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ABSTRACT

This document presents recommendations and generalizations from Project Synthesis, Educating Americans for the 21st Century, National Science Teacher Association Excellence Programs, and the Iowa Honors Workshop concerning the 861 teachers who were part of exemplary programs. Specific teaching strategies are listed that are associated with standard and exemplary teaching. Five proposed domains for science teaching and assessment include concepts, process, creativity, attitude, and connections and applications. Contrasts between student outcomes of classrooms taught by typical teachers and exemplary teachers are listed under each domain. Included are the results obtained when exemplary teachers assessed student growth in the five domains using a standard textbook format versus a science/technology/society (STS) framework. It was determined that teachers who use exemplary practices are able to stimulate growth in their students in all domains other than concept mastery to a far greater degree than when standard teaching practices are employed. Ten features of exemplary programs produced by exemplary teachers are listed. (KR)

The Practices of Teachers Who
Develop Exemplary Science Programs

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Harms and Yager (1981) reported on the results of Project Synthesis, an NSF supported research effort designed to synthesize indicators of a Desired State in science education and the Actual State of science education as determined by the NSF status studies and the 1978 results of the Third Assessment of Science by the National Assessment of Educational Progress (Helgeson, Blosser, & Howe, 1977; NAEP, 1978; Stake and Easley, 1978; Weiss, 1978). Basic to the Project Synthesis design were four goal clusters (justifications) for school science; these included:

1. **Science for Meeting Personal Needs.** Science Education should prepare individuals to use science for improving their own lives and for coping with an increasingly technological world.
2. **Science for Resolving Current Societal Issues.** Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.
3. **Science for Assisting with Career Choices.** Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.
4. **Science for Preparing for Further Study.** Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs.

The Desired State conditions for Project Synthesis became the criteria for Excellence as the National Science Teachers Association sought to identify Exemplary Science Programs in U.S. schools (NSTA, 1987).

Another NSF project was awarded to NSTA as a part of the National Science Board effort to produce the report Educating Americans for the 21st century (NSB, 1983). Two special monographs were produced with these funds (Yager, 1983; Bonnstetter, Penick, & Yager, 1983). One was a series of case studies describing the situation in six districts which were identified as meeting criteria of excellence in two or more categories (Yager, 1983). The second was a study of the teachers involved with the fifty exemplary programs identified in 1983 (Bonnstetter, 1983; Bonnstetter, Penick, & Yager, 1983). The Case Studies and the survey of 216 teachers from exemplary programs revealed many specific features of these special groups of teachers.

In 1983 an Honors Workshop was awarded to the University of Iowa by NSF (Yager, 1988). This three year study funded by a million dollar grant permitted direct work with 861 teachers during the summers and following academic years. Much was learned about such teachers who were considered exemplary because of the programs they had produced or their extraordinary professional involvement.

This work was followed by still another NSF grant that included work with 600 Iowa teachers who became active in Science/Technology/Society efforts. A total of 30 teachers who have become most involved have formed a cadre of Lead Teachers. Their involvement as a part of in-service staff teams and our observations of their teaching during extended visitations in their own communities have produced additional information about exemplary science teachers and the results of their work with K-12 students.

The study of 114 K-6 teachers and 102 7-12 teachers identified as the architects of the first fifty NSTA Excellence Programs revealed the following characteristics of "exemplary" science teachers; they:

1. Provide a stimulating environment;
2. Create an accepting atmosphere;
3. Expect different students to achieve differently;
4. Put in far more than minimal time;
5. Have high expectations of themselves;

6. Challenge students beyond ordinary school tasks;
7. Are themselves models of active inquiry;
8. Do not view classroom walls as a boundary;
9. Frequently use societal issues as a focus;
10. Work easily with community leaders, administrators, and parents;
11. Are extremely flexible in their time, schedule, curriculum, expectations, and view of themselves;
12. Are concerned with developing effective communication skills;
13. Provide systematically for reflection, and assessment;
14. Require considerable self-assessment of their students;
15. Ask questions, expecting to hear new, and often unpredicted, answers;
16. Expect students to question facts, teachers, authority, and knowledge;
17. Encourage pragmatism;
18. Stress science literacy;
19. Want students to apply knowledge;
20. Do make a difference.

