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Scope of Study: Science education in our secondary schools has mushroomed into the spotlight during recent months and has been the object of much study and criticism. Evidence supports the fact that the majority of our schools do offer science courses in adequate number, but the quality of such courses is being questioned. One fact stands out clearly in the matter of quality in science laboratory courses - many of our smaller secondary schools do not have adequate laboratory facilities. Since this problem is so broad and complex, no clear-cut and concise answer can be found in any text or reference book. Many good ideas which may be used to supplement each other have been discussed in this report.

Findings and Conclusions: Although the ideal laboratory will not make a good teacher out of a poor one, it certainly will permit the adequate teacher to accomplish more. The real challenge of providing adequate laboratory facilities lies with the instructor of science. He can lead the way to greater interest among his students, the administration of the school, boards of education, and the public. The science instructor must learn to recognize his own limitations and make every effort to lift himself above the frustrations of his profession and avoid the inertia which sometimes causes a science program to bog down. It is the duty of the instructor to utilize all means of inexpensive and improvised equipment in the laboratory. The greater interest which has been shown in science in our secondary schools recently may well be the greatest boon to the science program, if it is directed in constructive channels.

ADVISER'S APPROVAL James H. Zant

THE ROLE OF THE INSTRUCTOR IN SECURING ADEQUATE LABORATORY FACILITIES

By

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Vergil Kenneth McGee

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CHAPTER I

INTRODUCTION

Recently our educational system, as a whole, has met with more public attention than it has received in many years. Much of this attention has been in the form of criticism of various types, such as "What is wrong with our schools?", "Are they really lacking in certain important aspects?", and "What can be done about this lack?"

On television and in newspapers and magazines of every type, we hear mention made of the schools in general, the lack of adequate classrooms, low teaching salaries, and lack of necessary equipment and supplies.

Since Russia launched its first satellite, science in secondary schools has mushroomed into the spotlight and has become a source of extreme importance to civic groups, parents, and the press. As a result of the emphasis on science, an inquiry was made and it was established that most of our schools are doing about as well as they can with the science education facilities at their disposal. So far as the "opportunity" to study is concerned, our schools have little if anything to be apologetic about. Consider, for example, our senior highschools -- the upper grades where greatest emphasis is commonly placed on science teaching. The table below shows the percentage of all U.S. senior high schools offering various science courses in 1956:

General Science	89%
Biology	97%
Chemistry	92%
Physics	92% [1]

Since it has been recognized that most of our schools do teach science courses, we must examine the type of teaching and evaluate the science program to determine whether or not it can be made more effective.

Actually, a two-fold problem should be solved: (1) Encourage more students to study science as a general preparation for life; (2) provide the best possible science teaching and classroom facilities for the young man or woman preparing for a scientific career.

The purpose of this report is concerned with the second phase of this problem, that of the inadequacy of the classroom and laboratory facilities available to the science instructor and students.

That a lack of adequate laboratory facilities exists in many of our smaller secondary schools is supported by the personal experiences of the writer of this report and by discussions with other science instructors of small high schools.

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[1]"A Guide for Evaluating Your Science Facilities", Published by Scientific Apparatus Makers Association, 1958, p. 1

We now come to the question, "Whose responsibility is it to solve this problem?" It is the opinion of the writer of this report that the instructor of science must lead the way. Naturally, he cannot solve the problem alone, but he can create enough interest in his program that he will gain the support of citizens, board of education members, school administrators, and students. These people will, in turn, provide the necessary monetary support.

The purpose of this report is to bring to light some ways and means the science instructor may employ in helping to alleviate this lack of equipment in the laboratory and classroom.

Some of the following chapters will deal with the reasons for the lack rather than the solution to the problem. In order to solve any problem, it is necessary to determine why it exists and some of the underlying reasons.

In examining the lack of equipment in laboratories and classrooms and suggestions as to how this lack may be overcome, the writer of this report hopes to present ideas which may be useful to himself and other highschool instructors.

CHAPTER II

EDUCATING THE PUBLIC

As stated in the introduction, much interest has been shown recently in the over-all science programs of our public schools. This should prove to be a great boon to the science program and to the teacher of science since this presents a great opportunity for educating the public on the importance of science and the necessity of public support in improving our facilities for teaching.

