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AUTHOR	Yager, Robert E.; And Others
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IDENTIFIERS	*University of Iowa

ABSTRACT

This paper reviews the efforts to put science education into contexts that are considered more meaningful and useful than the classical approach. It focuses on S/T/S (science/technology/society) projects funded by the National Science Foundation, and especially on a project at the University of Iowa. Some of the features of S/T/S programs are described. Five major domains for science education are identified and discussed. These include connections and applications, attitudes, creativity, process, and information. Some of the results demonstrating the advantages of an S/T/S focus for school science from an assessment of 300 Iowa classrooms, grades four through nine, are shown and discussed. Included are differences in: (1) student abilities; (2) attitudes; (3) student behaviors judged to indicate degree of creativity; (4) student ability with selected science processes; and (5) acquisition of science information. The paper concludes that, since S/T/S students are so much better at making applications and connecting experiences to others, there is every indication that the information that students possess is useful. (CW)

Assessing Impact of S/T/S Instruction in 4-9 Science in Five Domains

Robert E. Yager
Susan M. Blunck
Achmad Binadja
William F. McComas
John E. Penick

University of Iowa
Iowa City, Iowa 52242
U.S.A.

Teaching classical science has been the conservative approach, i.e. reviewing what is known in a given area with the assumption that this basic knowledge is needed before applications can be made and/or actions taken. "Reforms" have concentrated on putting science (and other curricular areas) in contexts which have been considered more meaningful and useful. Those debates continue as political leaders seek the information that every high school student should possess. The one major time when this trend toward relevancy and usefulness was not in evidence was the 1957-75 period where the interest worldwide shifted to a focus on science for all as it is (was) known to scientists. These reforms of the 60s were the results of space exploits -- beginning in 1957 with the launching of the Soviet Sputnik. It is strange in retrospect that some of the most spectacular technological achievements prompted improved science education in schools which emphasized basic science and excluded technology (applications of science). The basic assumption was that science would be inherently interesting and appropriate for all if it were presented in a way that it is known to scientists. Much effort involving vast sums of money and many professional scientists was expended to define the unifying themes, basic concepts, major strands, the central structures of the various disciplines of science. Most projects also focused upon the skills possessed and practiced by the scientists who produced new knowledge and who conceptualized the basic structure of particular disciplines. Many of the curriculum develcpers called for an equal emphasis upon content and process.

As the 1980s emerged it was apparent world-wide that the fundamental assumptions of the efforts of the 60s were flawed. Science as it is known to scientists is not inherently interesting and it is not appropriate for all. Further, forcing all students enrolled in schools to learn such science was proving disastrous. Most left schooling in science with negative attitudes about science, science study, science teachers, and science courses. They could see little value in the science they had experienced and they could not use logic and other skills purported to be ingredients of science.

Ziman described the problems well in his (1980) book. He reviews course titles that have been used with various attempts to enlarge the domain of science as new courses and programs have been tried. Ziman developed a rationale (or offered a suggestion) for use of the term science/technology/society (S/T/S) as scholars across the world sought ways to define, describe, and model science programs that were more relevant and appropriate for students enrolled in elementary and secondary schools. Such programs were organized in ways other than some unique sequence of disciplines and some new ordering of topics characterizing a given discipline. Some of the first national efforts to develop S/T/S materials occurred in the United Kingdom.

In the United States several S/T/S projects have emerged. They have often utilized the 1980 Position Statement of the National Science Teachers Association to justify their efforts. This statement proclaimed:

> The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision-making. Such individuals both appreciate the value of

science and technology in society and understand their limitations.

The National Science Foundation in the United States has funded several projects in the last few years to emphasize S/T/S materials and approaches. One of the first was Rustum Roy's S-S/T/S Project at Pennsylvania State University. This project has established a national network for promoting S/T/S, a system for collecting and evaluating S/T/S materials, an annual national conference concerning technological literacy for all, and a module writing component.

Another major project at the University of Iowa has involved over 300 teachers in reorganizing their school programs around applications of science and technology with a focus on local relevancy. This project is an example of one where government, higher education, local schools, and industries are involved with developing and evaluating new instructional materials and teaching strategies. Science is becoming something to experience; it results in student actions; it is becoming central to the school program; it is visible in the community. Science for S/T/S teachers and students is not learning the material found in textbooks and further elaborated by teachers; it is no longer a matter of information acquisition; it is no longer information alien to living. Instead, science comes from a student and teacher problem that can be analyzed and studied. Possible actions/solutions are considered and perhaps tried. Experiences with actions and information needed to resolve issues is considered basic to learning.