The final report to NSB ended with the statement that it is important that a critical mass of teachers with such characteristics be assembled.

The Iowa Honors Workshop produced a list of generalizations concerning the 861 exemplary teachers who were selected to participate in the program and who had most of the characteristics listed above. These included:

1. Successful teachers are available and anxious to be involved in leadership development projects;
2. Exceptional teachers can develop skills and interests needed for heading workshops for other teachers;
3. Teachers of exceptional programs are able to collaborate and to produce exemplary teaching modules for others to use;
4. Exemplary teachers develop expertise in applying for competitive awards, projects, and grants;
5. Exemplary teachers participate to a greater degree in in-service projects, especiallv those focusing upon new curriculum and new teaching strategies;
6. Exemplary teachers can become proficient as authors of professional manuscripts; such activity can become an important means for communication and recognition.

The case studies of the six districts with multiple exemplary programs produced results which indicated that the science teachers responsible had traits in common. These included:

1. Exemplary teachers have great enthusiasm;
2. Exemplary teachers have boundless energy;
3. Exemplary teachers are discontented with the status quo;
4. Exemplary teachers are active professionally;
5. Exemplary teachers are concerned with constant renewal.

The inservice efforts and leadership development activities in Iowa have resulted in changes in specific teaching strategies, as the teachers continue to develop and their teaching philosophies and styles change. The following list shows the contrasts:

Standard	Exemplary
Teachers work in their classroom with several sections of students assigned to them	Teachers work as part of a staff team working toward common goals
Teachers feel tied to textbook and/or a curriculum guide	Teachers look beyond the boundaries of a textbook and/or curriculum guide; they define minimal concept and activities used

Teachers are discipline bound; they rarely work competently with teachers from other curriculum areas -- or science teachers from disciplines other than their own	Teachers are constantly seeking linkages with others in the total school; they also seek linkages with other teachers in the state and nation
Teachers tend to distrust the use of experts from the community (external to the school)	Teachers see themselves (and their students) as reaching into the community for information, expertise, ideas, and materials
Teachers are seen as dispensers of information they possess	Teachers are seen as learners themselves and as facilitators and collaborators in student learning
Teachers rarely think about goals for science teachers; they rarely enter into debate or meaningful dialogue about their teaching	Teachers are anxious to share their philosophies as they seek ways of expanding their thinking; they seek information that will help them improve teaching
Teachers complain about in-service learning opportunities	Teachers seek out in-service assistance as they seek to grow and to improve

Teachers who are armed with a vast quantity of strategies for effective teaching are able to perform in ways that permit instructional goals to be met. Their students are able to use the concepts and processes of the science they encounter better than students found in traditional classes. In addition, their students have superior attitudes concerning science and science learning. Further, the students demonstrate significantly better creativity skills related to questioning, suggestions of causes, and predictions of consequences. Such student growth is encouraging as they are related to teacher traits that produce them.

Yager and McCormack (1989) have identified five domains for science teaching and assessment. The use of these domains permits comparison of student outcomes in each when taught by a traditional/standard teacher and when taught by an exemplary teacher. The contrast may help with establishing criteria which distinguish between typical teachers and exceptional ones. The following contrasts have been observed.

Classrooms Taught by Typical Teacher	Classrooms Taught by Exemplary Teacher
Concepts	
1. Concepts are really materials to be mastered for a teacher test	1. Students see science concepts as personally useful
2. Concepts are seen as an outcome themselves	2. Concepts are seen as a needed commodity for dealing with problems
3. "Learning" is principally for testing	3. Learning occurs because of activity; it is an important happening but not a focus in and of itself
4. Retention is very short lived	4. Students who learn by experience retain it and can often relate it to new situations
Process	
1. Students see science processes as skills scientists possess	1. Students see science processes as skills they can use
2. Students see processes as something to practice as a course requirement	2. Students see processes as skills they need to refine and develop more fully for themselves

