SELECTED LABORATORY EXPERIMENTS FOR NINTH GRADE PHYSICAL SCIENCE

by

BARBARA ANN LEHMAN

B.S., Kansas State University, 1964

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

Approved by:

Charles M. Peccolo

Major Professor

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INTRODUCTION

Today more than ever before there is a need for a scientifically informed public as well as trained scientists. There has been an increased emphasis on science and mathematics in the past few years which is apparent in the schools where more courses in these subjects are now required of students and more advanced courses are being offered.

Science in the high school has taken great strides forward in the areas of biology, physics, and chemistry. The National Science Foundation and other agencies have sponsored several studies to up-date and revitalize these courses. Among the best known of these studies are the Physical Science Study Committee (PSSC), Biological Sciences Curriculum Study (BSCS), Chemical Education Material Study (CHEMS), and Chemical Bond Approach Project (CBA). Lockard published a report of current projects giving their titles, sponsors, and goals.[1] In general these projects have been aimed at increasing comprehension of scientific processes by introducing a discovery approach to learning. Students in these courses discover fundamental generalizations and concepts through their own laboratory work.

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[1] J. David Lockard, " The Secondary School Curriculum Projects, " Science Teacher, 32:48-9, May, 1965.

Elementary science is also being studied and improved. Wagner has published a list of thirteen projects in elementary school science.[2] The trend toward conceptual development is evident in the design of recent elementary science curricula as well as in the secondary science curricula. Piltz gives three main trends underlying curriculum change as increasing scientific knowledge, emphasis of methods of science and revolutionary modern equipment technology.[3]

The June 1964 issue of Review of Educational Research was concerned with research in science and mathematics. The studies reviewed were concerned mainly with the elementary and the secondary levels. There were 103 references on secondary science and only five on junior high science. Bennett described the situation in this way:

> It should not be inferred that these programs at the secondary and elementary levels are not worth while or that they are not improvements over the science teaching of 20 years ago, because they are effective when handled properly. What should be pointed out is that, in a sense, we are creating a two-tailed "monster" fat on both tailed ends but dwindling away in the middle body area, perhaps to the extent of either tail may be negated or stringently controlled by this middle void. This middle void is the junior high school, grades seven through nine.[4]

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[2]Guy Wagner, "Progress in Elementary School Science," Education, 87:55-9, September, 1966.

[3]Albert Piltz, "Promising Trends for Effecting Needed Changes in Curriculums in Elementary Science," Science Education, 48:12, 1964.

[4]Lloyd M. Bennett, "The Present Plight of Junior High School Science," Science Education, 49:470, December, 1965.

In many schools ninth grade science has been a general science course and still is. Mallinson lists three problems of junior high school science as shortage of teachers, undesirable course content, and simple redundant textbooks.[5] "Fortunately, junior-high-school-science is moving away from being a high speed, comprehensive, descriptive, indigestible rampant survey of the sciences."[6] Two curriculum projects that apply to junior high school science are the Introductory Physical Science and School Science Curriculum Project, both under the sponsorship of the National Science Foundation. Interest in junior high school science is increasing but there is need for more curricula development and coordination.[7]

Statement of the Problem

The purpose of this study was (1) to examine the course outline and textbook presently used in the ninth grade science course in the Iowa City Community School System; (see Appendix) (2) to develop a set of experiments designed to be carried out by ninth grade students in

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[5]George G. Mallinson, "Junior-High-School Science and the Implications of the Science Motivation Project," School Science and Mathematics, 64:614, October, 1964.

[6]Harold R. Hungerford, "Investigation in Science," Illinois Education, 53:300, March, 1965.

[7]Paul H. Hurd, "New Directions in Science Teaching, K-College," Education, 87:213, December, 1966.

the classroom with a minimum of expensive equipment; and (3) to tryout and report the results obtained from the selected experiments.

Importance of the Study

It is a common complaint of chemistry and physics teachers that their students do not seem to have the slightest idea of the purpose of laboratory or what a laboratory experiment is all about.[8] This is especially evident with the recent laboratory-centered programs. Norton found that student interest in science falls drastically during the junior high years and the nation may be losing many potential scientists because of the failure of teachers and the curriculum to challenge and interest the junior high student.[9]

There has been a transition from the lecture-demonstration approach to the laboratory-discovery approach. The following statements by Bennett seem to represent the majority of publications in this area.

> It is difficult to conceive of a science course that will achieve its goals without supplying actual contact with the phenomena to be studied. The experiences offered in a well-planned laboratory period are an integral link in the development of scientific thinking and the assimilation of theory.[10]

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[8]Fred T. Weisbruch, "Laboratory Oriented Courses for Ninth Grade Science," School Science and Mathematics, 63:494, June, 1963.

[9]Jerry L. Norton, "Need for an Activity Centered Science Program," Science Education, 47:285, April, 1963.

[10]Clifford Bennett, Jr., "From Concepts to Percepts," New York State Education, 51:12, March, 1964.

The emphasis in general science is changing from subject matter and facts to laboratory and problem-solving. Science objectives include the student and development of an understanding of science and its methods.

Students in general like to be in a laboratory-centered class. For many students the laboratory period is a time of release from the constant demands of the lacture period. It is a pleasant break from class, where supervision is not as close and where interesting things can be handled and exciting things happen. Here the learning process is less demanding and more enjoyable and the students like it.

