A survey of teaching methods

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Atlanta University

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DEDICATION

To

Brenda J. Burton

For Inspiration
ACKNOWLEDGEMENTS

The writer wishes to express his heartfelt thanks and appreciation to those who helped and contributed to the completion of this study.

He wishes to express direct thanks and appreciation to Dr. Edward K. Weaver for his patience, time and guidance throughout the period of this study.

M. R. W.
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CHAPTER I

INTRODUCTION

Rationale.—Science is one of the most powerful forces operating within the lives of individuals. In the civilized world, individuals encounter and use products of science in all of their daily experiences and activities. The food he eats, the clothes he wears and the way he is entertained are all influenced in some way by science. Science is now changing our entire existence in such important aspects as health, transportation, communication and power.¹ It is no wonder that science is given so much consideration and attention—our very existence is dependent upon it.

It had been noticed that in the mid-1950's the United States, as a nation, had not been producing scientists in sufficient numbers to maintain our position as the scientific leader of the world. This was before Russia launched Sputnik in 1957. Later, when Sputnik was launched, the United States was shocked, to say the least. The scientists of the United States marveled at the achievement.

Non-scientists, however, appeared to have experienced a different response: they suddenly realized that repeated warnings of Russian scientific and technological progress were not cries of "wolf", and that our own scientific and technological position could be challenged by a determined competitor, and perhaps surpassed.¹

Soul-searching of all phases of scientific and technological programs followed. The results of these self-examinations found that the research endeavors were sound in that topnotched performances were expected and required. It was further found that the apparent weakness in the scientific program was in education. If the level of scientific achievement was to move forward the educational system would need teachers that were better than average in skills and knowledge and the scientists and engineers who graduated from these systems must possess superior competence in scientific research and development. They must also have had a general education which enables them to understand the world society in which they would operate and be able to communicate effectively with associates.²

In the search for science manpower we must keep in mind the need for scientific literacy in all of the citizens for it is these people, from all walks of life, who make decisions in a democracy and


²Ibid., p. 2.
to make intelligent decisions they must have understanding. If it were
only necessary to decide whether to teach the rudiments of science to
everyone on a mass basis or to identify the gifted and carry them as
far as they can go, our task would be relatively simple. The public
school must educate both producers and consumers of scientific services.¹
Science education then must, of necessity, serve two purposes. First,
it must provide means for developing general understandings for students
not inclined toward careers in science, and provide advanced work for
students destined to work as scientists or technologists.

One of the major problems in science teaching today is the
approach to the teaching process itself. If America is to maintain its
world leadership in scientific achievement, it must plan programs to
attract students to pursue careers in science.

Evolution of the problem.—This problem evolved out of reactions
as a teacher of biology and chemistry for four years. During this time,
in reading literature related to science teaching, a conviction emerged
that teaching for the concept of problem-solving is one of the latest
and most accepted methods in science teaching, and it was decided to
attempt to find out the extent of acceptance of this method by science
teachers and the degree of success.

Contribution to educational knowledge.—Science educators are

¹John H. Fischer in Rethinking Science Education. The Fifty-
ninth Yearbook of the National Society of the Study of Education (Chicago:
striving to prepare students to become effective citizens and to live in a highly complex technological world. Science educators and scientists with grants given by industry and the government are continually studying science programs in efforts to improve science curricula and produce better science students. Science teachers are being paid to go back to school in an effort to upgrade their knowledge. Based upon these facts, it is hoped that this study will prove helpful to school administrators, science supervisors and science teachers in planning science programs that will enable the individual student to fit more effectively into a complex technological society.

**Statement of the problem.**—The problem of this study was to ascertain to what extent selected science teachers used the concept of problem-solving and the degree of success achieved.

**Purpose of the study.**—The general purpose of this study was to determine if selected science teachers were using methods to develop problem-solving techniques in their science classes. Specifically, this study attempted to achieve the following purposes:

1. To ascertain the number of teachers who used the problem-solving approach.

2. To determine methods they utilized to teach for problem-solving behavior.

3. To determine if teachers felt that the problem-solving method was the best method for teaching science.

4. To obtain the opinions of selected high school seniors as to what extent their science teachers had used problem-solving techniques.
Locale of the study.--This study involved science teachers from junior and senior high schools and 100 high school seniors from a selected Georgia school system.

Limitations.--This study was limited to data collected by the writer from 50 teachers and 100 students in selected junior and senior high schools in Georgia. Therefore, it can be assumed that the responses reported reflected only the ideas of the respondents involved in the study.

Description of instrument.--The instrument used to collect data for the study was specially prepared questionnaire similar to questionnaire published by the United States Office of Education and by the Science Manpower Project.

Description of subjects.--The subjects were science teachers in selected Georgia junior and senior high schools and a selected group of high school seniors. Females and males were included in the study, but no attempts were made to separate or classify results on the basis of sex or race.

Method of research.--The descriptive survey research method was used for this study, employing a special inventory form to collect data.

Research procedures.--The procedural steps for this study were as follows:

1. Permission to do the study was secured from the proper school officials.

2. Literature related to the study was surveyed.
3. Questionnaires to secure information from the subjects involved were obtained.

4. Questionnaires were sent to teachers and students of the selected schools accompanied by a letter explaining why the information was desired.

5. Follow-up cards were sent as a reminder to those who were slow in returning forms.

6. The data was tabulated into appropriate tables and treated by percentages for the various categories. Findings, conclusions, implications, and recommendations derived from this data are included in the finished thesis.

Survey of related literature.--A few years ago an examination of our science education programs revealed that science education was of a poor quality. It was of such poor quality that often professors at the colleges and universities were handicapped in the kind of training they could offer their freshman college students. These facts were reported in the National Science Foundation 14th Annual Report of 1964. This led to the establishment of summer institutes on an experimental basis. The results were so favorable that academic year institutes and the in-service institutes were established in following years. These things were done in an effort to bring science programs up to a respectable level. Today, as a result of the activities of the National Science Foundation, thousands of teachers have participated in these training programs and better science programs have been established.

Established methods are being discarded and replaced by methods that more nearly meet the needs of individual students. Educational psychologists have demonstrated that a good learning situation is one in
which children become involved. Involvement can occur if children are
able to relate new problems for study to their own experiences and their
own needs. Children will become involved also as they participate in
defining problems and planning the course of action.\(^1\) It is very
important that young people have experiences in depth in science in which
there are opportunities to investigate questions and problems in science
and where creativity is encouraged. These are the necessary kinds of
things needed to motivate students and to guide them toward careers in
science. One major mistake of present science programs is that it thinks
of scientific manpower in terms of individuals with IQ's of 130 or more.
The people in this category are a very small percentage of our total
population and even all of these will not enter into scientific or tech-
nological fields. There is an urgent need to provide education for
individuals with IQ scores considerably lower and those not going on to
college. A better approach, perhaps, would be to deal with the IQ group
of 100 to 120 and try to develop their fullest potentials. Certain
methods employed for classroom instructions work well with slow children
as offered by A. S. Fish and B. Goldmark in their "An 'A' for the Day
Method", as reported in the Journal of the National Science Teachers'
Association, in 1966. There is concern for the education of science-
talented youth which is resulting in more elective courses in science;

\(^1\)Beth Schultz, "The Use of Ecology in Teaching Science to
more advanced standing science courses; more science honor programs; more facilities and equipment; science project work; more summer institutes for high school students; more cooperation between school and industry involving scholarships, awards, gifts and loans of science equipment, books and periodicals, lecture series, employment during summers and after school, trips to industrial and research plants.¹

These things have made a tremendous impact on science education at the secondary level. The National Science Foundation has been instrumental in providing funds for such projects.