Today we live in a world of science. The fruits of science, the many advantages and benefits it has placed at our disposal, are in our homes, our stores, in our hospitals and doctors' offices; they are in our streets and in the air we breath.

The need for science education extends beyond the demands of the professional and allied services. It is not only in consumer services and tangible products that science meets the citizen at every turn. Politically, socially, and morally science is inescapable. The responsibilities of science confront us daily in our newspapers and magazines and on our television screens.

To lead a well-adjusted life and to help others maintain an orderly society, the citizen of today and tomorrow must have a greater understanding of this dominating factor in his environment. Our future citizens, all of them now in school and for all those who will follow, can acquire this understanding only if we provide the learning opportunity.

In order to provide this learning opportunity, it is necessary that adequate facilities for classrooms and laboratories be made available to the teacher. It is necessary that the public be informed of the cost of these facilities and encouraged to do its part in urging local school systems to build up the facilities for the students' use. Science is not just for a relatively few students -- the career-minded or the exceptionally bright -- but for all students.

Certainly, science should be a well-integrated part of any school system and not be expected to take precedence over other phases of curriculum. Judging, however, from personal observations and information received from numerous other instructors of science, it appears to the writer of this report that entirely too often, the teaching of science in our high schools has taken the back-seat and has been considerably slighted in the matter of providing facilities for the use of the instructor and students.

In one small school system in Oklahoma, this slight became quite noticeable when the local board of education voted to build a new gymnasium at a total cost of $90,000.00 to the school district at a time when there was in existence an extremely adequate gymnasium already. This same year, said school board voted the science department a sum of $300.00 for laboratory purposes when no laboratory existed at all.

A leading citizen of this community voiced the opinion that this was not what the majority of the school patrons desired, but that they did not have enough interest to speak up.

The public must be educated to the fact that a science teacher is a skilled professional. Any skilled professional, the doctor, the lawyer, or the atheletic director, will tell you that he needs the proper tools to do his best work.

The science teaching tools, or facilities, should remove, insofar as feasible, all restrictions on learning in science rooms. Naturally, facilities in themselves cannot make an honor student of every boy or girl. Facilities will not correct ineffective teaching, but they will enable the competent teacher to accomplish more.

The interested and conscientious school patron will ask questions and inspect the laboratory facilities which are placed at the disposal of his child. A few good questions should include these:

"Is general science or any other science course a primarily read about-talk about subject?"

"Is science taught only by instructor demonstration?"

"Is provision made for keeping apparatus and other teaching and learning materials within convenient reach at all times?"

"Are your science rooms and equipment so limited that only a relatively few students can be accomodated?"

The point seems clear enough: Science learning is learning by doing, and every opportunity should be provided

CHAPTER III

TEACHER INITIATIVE

It has been said, "The squeaking wheel gets the grease." This statement might well be applied to the teacher of science in secondary schools. Certainly it is the responsibility of the teacher to inspire his students in the science-learning process and also to "sell" his program to administrators, boards of education, and the patrons of the school. Inertia on the part of the teacher of science plays a part in the explanation of the lack of adequate classroom and laboratory facilities in existence in many of our secondary schools.

> "What was good enough for me is good enough for my children" continues to be paraphrased in antiquated but raucous cliches, for in spite of steady advances in scientific fields, there is resistance to steady advances in the field of science education.[2]

If our science education program is to keep pace with science progress, it must do so on merit. It is the responsibility of the science teacher to see that his program merits the interest and support of his students and the public.

The character of surroundings has a great deal to do with student behavior, and the science teacher can provide

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[2]Wells, Harrington, Secondary Science Education, (New York, 1952) p. 6.

stimuli conducive to learning through attention to physical aspects of his laboratory. Some classrooms fairly radiate a spirit of community effort and revelation in science, while others demonstrate a slothful sogginess in which otherwise capable instruction continually bogs down. Pride and loyalty toward the school which the adolescent attends and the classroom in which he studies science point the way to pride and loyalty behavior patterns with relation to the teacher himself and to the work done under his leadership.

Just as the colorful uniforms and the gleaming beauty of the instruments has a profound influence on the student who decides to participate in the band program, so will the interesting and well-equipped laboratory influence these same students to take a more active interest in the field of science.

