic of this program, they may initially experience some uneasiness. Students will press you for the "correct" answers when, in fact, there generally are none. Once they recognize your role as an observer and catalyst and not as a provider of information, they will resort to their own resources and begin to make decisions on their own. The activities provide ample guidance throughout the program to help facilitate this growth.

While the chapters in the Student Guides deal with different issues and utilize different strategies to deal with those issues, certain aspects of the program have common dimensions. For example, readings we used to provide information. Likewise, most activities involve dialogue, discussion, and questioning. Some activities utilize exercises to help improve oral and written communications skills. Rather than repeat the same suggestions for each chapter in which a particular activity is used, the following section will deal with those comments and suggestions that are common to several, sometimes all, of the modules. These include "Readings", "Classroom Discussion and Questioning Strategies", "Writing Activities", "Scenario/Dilemma Discussions", "Debates", and "Classroom Atmosphere and the Role of the Teacher". Specific chapter-by-chapter teaching suggestions are provided in the guides for each module.

## Readings

Consistent with the Socio-Scientific Reasoning Model, the readings are designed to help the students develop a knowledge of S-T-S issues. The readings provide students with enough

background information to acquaint them with the issues and help them begin to explore and analyze the situation presented. We have found that the more students know about the issue being investigated, the more easily they relate to the problems posed by that issue. Moreover, the greater the knowledge students have upon which to base their reasoning and judgments, the greater the likelihood that decisions will be based upon rational rather than emotional processes.

**NOTE - Determine if there are words or concepts that may be unfamiliar to your students. These should be defined and discussed so that the students can more easily grasp the essence of the problem under investigation.**

The background readings also help to bridge the gap between the real world and the classroom. Most of the activities included in this program are based on real life situations and problems that come about as a result of our scientific and technological advancements. The readings are designed to stimulate thinking and assist the students in formulating their own personal views regarding the situations presented.

**NOTE - If you have readings that you feel are more pertinent or appropriate, use them in place of those included in the Student Guide.**

The background readings provided in this program should be considered only a beginning. Many teachers find it desirable to include additional materials as the need arises. If, in your judgment, you have more suitable readings or articles for your students, do not hesitate to substitute or supplement what has been included in the Student Guide. This is particularly important if you are using this program in conjunction with an existing science program or social studies program. For example, if the program is being used to supplement an existing social studies program, you might substitute/supplement the reading provided with pages or chapters from the regular Student Guide or other articles that focus upon the social concerns of S-T-S. On the other hand, if you are a teacher of science, you could similarly supplement the readings included in this program with articles that highlight or add a greater science emphasis.

Some teachers have asked, "what should we do if our students have difficulty with or can't read the Student Guide?" In our experience with using this program in a variety of settings, this has not been a significant problem. As discussed in a previous section of this guide, students can be guided through the reading of the text by the teacher or even a more capable student if time and circumstances permit. The text can also be read orally by the teacher or more capable students while the poorer reader follows along in his/her text. These approaches, while a little more time-consuming, tend to help poor readers improve their reading ability. On the other hand, the most common approach taken by teachers with students who are unable to read the text is to use the book for developing good, key, or leading questions to help guide a lively discussion of the issue. During the course of discussing those questions, the information provided in the readings is emphasized. In this case, the Student Guide serves mainly as a guide for the teacher and a resource for the student. If the text is used in this manner, the student should still have his/her own book to follow along as much as possible and to serve as a reference for completing the various activities in the program. Some teachers might also want to assign the readings for homework or some other time when the student might have more time to read the articles.

When students' reading skills have not been developed to a level that will enable them to adequately profit from the readings, you might choose to help the student along using oral reading techniques for the most important sections of the readings. If the reading level of the student is far below that which is necessary to deal with the articles in the Student Guide, you might find it helpful to use the readings as your lecture notes and extend the discussion of the topic sufficiently to ensure at least a minimal degree of understanding. This technique has been used

very effectively in teaching this program, as well as many others currently in use in our nation's schools.

The readings pose various questions to the students. It is important that students address these questions as they arise before going on with the article. The questions are included to promote analytical and critical thought. During the classroom discussion of the readings, you should go over these questions with the class and stimulate discussion of both questions and the responses they elicit in order to help

- highlight important concerns,
- encourage students to analyze and synthesize information,
- promote thinking about the issue being studied, and
- serve as a model to help students begin to read analytically and critically.

Of course, the questions included as part of the readings are by no means the only questions one should include in a classroom discussion. They are only a start. Use your own skills and creativity to supplement the questions included in the text.