Funds provided by the National Science Foundation have provided summer institutes for academically exceptional students to study intensified subject matter during the summer at leading colleges and universities. The Foundation also provides money to give economically and educationally disadvantaged students who have academic ability special training. For example, 120 students from the urban area of Chicago were chosen for a six-week intensive course in modern mathematics and physical sciences conducted at the University of Chicago.² As a result of this project, almost all of the students responded with an awakened academic interest. Potential scientists can be reached through the programs that


provide training especially for them. Such programs are experimental, but good results can establish them as a permanent part of our educational system.

Another National Science Foundation program allows students to hear scientists give accounts of experimental work that they have performed. These programs are offered during school holidays during the winter and here, too, the results have been favorable. More than 4,000 high school students attended these lectures in 1963. Sponsoring programs to establish collaboration between colleges and universities is another function of the National Science Foundation. In programs of this nature, secondary school teachers and officials cooperating closely with college scientists have already increased the caliber of science and mathematics instruction in several school systems by providing for the retraining of key teachers, introduction of new courses and demonstration classes for students.¹

A few years ago American students were studying from books that were well written but these books were presenting materials that were obsolete. This particular problem was corrected by encouraging scientists to work with science educators in producing books that present contemporary science. With these modern textbooks, teachers that were trained in the latest developments in science and students with renewed interests in science, the problems of science education seemed to have

¹National Science Foundation 14th Annual Report, p. 78.
been resolved. In reality, though, they were not. The major problem facing science teachers today is the problem of presenting these materials in the best possible way. This method, whatever it may be, must present the material clearly and yet promote the spirit of inquiry and aid in the development of problem-solving. Man has been solving problems since time immemorial, but until recently there has been little conscious effort to teach the process.¹ This process was introduced about thirty-five years ago, and there has been an increase in its use, but the process has been slow. This is due, in part, to the fact that teachers had seldom been taught the process. The process of problem-solving can be described according to Lester C. Mills as both a way of thinking and a method of teaching. Essentially, this type of thinking occurs only when there is a need for it, when the situation presents a difficulty that cannot be met by other means.² The problem should be presented in a manner that will motivate the individual toward an objective and the stimulus must be strong enough to make the individual attain his goal. Lester C. Mills reports in Problem-Solving Methods in Science Teaching that in general the steps in problem-solving are as follows:

1. A difficulty is recognized.

¹Lester Mills, Problem-Solving Methods in Teaching (New York: Columbia University, Teachers College), 1960, p. 1.
²Ibid., p. 3.
2. The problem is clarified and defined.

3. A search for clues is made.

4. Various suggestions are made, and are evaluated or tried out.

5. A suggested solution is accepted, or the thinker gives up in defeat.

If the above-named steps seem that they are simply common sense, do not be disturbed because, in reality, the process involves nothing more than common sense or a systematic approach. Since the basic problem in science education is providing challenging situations to the student, this seems to be a good approach. Problems can be evolved that require only a class period or problems may continue for the entire year. A likely place to find interesting problems is in the immediate community of the student.

Although problem-solving is a method that most science educators will agree upon, there are some problems associated with the science program as it is today.

Some current problems in science education involve: (1) a recognition of the real significance of science on a modern world; (2) the need for a change in attitude toward science and the necessity for reducing the gap between the sciences and the humanities; (3) the development of a truly new curriculum which cannot be done by accretion but which must be done by a total and complete reorganization which will also provide for the development of a high degree of scientific literacy among the rank and file of our people; (4) a necessary change in the
attitude toward teaching at all levels with a view of recognizing its importance and its problems and with a dedicated effort toward the solution of the problem while, at the same time, retaining and expanding our efforts in the creation of new knowledge. These existing problems must be eliminated if we are to effectively achieve the purpose of the school.

What are schools supposed to do? Schools should be dedicated to the proposition that every youth in these United States regardless of sex, economic status, geographic location, or race should experience a broad and balanced education which will: (1) equip him to enter an occupation suited to his abilities and offer reasonable opportunity for personal growth and social usefulness; (2) prepare him to assume the full responsibility of American citizenship; (3) give him a fair chance to exercise his rights to the pursuit of happiness; (4) stimulate intellectual curiosity, engender satisfaction in intellectual achievement and cultivate the ability to think rationally; and (5) help him develop an appreciation of the ethical values which should undergird all life in a democratic society.

If we are to assist youth to be more effective in achieving these

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ends, we must provide them with the proper "tools". It is imperative that these tools be identified and that instructional programs be provided to help youth acquire them as they proceed through our school system. Among the tools slated as a minimum prerequisite to the above listed means are:

1. Strong general education--educational training that will enable students to think clearly and critically; to be able to articulate their thoughts through speech and writing; to widen their interest range in daily experiences; and to develop a "questioning mind".

2. Understanding of our natural resources--their characteristics, status, distribution and importance to man.

3. Ecological awareness--a blending of field and classroom experiences that will help youth develop a greater interest, awareness, understanding, and respect toward man's environment.

4. Problem-solving--inherent in this is the ability to define the problem, consider all related viewpoints and on the basis of substantial facts, determine the best solution.

5. Understanding that man is a part of the human eco-system--recognition that man is a part of his environment and is expected to make contributions to society according to his ability.

A large number of science educators are of the opinion that science taught for the purpose of developing problem techniques is the most effective approach to our problem.

What is science--its sources, aims and procedures?

This is the first fact about science; it is a human activity. As such, it is subject to all the frailties

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1Smith, The Science Teacher, Vol. 34, No. 4, p. 33.
of human endeavor. Its history is a history of errors, slowly corrected; a history of effort, a search for wider knowledge of facts and deeper, more embracing schemes for understanding and explaining them. Science is not a cold, infallible, impersonal machine; it is not just a collection of formulas and technical terms about obtrude questions remotely related to everyday life and thought. Science is ultimately refined common sense. It is the organized knowledge developed and possessed by men and women of the world they live in.

As a human endeavor, science is dependent on human motivation. The motivation for scientific endeavor is not hard to find. First, there is the ever-present need for knowledge that helps man master the environment he lives in making it subservient to his needs. Our knowledge of astronomy began its growth impelled by the need of a calendar for the season-conscious Babylonian farmers. In our own day, the growth of nuclear physics has been impelled in part by unhappier but no less practical considerations.

Secondly, and in the long run more important, there is the almost universal curiosity in men which seeks satisfaction in knowledge of the world for its own sake—knowledge not only of the facts themselves but of how they are related and how things are caused; in short, knowledge of how the world of facts can be explained and so understood. The simple and naive questions of the small child when they recur in mature minds are the life's blood of science. "Who dug it?" as a question on first seeing the Grand Canyon is naive only in phraseology; in the older man this child-question leads to our understanding of the cutting power of running water. Cats can be killed by curiosity, but science dies for lack of it.¹

For something so deeply rooted in common sense, it should be easy to teach for development of the problem-solving concept which some science educators refer to as the common sense method or as both a way of thinking and a method of teaching. One major reason for this method

¹Paul F. Brandwein, Teaching High School Science: A Book of Methods (New York: Harcourt, Brace & World), 1958, p. 44.
not being more popular is that teachers have not been trained to use it nor have a large number of science teachers been taught by people who use the problem-solving approach. The perfect formula for science education would fail when exposed to poor teaching. Poor teaching lacks either soundly conceived objectives or soundly conceived learning activities; the poorest teaching lacks both, the most effective lacks neither.¹

Since man cannot see actual thought processes in action, he must judge the content, quality and essence of these thought processes by means of the effect that they have on the individual. If it is to be believed that the most effective way to evaluate learning is through observations of the action patterns of the learner, it must follow that, since learning is based upon thought process, thinking must be also evaluated through observations of behavior. What patterns of behavior can be associated with thought processes? Four types of thinking in terms of behaviors have been isolated.²

1. The method of tenacity—resists change on the grounds that a given action has always been the way that they react to dilemma.