S/T/S programs have many features in common. One of the most important is the identification of problems and questions -- real ones for the students. It is not starting with an outline of information to be examined and mastered with the rationale that first one "needs to know certain information" before real questions (ones researchers raise) can be formulated or before students can be engaged in meaningful activities.

By definition S/T/S approaches must be local -- at least to the point of direct student involvement. Obviously this can and should include problems that are national or world-wide. However, the primary focus for S/T/S is personal involvement. It is an individual and his/her relationship to a social order -- the family, the school, the community. Some have argued that Ziman has inverted the two S's in S/T/S -- that the first one should be "society" which is an entity that all students (and all people) can feel a part.

For many, technology is the connector in S/T/S efforts; it is the entree for many to the world of science. Technology -- the applications of science -- is concrete and something that affects all. Modern technology separates nations and cultures; it too often separates the haves from the have-nots. Technology is basic to modern nutrition, to clothing, to buildings, to transportation, and to communication. Certainly technology is related to science and for most the only understandable and important facet. However, a skillful teacher can use the power (and concerns) of technology as a means of moving more students to science. Students often become curious about technology -- the how, why, what if questions. Often basic science information is needed to satisfy their curiosities. What a shift -- to have students requesting knowledge because it is useful/needed instead of because the teacher insists it <u>will be</u> useful or because it is in the textbook/course outline.

Some of the definitive features of the S/T/S programs which have been developed in Iowa include the following:

1) identification of problem with local interest/impact;
2) use of local resources (human and material) to locate information that can

be used in problem resolution;

3) active involvement of students in seeking information that can be used;

4) science teaching going beyond a given series of class sessions, a given meeting room, or a given educational structure;

5) a focus upon personal impact -- perhaps starting with student curiosity and concern -- not merely hoping to get to that level;

6) a view that science content is not something that merely exists for student mastery simply because it is recorded in print;

7) a de-emphasis upon process skills -- just because they represent glamorized skills of practicing scientists;

8) a focus upon career awareness -- especially careers that students might expect to pursue as they relate to science and technology and not merely those related to scientific research, medicine, and engineering;

9) students performing in citizenship roles as they attempt to resolve issues they have identified;

10) science study being visible in a given institution and in a specific community;

11) science being an experience students are encouraged to have;

12) science with a focus upon the future and what it may be like.

Teachers are attracted to four or five workshops which are held in population centers across Iowa each year. From 20 to 60 teachers are enrolled in a 2 1/2 day fall workshop where the meaning of S/T/S instruction is discussed, examples provided, S/T/S modules to fit local curricula are identified, the year long schedule discussed, pre and posttest assessment discussed and exemplified from past years. Teachers who enroll (about 150 each year for the past four years) then return to their schools for pretesting and for finalizing their S/T/S module. In the spring the teachers meet again at the same sites to present the results of their S/T/S efforts to their peers, to lead teachers from previous programs, and to the central staff. Teachers earn credit upon attending the fall and spring workshop sessions, developing and using an S/T/S module which lasts at least one month, and providing assessment data in several "domains."

Yager and McCormack (in press) have identified five domains for science education. These domains include: connections and applications, attitudes, creativity, process, and information. For S/T/S instruction the ordering of these domains is important. It is necessary to begin with a problem that students identify and internalize. This focus invariably improves attitude, and it encourages creativity. These two domains make it possible for most to enter the process and information domains--which are the starting points for traditional science teaching.

Figure 1 is an attempt to illustrate the domains of science and their applicability in visualizing S/T/S. Students from society at large identify problems related to their lives. Almost invariably current problems are related to science and technology. Technology, particularly, affects all lives most directly, including homes, clothing, transportation, communication, careers, leisure activities, food, health. Technology was separated from science study during the 60s; new technology has become central--the means of connecting people to the world of science. Dealing with and understanding technology provides opportunity for enhancing interests of students and their creative skills with dealing with them. In some respects creativity and attitude are like the dynamic membrane of a living cell--regulating and/or affecting what gets into and out of the system. Creativity and attitudes become more negative as a result of typical science instruction. The situation is reversed when science is experienced in the S/T/S format.

S/T/S ideas and approaches have been introduced in classrooms of 300 teachers in grades 4 through 9 in Iowa. Assessment of results have been central to the effort which has been supported by the National Science Teachers Association, the Iowa Utility Association, and the University of Iowa. Some of the emerging results demonstrate the advantages of an S/T/S focus for school science.

Students are better able to apply information, to relate information to other situations, to act independently, and to make decisions. Thirteen and 14 year old students were tested over a three year period in specific schools where one class experienced science in a traditional manner and one class with an S/T/S focus. Table 1 provides information concerning the general areas of contrast.