## THE DEVELOPMENT OF CRITICAL THINKING SKILLS THROUGH READING

The development of critical thinking skills, a major objective of this program, can be enhanced dramatically through the use of the readings included in the Student Guide. An important aspect of thinking critically is reading critically. Harris and Hodges in *The Dictionary of Reading and Related Terms* defines critical reading as

1. the process of making judgments in reading, evaluating relevancy and adequacy of what is read;
2. an act of reading in which a questioning attitude, logical analysis, and inferences are used to judge the worth of what is read according to an established standard; and
3. the judgment of validity or worth of what is read, based on sound criteria of standards developed through previous experiences.

Some of the major skills that are important to the development and maintenance of critical reading (and consequently critical thinking) include

- distinguishing between relevant and irrelevant details,
- determining main idea/supporting information,
- drawing conclusions,
- determining the author's purpose and nature,
- understanding cause-effect relationships,
- comparing and contrasting, and
- making judgments.

Students in grades 9 through 12 need development and reinforcement of skills which go beyond recall and comprehension and, instead, move towards the preceding higher-level skills.

Program materials provide readings and activities for the students in an attempt to develop an interactive process. This process involves both critical reading and thinking about the information that is being presented. Through the use of the reading materials in the Student Guide, students will be exposed to these higher-level skills and have the opportunity to apply them to various types of activities.

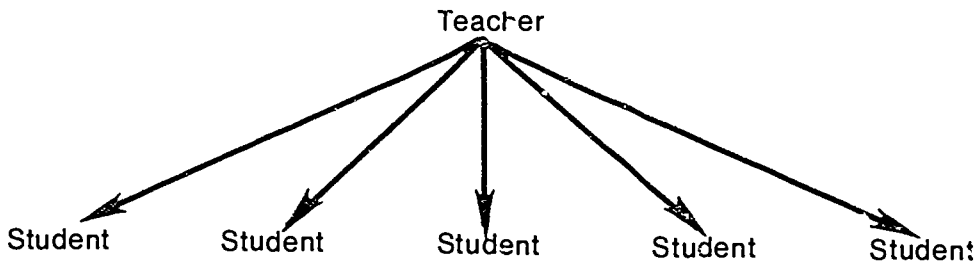
In your use of the reading materials included in this program, you should strive to focus upon developing higher-level thinking skills by providing opportunities for the students to engage in the following types of activities/exercises related to the readings (adapted from *Improving Students' Abilities to Read and Think*, 1985):

- **Distinguishing between relevant and irrelevant information**
  Students determine whether information is relevant or irrelevant according to the specific information presented. This requires
  - locating information from the readings,
  - listing the parameters of the concept,
  - clarifying and defining the concept, and
  - comparing information within the established parameters of the concept.
- **Determining main idea/supporting details**
  Students develop their own concepts and ideas from facts and details presented in the reading. This requires
  - locating and categorizing information,
  - determining weight of information,
  - analyzing and comparing information, and
  - making generalizations about the presented information.
- **Drawing conclusions**
  Students infer from the details in the readings and discussion and use prior knowledge to draw a conclusion. This requires
  - identifying main characters and relevant and irrelevant information,
  - categorizing the information,
  - analyzing concepts and categories, and
  - synthesizing relevant information with prior knowledge to develop logical general stances.
- **Determining author's purpose and motive**
  Students infer the purpose and motive of the author through interaction with the reading material. This requires
  - locating and categorizing information,
  - analyzing information through comparisons,
  - identifying causal relationships,
  - developing concepts from specific information and details, and
  - evaluating the concepts.
- **Understanding cause-effect relationships**
  Students locate and identify causal relationships from the information presented in the readings. This requires
  - identifying details and signal words from information,
  - making predictions from information and prior knowledge,
  - understanding relationships of multiple variables and actions,
  - analyzing relationships between events, and
  - developing new concepts based on cause and effect relationships.