2. The method of authority—a person who does something because a person of a particular status says that that was the way to react.

¹Ibid., p. 53.

3. Method of intuition—described by referring to the person who believes in astrology, but actually it was third on the hierarchy of methods of thinking because there is often a spark of reasoning behind some decisions that at first glance seem to be inspirational.

4. Method of science—weigh the pro and con of every possible answer to his question, then select the one answer which seems to be the most logical to him, and act on this information.

Methods of science or reflective thinking—only method that admits that it might lead to error and is, therefore, the most progressive.
CHAPTER II

PRESENTATION, ANALYSIS, AND INTERPRETATION OF THE DATA

This chapter presents some of the characteristics of the respondents who participated in this study and their opinions concerning various aspects of science education. The data were gathered through utilization of a specially constructed questionnaire designed to ascertain teachers' use of problem-solving techniques in their science teaching. Data are presented which indicate grades taught, extent of collegiate and university training, specific training in science instruction, number of pupils taught and the type of certificate held. Tables are presented that indicate the opinions of selected students as to the use of problem-solving techniques by their teachers.

The tables present data as gross numbers of individuals who responded to each item. Through close personal contact with individuals who aided in the administration of the questionnaires, it was possible to secure 100 percent response to all items. Therefore the total response is reported on all items and represents the opinions of the 50 teachers and 100 students who participated in this study.
Characteristics of Respondents—All teachers in this study held a college degree and all were employed as junior high or senior high school science teachers. Table 1 presents data pertaining to the characteristics of the respondents participation in this study.

<table>
<thead>
<tr>
<th>Items</th>
<th>Number Reported</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate Training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than one semester</td>
<td>23</td>
<td>46%</td>
</tr>
<tr>
<td>or none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One semester</td>
<td>8</td>
<td>16%</td>
</tr>
<tr>
<td>Two semesters or more</td>
<td>9</td>
<td>18%</td>
</tr>
<tr>
<td>Master's Degree</td>
<td>10</td>
<td>20%</td>
</tr>
<tr>
<td>Totals</td>
<td>50</td>
<td>100%</td>
</tr>
</tbody>
</table>

A high percentage of the respondents were educated in Georgia. This study revealed that forty-seven or 94 percent of the teachers in this study attended schools in Georgia. To this extent their responses should reflect the impact of these Georgia Teacher-Training Programs on their graduates as pertains to use of problem-solving techniques as a teaching method of strategy.

Table 2 shows that the teachers in this study had attained graduate or university training as follows: eight or 16 percent had one semester of graduate training, nine or 18 percent had two or more
TABLE 2
CHARACTERISTICS OF RESPONDENTS—AREA OF UNDERGRADUATE AND GRADUATE OR UNIVERSITY TRAINING

<table>
<thead>
<tr>
<th>Items</th>
<th>Number Reported</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Undergraduate Major</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Education</td>
<td>19</td>
<td>38%</td>
</tr>
<tr>
<td>Biology</td>
<td>24</td>
<td>48%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Physics</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Others</td>
<td>4</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Graduate Major</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Education</td>
<td>11</td>
<td>22%</td>
</tr>
<tr>
<td>Biology</td>
<td>15</td>
<td>30%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Physics</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>

Semesters of graduate training and ten or 20 percent had attained a master's degree. All respondents had completed at least one course in methods of teaching science. Since twenty-seven or 54 percent or respondents had at least one semester or graduate training or more, all held a college degree and all had completed a course in methods of teaching science, one might predict that the response of the teachers in this study represents a high level of sophistication.
Table 3 shows that two or $\frac{1}{4}$ percent of the respondents had fifteen to twenty pupils in their classes; twelve or $24\%$ had twenty-one to twenty-five pupils in their classes; thirty-three or $66\%$ had twenty-six to thirty pupils in their classes and three or $6\%$ reported having thirty-one to thirty-five pupils in their class. The size of the class reflected a situation where only a minimum amount of attention could be given to individual differences in needs, interests, abilities and skills and as a result of class size the level of instruction and pupil achievement can be predicted to be low.

**TABLE 3**

**CHARACTERISTICS OF RESPONDENTS—AVERAGE NUMBER OF PUPILS ENROLLED IN TEACHERS' CLASSES OF THE SELECTED SCHOOLS**

<table>
<thead>
<tr>
<th>Items</th>
<th>Number Reported</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Pupils in Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 - 20</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>21 - 25</td>
<td>12</td>
<td>24%</td>
</tr>
<tr>
<td>26 - 30</td>
<td>33</td>
<td>66%</td>
</tr>
<tr>
<td>31 - 35</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>36 - 40</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>50</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 4 reveals that six or $12\%$ of the teachers in this study had completed from thirteen to twenty-one semester hours in education; fourteen or $28\%$ had completed twenty-three to thirty-two
21

TABLE 4

CHARACTERISTICS OF RESPONDENTS--NUMBER OF SEMESTER HOURS COMPLETED
IN EDUCATION AND TYPES OF CERTIFICATES OBTAINED
BY TEACHERS OF THE SELECTED SCHOOLS

<table>
<thead>
<tr>
<th>Items</th>
<th>Number Reported</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hours Completed in Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 - 22</td>
<td>6</td>
<td>12%</td>
</tr>
<tr>
<td>23 - 32</td>
<td>14</td>
<td>28%</td>
</tr>
<tr>
<td>33 - 42</td>
<td>10</td>
<td>20%</td>
</tr>
<tr>
<td>43 and over</td>
<td>20</td>
<td>40%</td>
</tr>
<tr>
<td>Totals</td>
<td>50</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Types of Certificates</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-4</td>
<td>31</td>
<td>60%</td>
</tr>
<tr>
<td>DT-4</td>
<td>9</td>
<td>18%</td>
</tr>
<tr>
<td>T-5</td>
<td>4</td>
<td>8%</td>
</tr>
<tr>
<td>DT-5</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>T-6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DT-6</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Totals</td>
<td>50</td>
<td>100%</td>
</tr>
</tbody>
</table>

hours in education; ten or 20 percent had completed from thirty-three to forty-two hours in education and twenty or 40 percent had completed more than forty-three hours of education. Furthermore this study revealed that forty-six or 92 percent of the respondents had undergraduate majors
in the area of science and the four or 8 percent who did not have undergraduate science majors were certified science teachers. Hence, it can be said that all of the respondents were trained and certified in their present teaching assignment.

One may summarize the data pertaining to the characteristics of the respondents participating in the study as follows: (1) the respondents were science teachers from the seventh through the twelfth grades; (2) All respondents had graduated from college, ten or 20 percent held master's degrees, eight or 16 percent had one semester of graduate training and nine or 18 percent had two or more semesters of graduate training. The respondents represented a skilled and professional group of teachers; (3) Despite the fact that all three or 6 percent of the respondents taught classes with from thirty-one to thirty-five pupils in them the general class size was of such that some attention could be given to individual differences in needs, skills and intelligence; (4) Forty-six or 92 percent of the respondents had undergraduate majors in science and the four or 8 percent who were not science majors were certified science teachers. One might conclude that these respondents were adequately trained in their teaching areas.