Table 1. Differences in Student Ability to Apply Science Concepts by Students in Standard Courses vs. Those in S/T/S Courses.

	Percent students after traditional class	Percent students after S/T/S class
Demonstrate the use of information in new setting	25	81
Relate two phenomenon to a new situation	18	66
Identify related but divergent questions from a given situation	17	83
Offer valid interpretations for certain observations	23	65
Choose relevant information for solving a problem	26	91
Act based on new information provided	35	89

Utilizing some of the affective items from the Science Assessment of the National Assessment of Educational Progress provides a means for contrasting student attitudes after experiencing science in a traditional classroom vs. one focussing on S/T/S. Table 2 includes general information from several thousand students which serves to contrast the situation.

Table 2. Differences in Selected Attitude Items from NAEP Assessment Between Students in Random Classes and Those in S/T/S Classes.

Student Perception	Percent Students Enrolled in Randomly Selected School	Percent Students Enrolled in Schools with S/T/S Science Program
Science classes are fun	40	81
Science classes are boring	31	14
Science classes make me curious	24	71
Science classes help me make decisions	31	63
Science teachers like my questions	48	88
Science teachers admit to not knowing	22	74
Information from science classes is useful	69	81
Science is a favorite course	11	22
Science is least favorite	19	6

There are many facets of creativity and many instruments that have been developed to assess in this domain. One aspect that has received attention in

Iowa is concerned with questioning. Some of the differences in abilities of 13 and 14 year olds following traditional science instruction and S/T/S instruction are indicated in Table 3.

Table 3. Changes in Student Behaviors Judged to Indicate Degree of Creativity

	Average Number in 30 Traditional Classes	Average Number in 30 S/T/S Classes
Number of questions generated after same situation is presented	580	1160
Number with unique questions (less than 10% with similar ones in given class sample)	21	105
Number who can distinguish between cause and effect	216	643
Ability to offer unique explanations	51	342
Suggestions of unique tests of ideas	28	405

Process has been a dimension of science which has received major attention in science education for nearly 40 years. Unfortunately, most of the attention has been lip-service with little research evidence to demonstrate that science teaching resulted in students who possessed better science process skills than they had without instruction. Again, S/T/S efforts have produced students better able to perform basic science processes. Information that demonstrates the contrast for 13 and 14 year old students in 30 class groups is seen by examining Table 4.

Table 4. Differences in Student Ability with Selected Science Processes.

	Percent demonstrating ability from 30 traditional classes	Percent demonstrating ability from 30 S/T/S classes
Selecting best experimental procedure	24	52
Hypothesizing	18	63
Composing & differentiating	31	84
Measuring	33	91
Using numbers	40	89
Predicting	19	71
Drawing conclusions	24	82

Acquisition of information has been a primary focus for school science. Some have feared that an S/T/S approach would result in students who possess less information. The listing included in Table 5 demonstrates that such a fear is not well-founded with respect to 8 concepts studied in 30 schools involving 850 students who were 9, 13, and 17 years old.

Table 5. Percentage of Students Able to Select Most Accurate Definitions for Eight Basic Science Concepts