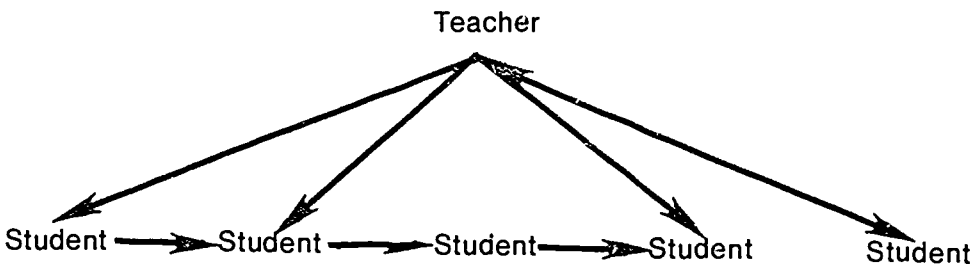
- **Comparing and contrasting**
  Students compare and contrast data by locating and categorizing various types of information. This requires
  - understanding the definitions and parameters of words, categories, and concepts,
  - making analogies between data, and
  - drawing relationships between two or more concepts or categories.
- **Making judgments**
  Students make judgments based on an analysis and evaluation of the data presented in the readings. This requires
  - identifying relevant and irrelevant information,
  - categorizing information and concepts within established parameters,
  - identifying discrepancies between existing information and results and desired information and results, and
  - judging how closely the existing and desired information and results are related.

## Classroom Discussion Activities and Questioning Strategies

Nearly all of the S-T-S activities place a heavy emphasis on discussion between teacher and student and among students. Usually, in typical secondary school classrooms, most of the discussion takes place between the teacher and one student at a time. The conversation tends to move back and forth between the teacher and a student. One could compare this type of classroom discussion to a game of ping-pong in which the ball moves back and forth between two people.




In contrast, most of the activities included in this program require an approach in which the teacher is one of many people involved in a dialogue/discussion. This type of discussion, which can be compared to a basketball game, has been found to be much more meaningful and effective than the "ping-pong" approach.




As can be seen from this diagram, the teacher plays an important role as a catalyst, interjecting appropriate comments, suggestions, questions, etc., to stimulate thinking and further student-to-student interaction. In this case the students are interacting much more with each other, elaborating upon each others' comments, criticizing them, and adding to them, etc.

In a "basketball" type of discussion, the teacher has two important tasks to keep the discussion moving and on track: (1) to guide the students to explore ideas they may not have considered, and (2) to challenge and to promote higher-level reasoning. During classroom discussions, the use of various types of probe questions is extremely important. Fenton, et al. (1974) have provided useful guidance relative to different types of "probe" questions:

- **Clarifying probe** — Asking student to explain what he/she means in his/her statement. "What do you mean when you say Scientists shouldn't 'mess around' with genes?"
- **Perception-checking probe** — Determining whether the student understands a statement made by another individual. "Barbara, can you explain to us what Joe has just said?"
- **Examining student thinking on the major issue** — "Why should government establish standards for air quality? What guidelines should be taken into account?"
- **Inter-issue probe** — Resolving conflict when two or more issues conflict or appear to be at odds. "Should a richer country be allowed to use a greater share of the Earth's resources?"
- **Role-switch probe** — Placing the student in the position of someone involved in the scenario or problem under discussion. "What would you do if you had to make that decision?"
- **Universal consequences probe** — Considering the implication of the judgment made when applied to everyone. "What might happen if every household was required to reduce its use of electricity by 30 percent? Is it fair to place such demands on everyone?"

  **Reason-seeking probe** — This means, "How do you come to that conclusion?" or simply, "Why?"

Other types of useful questions that should be used more in our teaching include

*Tell me more about...?*

*What else might happen if...?*

*If... then...?*

*How did you arrive at your answer?*

*What made you ask that question?*

*Why do you say that?*

*How did you think of that idea?*

It is also important to ask students to give evidence for their conclusions, underlying assumptions upon which they are operating, counter examples, analogies, advantages, disadvantages, etc.

Questioning along these lines will lead students to broaden their scope of thinking and to evaluate the effects and consequences of different problem solutions. This approach also offers opportunities to see how others might think about the same issues and challenge them to consider all sides of the issue under investigation or discussion.

A further important task of the teacher is to "referee" the basketball game — to act as a buffer in order to protect a student offering a controversial or divergent point of view who may be "fouled" by others in the group.

It is recommended that many discussions be conducted in small groups rather than with an entire class. Students are often more willing to speak out in small, rather than, large groups. This approach offers individuals opportunities to speak out and places greater responsibility on each person to contribute his/her share to the group's activities. The sense of informality in

a small group allows for entertaining unique or unusual ideas that students may be hesitant to bring out in a large group for fear of ridicule or "put down". Moreover, small groups encourage less forceful students to contribute more easily to classroom activities.