It is the privilege of the instructor to bring new fire and enthusiasm into the secondary school laboratory. His service will contribute in enormous measure to the lives and life attitudes of those fortunate enough to experience his stimulative leadership.

> Budget moneys and expensive equipment have very little to do with the subconscious appeal of mutual endeavor which the dynamic educator strives to create and maintain; much may be done with little if the drive is urgent and the significance of psychological appeal is realized and put to work by the classroom teacher.[3]

The teacher who demonstrates what he can do with perhaps meager equipment and money will, no doubt, create

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[3]Ibid., p. 9.

enough interest that his efforts will be greatly rewarded by improvements in his laboratory. The long climb upwards in the realm of recognition for his efforts proves to be frustrating to many teachers causing them to lose sight of their objectives and lessen their dynamic approach to the science education program.

It seems apparent at this point that the outstanding teacher must be a dedicated man. He must also be willing to stand up and fight for his program and for the materials he deems necessary for the welfare of his students.

Inertia on the part of the science teacher is a difficult thing to overcome because often recognition is too slow in being granted. There is about as much difference in the best and worst teachers as there is between the best and worst lawyers or actors. In the case of teachers, however, the differences are rarely recognized except by the few students in their classes.

> One may become the best teacher of English, Mathematics, or Biology in the United States, and yet receive only minor local acclaim and no additional salary whatever. A teacher's name will never be mentioned in "Who's Who?" and his income will be about that of a journeyman plumber. Yet he is, remember, the best teacher in the United States. The frustrations of the able teacher in such a situation can be easily imagined. [4]

The teacher of science who rises above these frustrations and demonstrates a dynamic and forceful interest in the field of science will do a great deal in attracting the interest of his students, administrators, and public. This

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[4] Paul Woodring, "Rewards of Good Teaching", Tulsa Daily World, November 2, 1958. p. 6.

interest, in turn, will bring about the necessary monetary rewards which will enable him to improve and add good equipment to his laboratory.

Some suggestions the instructor may employ for the purpose of creating interest in the science program are listed below:

1. Hold a science fair annually, inviting participants from surrounding schools, at which students display and explain their science exhibits. Invite the parents and general public to attend these affairs. Just as the doting father joins the quarter-back club to back his son's team, so will he attend and give his support to the science program.

2. Plan an occasional assembly program in which science students demonstrate their prowess in performing experiments.

3. Set aside a particular day for inviting parents to visit and inspect the science laboratory. Put students in charge of explaining equipment and its use.

There are a number of ways in which students can serve the community through the science program, thereby gaining personal experience and information as well as bringing recognition to the science program. Some suggestions are:

1. Soil testing: Pupils have set up a center for simple soil testing, giving home gardeners advice on improving their soil. This was first done during the Victory Garden period, but it is equally valuable now.

2. Health campaigns: Pupils can aid in disseminating

information about cancer, heart disease, or in other health campaigns. Pupils have even worked in a diabetes campaign, doing simple urine examinations for sugar for the school or the entire community.[5]

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[5]Zim, Herbert S., "Opportunities for Pupils with Unusual Science Talent." Science in Secondary Schools Today, the _Bulletin of the National Association of Secondary School Principals_, 37: 156-165, January 1953.

CHAPTER IV

AUDIO-VISUAL MATERIALS

Since few small schools are financially able to supply the instructor with the ideal laboratory, it is imperative that the instructor avail himself of all means of substitutions for science experiences. One of the most valuable substitutions is the use of audio-visual materials as a part of the classroom and laboratory facilities.

Learning has its basis in first-hand experiences. One of the major concerns is to provide these experiences, which is the interaction of students and situations. Of course, many experiences cannot be provided directly. For various reasons it may be necessary to provide representations of real things. A simple representation may be more effective than the real resource. If it is at hand and less expensive, it may even be more desirable.[6]

Some suggestions that the science instructor may use in his visual-aids program as a supporting part of his science facilities are listed:

1. The use of motion picture film. Much of our science teaching has been limited to the use of printed and spoken words. When the word is used alone out of relation to some more direct experience, it is likely to give little meaning to the reader. The result is a verbalism. The use of good science films can give a representation of experiments which may be difficult to actually perform in the science labora-

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[6] Richardson, John S., Science Teaching in Secondary Schools, (Englewood Cliffs, N.J., 1957) p. 301.