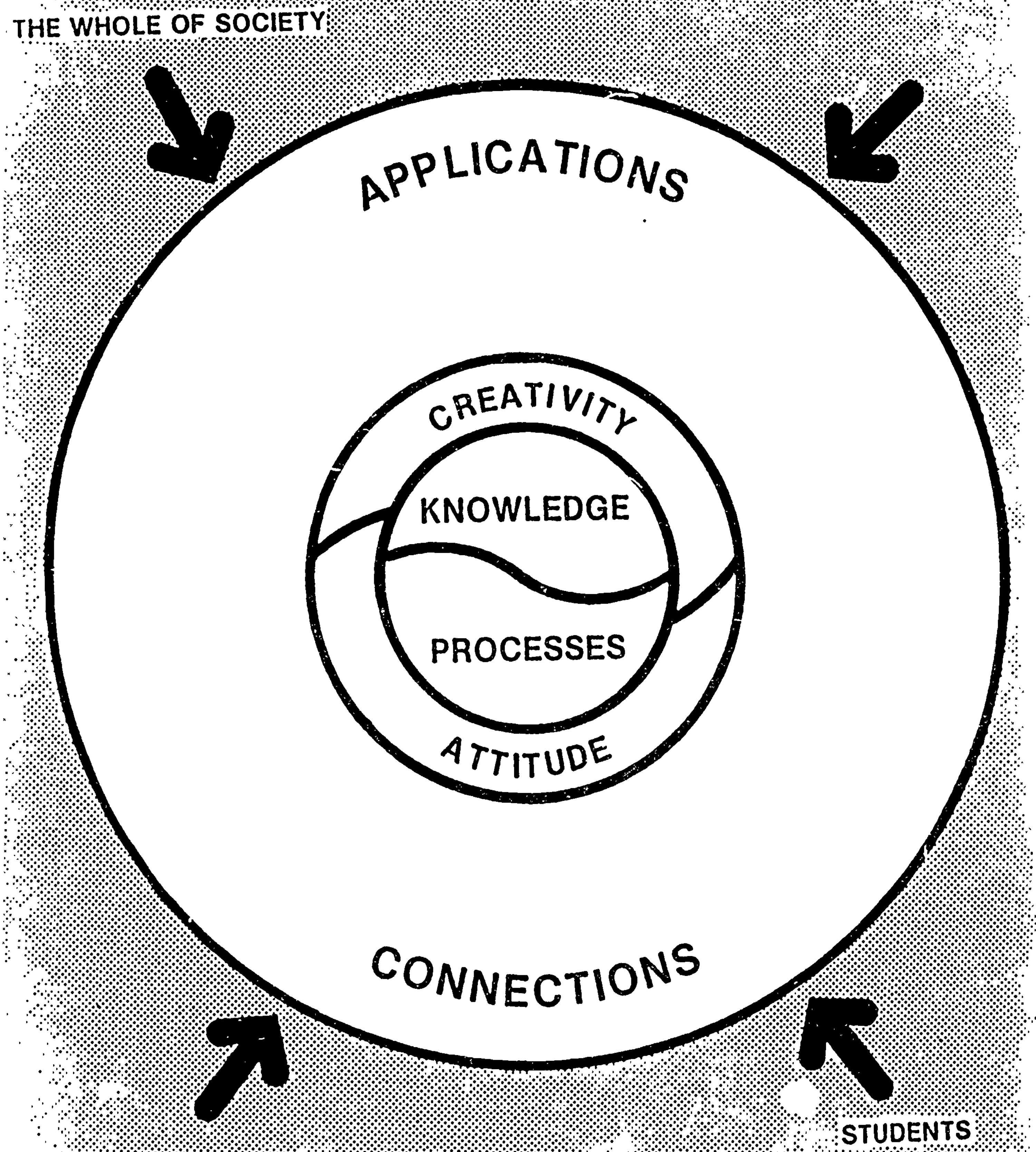
	Nine Year Olds		Thirteen Year Olds		Seventeen Year Olds	
	Random	S/T/S	Random	S/T/S	Random	S/T/S
Volume	29	12	75	65	57	71
Organism	66	43	67	71	61	84
Motion	41	14	65	62	66	89
Energy	40	29	54	45	39	64
Molecule	25	29	54	48	53	68
Cell	15	17	46	43	44	42

Enzyme	23	19	24	31	21	52
Fossil	36	29	54	48	48	71

Information concerning student retention over time has not been collected. Some of the S/T/S efforts have been too new to permit follow-up studies over the span of several years. However, since S/T/S students are so much better at making applications and connecting experiences to others, there is every indication that the information students possess is indeed knowledge, i.e. information that is useful. If information which is mastered can be used and if it has real meaning for the learner, there is every reason to believe that S/T/S instruction is providing a much better experience in the information domain. The S/T/S effort with 300 teachers in Iowa has provided specific results with the students they have touched that demonstrate the power of S/T/S as a primary focus for science teaching/learning.

There is nothing magical about Ziman's suggestion that the term S/T/S be used in connection with current efforts to provide a more meaningful science experience for all people. It does provide a useful label -- and one that has generated much attention and excitement. And yet that can be a problem as well! Some are already arguing that S/T/S is just the latest fad -- that it is an attempt to deemphasize basic science -- that it can not succeed unless teachers and students first have some "basics". This is the major reason for putting such current reform efforts into an historical context. Are we not debating the issue described by Aristotle? What is appropriate school science for all -- that which can be used or that which presents the basic discipline structures visualized by science practitioners? Is science which focuses upon experiences and ideas that students can use in their daily existence, that they can use in dealing with current societal issues, or that can be used in making career choices different from the science that is often found in course outlines and textbooks? Can traditional science be useful for most without some help, guidance, and practice with such use? Science education for all implies that it must be useful for all. And, this usefulness must be apparent to the learner and must be an actuality--not merely a promise.

FIGURE 1


THE WHOLE OF SOCIETY
APPLICATIONS
CREATIVITY
KNOWLEDGE
PROCESSES
ATTITUDE
CONNECTIONS
STUDENTS

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