Table 5 reveals the response of teachers in this study to the section of the questionnaire concerned with aiding the student sense and define problems. Lester C. Mills in his book Problem-Solving Methods in Science Teaching, states that a genuine problem for a student exists when
### TABLE 5
RESPONSE TO SENSING AND DEFINING PROBLEMS

<table>
<thead>
<tr>
<th>Sensing and Defining Problems</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help pupils sense situations involving personal and social problems?</td>
<td>34</td>
<td>52</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>2. Help pupils recognize specific problems in these situations?</td>
<td>32</td>
<td>54</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>3. Help pupils in isolating the single major idea of a problem?</td>
<td>36</td>
<td>48</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>4. Help pupils state problems as definite and concise questions?</td>
<td>44</td>
<td>40</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>5. Help pupils select and define the key words as means of getting a better understanding of the problems?</td>
<td>36</td>
<td>48</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>6. Help pupils evaluate problems in terms of personal and social needs?</td>
<td>28</td>
<td>40</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>7. Help pupils to be aware of the exact meaning of word-groups and shades of meaning of words in problems involving the expression of ideas?</td>
<td>38</td>
<td>42</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>8. Present overview lessons to raise significant problems?</td>
<td>30</td>
<td>42</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>9. Permit pupils to discuss possible problems for study?</td>
<td>36</td>
<td>40</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>10. Encourage personal interviews about problems of individual interest?</td>
<td>26</td>
<td>24</td>
<td>36</td>
<td>14</td>
</tr>
</tbody>
</table>

Code for Tables 5 - 16: (A) Frequently - one to three times per week; (B) Regularly - one to three times every two weeks; (C) Seldom - once per month to once every six weeks; (D) Rarely - once every two months or more.
something, no matter how slight or common-place in character, puzzles
or perplexes him; when something appears to him as unexpected, strange
or disconcerting. Authorities in the field in general agree that
identifying or recognizing the problem is the first step in developing
problem-solving techniques. In selecting the problems to be solved
care must be taken to insure that they are adapted to the student's
maturity level, that the problem relates to previous experiences and
that the students are motivated to be willing to solve problems. The
teachers selected frequently and regularly more than 50 percent of the
time to all items in this section of the questionnaire. One could
predict on the selections of the teachers that students were encouraged
and in fact aided by teachers in developing abilities in sensing and
defining problems.

If the student is stimulated to a point of uncertainty in a
given situation which leads to the recognition of a problem, the next
step involved collecting data or evidence on that problem. This phase
of developing problem-solving techniques involved helping the student
develop abilities in differentiating between revelant and irrevelant
materials, develop skill in using references and note taking, to produce
controlled experiments and to develop techniques in interviewing and in
using community resources. According to the response to this part of the
questionnaire one might predict that students were being aided to develop
techniques on collecting data or evidence on problems. Table 6 summarizes
the response of teachers to this part of the questionnaire.

TABLE 6
RESPONSE TO COLLECTING EVIDENCE ON PROBLEMS

<table>
<thead>
<tr>
<th>Collecting Evidence on Problems</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you:</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>1. Provide a wide variety of sources of information?</td>
<td>36</td>
<td>42</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>2. Help pupil develop skill in using reference sources?</td>
<td>36</td>
<td>40</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>3. Help pupils develop skill in note taking?</td>
<td>34</td>
<td>46</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>4. Help pupils develop skill in using reading aids in books?</td>
<td>22</td>
<td>54</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>5. Help pupils evaluate information pertinent to the problem?</td>
<td>28</td>
<td>46</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>6. Provide laboratory demonstrations for collecting evidence on a problem?</td>
<td>22</td>
<td>40</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>7. Provide controlled experiments for collecting evidence on a problem?</td>
<td>20</td>
<td>40</td>
<td>26</td>
<td>14</td>
</tr>
<tr>
<td>8. Help pupils develop skill in interviewing to secure evidence on a problem?</td>
<td>10</td>
<td>34</td>
<td>38</td>
<td>18</td>
</tr>
<tr>
<td>9. Provide for using the resources of the community in securing evidence on a problem?</td>
<td>14</td>
<td>26</td>
<td>42</td>
<td>18</td>
</tr>
<tr>
<td>11. Evaluate the pupils' ability for collecting evidence on a problem as carefully as you evaluate their knowledge of facts?</td>
<td>40</td>
<td>38</td>
<td>20</td>
<td>2</td>
</tr>
</tbody>
</table>
The process of collecting evidence pertinent to a particular problem can often result in a vast accumulation of data. This data is often meaningless unless it can be placed into appropriate charts and graphs, arranged in some specific order or fixed in outline form so that studying the data is made easier and elimination of irrelevant information be facilitated. On the basis of the response to this section of the questionnaire one might predict that students had been aided in organizing evidence on problems. Table 7 summarizes the responses of teachers to questions concerning organizing evidence on problems.

If students develop the attitude that they know the answer, evidence collected on problems will serve very little purpose because of biased opinions. Toward this end teachers have as a responsibility to keep students from making hasty decisions. This can be done in part by aiding the student in learning to interpret evidence that has been collected and organized. Interpretation of evidence involves aiding the student in developing concepts that will allow him to select the important ideas related to the problem, see the consistencies and weaknesses in data and to state relationships as generalizations that may serve as hypotheses. On the basis of the teachers' response to items in this section of the questionnaire one could predict that students had been aided by their teachers in developing concepts on interpreting evidence on problems. The teachers' response to questions
### Table 7

**RESPONSE TO ORGANIZING EVIDENCE ON PROBLEMS**

<table>
<thead>
<tr>
<th>Organizing Evidence on Problems</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How often do you:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help pupils develop skill in arranging data?</td>
<td>24</td>
<td>54</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>2. Help pupils develop skill in making graphs of data?</td>
<td>16</td>
<td>42</td>
<td>32</td>
<td>10</td>
</tr>
<tr>
<td>3. Help pupils make use of deductive reasoning in areas best suited?</td>
<td>38</td>
<td>38</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>4. Provide opportunity for pupils to make summaries of data?</td>
<td>24</td>
<td>24</td>
<td>26</td>
<td>6</td>
</tr>
<tr>
<td>5. Help pupils distinguish relevant from irrelevant data?</td>
<td>24</td>
<td>46</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>6. Provide opportunity for pupils to make outline of data?</td>
<td>24</td>
<td>46</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>7. Carefully evaluate the pupils' ability to organize evidence on a problem as you evaluate their knowledge of facts?</td>
<td>30</td>
<td>44</td>
<td>22</td>
<td>4</td>
</tr>
</tbody>
</table>

Concerning interpretation of evidence is found in Table 8.

To insure against erroneous judgments or decisions as a result of interpretation of evidence students should develop concepts in selecting and testing hypotheses. This would involve aiding the student in rechecking data for possible errors, learning to consult authorities, setting up controlled experiments, judging the significance or pertinence of data for immediate problems, formulating assumptions basic to given hypothesis and in making inferences from facts and observations. The
TABLE 8
RESPONSE TO INTERPRETATION OF EVIDENCE ON PROBLEMS

<table>
<thead>
<tr>
<th>Interpret Evidence on Problems</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help pupils select the important ideas related to the problem?</td>
<td>50</td>
<td>44</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>2. Help pupils see the consistencies and weaknesses in data?</td>
<td>42</td>
<td>42</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>3. Help pupils state relationships as generalizations which may serve as hypotheses?</td>
<td>24</td>
<td>50</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>4. Evaluate the pupils' ability for interpreting evidence as carefully as you evaluate their knowledge of facts?</td>
<td>36</td>
<td>40</td>
<td>22</td>
<td>2</td>
</tr>
</tbody>
</table>

Response by the teachers to items in this section of the questionnaire indicates that they had aided students in selecting and testing hypotheses. The response of the teachers to these questions is summarized in Table 9.