3.	Teacher concerns for process are not understood by students, especially since they rarely affect the course grades	3.	Students readily see the relationship of science processes to their own actions
4.	Students see science processes as abstract, glorified, unattainable skills that are unapproachable for them	4.	Students see processes as vital parts of what they do in science classes
	<u>Creativity</u>		
1.	Students decline in their ability to question; the questions they do raise are often ignored because they do not fit into the course outline	1.	Students ask more questions, such questions are used to develop meaningful activities and materials
2.	Students rarely ask unique questions	2.	Students frequently ask unique questions that excite their own interests, that of other students, and that of the teacher
3.	Students are ineffective in identifying possible causes and possible effects in specific situations	3.	Students are skilled in suggesting possible causes and effects of certain observations and actions
4.	Students have few original ideas	4.	Students seem to effervesce with ideas
	<u>Attitude</u>		
1.	Student interest declines at a particular grade level and across grade levels	1.	Student interest increases in specific courses and from grade to grade
2.	Science seems to decrease curiosity	2.	Students become more curious about the material world
3.	Students see the teacher as a purveyor of information	3.	Students see the teacher as a facilitator/guide
4.	Students see science as information to learn	4.	Students see science as a way of dealing with problems
	<u>Connections & Applications</u>		
1.	Students see no value and/or use of their science study to their living	1.	Student can relate their science study to their daily living
2.	Students see no value in their science study for resolving current societal problems	2.	Students become involved in resolving social issues; they see the relativity of science study to fulfilling citizenship responsibilities
3.	Students can recite information/ concepts studied	3.	Students seek out information and use it
4.	Students cannot relate the science they study to any current technology	4.	Students are engrossed in current technological developments and use them to see the importance and ıelevance of science concepts

Use of these domains permit specific differences in terms of student learnings in each domain Figures 1 through 5 indicate typical results obtained by twelve exemplary teachers in Iowa who assessed student growth in the five domains when taught in a standard textbook format versus a Science/Technology/Society (STS) framework. In Iowa exemplary teachers are defined as those who develop and implement science programs which are meaningful to students, are developed around student interest, and are tied to local situations. The ten features of exemplary programs produced by exemplary teachers can be distinguished as those which:

1. students identify problems with local interest and impact;
2. use local resources (human and material) to locate information that can be used in problem resolution;
3. actively involve students in seeking information that can be applied to solve real-life problems;

4. sees learning goes beyond the class period, the classroom, the school;
5. emphasize the impact of science on each individual student;
6. casts science content as more meaningful than something that exists for students to master for tests;
7. de-emphasize process skills *per se*--just because they represent glamorized skills of practicing scientists;
8. emphasize career awareness--especially careers related to science and technology;
9. provide opportunities for students to perform in citizenship roles as they attempt to resolve issues they have identified;
10. identify of ways that science and technology are likely to impact the future.

The results reported in Tables 1 through 5 were obtained from 24 classrooms of twelve Iowa middle school teachers who were judged as exemplary because their programs possessed the ten characteristics above and because they experienced the most success with teaching in such a manner. The twelve STS sections enrolled a total of 365 students while 359 were enrolled in the textbook sections. In all cases the STS students scored significantly higher than textbook sections -- except in the area of concept mastery. In this instance no significant advantages were found either for the textbook or the STS approach.

Teachers who use exemplary practices (like those who utilize STS strategies) are able to stimulate growth in their students in all domains other than concept mastery to a far greater degree than when standard teaching practices are employed. Perhaps it is fair to define exemplary science teaching in terms of its effect upon producing more student learning. The specific practices of teachers are more important than the curriculum structure and the particular science concepts that a teacher may decide students should know. Teacher attention to concept mastery directly may contribute to learning problems in students. In addition, such attention may signal the existence of a less than exemplary teacher.