However, laboratory alone is not a good thing. Students often seem to miss the whole concept of the laboratory period as a time for solving problems by making measurements and observations, organizing and analyzing data, and reaching logical conclusions. This may be the fault of the teacher in lack of student preparation. Ausubel felt that students waste many valuable hours in the laboratory collecting and manipulating data which at the very best helped them rediscover principles that the instructor could have presented verbally and demonstrated visually in a matter of minutes.[11] Hence, although laboratory work can easily be justified on the grounds of giving students some appreciation of the

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[11]David P. Ausubel, "Some Psychological Considerations in the Objectives and Design of an Elementary School Science Program," Science Education, 47:184, April, 1963.

spirit and methods of scientific inquiry, and promoting problem-solving, and generalizing ability, it is a time consuming and inefficient practice for routine purposes of teaching subject-matter content or illustrating principles where lecture or simple demonstrations would be adequate. The new science curricula are good in theory but they lack practicality in applying the programs to existing school curricula, facilities, and personnel.

Limitations

The review of literature and the resources available to the author were limited to periodicals located in the State University of Iowa library in Iowa City, Iowa.

During the 1965-66 school year the writer taught science to 150 ninth grade students at Southeast Junior High School in Iowa City. These students were divided into five classes representing three achievement levels according to their eighth grade biology grades. The writer had two low sections, one average and two high sections. Three additional average sections were taught by other faculty members.

During the 1966-67 school year the writer had 150 students in three average sections, one low section, and one high section. The other ninth grade science teacher had an identical assignment.

The students attending Southeast Junior High School had a varied background. The parents were employed at the University, in business, industry, farming, and other jobs typical of a town of 30,000 people in the Midwest. The ninth grade students ranked in the 82nd percentile nationally in IQ and in the 99th percentile nationally in achievement as measured by the Iowa Test of Educational Development.

Experiments included in this report were designed for the facilities and equipment available at Southeast Junior High School. Ten gas outlets and three sinks with running water were available in the science room. General physics and chemistry equipment was available either through purchase from scientific companies or through loan from the high school.

Procedures Employed in the Study

The procedures employed in this study consisted of a review of pertinent literature, examination of groups of students for which experiments were designed, development of a format of experiment and a study of the textbook and units in the course outline for which the experiments were designed. (The Iowa City Community School System course outline for ninth grade physical science may be found in the Appendix.)

Definition of Terms

As a guide to the reader and to prevent any misunderstanding, the following terms are defined according to their use in this report:

Ninth Grade Physical Science: A year course covering subject matter in physics and chemistry. (A course outline and name of textbook for the Iowa City Community School System ninth grade physical science may be found in the Appendix.)

Laboratory Experiments: Classroom activities ninth grade students can perform individually or in groups covering material from the course outline.

Junior High School: Grades seven, eight, and nine.

REVIEW OF THE LITERATURE

A review of the literature in the area of secondary school science laboratory was carried out to evaluate the merit of the laboratory experience for the student of science.

The National Science Foundation has sponsored several studies and committees that have developed science courses generally emphasizing unification of concepts, logical reasoning processes, laboratory experiences, and problem-solving methods. There has been considerable controversy over the value of inductive discovery methods of science instruction and the traditional "cookbook" method. Inductive discovery methods of science instruction failed to produce more effective learning than traditional deductive verification methods.[12] The results of studies comparing the effectiveness of the new laboratory-centered courses were generally inconclusive. It was difficult to design a test that would be an appropriate measure for both the old and new course. Students taking the Biological Sciences Curriculum Study course excelled other students when taking the BSCS test, while the students taking the standard course excelled on a traditional test.[13]. Comparable

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[12] Paul H. Hurd and Mary B. Rowe, "Science in the Secondary School." Review of Educational Research, 34:290, June, 1964.

[13] Ibid.

results were found by Sawyer in an investigation of the program recommended by the Physical Science Study Committee.[14] According to Stevenson, students felt that the Chemical Bond Approach course was valuable to them when taking further science courses.[15] In a comparative study of Chemical Educational Material Study and traditional chemistry, Anderson found no significant difference in students' ability concerning cognitive processes.[16] Bungert questioned 220 chemistry teachers on the effects of Chemical Educational Material Study. The teachers felt that conceptual understanding, use of the laboratory, problem solving skills, and reasoning ability had increased.[17] It should be noted that in these studies there was some influence of the "Hawthorne Effect" present because of the higher interest and

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[14] Robert L. Sawyer, "An Investigation of the Effectiveness of the Program Recommended by the Physical Science Study Committee," Dissertation Abstracts, 24:5254, 1964.

[15] Andrew Stevenson, "How Experimental is Chemistry?" Iowa Science Teachers' Journal, 1:7, December, 1963.

[16] Jane S. Anderson, "A Comparative Study of Chemical Education Material Study and Traditional Chemistry in Terms of Students' Ability to Use Selected Cognitive Processes," Dissertation Abstracts, 25:5147, 1965.

[17] William C. Bungert, "Effects of the Chemical Education Materials Study Curriculum on the Teaching of High School Chemistry," Dissertation Abstracts, 25:6224, 1964.

motivation in the laboratory approach. Marshall and Herron have concluded that there is no effective measure for curriculum evaluation.[18] It was impossible to show that one course was better than another.

Karl made a comparison of the effectiveness of open-ended chemistry experiments with the conventional laboratory exercises in high school. He found no significant differences between groups taught by the two methods on measures of critical thinking, interest in science, recall of information or application of principles.[19] Charen found that although both methods resulted in learning chemistry, neither improved critical thinking as measured on a test developed by Charen. Scores on the Watson-Glaser Critical Thinking Appraisal test tended to favor the traditional method. Teachers needed more time for preparation of open-ended experiments. Charen stated that his study justified the continuance of open-ended experiments.[20]

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[18] J. Stanley Marshall and James Dudley Herron, "Trends in Science Education Research," Education, 87:207, December, 1966.

