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# Evaluation of a series of field trips for elementary teachers.

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EVALUATION OF A SERIES OF FIELD TRIPS  
FOR ELEMENTARY TEACHERS

Submitted by

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(B.S., Springfield College, 1941)

In Partial Fulfillment of Requirements for  
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1952

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## CHAPTER I

Introduction.--- In 1949 and 1950 The New England School Science Council of the American Academy of Arts and Sciences of Boston <sup>1/</sup> conducted a series of trips for nearby science teachers through several leading industries in New England. In their letter to the guest teachers introducing the plan they expressed the following ideas:

"The New England School Science Council has as one of its primary objectives the creation of a growing interest in the principles and applications of science on the part of secondary-school students. This program is based upon the conviction that in a society dominated by the technological adaptations of scientific principles it is of vital importance that all students, whether or not they go to college, have a sense of intelligent orientation to the fundamental influence and exciting interplay of the physical, natural, and social sciences.

It is recognized that if the high school student is to be drawn actively to the sciences, the teaching of science must be made as vivid and imaginative as possible and must be illustrated by numerous examples of 'science at work' in the immediate environment of the student.... Further it is recognized that this integration of 'principle and practice' can be accomplished only if teachers are afforded ample

1/New England School Science Council in cooperation with the Textile Information Service, Outline of purpose and scope of field trip to the Naumkeag Steam Cotton Company, Salem, Massachusetts, May 25, 1949, Bulletin, 1949, New England School Science Council, Boston, Massachusetts, p. 1.

opportunity to study first hand, civic and private enterprises covering the widest possible range of human activity."

Enlarging on this concept to include the elementary pupil and his teacher the following study is undertaken. It was felt that to give direction to the trips the application of science principles would be stressed; not that they are the only values to be received from a tour of industry but that they are important to the teaching of science and can be readily observed as an individual moves through the various processes of industry at work.

Purpose.--- The purpose of this study is to organize, conduct, and summarize a series of field trips to local industries for some of the elementary teachers of Little Falls, New York, so that they may have an opportunity to observe certain scientific principles at work. Furthermore, it is felt that this study may serve as an incentive for other teacher groups to employ similar means of benefiting from the contributions that industry possesses in the teaching of science.

#### Justification

Need for the teaching of principles.--- The teaching of science through the use of principles is now well established. Until relatively recently the emphasis in science teaching

had been on the accumulation of facts. More and more however, the emphasis is shifting to the study and application of basic scientific principles around which certain necessary facts may be grouped. The report by the committee on science of the National Society of the Study of Education in 1932 states <sup>1/</sup> "The major aim of general education set forth in this report is life enrichment. The committee members agree that this goal can be accomplished by developing and understanding of principles or generalizations that are functional in the lives of girls and boys. <sup>3/</sup>

Finally, the committee recommended that facts should be taught as an aid to facilitate the functional understanding of principles and to promulgate <sup>4/</sup> the development of their associated scientific attitudes.

Furthermore, the Thayer Commission on Secondary School Curriculum of the Progressive Education Association in its report of findings pertaining to the function of science in general education states that the developing of

1/Committee on the Teaching of Science, National Society for the Study of Education, A Program for Teaching Science, Thirty-first Yearbook, 1932, Part I, Public School Publishing Company, Bloomington, Illinois, p. 43.

2/Op. cit., p. 43.

3/Loc. cit.

4/Loc. cit.

interpretational understanding as a goal in science teaching should result in a notable change in the individual's behavior. <sup>1/</sup>

Although this commission refers to a generalization as interpretive understanding while the Thirty-first Yearbook Committee calls the same generalization a principle, they both agree that the major goal of science instruction at all grade levels is a functional understanding of scientific principles.

As early as 1925 Downing <sup>2/</sup> presented his belief that a scientific problem is solved in three stages: (1) the accumulation of facts (2) discovery of the apparent relation and sequence of these facts reduced to principles, and (3) the discovery of the approximate causes that are amenable to laws or generalizations. Under his supervision several notable studies were conducted to establish the need for greater use of principles in the teaching of science.

Craig in his doctor's dissertation at Columbia University held that the problem in the elementary school in regard to science was not so much that of training boys

<sup>1/</sup>Progressive Education Association, Commission on Secondary School Curriculum, Science in General Education, D. Appleton-Century Company, New York, 1938, pp. 55.