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Figure 1
Differences in Percentages of Student in Applying Science Concepts in New Situations When Students are Taught from the Textbook and in an STS Framework

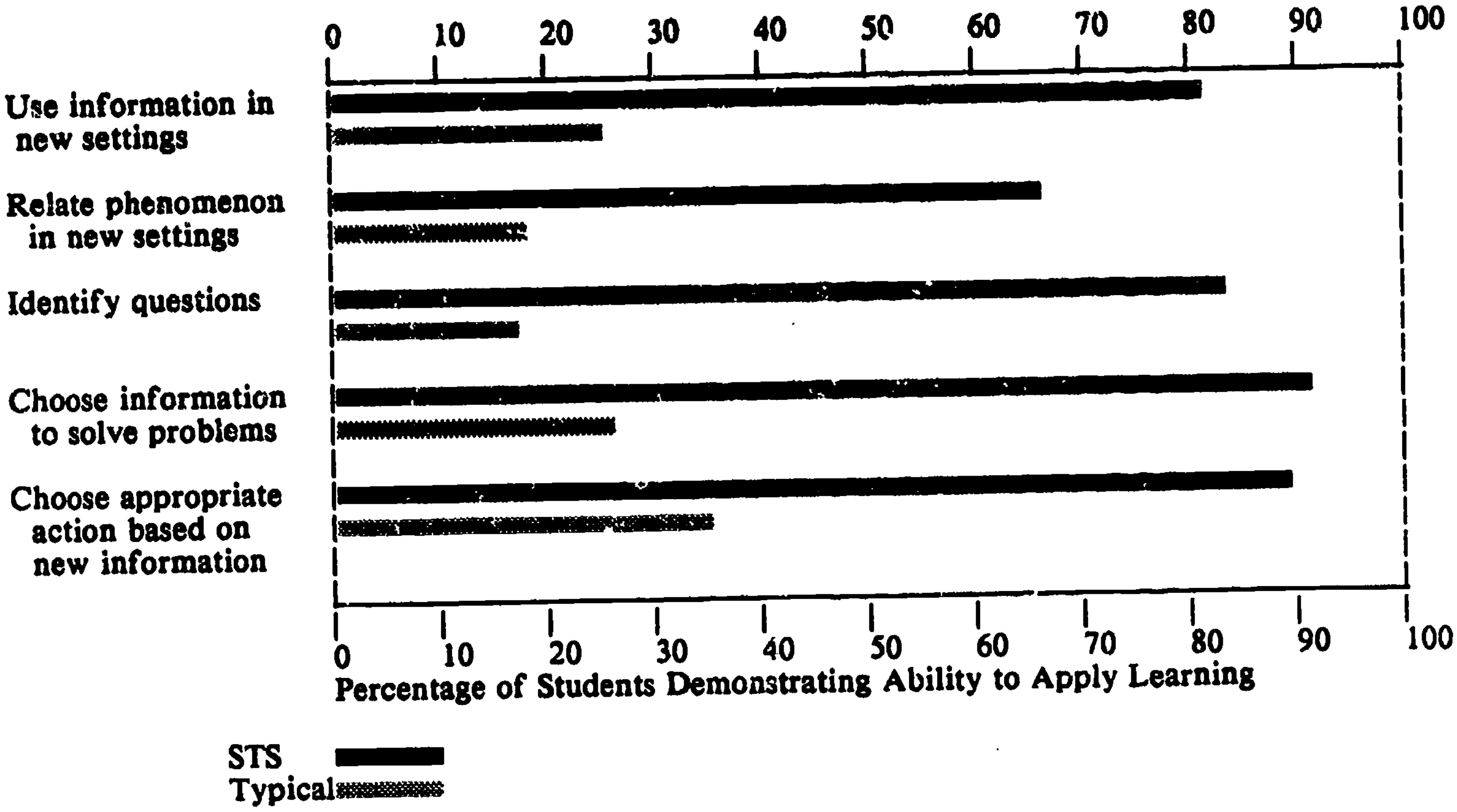

Figure 2
Percentage of Students With Positive Attitudes Concerning Their Science Classes and Science Teachers for the STS Group and the Contrast Group