[19] Irmgard F. Karle, "The Effectiveness of Open-Ended Chemistry Experiments in a High School Setting: A Comparison of Open-Ended Chemistry Experiments with the Conventional Laboratory Exercises in Teaching Selected High School Chemistry Classes," Dissertation Abstracts, 21:1099, 1960.

[20] George Charen, "The Effect of Open-Ended Experiments in Chemistry on the Achievement of Certain Objectives of Science Teaching," Journal of Research in Science Teaching, 1:190, 1963.

Montague found no significant difference in subject-matter achievement between a group of college students in open-ended laboratory and a group taking "cookbook" laboratory as measured by the final exam.[21] Rainey had comparable results with a study at the high school level.[22]

Lee found that students taught by problem-solving experiences show just as much improvement in critical thinking as those taught by conventional methods. However, motivation and interest is greater among students participating in problem-solving experiences.[23] On the other hand, Kastrinos reported that a biology course planned and taught to improve critical thinking did produce improvement in critical thinking mean scores. He measured critical thinking with standardized tests as well as with a test he devised himself. Kastrinos discovered that the tests used in his study varied in the extent to which they could furnish evidence concerning critical thinking of different IQ groups.[24]

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[21]Earl J. Montague, "Using the College Chemistry Laboratory to Develop an Understanding of Problem Solving in Science," Dissertation Abstracts, 23:2815, 1964.

[22]Robert G. Rainey, "The Effects of Directed Versus Non-Directed Laboratory Work on High School Chemistry Achievement," Dissertation Abstracts, 24:146, 1963.

[23]Ernest W. Lee, "A Study of the Effect of Two Methods of Teaching High School Chemistry Upon Critical Thinking Abilities," Dissertation Abstracts, 25:4578, 1965.

[24]William Kastrinos, Jr., "The Relationship of Methods of Instruction to the Development of Critical Thinking by High School Biology Students," Dissertation Abstracts, 22:2251, 1962.

Kleinman found that seventh and eighth grade teachers who ask more critical thinking questions impart greater understanding of science to their students.[25] In another study Riggs found no difference in achievement of students taught college chemistry laboratory by problem-solving methods versus the traditional laboratory method.[26]

Tookey,[27] Humphreys,[28] Strehle[29] and Bradley[30] studied the effectiveness of a science course with and without a laboratory. Tookey stated that students gained more in learning and retention when an earth

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[25] Gladys S. Kleinman, "General Science Teachers" Questions, Pupil and Teacher Behaviors, and Pupils' Understanding of Science," Dissertation Abstracts, 25:5153, 1965.

[26] Virgil M. Riggs, "A Comparison of Two Methods of Teaching College General Chemistry Laboratory," Dissertation Abstracts, 23:165, 1962.

[27] Jack V. Tookey, "The Comparative Effects of Laboratory and Lecture Methods of Instruction in Earth Science and General Science Classes," Dissertation Abstracts, 24:324, 1964.

[28] Alan H. Humphreys, "A Critical Analysis of the Use of Laboratories and Consultants in Junior High School Science Courses," Dissertation Abstracts, 23:1623, 1962.

[29] Joseph A. Strehle, "The Comparative Achievement of Seventh-Grade Exploratory Science Students Taught by Laboratory Versus Enriched Lecture-Demonstration Methods of Instruction," Dissertation Abstracts, 25:2386, 1964.

[30] Robert L. Bradley, "Lecture-Demonstration Versus Individual Laboratory Work in a General Education Science Course," Journal of Experimental Education, 34:33-42, Fall, 1965.

science course is taught by a laboratory method than when taught by lecture method of instruction. Humphreys' study of laboratory versus no laboratory in junior high school sciences concluded that laboratory does not affect achievement or interest scores of students at a statistically significant level. Strehle also found no significant differences between the gain in achievement of seventh grade science students taught by laboratory versus enriched lecture-demonstration method. He felt lecture-demonstration should be emphasized at the seventh grade level due to drawbacks of apparatus and teacher time in the laboratory method. Both the lecture-demonstration method and the individual laboratory method were equally effective means of teaching general science in college as measured by a paper and pencil test. Also there was no difference in achievement of students with previous laboratory courses versus those with no laboratory experience. In this study Bradley felt that the savings of the lecture-demonstration method in apparatus and instructor time may offset any supposed advantage of laboratory.

Oliver compared the relative efficiency of three methods of teaching high school biology: (1) lecture-demonstration, (2) lecture-discussion-demonstration, and (3) lecture-discussion-demonstration-laboratory exercises. The groups were tested on factual information, over-all achievement in biology, application of scientific principles and attitudes toward science and scientists. Results showed no significant differences in learning.[31]

The lack of an effective measure made it difficult to evaluate one science program as better or worse than the next program. Also the variables of human behavior made it difficult to obtain statistically significant results in studies comparing teaching methods. Both extremes, the lecture and the laboratory, had their own merits. The facilities, money, time and personnel available at the individual school dictated what program was best.

The writer tried a modified laboratory approach with the ninth grade science classes. This meant essentially a lecture-discussion-demonstration class with laboratory about fifteen percent of the class periods. The laboratory had a definite role in ninth grade science both as a preparation for future laboratory courses and as a teaching method that was alive and interesting to ninth grade students.