Grouping can be based on whatever criteria you consider important. All of the S-T-S activities included can work equally well with homogeneous or heterogeneous grouping. Each of these grouping schemes has advantages and disadvantages. Teachers should select the grouping mode according to their needs and preferences.

## Writing Activities

Helping students to improve their writing skills should be an important objective for all teachers - not just teachers of language arts. When the science and/or social studies teacher includes activities that systematically require the student to write and speak, there is clear evidence that the material being studied is better learned, understood, and applied (Holdzkom, Reed, Porter, Rubin, 1983).

The systematic or routine use of writing in all classrooms is also important because it helps to develop higher-order thinking skills. The process of first structuring one's thoughts into a scenario, essay, short story, etc., takes the student through several levels of thinking. Brainstorming, selection of ideas, reflecting and expanding information to support hypotheses, evaluation, and so on, all serve to help develop the student's ability to think logically and critically.

When using writing activities, it is useful to consider writing a **process** and not merely a product. Reseachers in the field of language arts development have proposed a five-step process for developing writing skills and, subsequently, several thinking skills.

**Pre-writing.** The preliminary activities, such as brainstorming or generating lists. This is, essentially, a rehearsal period in which ideas are generated.

**Drafting.** During this step, the writer uses the information generated during the previous (pre-writing) stage to draft the composition. At this point, the important thing is to compose without worrying too much about grammar, spelling, sentence structure, etc. The idea is simply to "get it down on paper"; refinements will come later.

**Revising.** This is the step in which the writing completed in the drafting stage is refined a bit further. This is the time to focus upon improving the clarity and meaning of the material.

**Editing.** This fourth step in the writing process requires the writer to proofread the document and to correct spelling, grammar, sentence structure, re-phrasing, and completing what is essentially the "finished product".

**Post-writing.** During this essential phase in the writing process, the manuscript is "turned in to the teacher" for review or evaluation, or filed for future reference or, perhaps, publication.

Throughout this process, the teacher should provide suggestions and guidance. They should ask the student to consider alternatives and encourages them to consider the audience and the purpose for the writing (e.g., to describe, to prescribe, to explore, to tell, and so on). The several types of questions discussed and described in the previous section of this guide are helpful for developing not only oral communication but written communication as well. These examples should prove helpful in teaching and guiding your students through the writing process and thus developing these essential skills.

## SCENARIO-WRITING

The term "scenario" was used to describe a type of comedy play developed by medieval Italian actors. The scenario was the written plot but contained no set dialogue. The actors simply improvised the dialogue when they acted out their roles as outlined. In the motion picture business scenarios have come to mean a plot, a screenplay or the script.

In more recent years the scenario has acquired a new meaning. It describes a tool/technique used by planners, futurists, businessmen and other types of decision makers to help them examine a future possibility in greater detail. The scenario serves as an interesting, flexible and creative way to project into the future and explore possibilities and different alternatives. It is, in essence, a story describing a future event. Scenarios examine the series of steps leading to a future goal or investigate effects of different decisions. They help the writer or policymaker to make better decisions because they force him/her to consider how changes interact with other changes in a more dynamic manner, through descriptions of the effects and consequences of the future possibilities. By working out the details of the interaction, the future situation becomes clearer, and one can begin to identify relationships that have not been considered before.

A scenario is a short story or a description of a possible event or action. It is a useful exercise to explore new or different ideas. In writing a scenario one takes an idea and follows where that idea might lead. It is like asking the question, "What would happen if I did this?" One tries to think of the many effects of a certain decision and the kinds of changes that might take place. One type of change may cause other changes. When one starts thinking about the changes that might occur, a new scene unfolds - a scenario story.

A scenario is more than just a **list** of changes or effects. It tries to tie in the different and possible kinds of changes and weave together a complete story. Many people develop scenarios to help them make future decisions. With a scenario, one can begin to picture new or different ideas more completely because many effects are being examined at one time.

For example, if one wanted to establish a space community one would want to think about all that is required and plan to meet those needs. The scenario's description might include the number and kinds of people living there, the work to be done, kinds of food and housing, what people would do for recreation, and so on. One might decide that all the work would be done by robots. What then would the humans do? Would all the free time be used for such activities as playing baseball, watching television, painting, composing music, hobbies? Will the people have enough to do to keep them busy? Would they become bored and lazy? What are the advantages of using robots? What are the disadvantages of using robots?