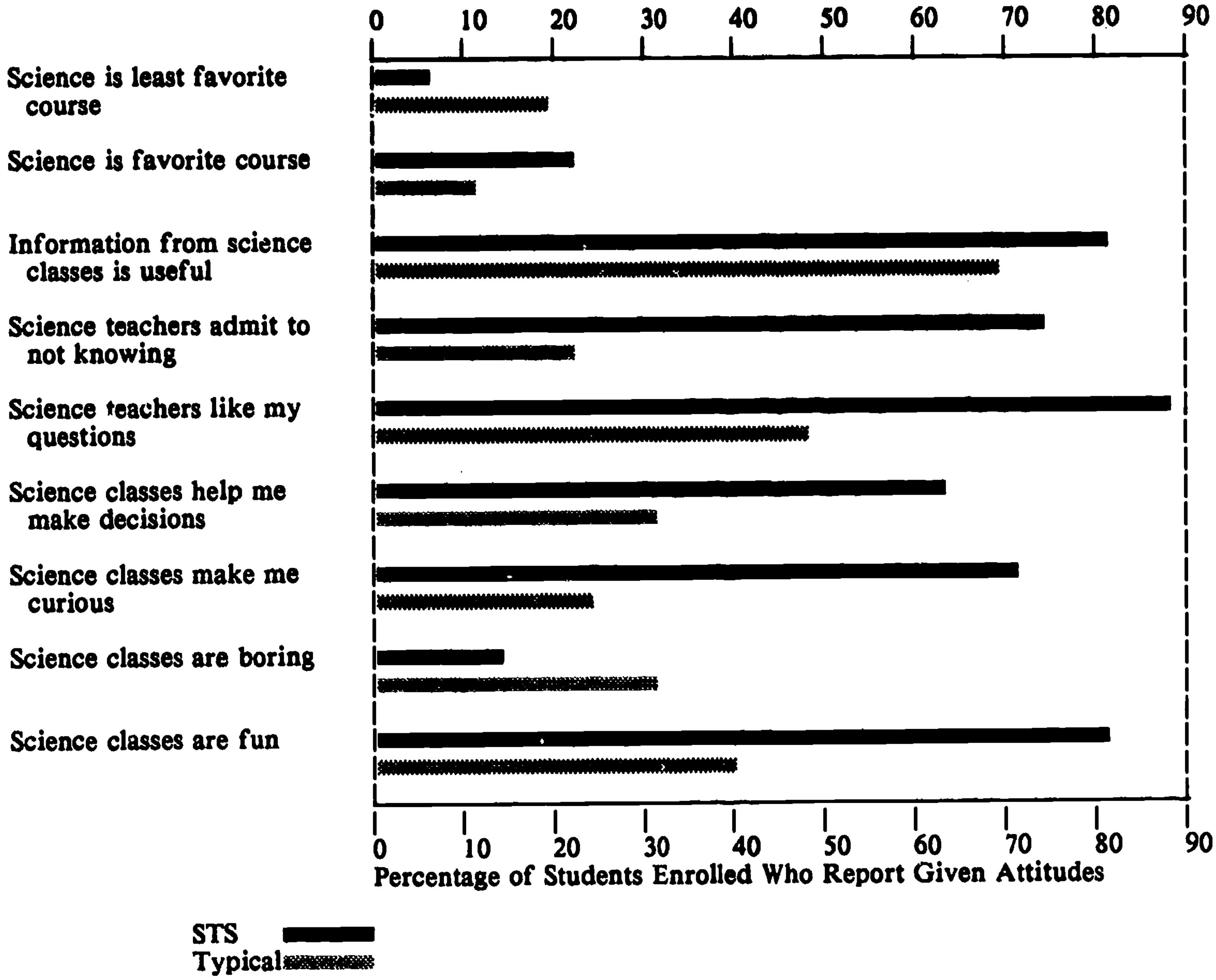

Figure 3
Average Number of Responses Given by Students in the STS Group and in the Contrast Group in the Creativity Instrument