The final step in developing the problem-solving technique involved formulating conclusions. To insure that the student developed concepts in this area the teacher gave guidance in making conclusions on the basis of tested evidence, in applying their conclusions to new situations and in evaluating their conclusions in light of assumptions they set up for the problem. One could predict on the basis of the response to items in this section of the questionnaire that teachers aided students to develop concepts involving formulating conclusions.
TABLE 9
RESPONSE TO SELECTING AND TESTING HYPOTHESES

<table>
<thead>
<tr>
<th>Selecting and Testing Hypotheses</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help pupils judge the significance or pertinence of data for the immediate problem?</td>
<td>32</td>
<td>54</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>2. Help pupils check hypotheses with recognized authorities?</td>
<td>10</td>
<td>64</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>3. Help pupils make inferences from facts and observations?</td>
<td>22</td>
<td>60</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>4. Help pupils devise controlled experiments suitable for testing hypotheses?</td>
<td>18</td>
<td>38</td>
<td>38</td>
<td>6</td>
</tr>
<tr>
<td>5. Help pupils recognize and formulate assumptions basic to a given hypothesis?</td>
<td>30</td>
<td>50</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>6. Help pupils recheck data for possible errors in interpretation?</td>
<td>36</td>
<td>40</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>7. Evaluate the pupils' ability for selecting and testing hypotheses as carefully as you evaluate their knowledge of facts?</td>
<td>26</td>
<td>38</td>
<td>30</td>
<td>6</td>
</tr>
</tbody>
</table>

The response of the teachers to this area is summarized in Table 10.

A group of seniors were administered the questionnaire in an effort to ascertain the attitude of the students toward the use of problem-solving techniques by their science teachers. The questionnaire administered to the students was changed to ask how often the teacher helped the student to accomplish these items related to problem solving.
TABLE 10
RESPONSE TO FORMULATING CONCLUSIONS

<table>
<thead>
<tr>
<th>Formulating Conclusions</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help pupils formulate conclusions on the basis of tested evidence?</td>
<td>36</td>
<td>50</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>2. Help pupils evaluate their conclusions in light of assumptions they set up for the problem?</td>
<td>28</td>
<td>50</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>3. Help pupils apply their conclusions to new situations?</td>
<td>34</td>
<td>48</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>4. Evaluate the pupils' ability to formulate conclusions as carefully as you evaluate their knowledge of facts?</td>
<td>32</td>
<td>36</td>
<td>30</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 11 summarizes the response of the students to section one of the questionnaire. This section of the questionnaire contains ten items and it concerns itself with sensing and defining problems which is the first step in developing the problem-solving technique. The students responded to this section by answering frequently and regularly to the ten questions 51.20 percent of the time. The teachers selected frequently and regularly 77 percent of the time. Though there is a difference of 25.80 percent in the response of the teachers and the students one could assume that the concept for sensing and defining problems was being developed because the teachers and students selected frequently and regularly more than 50 percent of the time.
## Table 11
### Response to Sensing and Defining Problems

<table>
<thead>
<tr>
<th>Sensing and Defining Problems</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often does your teacher:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help you sense situations involving personal and social problems?</td>
<td>13</td>
<td>28</td>
<td>24</td>
<td>35</td>
</tr>
<tr>
<td>2. Help you recognize specific problems in these situations?</td>
<td>10</td>
<td>30</td>
<td>26</td>
<td>34</td>
</tr>
<tr>
<td>3. Help you in isolating the single major idea of a problem?</td>
<td>14</td>
<td>34</td>
<td>30</td>
<td>22</td>
</tr>
<tr>
<td>4. Help you state problems as definite and concise questions?</td>
<td>20</td>
<td>30</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>5. Help you select and define the key words as means of getting a better understanding of the problems?</td>
<td>32</td>
<td>39</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>6. Help you evaluate problems in terms of personal and social needs?</td>
<td>10</td>
<td>38</td>
<td>21</td>
<td>31</td>
</tr>
<tr>
<td>7. Help you to be aware of the exact meaning of word-groups and shades of meaning of words in problems involving the expression of ideas?</td>
<td>21</td>
<td>36</td>
<td>26</td>
<td>17</td>
</tr>
<tr>
<td>8. Present overview lessons to raise significant problems?</td>
<td>21</td>
<td>31</td>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>9. Permit you to discuss possible problems for study?</td>
<td>22</td>
<td>38</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>10. Encourage personal interviews about problems of individual interest?</td>
<td>17</td>
<td>28</td>
<td>30</td>
<td>25</td>
</tr>
</tbody>
</table>

The second section of the questionnaire is concerned with collecting evidence on problems. This section consists of eleven items
<table>
<thead>
<tr>
<th>Collecting Evidence on Problems</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often does your teacher:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Provide a wide variety of sources of information?</td>
<td>25</td>
<td>33</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>2. Help you develop skill in using reference sources?</td>
<td>16</td>
<td>41</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>3. Help you develop skill in note taking?</td>
<td>26</td>
<td>37</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>4. Help you develop skill in using reading aids in books?</td>
<td>14</td>
<td>27</td>
<td>34</td>
<td>25</td>
</tr>
<tr>
<td>5. Help you evaluate information pertinent to the problem?</td>
<td>12</td>
<td>34</td>
<td>39</td>
<td>15</td>
</tr>
<tr>
<td>6. Provide laboratory demonstrations for collecting evidence on a problem?</td>
<td>13</td>
<td>38</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>7. Provide controlled experiments for collecting evidence on a problem?</td>
<td>15</td>
<td>35</td>
<td>23</td>
<td>27</td>
</tr>
<tr>
<td>8. Help you develop skill in interviewing to secure evidence on a problem?</td>
<td>9</td>
<td>31</td>
<td>39</td>
<td>21</td>
</tr>
<tr>
<td>9. Provide for using the resources of the community in securing evidence on a problem?</td>
<td>12</td>
<td>28</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>11. Evaluate your ability for collecting evidence on a problem as carefully as he evaluates your knowledge of facts?</td>
<td>18</td>
<td>37</td>
<td>29</td>
<td>16</td>
</tr>
</tbody>
</table>
and the students responded by selecting an answer of frequently or regularly to these eleven items more than 50 percent of the time. The students selected frequently or regularly 50.45 percent of the time while the teachers selected the same answers 67.09 percent of the time. The percentage difference between the two groups is 16.65 percent but because both groups selected frequently and regularly more than 50 percent of the time one could assume that concepts on collecting evidence on problems were being developed by the students and being taught for by the teachers. Table 12 summarizes the response of the students to the second section of the questionnaire.

Section three of the questionnaire deals with organizing evidence on problems. This section contains seven items and the students selected frequently and regularly 45.57 percent of the time while the teachers selected those two answers 68.57 percent of the time. The percentage difference between the two groups is 23 percent. This data indicates that the teachers felt they were teaching for the concept, but the students selected frequently and regularly less than 50 percent of the time which could mean that they did not feel the teachers aided them to develop concepts involving organizing evidence on problems. Table 13 summarizes the response of the students to this section of the questionnaire.