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[31]Montague M. Oliver, "An Experimental Study to Compare the Relative Efficiency of Three Methods of Teaching Biology in High School," Dissertation Abstracts, 22:2293, 1962.

PROPOSED LABORATORY EXPERIMENTS

This section contains ten experiments designed for the average ninth grade student taking a general physical science course. The experiments offered are flexible. For a slow class more information may need to be supplied or careful step-by-step instructions given by the teacher during the laboratory period. Advanced classes should be able to take the problem and devise their own procedure. As students gain experience in the laboratory throughout the year, progressively less information needs to be given.

Sometimes a "warm-up" experiment was valuable. Before undertaking the density experiment students had some experience in weighing objects and finding the volume of regular and irregular shaped objects. Before the heat experiment they practiced using thermometers and burners. This saved time and confusion in later laboratory periods.

A general format for science experiments was adopted by science teachers at Southeast Junior High School. The experiments included here consist of six main items: (1) problem, (2) materials, (3) procedure, (4) diagram, (5) results, and (6) conclusions. The problem presents a question to the students that they will attempt to answer through the results of the experiment. Materials is simply a list of equipment and supplies needed to perform the experiment. Procedure gives the steps to be taken in the experiment. The diagram is a drawing showing how the materials are used. The results includes data, observations, and calculations. The conclusion is an important part of the experiment. Here the student attempts to summarize the results and to answer the problem presented in the first step. Often questions are included to guide the students in their laboratory reports.

Unit I - Introduction

Problem: What is the density of rock # ____?

Materials: spring scale, overflow can, graduated cylinder, rock, water

Procedure:
1. Find the weight of the rock.
2. Find the volume of the rock by displacement of water.
3. Calculate the density of the rock.

Diagram:

Results: $\text{Density} = \frac{\text{weight}}{\text{volume}}$

1. Weight = ________________ grams
2. Volume = ________________ cubic centimeters
3. Density = ________________ grams/cu. cm.

Conclusions:

Unit II - Mechanics of Liquids and Gases

Problem: What is the buoyant force of water on rock # _____?

Materials: spring scale, overflow can, graduated cylinder, rock, water

Procedure: 1. Find the apparent buoyant force of water by weighing the rock in air and then in water.

The apparent buoyant force is the difference of these two weights.

2. Find the buoyant force according to Archimedes' Principle.

The buoyant force on the rock is equal to the weight of the water the rock displaces.

Diagram:

Results: 1. The weight of the rock in air = _______________ grams

The weight of the rock in water = _____________ grams

The apparent buoyant force = _________________ grams

2. The weight of water displaced = ______________ grams

The buoyant force (Archimedes) = _____________ grams

Conclusions:

Unit III - Motion and Machines

Problem: What is your horsepower?

Materials: stop watch, ruler, scales

Procedure:
1. Measure the height of the stairs.
2. Find your weight.
3. Time yourself running from the bottom step to the top.
4. Calculate your horsepower.

Diagram:

Results: $\text{Horsepower} = \frac{\text{force x distance}}{550 \text{ x time}}$

1. Distance (height of stairs) = __________ feet
2. Force (your weight) = __________ pounds
3. Time (running) = __________ seconds
4. $\text{Horsepower} = \frac{\_\_\_\_\text{ lbs x }\_\_\_\_\text{ ft.}}{550 \text{ x }\_\_\_\_\text{ sec.}}$ = __________ H.P.

Conclusions:

*What would your horsepower be if you walked up the stairs? Try this if there is time.

Unit IV - Heat and Engines

Problem: How does temperature change when ice melts and the water is boiled to form steam?

Materials: bunsen burner, ring stand and ring, wire screen, hose, thermometer, beaker, ice

Procedure:
1. Place a beaker of ice on the ring over the burner.
2. Record the time and temperature and light the burner.
3. Record the time and temperature at one minute intervals until the water has been boiling for ten minutes. Stir the water before each reading.
4. Plot your data on graph paper using time as the horizontal axis and temperature as the vertical axis.

Diagram:

Results:

Temp. (°C.)	Time	Temp. (°C.)	Time

Conclusions:

Unit V - Magnetism, Static and Current Electricity

Problem: What is the shape, size, and direction of a magnetic field?

Materials: bar magnet, compass, pencil, paper

Procedure:
1. Use the compass to determine north and south directions in the classroom.
2. Lay a piece of paper lengthwise in the north and south direction.
3. Place the magnet so the north pole points north.
4. Place the compass at the pole of the magnet. Either pole may be used. The compass should touch the end of the magnet.
5. Now put a pencil dot on the paper at the end of the compass needle that is farthest from the magnet.
6. Move the compass so that the end which was closest to the magnet is now pointing to the pencil dot. This means that the compass is moved out and the needle now points to the pencil dot.
7. Now make a second pencil dot at the opposite end of the compass needle.
8. Repeat steps 6 and 7 until you have drawn several dots. Then draw lines connecting the dots which represent the lines of force of the magnetic field.
9. Repeat steps 3 through 8 to obtain several lines of force from both poles. Also draw lines of force starting from the side of the magnet.
10. Show the direction of each line. (From north to south)

Diagram: This is on the other peice of paper. Be sure you have connected all the dots to show the lines of force. Draw in the shape and label the poles of your magnet.

Results:

Conclusions:

Unit VI - Sound and Communication

Problem: What materials are good conductors of sound?