When writing a scenario, one typically begins by asking the questions, "What if...?" One possible change leads to other changes and the scenario story unfolds. Your scenario can be presented in a number of different ways: a science fiction story, a short skit, a planning diagram, visionary drawings, a cartoon story or even a simple outline of events. The main purpose is to explore alternative possibilities and show where they might lead. It allows you to test the different underlying assumptions and values of a future goal.

Scenarios are sometimes used as a planning guide. One may determine one's goals for the future and use the scenario to lay out the steps necessary to get there. For example, if one's goal were to establish a community in space, the scenario should describe how the community functions. The descriptions would include the number and types of people living there; the work that will be done; the kinds of food and shelter needed; the methods for obtaining supplies; types of leisure activities; the possible effects of living in outer space; and so on. As problems and needs begin to emerge, the planner will have a framework from which to work out the necessary details and consider the different ways to create a space community.

Scenarios are also used to examine the effects of decisions. Different decisions lead to different futures. The scenarios in this case would describe where a particular decision will lead. By looking at that possible end result, one can perhaps decide better whether that's the change one wants.

Science fiction is one form of scenario writing. Some writers base their scenes on today's current trends and try to project what the future holds if the trends continue. Jules Verne in the 1800's accurately predicted the existence submarines, airplanes, and spaceships for the future. Other writers have suggested new and different styles of living. For example, societies where everyone is identical and people live free from conflict and competition, such as Aldous Huxley's *Brave New World*. Others have used their stories to point out in a more diametric way the problems of our current society. In all cases, science fiction writers tested new visions by letting their imaginations explore different and unusual ideas.

Here are some helpful questions to guide your students in scenario writing.

- *What are the main ideas of the situation?*

  *What are some of the known facts or trends which might support your ideas?*

  *How well does the story hold together? Does one idea relate to another to build a complete story?*

  *Do you have any suggestions about how a different problem might be solved?*

  *Are your arguments well presented? How might you make your ideas more believable?*

  *Is the scenario intriguing to the reader?*

When writing scenarios, it is sometimes difficult to think hypothetically because our thinking is so influenced by what we know and what we have experienced. For this reason, scenario writing may be facilitated when conducted as a group activity which allows for the generation of a number of different ideas from a number of different sources.

One way of generating different and unusual ideas in group situations is brainstorming. This technique is usually approached through first posing a question. Each person, in turn, contributes an idea until all possible ideas seem to be exhausted. One person's idea often leads to other ideas. Ideas may result from combining several ideas. The important rule for brainstorming is to reserve judgment. **No one should critically comment on another person's idea.** Each and every idea is treated equally, no matter how far-fetched it may seem. Have one person record the ideas. At the end of the session, the list is read aloud and the group decides which ideas are more interesting, practical, or feasible to incorporate into the scenario.

## Conducting Scenario/Dilemma Discussions

One of the major activities throughout the program centers around the scenario or dilemma discussion. It is important to employ systematic and sensitive techniques in conducting these discussions. We recommend the following proceedures:

**Background Information.** Background information is provided via the readings, and as part of the activities included in the text.

**Presentation of Scenario.** The scenario is simply read silently by each student, aloud by the teacher or a student, or both. The main point is to ensure that the students fully understand the scenario and what they are expected to do. This is often best accomplished by asking various students to

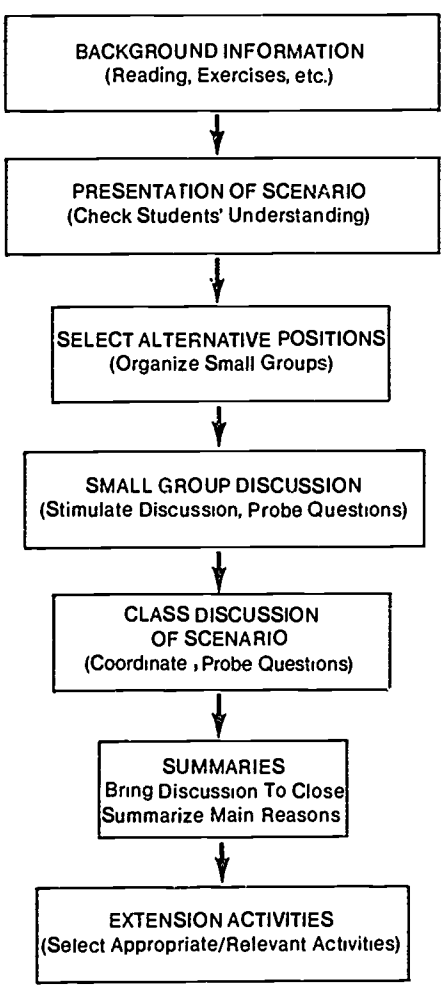
1. summarize the scenario and its important points,
2. identify the main characters in the scenario,

3. identify the main issues and list a few questions that might help clarify the issues for the students, particularly how these issues might relate to the students' lives), and
4. state the basic question the students will be required to answer.