2. <u>Specimens</u>, <u>models</u>, <u>and</u> <u>displays</u>: Among the real things which the science teacher can use readily are specimens, models, and exhibits of these materials. Specimens have the advantage of being a segment of reality; often they come from a source which the student knows. Mushrooms, fossils found in stone and coal, a cross section of co-axial cable -- such are the specimens which may be presented in the laboratory. These specimens must be used in a learning situation. There will be reading to do in relation to them. There may be chemical testing or the identification of plants.

Models have been a stock in trade of the science teacher for many decades. In general, they are representations of such things as plants, animals, structures, and natural objects. Sometimes they are parts of such things. The models are intended to simplify, to develop in the student an understanding of form and function which cannot be gained through the real things.

The preparation of effective displays is one of the important phases of the work of the science teacher. The effective arrangement of the display may be described in terms of three major criteria, each with its illustrative factors:

a. Does the display attract the student? Does it have an intriguing title question, easily read? "How Polio Shots Protect You", "Will You See the Eclipse Next Week?"

b. Does the display involve the student? The mechanics of a "hot-rod" involve considerable science. Is there something for him to do? Intellectual involvement must be secured; stimulus is often given by a crank to be turned, questions to be answered, a bell to be rung, or an experiment to be done at home.

c. Is the display physically available? Students should come into contact easily with the display, not by excessive effort.

Are the labels clear, concise? Carefully lettered cards that do not require much reading help to reveal the meaning of the display.[7]

3. The science museum: In many schools it has become possible to provide a science museum. Occupying a relatively small room or a portion of a larger room, it displays materials that may or may not relate directly to the ongoing class work. It may contain models, specimens, exhibits, and materials brought from field trips, such as plant and animal life, geological samples, and samples of industrial products.[8]

4. The tackboard: The tackboard, or bulletin board, should become more than that -- it should carry more than bulletins or notices. It is actually a medium for the common use of materials which are not available for general

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[7]Ibid, pp. 304-305.

[8]Davis, Helen Miles, Exhibit Techniques. Science Service. (Washington, D.C., 1951) pp. 34-36.

distribution. Upon it are placed not only mounted clippings but also the unmounted ones. Cork is a common and satisfactory material for tackboards and is also quite inexpensive.

The qualities of a good tackboard layout have been summarized in the following fashion:

a. Simplicity and Clarity. An arrangement which is complicated and confusing to the eye is likely to alienate the passer-by and speed him on his way. Keep the display simple and clear.

b. Variety. If the materials displayed are too similar to one another, the layout will offer no challenge to the eye. In any display the attempt should be made to utilize materials of contrasting sizes, shapes, and colors.

c. Movement. Movement is an established directional flow which leads the reader's eye from one element to another in their order of importance.

d. Balance. Balance is not achieved by producing displays which are merely lop-sided or top-heavy. Both balance and movement are achieved by juxtaposing masses of approximately the same size but different shapes, or by using two or three small items to counter-balance one large mass.

e. Unity. A display which scatters items over a large area is not really one display -- it is a hodge-podge of materials which compete for the observer's attention. Each part of a display should be visually related to the others so that the net impression is that of a unified arrangement.[9]

5. Maps and Globes: The social and economic implications of science are often inadequately stressed. Careful use of the map and the globe can contribute greatly to this objective. The science teacher can use maps and globes to show sources of raw materials for industry, the locations of industries, and the destinations of industrial products. The distribution of forms of plant and animal life, bird migration routes, and conservation and irrigation projects

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[9]Richardson, John S., p. 309.

are more effectively shown through maps and globes; weather and climate, as well as various aspects of astronomy and earth science depend heavily upon these devices.

6. The chalkboard. The chalkboard has three principal uses; (1) upon it have been placed lists of questions and directions to students; (2) the students have used the board for their writing, drawing, and problem-solving; (3) the teacher has used it for his own drawings, diagrams, and charts.

There are a number of aids which can be used to make the traditional chalkboard more effective. These include using colored chalk, particularly that which stands out by contrast; the use of pencil lines for the instructor to follow during the regular class period. (These lines are hardly visible to the students and provide the teacher with ready assistance in making the more complicated or critically proportioned drawings.); the use of stencils made from paper with holes cut through for easy outlining; the use of templates of commonly drawn objects made from plywood or heavy cardboard.