Materials: tuning fork, water, wood, rock, metal, paper, air, cardboard, glass.

Procedure:

1. Using the tuning fork as a sound source, compare the loudness of the sound after it travels through one foot of the materials listed above to your ear.
2. To test air, hold the tuning fork 1 foot from your ear after it has been struck.
3. To test other materials hold one end next to your ear while your partner strikes the tuning fork and places the end against the object one foot from your ear.
4. Record your observations and comparisons below. Test any other materials you might find around the room.

Diagram:

Results:

Conclusions:

Unit VII - Light

Problem: How is light reflected by a mirror?

Materials: pins, pencil, mirror, ruler, paper, cardboard

Procedure:
1. Place this piece of paper on the cardboard. Set the mirror on the line drawn below. Hold the mirror perpendicular to the surface of the paper. Stick the colored pin into the paper a few inches in front and to the right of the mirror. Be sure you can see the pin in the mirror.

2. Move your head to the left of the mirror. With one eye closed lower your head until your open eye is level with the paper and you can see the image of the colored pin in the mirror.

3. Put a mark on the line the mirror is on where the image appears in the mirror. Hold your head still. Now put a pin a few inches in front of the mirror directly between your eye and the image in the mirror.

4. Remove the mirror and draw a line from each pin to the mark on the mirror line. Then draw a line perpendicular to the mirror line from this same mark. Label the incident and reflected rays.

5. Study the angles between the lines from the pins and the perpendicular line. How do these two angles compare in size? How large are they? Label the angle of incidence and the angle of reflection.

Diagram: mirror line

Results:

Conclusion:

Unit VIII - Organization of Chemistry

Problem: What is the difference between a mixture and a compound?

Materials: iron filings, sulfur, paper, magnet, test tube, spoon, test tube holder and burner

Procedure & Results:

1. Observe a spoonful of iron and sulfur. Describe the properties of these two elements. Describe their similarities and differences.

   Iron:

   Sulfur:

2. Mix together a spoonful of sulfur and a spoonful of iron on a piece of paper. Describe the appearance of this mixture. Find a way to separate the elements in the mixture. Describe your procedure below.

3. Mix together a spoonful of sulfur and a spoonful of iron on a piece of paper. Transfer the mixture to a dry test tube. Heat the tube until a red glow is observed throughout the contents. Remove the tube from the flame and wait until the reaction stops and the test tube cools. Carefully remove the product with your forceps. Examine it and describe its appearance.

   Can you separate the iron and sulfur?

   What has happened to the elements?

Conclusions:

Unit IX - Our Essential Environment

Problem: How is oxygen prepared and what are its properties?

Materials: bottles, burner, burette clamp, glass plates, test tube, trough, forceps, manganese dioxide, potassium chlorate

Procedure:
1. Put four spoons of the manganese dioxide and potassium chlorate mixture in your test tube.
2. Assemble the apparatus as shown by your instructor. Have your apparatus checked before going to the next step.
3. Heat the mixture with a small flame from your burner. Heat slowly, one area at a time. When the oxygen bubbles are coming too fast to be counted, take away the heat until they slow down.
4. Collect the gas by placing the bottles one at a time over the end of the delivery tube. When each bottle is filled, slip a glass plate under it, and set it upright on the desk.
5. When four bottles have been filled, remove the delivery tube from the water and then take the flame away from the test tube.

Diagram:

Results: Properties of oxygen

1. Use a glowing splint to test the gas in the first bottle.
2. Heat a sliver of charcoal in the burner flame and then lower it into a bottle of oxygen. Record your observations.
3. Heat a piece of steel wool in the burner flame and lower it into a bottle of oxygen. Record your observations.

(The remaining bottle of oxygen may be used to repeat one of the above tests if your results were unsatisfactory.)

Conclusions: What are the properties of oxygen?

Write the chemical equations for #1, 2, and 3 in Results.

Unit X - Inorganic Compounds

Problem: How can you test for acids and bases?

Materials: litmus paper, stirring rod, sample of matter listed below.

Procedure & Results:

1. Sulfuric acid is an acid. Place one drop of the dilute sulfuric acid on pieces of red and blue litmus paper. What do you observe?

2. Sodium hydroxide is a base. Place one drop of the dilute sodium hydroxide on pieces of red and blue litmus paper. What do you observe?

3. Using the results from sulfuric acid and sodium hydroxide as a guide, test the solutions at your table to determine if they are acids or bases. Observe what happens when they are tested with litmus paper and record your results.

   vinegar
   coke
   ammonia
   water
   salt water
   liquid soap
   oven cleaner
   orange juice

Conclusions: What is the effect of acids on litmus paper?

What is the effect of bases on litmus paper?

How do you know when a solution is neutral?

REPORT ON TRY-OUT OF PROPOSED LABORATORY EXPERIMENTS

The purpose of this section was to provide the reader with some insight as to problems and questions that might arise during the laboratory period. Suggestions were also included on prior background information the students should have before attempting the experiments.

Comments were based on the results of experimental trial with ninth grade students in the 1965-66 and 1966-67 school years. The writer had 300 students during the two years. They were arranged into three slow classes, three fast classes, and four average classes.

Grades received by students in the different sections were fairly constant through the year for laboratory. The advanced sections received about 99 percent on the laboratory experiments. The average sections received mainly C and C- grades with a few B grades. The slow sections' scores depended greatly on how much individual guidance they received from the instructor during the period. The average laboratory grade was C for these sections. Unless there was a large deviation from the above averages in the experiments, the grades received by the various classes were not discussed in the following report on try-out of experiments.