The fourth section of the questionnaire contains four items concerned with developing concepts on how to interpret evidence on
TABLE 13
RESPONSE TO ORGANIZING EVIDENCE ON PROBLEMS

<table>
<thead>
<tr>
<th>Organizing Evidence on Problems</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often does your teacher:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help you develop skill in arranging data?</td>
<td>9</td>
<td>30</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>2. Help you develop skill in making graphs of data?</td>
<td>6</td>
<td>38</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>3. Help you make use of deductive reasoning in areas best suited?</td>
<td>9</td>
<td>40</td>
<td>31</td>
<td>20</td>
</tr>
<tr>
<td>4. Provide opportunity for you to make summaries of data?</td>
<td>13</td>
<td>32</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>5. Help you distinguish relevant from irrelevant data?</td>
<td>7</td>
<td>37</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>6. Provide opportunity for you to make outline of data?</td>
<td>9</td>
<td>33</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>7. Evaluate your ability to organize evidence on a problem as carefully as he evaluates your knowledge of facts?</td>
<td>15</td>
<td>41</td>
<td>25</td>
<td>19</td>
</tr>
</tbody>
</table>

on problems. The students selected the answers frequently and regularly 43.50 percent of the time. The teachers selected frequently and regularly 82 percent of the time. There was a percentage difference of 38.50 percent between the answers of the two groups. One could assume that because the students selected frequently and regularly less than 50 percent of the time that the students were not developing concepts involving the interpretation of evidence on problems. The response of the
Table 14 summarizes the response of the students to the fifth section of the questionnaire. This section of the questionnaire is concerned with selecting and testing hypotheses and it contains seven items. The students selected frequently and regularly as answers to the questions in this section 49 percent of the time. Teachers selected frequently and regularly as answers to the questions in this section 74 percent of the time. There was a 25 percent difference in the response of the two groups and since the selection of frequently or regularly was below 50 percent for students one might assume that the majority of the students are not developing concepts in selecting and testing hypotheses.
### Table 15

RESPONSE TO SELECTING AND TESTING HYPOTHESES

<table>
<thead>
<tr>
<th>Selecting and Testing Hypotheses</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often does your teacher:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help you judge the significance or pertinence of data for the immediate problem?</td>
<td>12</td>
<td>39</td>
<td>33</td>
<td>16</td>
</tr>
<tr>
<td>2. Help you check hypotheses with recognized authorities?</td>
<td>10</td>
<td>32</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>3. Help you make inferences from facts and observations?</td>
<td>10</td>
<td>49</td>
<td>24</td>
<td>17</td>
</tr>
<tr>
<td>4. Help you devise controlled experiments suitable for testing hypotheses?</td>
<td>12</td>
<td>33</td>
<td>33</td>
<td>22</td>
</tr>
<tr>
<td>5. Help you recognize and formulate assumptions basic to a given hypothesis?</td>
<td>11</td>
<td>29</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>6. Help you recheck data for possible errors in interpretation?</td>
<td>16</td>
<td>38</td>
<td>21</td>
<td>25</td>
</tr>
<tr>
<td>7. Evaluate your ability for selecting and testing hypotheses as carefully as he evaluates your knowledge of facts?</td>
<td>13</td>
<td>39</td>
<td>26</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 16 summarizes the response of the students to the sixth section of the questionnaire. This section of the questionnaire is concerned with developing concepts on formulating conclusions. This section consists of four items and the students selected answers of frequently or regularly 59.75 percent of the time. Teachers selected frequently or regularly 78.50 percent of the time. The percentage difference between the two groups was 18.75 percent, but both groups
TABLE 16
RESPONSE TO FORMULATING CONCLUSIONS

<table>
<thead>
<tr>
<th>Formulating Conclusions</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often does your teacher:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Help you formulate conclusions on the basis of tested evidence?</td>
<td>27</td>
<td>39</td>
<td>23</td>
<td>11</td>
</tr>
<tr>
<td>2. Help you evaluate your conclusions in the light of assumptions they set up for the problem?</td>
<td>11</td>
<td>41</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td>3. Help you apply your conclusions to new situations?</td>
<td>20</td>
<td>42</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>4. Evaluate your ability to formulate conclusions as carefully as he evaluates your knowledge of facts?</td>
<td>21</td>
<td>38</td>
<td>25</td>
<td>16</td>
</tr>
</tbody>
</table>

selected answers of frequently or regularly more than 50 percent of the time. The assumption on the basis of this data is that students were developing concepts concerning formulating conclusions.

The response of the teachers to the questions in all of the six areas involved on the questionnaire showed that answers of frequently or regularly was selected more than 65 percent of the time. The data would tend to indicate that the teachers were aware of the techniques of problem-solving and were teaching for these concepts. The results of the response of the students, however, indicated that discrepancies existed between the response of the two groups. The students selected frequently or regularly in excess of 50 percent in only three areas. These three areas were in sensing and defining problems, collecting evidence on
problems and formulating conclusions. The students selected answers of frequently or regularly less than 50 percent of the time in the areas of organizing evidence on problems, interpreting evidence on problems and in selecting and testing hypotheses.

Though the teachers indicated that they were using the problem-solving approach to teaching science, the students' response indicate that the techniques for problem-solving are being developed to a very limited degree if at all.
CHAPTER III

FINDINGS, CONCLUSIONS, RECOMMENDATIONS

Introductory statement.—This study sought to determine the extent to which teachers of selected junior and senior high schools in a Georgia school system were teaching for problem-solving abilities in their classrooms. The data was collected utilizing a specifically designed questionnaire.

Rationale.—Science is one of the most powerful forces operating in our lives today. In the civilized world, individuals encounter and use products of science in all of their daily experiences and activities. The food he eats, the clothes he wears and the way he is entertained are all influenced in some way by science. Science is now changing our entire existence in such important aspects as health, transportation, communication and power.¹

It had already been noticed before Russia launched Sputnik that the United States was not producing scientists in sufficient numbers to maintain our position as the scientific leaders of the world. After Sputnik was launched the United States realized that she was behind.

Soul-searching of our scientific and technological programs followed and the major weakness in our scientific program was revealed. It showed that education was the apparent weakness in our science program. It was shown that if our level of scientific achievement was to move forward the education system would need teachers that were better in skills and knowledge, and these teachers had to produce scientist that possessed superior competence in scientific research and development. They must also have general education which enables him to understand the world society in which he operates and he must be able to communicate effectively with his associates.¹

We must, at the same time, keep in mind the need for scientific literacy for all our citizens. Our education program must provide general understandings for those not inclined toward science and provide advanced work for those destined to become scientist. If it were only necessary to decide whether to teach the rudiments of science to everyone on a mass basis or to identify the gifted and carry them as far as they can go, our task would be relatively simple... The public school must educate both producers and consumers of scientific services.²


Purpose of the study.--The general purpose of this study was to determine if selected science teachers were using methods to develop problem-solving techniques in their science classes. Specifically, this study attempted to achieve the following purposes:

1. To ascertain the number of teachers who used the problem-solving behavior.

2. To determine methods they utilized to teach for problem-solving behavior.

3. To determine if teachers felt that the problem-solving method was the best method for teaching science.

4. To obtain the opinions of selected high school seniors as to what extent their science teachers had used problem-solving techniques.

Locale of the study.--This study involved junior and senior high school science teachers and 100 high school seniors in a Georgia school system.

Limitations.--This study was limited to data collected by the writer from 50 teachers and 100 high school seniors from selected junior and senior high schools in Georgia. Therefore, it can be assumed that the responses reported reflected only the ideas of the respondents involved in the study.