7. The pegboard. Displays in science are facilitated by the commercially available pegboard -- a composition material in sheet form with regularly spaced rows of holes. Pegs or wire hooks inserted in these holes support pieces of apparatus specimens, and other objects for display. For example, the parts of a simple radio can be assembled and the circuits completed on a pegboard.

The interested and resourceful science instructor will make good use of all these visual aid materials. Often, they will take the place of more expensive equipment in a science laboratory and serve the purpose just as well.

CHAPTER V

USE OF FREE MATERIALS

An important portion of classroom and laboratory facilities can be obtained through the use of various types of free materials available. Free materials are available in the form of charts, graphs, pamphlets, and film strips. To gain effective use from these materials as teaching aids requires careful thought and preparation on the part of the instructor. It is entirely possible for the science instructor to lose his perspective with respect to these materials and allow them to dominate his teaching.

The science teacher must use caution in his use of these materials to assure the fact of his educational program not being thrown out of balance by the materials available. He must carefully check these materials for blatant advertising, and be sure that the material is significant to the students at a given time.

The use of these materials must be kept on a up-to-date level and care must be exercised in discarding all material as soon as it becomes obsolete to avoid a mumble-jumble of useless, uncoordinated data.

There are many listings of sources of free and inexpensive teaching materials. Some of the principal sources of concern to the science teacher are listed:

American Museum of Atomic Energy. Oak Ridge, Tennessee. Leaflets and booklets and list of film sources on atomic energy.

Catalog of Man and Nature Publications. New York: Committee on Consumer Relations in Advertising, Inc., 420 Lexington Ave. An annotated list of free pamphlets, exhibits, motion pictures, etc.

Free and inexpensive learning materials. Nashville, Tenn.: Division of Surveys and Field Service, George Peabody College for Teachers, 1956.

Sponsor Handbook, Science Clubs of America. Washington, D.C., Science Service. Lists of books and of free and low cost materials.

Pamphlets:

American Cancer Society Public Education Division 47 Beaver Street New York 20, N.Y.	Pamphlets on cancer its treatment.
American Cyanamid Company Agriculture Chemicals Division 30 Rockefeller Plaza New York 20, N.Y.	Booklets concerning artificial fertilizers.
American Forest Products Industries 1319 Eighteenth St., N.W. Washington 6, D.C.	Booklets, as well as charts, tape recordings, and motion pictures on trees, forest products, and conservation.
American Medical Association Bureau of Health Education 535 N. Dearborn St. Chicago 10, Illinois	Pamphlets on health.
American Optical Company Public Relations Department Scientific Instrument Division Buffalo 15, New York	Pamphlets on microscopes and their uses, and the history of the microscope builders.
Armstrong Cork Company 5012 Madison St. Lancaster, Pennsylvania	Leaflets on cork and its uses.
Bakelite Company 30 East Street New York 17, N.Y.	Booklets concerning modern plastics.

Better Vision Institute, Inc. 3157 International Bldg. 630 Fifth Avenue New York 20, N.Y.	Leaflets on vision. Films available on loan.
Bituminous Coal Institute Educational Department Southern Building Washington 5, D.C.	Booklets on coal production and use of coal products.
Celanese Corporation of America 180 Madison Avenue New York 16, N.Y.	Pamphlets on plastics and fibres.
Celotex Corporation Dept. S-10 120 S. La Salle St. Chicago 3, Illinois	Catalogs of structural and acoustical materials.
The Electric Storage Battery Company 17th and Indiana Ave. Philadelphia 32, Pennsylvania	Pamphlets and charts on the science of a storage battery.
General Electric Company Educational Service Schenectady 5, New York	Booklets, pamphlets, and charts on automotives, engines, and safety.
H.J. Heinz Company Public Relations Department 1052 Progress St. Pittsburgh 12, Pa.	Pamphlets and motion pictures on food.
Hayden Planetarium 81st St. at Central Park West New York 24, N.Y.	Instructional material for Astronomy.
The Lufkin Rule Company Saginaw, Michigan	Pamphlets on the mathematics of instruments for measurements.
The National Foundation for Infantile Paralysis 120 Broadway New York 5, N.Y.	Pamphlets on polio and its treatment.