Try-Out of Density Experiment

Before this experiment was performed by the students, they practiced finding the volume of different types of substances and weighing a variety of objects. Density was discussed in class and a problem sheet was completed in class finding density from weights and volumes. Extra time was spent with the slow classes to help them grasp the meaning of density.

The experiment was simple and went quite smoothly. Breakage of graduated cylinders was a big problem but plastic cylinders were ordered for the following years. In later experiments, when students had become familiar with laboratory procedure and handling equipment, there was very little breakage. The main question asked during the laboratory period was "How do I find the volume of the rock?". The students were not familar with the term "displacement of water" and this had to be explained many times.

The students' grades on the experiment were mainly B's and C's in the average classes, A's in the advanced classes, and B's and C's in the low classes. In the slow classes the teacher performed the experiment at the beginning of the period and then gave personal attention to each student as he attempted the experiment. The slow sections contained about 24 students while the others contained an average of 32 students.

Further experiments in density and specific gravity were carried out by the classes. A block of wood, a nail, a liquid, and a cork were given to the students and they were asked to find the density or specific gravity of the objects. The advanced classes were given no further instructions. They had many questions but most of these were returned to the students. Once they took time to think a little they achieved quite good results. Each developed slightly different methods of attacking the problem. The average classes were given a paper asking for the weight, volume, density, and specific gravity of the four objects. They needed some help in finding an acceptable method to determine the weight of the liquid. In the slow class, each object was first discussed and then a method was decided on by the class. They then followed their selected procedure in the laboratory. Grades for the slow class this time were C's and D's. There were questions over material that had just been covered.

Try-Out of Buoyancy Experiment

The buoyancy experiment dealt with only one new concept for the students--buoyant force. The equipment and methods were made purposely similar to the previous density experiment.

Before the laboratory period, floating objects and those that sink were discussed by the classes. Archimedes' Principle was explained and discussed and the instructor demonstrated how to find the buoyant force of water on a rock. The laboratory was confusing to the majority of the students. The two methods given in the directions for finding the force seemed to confuse them. The writer suggested attempting just one method during one laboratory period and applying it to several objects. They also had problems in finding the weight of the water displaced even if they knew the volume of the water displaced.

When the classes were given a chance to repeat the experiment on another object several days later, the results were much better and there were very few problems. The advanced class was given the problem of finding the buoyant force of alcohol or salt water on their object in addition to water. A few forgot to weigh the liquid displaced and assumed that one milliliter of their liquid weighed one gram.

Information given under <u>results</u> on the laboratory report form was not necessary but facilitated the grading of the reports by the instructor.

Try-Out of Horsepower Experiment

Prior to this experiment the classes read about work and power. Simple demonstrations were given to the class and the work and power calculated for each case. The students were slow to grasp the meaning of the units foot-pounds and foot-pounds/second. The instructor tried to let each student have a chance to do some work and determine just how much work he did.

The only problem in the experiment was finding a long, straight stairway away from other classrooms. In the average classes two students at a time went in the hall and timed running up the stairs.

There was a short reading assignment in the book while the others waited for their turns. Following this procedure the experiment filled the full hour class period. This included time for calculations and the writing of conclusions.

The slow classes went in a group to a flight of stairs outside the building and timed four students. It then took the rest of the period to find the results for these four students.

The question "What is my horsepower?" was written on the board in the advanced classes. They were given the entire class period and evening to devise a method of finding horsepower and reported back to the class the next day. About fifty percent used the stair method which was mentioned in the book. The rest developed generally original methods usually involving lifting or carrying objects.

Try-Out of Heat Experiment

This was a very successful experiment from the standpoint of learning experience and one of the students' favorites. The plots of temperature versus time were excellent and instructional to the students. Most students seemed quite surprized that the water never got hotter than 100°C. The line on the plot while the ice was melting was quite irregular since the temperature was hard to determine.

Several questions were written on the board for the students to consider in writing the conclusion of the experiment. This was done to be sure that they thought through their results and tried to explain the plots from their present knowledge. Example of questions asked were: (1) Why doesn't the temperature get any higher than 100°C ?, (2) What would happen if your burner flame had been larger for this experiment ?, (3) What would a plot of the temperature and time look like ?, and (4) What would happen to your plot if the flame went out when the water temperature was 60°C ?.

There was a problem of breakage of the thermometers. This was the first time they had used the science thermometers. They should have had complete instructions on how to read the thermometers and how to handle them.

Try-Out of Magnetism Experiment

There were many questions from the students on the procedure in this experiment. The results seemed best when the teacher demonstrated on the board exactly how to locate the points using the compass and to draw one of the lines for the class. Minor problems such as taking the magnet off the paper and working too close to their neighbor's magnet required a watchful eye of the teacher.

The 1965-66 school year this experiment was followed by a laboratory using iron filings to show the magnitude and direction of lines of force.

The 1966-67 school year this order was reversed and the students seemed to have a better understanding of what the compasses indicated. Grades were high on this experiment but conclusions were very brief.

In the advanced class this experiment was not graded. They were given combinations of magnets, horseshoe magnets and some four pole bar magnets to work with after they mastered the compass experiment using a single bar magnet.

Try-Out of Sound Experiment

This experiment was used the first day the classes started on the sound unit. Different properties of sound were discussed by the class and then with about twenty minutes left in the period they were given this experiment and asked to some prepared to discuss the results the next day.