Description of instrument.--The instrument used to collect data for the study was specially prepared questionnaire similar to questionnaire published by the United States Office of Education and by the Science Manpower Project.
Description of subjects.--The subjects were science teachers in selected Georgia junior and senior high schools and a selected group of high school seniors. Females and males were included in the study, but no attempts were made to separate or classify results on the basis of sex or race.

Method of research.--The descriptive survey research method was used for this study, employing a special inventory form to collect data.

Research procedures.--The procedural steps for this study were as follows:

1. Permission to do the study was secured from the proper school officials.

2. Literature related to the study was surveyed.

3. Questionnaires to secure information from the subjects involved were obtained.

4. Questionnaires were sent to teachers and students of the selected schools accompanied by a letter explaining why the information was desired.

5. Follow-up cards were sent as a reminder to those who were slow in returning forms.

6. The data was tabulated into appropriate tables and treated by percentages for the various categories. Findings, conclusions, implications, and recommendations derived from this data are included in the finished thesis.

Evolution of the problem.--This problem evolved out of reactions as a teacher of biology and chemistry for four years. During this time, in reading literature related to science teaching, a conviction emerged that teaching for the concept of problem-solving is one of the latest
and most accepted methods in science teaching, and it was decided to attempt to find out the extent of acceptance of this method by science teachers and the degree of success.

Contribution to educational knowledge.—Science educators are striving to prepare students to become effective citizens and to live in a highly complex technological world. Science educators and scientists with grants given by industry and the government are continually studying science programs in efforts to improve science curricula and produce better science students. Science teachers are being paid to go back to school in an effort to upgrade their knowledge. Based upon these facts, it is hoped that this study will prove helpful to school administrators, science supervisors and science teachers in planning science programs that will enable the individual student to fit more effectively into a complex technological society.

Statement of the problem.—The problem of this study was to ascertain to what extent selected science teachers used the concept of problem-solving and the degree of success achieved.

Summary of related literature.—The literature used in this study was chosen for its pertinence to the problem itself.

What are schools supposed to do? Schools should be dedicated to the proposition that every youth in these United States regardless of sex, economic status, geographic location, or race should experience a broad and balanced education which will (1) equip him to enter an
occupation suited to his abilities and offer reasonable opportunity for personal growth and social usefulness; (2) prepare him to assume the full responsibility of American citizenship; (3) give him a fair chance to exercise his rights to the pursuit of happiness; (4) stimulate intellectual curiosity, engender satisfaction in intellectual achievement and cultivate the ability to think rationally; and (5) help him develop an appreciation of the ethical values which should undergird all life in a democratic society.¹

If we are to assist youth to be more effective in achieving these ends, we must provide them with the proper "tools". It is imperative that these tools be identified and that instructional programs be provided to help youth acquire them as they proceed through our school system.²

Educational psychologist have demonstrated that a good learning situation is one in which children become involved. Involvement can occur if children are able to relate new problems for study to their own experiences and their own needs. Children will become involved also as they participate in defining problems and planning the courses of action.³


²Smith, The Science Teacher, Vol. 34, No. 4, p. 33.

The major problem facing science teachers today is the problem of presenting these materials in the best possible way. This method, whatever it may be, must present the material clearly and yet promote the spirit of inquiry and aid in the development of problem-solving. Man has been solving problems since time immemorial, but until recently there has been little conscious effort to teach the process.¹

This process was introduced about thirty-five years ago, and there has been an increase in its use, but the process has been slow. This is due, in part, to the fact that teachers had seldom been taught the process. The process of problem-solving can be described according to Lester C. Mills as both a way of thinking and a method of teaching. Essentially, this type of thinking occurs only when there is a need for it, when the situation presents a difficulty that cannot be met by other means.²

For something so deeply rooted in common sense, it should be easy to teach for development of the problem-solving concept which some science educators refer to as the common sense method or as both a way of thinking and a method of teaching. One major reason for this method not being more popular is that teachers have not been trained to use it nor have a large number of science teachers been taught by people who

¹Lester C. Mills, Problem-Solving Methods in Teaching (New York: Columbia University, Teachers College), 1960, p. 1.

²Ibid., p. 3.
using the problem-solving approach. The perfect formula for science education would fail when exposed to poor teaching. Poor teaching lacks either soundly conceived learning activities; the poorest teaching lack both, the most effective lacks neither.¹

Since man cannot see actual thought processes in action, he must judge the content, quality and essence of these thought processes by means of the effect that they have on the individual. If it is to be believed that the most effective way to evaluate learning is through observations of the action patterns of the learner, it must follow that, since learning is based upon thought process, thinking must be also evaluated through observations of behavior. What patterns of behavior can be associated with thought processes? Four types of thinking in terms of behaviors have been isolated.²

1. The method of tenacity—resists change on the grounds that a given action has always been the way that they react to dilemma.

2. The method of authority—a person who does something because a person of a particular status says that was the way to react.

3. Method of intuition—described by referring to the person who believes in astrology, but actually it was third on the hierarchy of methods of thinking because there is often a spark of reasoning behind


some decisions that at first glance seem to be inspirational.

4. Method of science—weigh the pro and con of every possible answer to his question, then select the one answer which seems to be the most logical to him, and act on this information.

Methods of science or reflective thinking—only method that admits that it might lead to error and is, therefore, the most progressive.

**Major findings.**—The analysis and interpretation of data pertinent to the findings of this research are summarized in the numbered sections below:

1. There was a general spread of respondence from the seventh through the twelfth grades.

2. A high percentage of the respondents were educated in Georgia colleges; 50 or 100 percent were college graduates; 17 or 34 percent had completed at least one semester of graduate study and 10 or 20 percent held master's degrees.

3. All the respondents (50 or 100 percent) had had specific courses in methods of teaching science.

4. Thirty-six or 72 percent of the respondents had more than twenty-five pupils in their classes.

5. Forty-six or 92 percent of the respondents had majors in the area of science.

6. The majority of the respondents indicated that they aided students to sense and define problems by indicating frequently and regularly to questions in this area of the questionnaire 77 percent of the time.

7. The majority of the respondents indicated that they aided students in collecting evidence on problems by indicating frequently and regularly to questions in this area 67.09 percent of the time.

8. The majority of the respondents indicated that they aided students in organizing evidence on problems by indicating
frequently or regularly to questions in this area 68.57 percent of the time.

9. The majority of the respondents indicated that they aided students develop techniques in interpreting evidence on problems by selecting frequently or regularly to questions in this area 82 percent of the time.

10. The majority of the respondents indicated that they aided students select and test hypotheses by selecting frequently or regularly 74 percent of the time.

11. The majority of the respondents indicated that they aided students in formulating conclusions by selecting frequently or regularly 78.50 percent of the time.

12. The students that participated in the study indicated that they felt the teachers were not aiding them to organize evidence on problems, interpret evidence on problems and select and test hypotheses by selecting frequently and regularly less than 50 percent of the time.

13. The students that participated in the study felt that teachers were aiding them in sensing and defining problems, collecting evidence on problems and formulating conclusions by selecting frequently and regularly more than 50 percent of the time.

14. There is a relatively wide range of difference between the opinions of the teachers and the students as to the use of problem-solving techniques.

Conclusions--The major findings of this research support the following conclusions:

1. Major finding one through five indicated that the respondents were representative of science teachers in the public schools.

2. Major finding four indicated that because of class size, the teachers though adequately trained could make few allowances for individual differences and needs in their classes.