**NOTE - Review carefully the scenario to be discussed in class and try to anticipate any problems that the students might encounter when dealing with the scenario.**

**Select Alternative Positions.** Ask the students to think about the answer to the main question posed by the scenario, then initiate a brief discussion of the student opinions offered. This short discussion is merely to help motivate the class and to provide some clues for dividing the class into small groups. You could divide the class according to "like" responses to the scenario question, or according to "unlike" responses or opinions about the resolution of the scenario dilemma, or frankly, any other way you would like. Excellent results have been achieved using a variety of types of grouping to conduct these exercises. See the discussion concerning "grouping" presented previously in this guide.

**SCHEMA FOR SCENARIO DISCUSSION**



Ask each group to select a recorder who will be responsible to write down the main ideas generated by the group. Each group should also select a spokesperson who will be responsible for presenting the group's position to the class later during this activity. The recorder and the spokesperson could be the same person or two different people.

**Small Group Discussion.** Assign members of the class to small groups of about 3 to 5 students. Then ask them to

1. arrive at the answer to the main scenario question (e.g., what should the main character in the scenario do?), and
2. give **two** reasons why. The two reasons are the "most important" reason and the "next most important" reason why the recommended action should be taken.

Step 2 is really the "heart" of the activity. It is through discussing the reasons WHY a particular course of action should be taken that growth of mental structures and reasoning takes place (see Part I of this guide and the discussion of the Socio-Scientific Reasoning Model).

> **NOTE - Consider whether or not the scenario poses conflict for your students. It may be that the scenario as written is either too sophisticated or too simplistic for your group and the students cannot appreciate the implicit conflict. The scenario question might be reworded or altered in order to elicit a division of opinion among the students.**

During this step in the scenario discussion process, circulate about the room providing guidance, asking motivating questions, responding to questions and, in general, try to stimulate a lively discussion.

> **NOTE - The students may continually look to you as teacher for direction and "correct" answers. When asked a question you can shift the attention by posing that question to another student and seek his/her opinion. In this way, the dynamics of student interaction can be maintained.**

This is a perfect time to use the various types of probe questions discussed earlier in this guide.

**Class Discussion.** After the students have had ample time to discuss and resolve the dilemma in their small groups, conduct a full class discussion of the results. Ask each group to give its position (what should the main character do?) and, most important, its reason (why they should take that action). During the class discussion, probe questions provide an excellent way to promote a lively class discussion. Continue until all groups have had an opportunity to present their positions. Try not to be too impatient if the discussion does not seem to go anywhere immediately. As in any other type of group interaction, some warm-up time is necessary so that the students can relax and reflect on their own thoughts.

> **NOTE - If there is difficulty getting the discussion started or if the discussion begins to "bog down", have the students role-play the main characters. This shift in focus can assist the students in gaining additional perspective into the situation.**

**Small Group Discussion.** You will probably find that most of the groups will tend to focus on the same - relatively few - reasons for why the main character(s) in the scenario should take a particular course of action. Simply, the students tend to focus on the same moral dimensions of the scenario. The purpose of this second small-group discussion is to "broaden the horizons" of the students by forcing them to consider several other dimensions that they may have previously overlooked. This is accomplished by having the small groups respond to the various questions that appear at the end of the scenario. Each of those questions focuses on a dif-

ferent dimension of the scenario. Frequently, after reviewing the "end of scenario" questions, many groups actually change their original positions regarding what the main character(s) in the scenario should do. This strategy is particularly useful for developing several higher-order thinking skills.

> **NOTE - If a class is not accustomed to discussion-type activities, it might be wise to group the students in such a way that those who are more vocal and aggressive do not dominate or monopolize the discourse. Try to balance each group with different personality characteristics.**

**Class Discussion.** During this closing class discussion, coordinate the dialogue using probe questions and asking the various groups which, if any, changed their original position as a result of responding to the questions. It is most appropriate to ask the groups why they changed their position OR, why they still maintained their original position even after the various other dimensions to the dilemma scenario were considered.

> **NOTE - Tape recording some of the student dialogue may be useful as an evaluation tool to help organize future discussions and suggest additional probe questions.**

**Summaries.** Bring the discussion to a close by asking the students to summarize the main aspects of the scenario and the main reasons for the recommended actions.