Motion Pictures, Filmstrips, and Slides:

American Council on Education 1785 Massachusetts Ave., N.W. Washington 6, D.C.	Several filmstrips.

American Heart Association, Inc. 44 East 23rd St. New York 10, N.Y.	Several motion pictures.
American Museum of Natural History, Slide Division Central Park West at 77th St. New York, N.Y.	Free catalogs of slides and films; nominal charge for use of materials.
United States Atomic Energy Commission Washington 25, D.C.	Many motion pictures and filmstrips.
Bailey Films, Inc. P.O. Box 2528 Hollywood 28, California	Catalog of motion pictures; many for science teaching.
Educators Progress Service Randolph, Wisconsin	Educator's Guide to Free Films and Educator's Guide to Free Slidefilms. Subject classification and brief description of each film and slidefilm. Each guide revised annually.
Encyclopedia Britannica Films 207 S. Green Street Chicago 7, Illinois	Catalog; produce motion pictures and filmstrips, many for science teaching.
National Audobon Society 1130 Fifth Avenue New York 28, N.Y.	Many motion pictures.

<u>Sources of Charts</u>:

American Institute of Baking 1135 West Fullerton Avenue Chicago 14, Illinois	Food charts.
Bausch and Lomb Optical Company Rochester 2, New York	Microscope charts.
Borden Company 350 Madison Avenue New York 17, N.Y.	Charts on milk pasteurization.
Denoyer Geppert Company 5235 Ravenswood Avenue Chicago, Illinois	Biology and astronomy
Thomas A. Edison, Inc. Edison Storage Battery Division West Orange, New Jersey	Storage battery.

Ohmite Manufacturing Company Chicago, Illinois	Laws of electricity.
Rand McNally and Company 111 Eighth Avenue New York 11, New York	Maps; astronomical charts.

CHAPTER VI

FINANCING EQUIPMENT

In too many instances in the past the planning of science facilities has been limited to a few persons, most of whom have had no immediate responsibility for the science program. To a limited extent science teachers have been involved in the planning of science rooms, but unfortunately this has not been a widespread practice. The alert science teacher will let it be known to the school administration and other interested parties that it is he who is to make use of the science facilities and should certainly have a voice in their selection.

The science teacher should make arrangements to be present at a board of education meeting when the question of science facilities are to be discussed. The industrious teacher will have the attention and backing of the school administration, since the administrators have had ample opportunity for observing his teaching practices and will be in a position to judge his ability and sincerity.

The instructor must be well-prepared for this meeting so that he can outline his needs for equipment. He should have a concrete idea in mind of what is needed and why. He should be able to explain each piece of equipment and how it will be valuable in his particular teaching situation.

He should be able to provide the board of education members and administrators with price lists from different companies for their comparison.

The instructor who presents a well-planned list of facilities needed and who sincerely has made every effort to make effective use of the existing equipment will be in a position to present a good argument on the necessity of purchasing new equipment.

Another practice which is commonly used for raising funds for the science department is that of collecting student fees. Caution must be exercised in this procedure, however, to keep the fees within reach, financially, of all students who might wish to take science courses. This necessitates a fee quite low, but sometimes even a small fee collected from each student enables the teacher to replace and maintain equipment in good, usable condition.

It will be wise for the science teacher to keep abreast of developments made in the national and state legislatures for possibilities of federal and state aid in obtaining laboratory equipment. Legislation has been passed by the federal government in the form of the National Defense Education Act of 1958 to grant sizeable sums of money to each state for use in furthering science education. At the time of the writing of this report, the state of Oklahoma is in the process of making definite arrangements for the disbursement of these funds. It is possible that current state legislation may make possible some financial assistance to school systems to assist with providing adequate laboratory facilities, though present plans call for some contribution by the particular school district.

CHAPTER VII

EXPERIMENTS USING IMPROVISED EQUIPMENT

The list of experiments which can be performed with inexpensive or improvised equipment is quite lengthy and the discerning teacher can choose from a wide variety to suit his teaching situation.

The use of these experiments can accomplish two things:

1. Keeping the expense of the experiments to a minimum.

2. Impress on the student that the science studied in school is actually closely related to everyday life and bring about enough interest in these experiments which use common every-day equipment to encourage the student to try them at home in his spare time.