3. Major findings six through eleven indicated that a majority of the teachers in the study were aware of the problem-solving approach to teaching science and that they taught for
the development of problem-solving techniques.

4. Major finding twelve indicated that students did not feel they were being aided in developing concepts on organizing evidence on problems, interpreting evidence on problems and on selecting and testing hypotheses.

5. Majoring finding thirteen indicated that students felt that teachers had aided them in sensing and defining problems, collecting evidence on problems and in formulating conclusions.

6. Major finding fourteen indicated that there was a relatively wide range of difference in opinions of the teachers versus the students as to the use of the problem-solving approach.

Implications--The major findings of the study support the following implications:

1. That there is a need for some attention to be given to the number of students assigned to science classes.

2. There is a need for science teachers to be included in administrative planning, especially when assigning students to classes is involved.

3. That there is a need for developing in-service methods courses for teachers involving teaching for the concept of problem-solving.

4. That there is a need for teachers to test students frequently to find out if the concepts that are being taught are actually developed.

5. That there is a need for teachers to give special attention to aiding students on organizing evidence on problems, interpreting evidence on problems and on selecting and testing hypotheses.

6. That there is a need for in-service seminars for teachers so that those teachers familiar with problem-solving techniques can aid those teachers who are not familiar with the techniques of problem-solving.
Recommendations—On the basis of the major findings, conclusions and implications the following recommendations are made to the administrative and teaching staff of the school system involved.

1. The number of students assigned to science classes be reduced.

2. Science teachers be included during administrative planning sessions.

3. In-service methods courses stressing problem-solving be offered to teachers.

4. Teachers test their students often to be sure that concepts being taught are being developed by the students.

5. Teachers plan exercises that will involve and aid students in developing concepts in organizing evidence on problems, in interpreting evidence on problems and in selecting and testing hypotheses.

6. In-service seminars be set up so that teachers familiar with problem-solving techniques can aid those teachers who are not familiar with the concepts.
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Books


**Periodicals**


**Unpublished Material**

VITA

WEBB, Melvin R.

Education:

B. S., Albany State College (Science Education), 1962.
National Science Foundation Institute, Albany State College,
Summer, 1964.
Plan to complete requirements for the Master of Arts degree,
June, 1968.

Experience:


Personal Information:

Single; member—NEA, GTEA, DCT and NSTA.
PERSONAL INFORMATION

Please fill in the blank spaces provided for your response.

1. Sex: Male _____ Female _____

2. What Grade do you teach? ______

3. Give highest level of college completed:
   
   A. Undergraduate - ( ) Freshman ( ) Sophomore ( ) Junior ( ) Senior

   B. Graduate - ( ) One semester ( ) Two semesters ( ) More than two semesters ( ) Masters Degree

4. Kind of certificate you hold: ______ ______ ______ ______ ______.

5. Number of courses in Methods of Teaching Science completed. ______
   Give approximate number of total hours received in Methods of
   Teaching Science ______.

6. Did courses in Methods of Teaching Science involve teaching for the concept of problem solving? ( ) Yes ( ) No.

7. Approximate number of hours completed in Education. ______

8. Were you a Science Major in Undergraduate school? ( ) Yes ( ) No.
   If (Yes), check area - ( ) Biology ( ) Chemistry ( ) Physics ( ) Science Education.
   If (No), name area of undergraduate major. ________________________.

9. Was your graduate work in Science? ( ) Yes ( ) No.
   If (No), name area of graduate work. ________________________.

10. When did you attend school last? Year ________________________.

11. How many classes do you teach each day? ______

12. What is the average size (number of pupils) of your classes? ______.
USING PROBLEM SOLVING AS A TEACHING TECHNIQUE

Please indicate your answer in the parenthesis by using one of the following letters which corresponds to your answer.

(A) Frequently - One to three times per week
(B) Regularly - One to three times every two weeks
(C) Seldom - Once per month to once every six weeks
(D) Rarely - Once every two months or more

TEACHER’S ROLE

A. Sensing and Defining Problems

How often do you:

( ) 1. Help pupils sense situations involving personal and social problems?
( ) 2. Help pupils recognize specific problems in these situations?
( ) 3. Help pupils in isolating the single major idea of a problem?
( ) 4. Help pupils state problems as definite and concise questions?
( ) 5. Help pupils select and define the key words as means of getting a better understanding of the problems?
( ) 6. Help pupils evaluate problems in terms of personal and social needs?
( ) 7. Help pupils to be aware of the exact meaning of word-groups and shades of meaning of words in problems involving the expression of ideas?
( ) 8. Present overview lessons to raise significant problems?
( ) 9. Permit pupils to discuss possible problems for study?
( ) 10. Encourage personal interviews about problems of individual interest?

B. Collecting Evidence on Problems

How often do you:

( ) 1. Provide a wide variety of sources of information?
( ) 2. Help pupil develop skill in using reference sources?

( ) 3. Help pupils develop skill in note taking?

( ) 4. Help pupils develop skill in using reading aids in books?

( ) 5. Help pupils evaluate information pertinent to the problem?

( ) 6. Provide laboratory demonstrations for collecting evidence on a problem?

( ) 7. Provide controlled experiments for collecting evidence on a problem?

( ) 8. Help pupils develop skill in interviewing to secure evidence on a problem?

( ) 9. Provide for using the resources of the community in securing evidence on a problem?

( ) 10. Provide for using visual aids in securing evidence on a problem?

( ) 11. Evaluate the pupils' ability for collecting evidence on a problem as carefully as you evaluate their knowledge of facts?

C. Organizing Evidence on Problems

How often do you:

( ) 1. Help pupils develop skill in arranging data?

( ) 2. Help pupils develop skill in making graphs of data?

( ) 3. Help pupils make use of deductive reasoning in areas best suited?

( ) 4. Provide opportunity for pupils to make summaries of data?

( ) 5. Help pupils distinguish relevant from irrelevant data?

( ) 6. Provide opportunity for pupils to make outline of data?

( ) 7. Evaluate the pupils' ability to organize evidence on a problem as carefully as you evaluate their knowledge of facts?
D. Interpret Evidence on Problems

How often do you:

( ) 1. Help pupils select the important ideas related to the problem?

( ) 2. Help pupils see the consistencies and weaknesses in data?

( ) 3. Help pupils state relationships as generalizations which may serve as hypotheses?

( ) 4. Evaluate the pupils' ability for interpreting evidence as carefully as you evaluate their knowledge of facts?

E. Selecting and Testing Hypotheses

How often do you:

( ) 1. Help pupils judge the significance or pertinence of data for the immediate problem?

( ) 2. Help pupils check hypotheses with recognized authorities?

( ) 3. Help pupils make inferences from facts and observations?

( ) 4. Help pupils devise controlled experiments suitable for testing hypotheses?

( ) 5. Help pupils recognize and formulate assumptions basic to a given hypothesis?

( ) 6. Help pupils recheck data for possible errors in interpretation?

( ) 7. Evaluate the pupils' ability for selecting and testing hypotheses as carefully as you evaluate their knowledge of facts?

F. Formulating Conclusions

How often do you:

( ) 1. Help pupils formulate conclusions on the basis of tested evidence?
( ) 2. Help pupils evaluate their conclusions in the light of assumptions they set up for the problem?

( ) 3. Help pupils apply their conclusions to new situations?

( ) 4. Evaluate the pupils' ability to formulate conclusions as carefully as you evaluate their knowledge of facts?

Note: Similar questionnaires seeking students' opinions were administered to the 100 students who participated in this study.