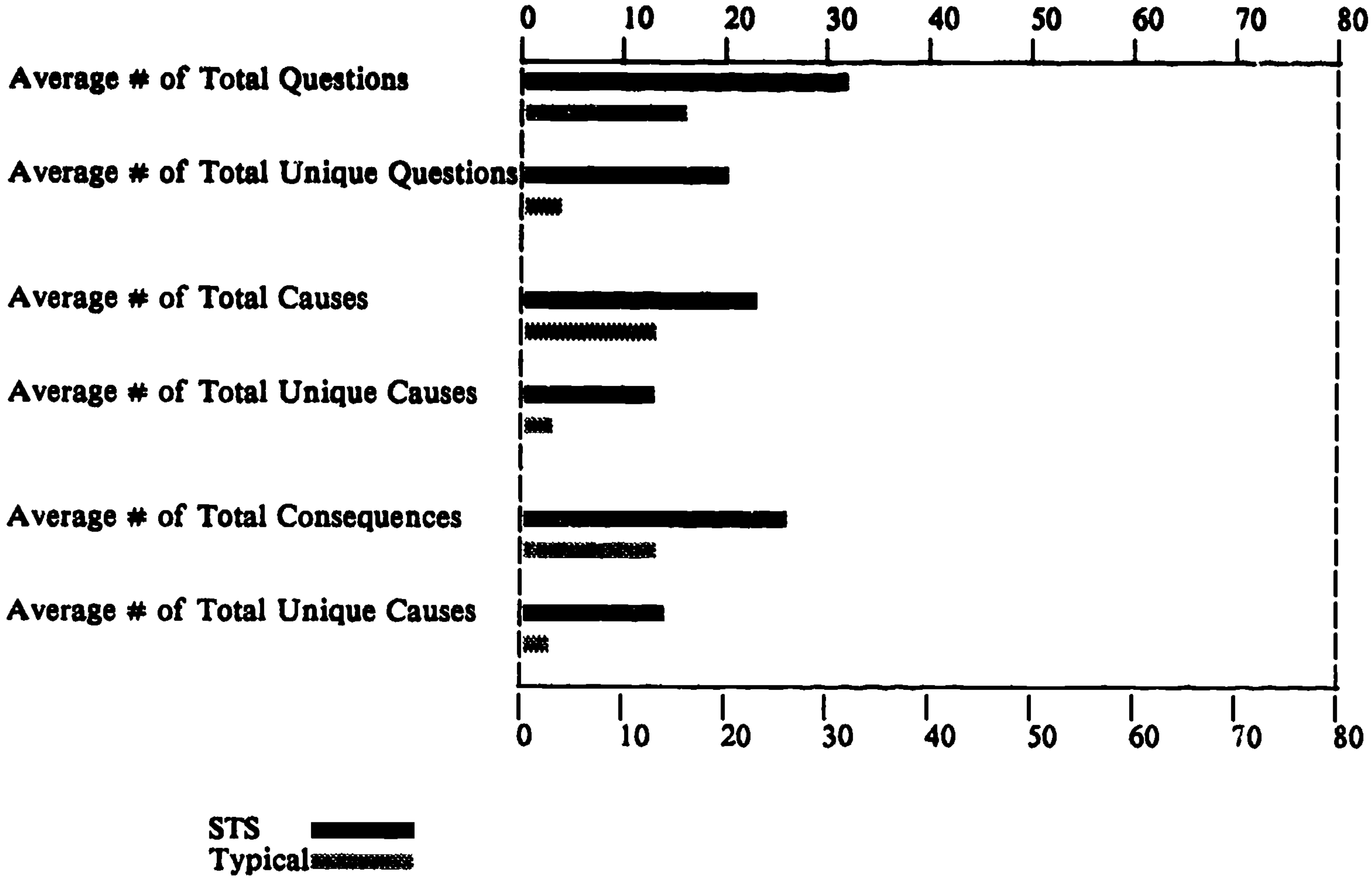

Figure 4

Percentage of Middle School Students who Demonstrate Their Ability to Perform in Fourteen Processes of Science Areas While Enrolled in Traditional Class Sections Versus Students Enrolled in STS Sections