This was a noisy laboratory and they seemed interested in what they were doing. Students were all over the room testing the acquarium, the blackboard, the doors, and other items. The discussion of this experiment the next day was important in determining how much they gained from it. The low classes turned in their reports to be graded. The average classes received no grades.

In the advanced classes just the problem was given to them. In class discussion different methods were suggested. They could not agree on one method so they formed teams and each team checked certain objects. The next day they compared results. The class judged which method was best and their opinions were used to grade the team efforts.

Try-Out of Light Experiment

The same experiment was given to all classes. After one class period it became obvious that it would be necessary for the teacher to explain and demonstrate how to follow the steps given. They had had no experience with sighting along a straight line. It was also necessary to check each student and help him through the first step.

The scores of students in the average sections were lower than usual--almost all C and D grades. The slow classes completed the experiment with help from the teacher but had little or no idea of what they had done.

In this experiment discussion of results and the material in the textbook was very important. It was during the discussion that many of the students finally figured out what they had done and what the lines meant that they had drawn.

The confusion seemed to last all through the light unit. It was difficult for them to work with something invisible that they could not see or touch. The experiment following this one, on refraction of light through glass, was simpler and more satisfying as a learning experience.

Try-Out of Iron Sulfide Experiment

This was the first "real" experiment in chemistry and the students were enthusiastic. This was a standard experiment in nearly every reference because it was relatively safe and easy and demonstrated vividly the differences between compounds and mixtures.

Prior to this experiment the students had laboratory in using the burners and other laboratory techniques. They had also had extensive practice in identifying the physical properties of different materials. This experiment went very smoothly and the student reports were good. All students received A's and B's except for a few who did not try the experiment.

This experiment required burners which might limit its use to demonstration in schools not having all the equipment. Also the test tubes were permanently dirty but could be used in some similar experiments in following years.

In discussion of the results the use of carbon disulfide as a method of separating the mixture was presented. There were many experiments on separating mixtures requiring a minimum of equipment. Possible mixtures would be salt, sand, water, iron, and other substances.

Try-Out of Oxygen Experiment

This experiment should be attempted only after the laboratory techniques have been well mastered by the students. There are several safety warnings that should be given to the students that they must follow. The 1965-66 school year this was tried only in the advanced classes. In the 1966-67 school year all students except those in slow sections prepared oxygen. The slow sections were given bottles of oxygen prepared in other classes and then proceded to check the properties of oxygen as outlined under results in the experiment.

The results turned in by the students were satisfactory. The students worked in groups of three which is not too efficient and made the laboratory a little crowded. The students usually tended to heat the mixture too strongly, causing side reactions. Alcohol lamps were used the second year instead of gas burners. The three tests of the oxygen gave positive results. The laboratory experiment was good because it involved a variety of laboratory techniques. There were a few questions from students on the procedure to be followed. It was suggested that the instructor have a sample of the laboratory apparatus set up to serve as a guide. The "teacher check" of the apparatus before proceeding with the experiment was enforced and eliminated most accidents.

Try-Out of Acids and Bases Experiment

During the 1965-66 school year this experiment was carried out near the end of the chemistry unit. It is a very simple exercise and was included in an earlier part of the chemistry unit in 1966-67. There was not much thinking involved in this laboratory. Generally the students learned how to test for acids and bases with litmus paper and they learned what items that they use at home are acids and bases. This was effective in introducing the acids and bases unit in chemistry.

Students had many questions concerning other substances and whether they were acidic or basic. The following day they brought some items from home to check. They also brought some "stomach preparations" that are advertised on their ability to neutralize stomach acids. This opened up several possible experiments including a determination of just how much acid the different brands could neutralize.

SUMMARY AND IMPLICATIONS

Science at the ninth grade level contained both the learning of scientific principles and experimenting with these principles. It was not possible to teach all the facts to students in view of the immense collection of scientific data available. Neither was it possible to let students duplicate or "discover" great scientific principles. Throughout history this has been a slow and tedious process. The junior high student was limited by his level of maturity, his mathematical and scientific background, and the time and facilities available for experimentation. It was necessary to compromise the ideal situation with the actual situation. The teacher helped students learn how to perform experiments as a scientist would perform them. It was important to keep the student interested in science and to provide a foundation for high school science courses.

Demonstrations were important in presenting information and ideas to the students and were useful when equipment or time was limited. They were also used in presenting complex ideas or difficult experiments. Actual student experimentation, however, with scientific equipment and methods was also vital. Students were given a chance to discover on their own how certain laws and principles work.

Most ninth grade students were not willing to accept blindly the laws and principles set forward by the teacher or book. Therefore, the writer felt verification experiments were not wasted time as some might argue. It was true that lecture-demonstration methods might have been more efficient and less time consuming--but these advantages did not outweigh those of student laboratory experiences. Teachers should not be concerned at the junior high school level with covering the textbook. They should strive to provide a solid basis for high school science courses, familiarize students with equipment, and help students learn the methods and procedures of the scientist.

The ten laboratory experiments proposed in this report were designed to supplement a physical science course and serve as a starting point for student experimentation. These were amended and changed each year and more experiments included in the science course. The value of the laboratory experience rested in the hands of the teacher. It was his responsibility to create the inviting atmosphere conducive to scientific study and to see that students had the background information necessary before attempting an experiment. The introduction to the laboratory period was important as well as the discussion later of the student results. These determined how much the students learned from the experience. Laboratories were work and time consuming for the teacher, but well worth the investment in terms of student interest and achievement.