The following are some illustrations: (For more examples, see bibliography).

Sound Cannot Travel Through a Vacuum:

No matter how powerful, sound waves can never be used to speak to the Man in the Moon or to communicate with the inhabitants of Mars. For, unlike light and radio waves, sound waves must have a gas, liquid, or solid to carry them and hence can't travel beyond the earth's atmosphere.

A simplified demonstration of this principle can be performed, using a vacuum coffeepot bottom, a pencil, and a tiny bell. Tie the bell loosely to one end of the pencil by means of a rubber band. Push the other end of the pencil into a stopper which fits the flask snugly. Now pour a little water into the flask and boil until all the air is driven out. Remove the flask and insert the stopper the instant the steam stops expanding. When the water has cooled, shake the flask near your ear. The sound of the bell is almost inaudible, because the condensed steam has produced a partial vacuum. Let air into the flask again, and the tinkle can be heard easily.[10]

Air Pressure Crushes a Can:

If your body were not composed chiefly of incompressible liquids and solids and if air did not fill the spaces between them, you would be crushed flatter than a pancake by the external pressure of the atmosphere. If all the air could suddenly be removed from inside your house, that structure would instantly be smashed to the ground.

This squeezing ability of air is easy to prove. All you need is a flat-sided gallon can and a stopper that fits it tightly. Put about 1/2 inch of water into the can and set the can on the stove; boil the water briskly for several minutes. Then remove the can from the heat and insert the stopper firmly as soon as the outgoing steam permits.

As the can cools, the steam inside condenses to form a partial vacuum. The air at reduced pressure inside the can soon begins to lose out against the greater pressure of the

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[10] Swezey, Kenneth M., After-Dinner Science. (New York, 1948). p. 78.

atmosphere without. Finally, amid creaks and groans, the sides of the can collapse, literally crushed in the hand of an invisible giant.[11]

Dust May be Explosive:

Just how dust explosions occur in coal mines, grain elevators, sugar refineries, and starch factories may be demonstrated spectacularly with a candle, a small paper tube, and some cornstarch. First dry the starch by warming it for a few minutes on a radiator or over a low flame. Then blow the powder into the candle flame. Instantly the starch bursts into a blaze of fire. Finely divided and thoroughly mixed with air, many substances that ordinarily do not burn well will burn almost as rapidly as gases.[12]

Hot Water Leaks Faster Than Cold:

The mystery of the car radiator that leaks when the water it contains is hot and seems intact when the water is cold can be explained by the laws of molecular motion. When water is cold, its molecules hug each other closely and move about slowly. Heating water speeds up their motion and permits them to slide over each other freely. In viscuous liquids such as heavy oil or molasses, the effect of temperature is obvious. But even in liquids as thin as water, heat has the same effect.

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[11]Ibid, p. 4.

[12]Ibid, p. 165.

As a demonstration, make a hole with a very fine needle in the bottom of each of two identical cans. In one place ice water and in the other the same amount of hot water. Set each over a glass and watch the race. The hot water flows much faster. In fact, if the hole is small enough and the water level not too high, the cold water may not flow at all.[13]

[13] Swezey, Kenneth, Science Magic. (New York, 1952) p. 39.

CHAPTER VIII

CONCLUSION

It is the belief of the writer of this report that the science teacher must lead the way to a greater interest in science and a solution to the problem of inadequate laboratory and classroom facilities.

It is his problem, also, to improvise equipment, find suitable experiments adaptable to this improvised equipment, make use of all available free materials and visual aids in order to keep the science program a going concern on the existing facilities in order to make the science program interesting to students and to create enough public interest that he will granted sufficient funds to eventually overcome this inadequacy.

It is the belief of the writer, also, that it is time for the science teacher to openly and publicly declare his desire and need for more adequate facilities and that he make it a point to be heard by the school administrators and boards of education.

The science teacher must examine his own personality and determination. He must be sure that he believes personally in the importance of science in our lives as well as in our secondary school curriculum and that he has information at his fingertips to back up his assertions.

It has not been the intention in this report to, in any way, imply that the science program should dominate the secondary school curriculum or occupy any more than its rightful place in the apportionment of funds.

It is hoped that this report will give a few ideas and suggestions to the high school science teacher who is interested in building up an adequate science laboratory.

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