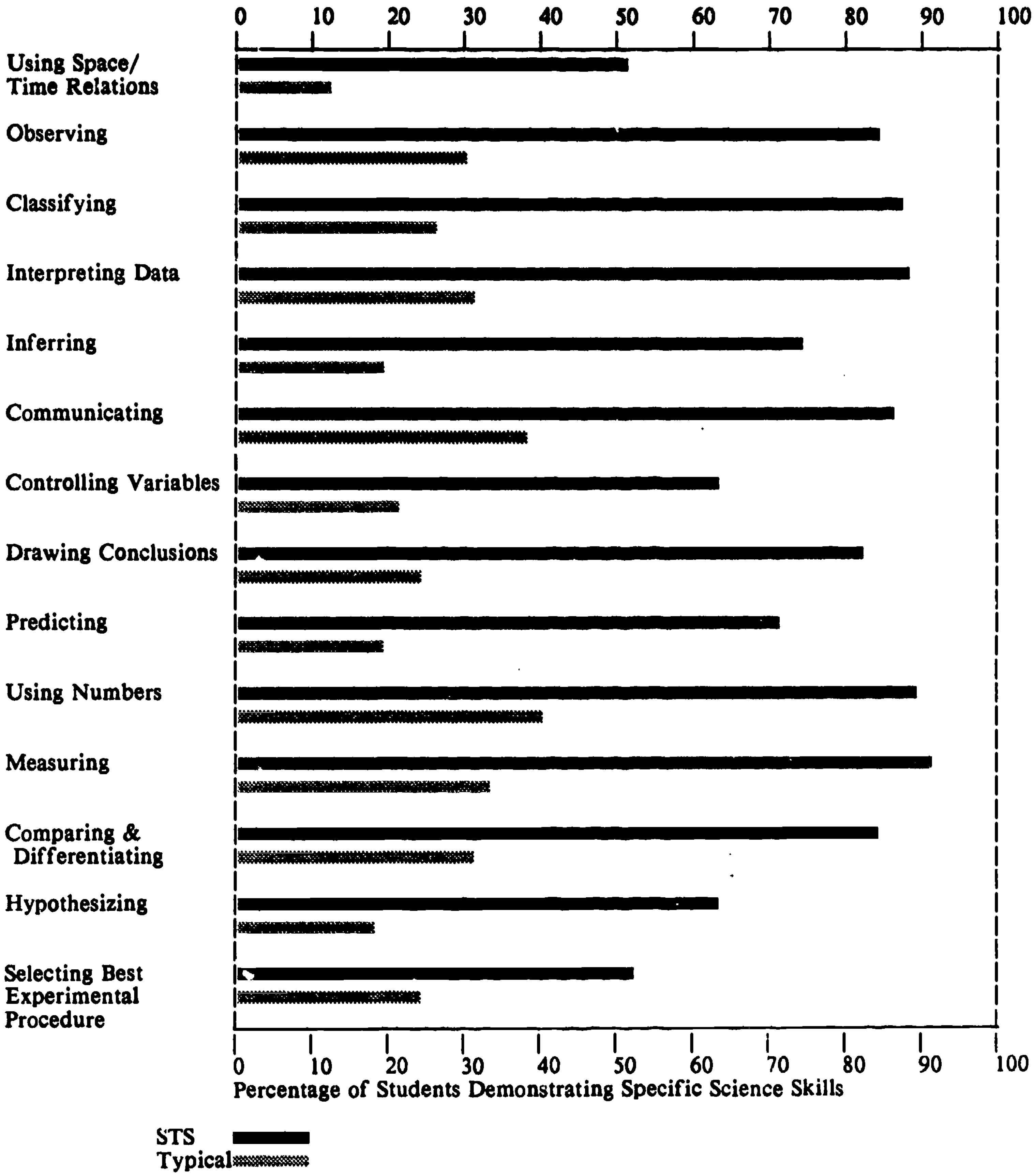

Figure 5

Percentage of Students Selecting Definitions Correctly for Eight Science Concepts After Instruction in Textbook-Centered Courses and STS Courses