ACKNOWLEDGMENTS

The writer would like to express her appreciation to Dr. Charles M. Peccolo, major advisor, for his guidance and advice. The writer also wishes to express her thanks to her husband, Don, for his cooperation and understanding during the writing of this report.

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APPENDIX

Ninth Grade Science Course Outline

UNIT I - Introduction
- A. Scientific Method
- B. Equipment Orientation
- C. Matter
- D. Energy
- E. Measurements

UNIT II - Mechanics of Liquids and Gases
- A. Force and Pressure
- B. Applications of Liquid Pressure
- C. Buoyancy
- D. Specific Gravity
- E. Gas Laws
- F. Bernoulli's Principle
- G. Pumps

UNIT III - Motion and Machines
- A. Forces
- B. Gravitation
- C. Motion
- D. Work
- E. Power
- F. Machines

UNIT IV - Heat and Engines
- A. Nature of Heat
- B. Sources of Heat
- C. Temperature
- D. Theory of Expansion
- E. Transfer of Heat
- F. Measuring Heat Quantities
- G. Changes of State
- H. Boiling and Evaporation
- I. Distillation
- J. Refrigeration
- K. Steam Engine
- L. Gasoline Engine
- M. Diesel Engine
- N. Turbines

UNIT V - Magnetism, Static and Current Electricity

A. Magnetism
B. Theory of Magnetism
C. Making Magnets
D. Demagnetizing
E. Causes of Static Electricity
F. Differences: Magnetism and Static Electricity
G. Static Charges
H. Law of Attraction and Repulsion
I. Conductors and Insulators
J. Electroscope
K. Potential Difference
L. Lightning
M. Nature of an Electric Current
N. Factors
O. Power
P. Producing Electricity
Q. Automobile Storage Battery
R. Cells in Series and Parallel
S. Series Circuit
T. Parallel Circuit
U. Protection
V. Transmitting
W. Electrical Devices

UNIT VI - Sound and Communication

A. Origin of Sound
B. Transmission
C. Characteristics
D. Echoes
E. Acoustics
F. Hearing
G. Communication
H. Doppler Effect

UNIT VII - Light

A. Radiant Energy
B. Sources
C. Transmission
D. Reflection
E. Diffusion
F. Refraction
G. Diffraction
H. Color
I. Vision

J. Lighting
K. Lighting Methods
L. Intensity

UNIT VIII - Organization of Chemistry
A. Atomic Theory
B. Structure of the Atom
C. Symbols
D. Periodic Chart
E. Formation of Compounds
F. Equations
G. Chemical Mathematics

UNIT IX - Our Essential Environment
A. Oxygen
B. Hydrogen
C. Water
D. Carbon Dioxide

UNIT X - Inorganic Compounds
A. Acids
B. Bases
C. Salts
D. Ionization Theory

UNIT XI - Organic Compounds
A. Survey of Organic Chemistry
B. Writing Structural Formulas
C. Methane or Paraffin Series
D. Petroleum
E. Alcohols
F. Organic Acids
G. Plastics
H. Food
I. Medicine and Drugs

UNIT XII - Nuclear Energy
A. Nature of Radioactivity
B. Detection of Radioactivity
C. Nuclear Energy
D. Uses of Radioactivity
E. Radiation Dangers

Textbook Used in Ninth Grade Science

The Physical World, by Richard Brinckerhoff, Burnett Cross, Fletcher Watson, and Paul F. Brandewein, second edition, published by Harcourt, Brace and World, Inc., New York, 1958.

SELECTED LABORATORY EXPERIMENTS
FOR NINTH GRADE PHYSICAL SCIENCE

by

BARBARA ANN LEHMAN

B.S., Kansas State University, 1964

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

The purpose of this study was (1) to examine the course outline and textbook presently used in the ninth grade science course in the Iowa City Community School System; (2) to develop a set of laboratory experiments for ten main units of study designed to be carried out by the average ninth grade student in the science classroom; and (3) to try the experiments and report on the results and their implications.

The procedure employed in this study consisted of a review of the literature, study of groups for which experiments were designed, design of format of experiments, review of the textbook and units for which experiments were designed, and writing and tryout of experiments.

The review of literature showed that laboratory, lecture, demonstration, or any combination were all valuable in teaching science. There were studies supporting the various methods of presentation. It was difficult to design a test or true measure of the effectiveness of a course. A traditional test allowed students of a traditional course to score higher than students in an open-ended laboratory course. No one method was consistently found to be significantly more effective in teaching science than the other methods. Criteria suggested for determining the best method for a school included time, personnel, money, facilities, and general course objectives.

A set of ten laboratory experiments were tried in ten ninth grade classes during the 1965-66 and 1966-67 school years. The results indicated that laboratory at the ninth grade level was an important part of the science course. It was important in elevating student interest and motivation and provided a background for later science courses in high school. Demonstrations and lecture were valuable in presenting information and ideas to the students, especially when time or materials were limited.

The value of the laboratory experience to students rested in the hands of the teacher. It was his responsibility to create the inviting atmosphere conducive to scientific study and to see that students had the background information necessary before attempting an experiment. The introduction to the laboratory period was important as well as the discussion of the results afterwards.

The same experiments were used sucessfully in low, average, and high classes with only slight changes. In slow classes the experiments were usually performed step by step with the teacher demonstrating each step. Students in the high classes were encouraged to perform other tests or related experiments and to discuss their successes and their failures completely. Students reacted most favorably when class time was divided equally between laboratory and lecture-discussion.