**Extension Activities.** At this point you can use a variety of follow- up activities. Some suggested activities include role-playing the scenario and using creative drama to enact this or any other scenarios the class would like to try. Another effective follow-up activity is to have the class write their own scenarios about a variety of other topics. These student-developed scenarios can also be "played out" using creative drama, role play, etc.

## Debates

Debating is a good technique to use to get students to carefully think through complex issues. While debates can take many forms, the following procedures have proven particularly effective in the classroom.

### INFORMAL DEBATE

The class will form two teams - one in support of and one against the debate statement. The teams should be seated facing one another.

Arguments are presented by a team member from one side, then a team member from the other side. Arguments are presented alternately until all students have had an opportunity to speak. Each speaker will be allowed one minute. (A person should be selected to be timekeeper.)

This debate should be a spontaneous activity. Teams should not prepare in advance but try to develop the arguments as the debate progresses. Each student will need to listen carefully to the arguments that are presented and introduce his/her own new idea. The object is to try to think and organize ideas quickly. It is almost like brainstorming where someone presents an idea and that idea leads to another idea. Each debater can build his/her idea from the previous idea or present a totally different idea.

After all arguments have been presented, the class will then discuss some of the main points that were brought out by each side. What were the best arguments presented by each team?

## FORMAL DEBATE

Organization

Judges

A minimum of three members of the class should serve as judges (or preferably, invite three persons from outside the class). One of the judges must serve as timekeeper and monitor the length of each of the presentations. A second judge should act as the Presiding Judge and supervise the proceedings. He/she will be responsible for keeping the debate orderly and calling on the presenters in turn.

Teams

After the judges have been selected, the remainder of the class should form two equal teams--one supporting the debate statement and the other opposing the statement. Each team should elect a coordinator whose responsibility will be to organize the team members. The recorder will take notes on the group's activities and decisions. The recorder and coordinator may be the same person, depending on the size of the task.

Preparing for the Debate

Team members will meet to develop the arguments for their position. Each team will first make a list of the major arguments (abbreviated statements) supporting its position. The coordinator will review the list to make sure that all the important arguments have been included and no argument is duplicated. There should be as many arguments as there are team members. If there are too many, the least important should be eliminated. If there are too few, additional ones should be developed.

Make two copies of your team's list and exchange one copy for the list from the other team.

Each team member will select an argument from his/her own list to develop into a short, two- to three-minute defense. He/she will also select an argument from the list submitted by the other team and prepare a two- to three-minute rebuttal (counter argument). Each person will thus be responsible for two arguments: one that supports his/her team's position and the other that answers/attacks the other team's arguments.

### The Debate

The debaters make their presentations in the following order:

3 min. - Team 1 presents argument.

3 min. - Team 2 presents rebuttal.

3 min. - Team 2 presents argument.

3 min. - Team 1 presents rebuttal.

The sequence is repeated until all debaters have presented their arguments and rebuttals. A five-minute summation speech is then given by a member (usually the coordinator) from each team. This summation reiterates the most important points made by the team members.

### Judging - Method 1

A convenient method for judging the debate is to evaluate each set of arguments in turn. After each argument and counter argument is presented, the judges will determine which one of the debaters delivered the most effective and convincing argument. Each judge will set up a score sheet similar to that shown below and assign points as follows:

Score Sheet

| | Team I (Pro) | Team 2 (Con) |
|---|---|---|
| Argument 1 | | |
| Argument 2 | | |
| Argument 3 | | |
| Argument 4 | | |
| Total Points | | |

4 points = excellent 3 points = good 2 points = fair 1 point = poor

**Judging - Method 2**

A more complex method of judging provides the judges with scoring criteria as follows.

Style of Presentation

- Does the person speak clearly and smoothly?
- Is the speaker poised?
- Does the speaker seem to believe in what he/she is saying?
- Does the speaker fidget or make distracting movements?

Organization of Arguments

- Does the speaker organize his/her ideas well? Or does he/she jump from one idea to another randomly?
- Are the points made clear and easily understood?
- Is the argument well thought out?

Use of Information

- Does the speaker seem to know what he/she is talking about?
- Are facts and other information included?
- Do the facts help to support the argument?

Strength of Argument

- How convincing are the arguments? Do the arguments persuade you to support the speaker's position?
- How important are the arguments? Does the speaker agree about unnecessary details?
- Does the speaker's point come across strongly?

Under this method, judges will record a score for each speaker for each of the above criteria. Each speaker will then receive four scores. Judges should add up the four scores and record the amount under the "subtotal" column (see following score sheet). The highest possible score is 20 (i.e., 5 x 4).

5 - excellent 4 - very good 3 - good 2 - fair 1 - poor

The subtotal column will then be added to obtain the total team score. The team with the highest total (total score of all the judges) will be declared the winner.

Sample Judge's Score Sheet

| | ORG. STYLE | PRES. STYLE | USE OF INFO. | ARGU-MENT | SUB TOTAL |
|---|---|---|---|---|---|
| FOR DEBATE STATEMENT<br>1.<br>2.<br>3.<br>4.<br>5.<br>6. | | | | | |
| | | | | TOTAL | |
| AGAINST DEBATE STATEMENT<br>1.<br>2.<br>3.<br>4.<br>5.<br>6. | | | | | |
| | | | | TOTAL | |

## DEBATING POINTERS

The following tips may be helpful to your students in their preparation for and presentation of a debate argument.

- Skillful debating is skillful communication. Make sure your argument is clearly stated and well supported by evidence.
- Explain why your argument is important. This is best conveyed by presenting examples of possible effects.
- Present the argument in a logical sequence, making the most important points first and backing them with sound evidence.
- Speak clearly and slowly so that your argument can be followed by all listeners.
- Be forceful and imaginative. Concentrate on conveying the main issues of your argument.

## Classroom Atmosphere and the Role of the Teacher

Every effort should be made to create a classroom climate conducive to an open, free exchange of ideas. Students should feel at ease when expressing their thoughts. When confronted with a challenge or question, students should not feel that they are being personally attacked. The emphasis should be on analyzing the reasoning process by considering divergent viewpoints and alternative choices. It should be stressed that, generally, there are no single correct or absolute answers to problems. Each position should be considered to have merit and be investigated.

For various activities, classroom furniture should be arranged in such a way that students can speak directly with one another and can be easily heard. For small group discussions, the chairs might be arranged in a number of small circles, perhaps around a table, so that attention can be given to all members of the group, eliminating an authority focal point. The seating should offer some degree of flexibility so that students might be able to shift groups or share their thoughts with members of other groups. A student who is uncomfortable with one group or who wishes to take another opposing position may feel better by moving to another group.

A **crucial** role for the teacher is to act as a creative process facilitator whose function is to stimulate students' searching and stretching, and to help students embark on their own personal investigation. Sensitive listening is a key skill. Too frequently, teachers, in their enthusiasm and zeal to formulate the "next question" in their own minds, fail to listen to the response or responses their students make to the question under discussion. By listening with care, however, the teacher can more effectively

- identify problems that students may have in coming to grips with the issue (for example, does the question on the floor need further elaboration? Clarification?);
- identify and deal appropriately with students who may monopolize or dominate the conversation;
- identify students who are hesitant to express their ideas and encourage their involvement in a non-threatening way;
- prevent the discussion from becoming a clash of personalities;
- force the students to make rational rather than emotional decisions; and
- prevent the discussion from lagging or focusing on irrelevant details.

The teacher must always be supportive and reinforce in a positive manner. Students should not be singled out as having given particularly "good" or "bad" answers. Each response should be viewed as a needed point of departure for further discussion. The question "why" should be a dominant concern and should be asked frequently. While some structure to the discussion is necessary, structure should never hinder ideas. Probe questions and the other types of questions should serve as the guiding structure. Depending on the students, some questions may stimulate more interest than others, the less fruitful questions, therefore, need not be pursued.

Promoting student-to-student interaction is another major role of the teacher that requires insight and patience. The discussion process is an evolutionary one, often requiring a reasonable amount of time before a definite direction can be perceived. At times, it might even appear that the discussion is circuitous, but it is imperative that each student has the opportunity to express his/her views and take an active part as a member of the group. When the students become confident in themselves and recognize the worth of their ideas, they will then accept the responsibility of their role in the group and become more receptive to the ideas of the others.

**NOTE - Don't immediately expect "the world" from your students. Remember the issues and activities in this program will be very new and your students will need time to acclimate with the strategies, techniques, and information before they can really begin to feel comfortable. If students instantly seem apprehensive,don't worry about it . . . get started and everything will fall into place. Remember also, that the number and complexity of the issues in STS are great. The purpose of this program is to assist you to begin to deal with some of the critical issues of our times.**

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