<sup>2/</sup>Elliot R. Downing, Teaching Science in the Schools, University of Chicago Press, Chicago, Illinois, 1925, p. 53.

and girls to become scientists as it was of helping them to become intelligent laymen. He further asserts that in order to accomplish this purpose, a course of study should be formulated that will develop certain objectives that are in accord with the facts, principles, generalizations, and hypotheses of science that are essential in the understanding of natural phenomena which challenge and intrigue children.<sup>1/</sup>

Again in 1934 in An Introduction to the Teaching of Science, Downing<sup>2/</sup> emphasizes the need for teaching principles in science. He writes:

"Two methods of instruction are conceivable in preparing pupils to meet the problematic situations involving scientific knowledge that will arise in their lives: (1) One may list all such problems that occur in the community and make pupils skillful in meeting each, teaching them how to do each specific thing. Or (2) one may give them an understanding of the principles of science that are most often needed to solve such problems and then may drill them in solving problems under such principles. In other words he may try to make them skillful in solving such problems."

In establishing principles which should be included in the various grade levels in the teaching of science, the work of three men stands out.

1/Gerald S. Craig, Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School, Teachers' College Contribution to Education, Number 276, Teachers' College, Columbia University, New York, New York, 1927, pp. 12-13.

2/Elliot R. Downing, An Introduction to the Teaching of Science, The University of Chicago Press, Chicago, Illinois, 1934, p. 7.

In 1934 Robertson set out to determine science principles suitable as goals for instruction in general education grades one through six. In his investigation of four masters' theses, an unpublished study from the University of Michigan, three published studies by Downing, and two unpublished studies from the University of Chicago, Robertson compared the principles to an established criteria and those that did not apply were rejected.

The criteria used by Robertson <sup>1/</sup> are as follows:

"To be a principle a statement

Must be a comprehensive generalization

Must be true without exception within the limitations specifically stated

Must be a clear statement of a process or interaction

Must be capable of illustration so as to gain conviction

Must not be part of a larger principle

Must not be a definition

Must not deal with a specific substance or variety or with a limited group of substances or species."

In all he found that 243 principles conformed to the above criteria. After rating by fifteen science teachers using a five point scale to determine whether or not they

1/Martin L. Robertson, "The Selection of Science Principles Suitable as Goals of Instruction in Elementary Science," Science Education, XIX (February, 1935), pp. 1-4; (April, 1935), pp. 65-70.

would apply as suitable teaching goals in the elementary grades, many were declared unsuited for use in the lower grades. The final result was a list of 113 principles suitable as teaching goals in grades one to six.

The second work of importance in establishing the principle of science and their grade placement was that of Harold E. Wise.

Wise <sup>1/</sup> in his investigation of the principles of the physical sciences developed the following criteria similar to but more concise than those of Robertson.

"To be a principle a statement must be a comprehensive generalization describing some fundamental process, constant mode of behavior, or property relating to natural phenomena

It must be true without exception within limitations specifically stated

It must be capable of illustration

It must not be a definition."

The work of Wise resulted in a list of 272 principles of physical science. He used lists developed by Arnold, Hartman and Stephens, Pruitt, and Robertson, and arranged 264 of them in order of importance for general education

<sup>1/</sup>Harold E. Wise, "A Determination of the Relative Importance of Principles of Physical Science for General Education," Science Education, XXV (December, 1941), pp. 371-379; XXVI (January, 1942), pp. 8-12; XXVII (February, 1943), pp. 67-76; XXVII (September-October, 1943) pp. 67-76.

grades one through fourteen inclusive. The entire physical science field was covered including chemistry, geology, physics, astronomy, and meteorology.

Previously the Thirty-first Yearbook Committee recommended that the assignment of scientific generalizations to definite grade levels be considered in terms of certain principles established as goals of instruction; in preceding levels, Wise's study helped in the fulfillment of this recommendation by establishing important principles found in the physical sciences.

To complete the recommendations of the Thirty-first Yearbook Committee, an investigation of biological science principles was made in 1944 by Martin <sup>1/</sup> using the following criteria for establishing a principle.

"It must be a comprehensive generalization which resumes the widest possible range of facts within the domain of facts with which it is directly concerned. The facts resumed in the generalization must denote:

- a. Objects and/or events and the relation between them
- b. Properties

1/W. Edgar Martin, "A Determination of the Principles of the Biological Sciences of Importance for General Education," Science Education, XXIX (March, 1945), pp. 100-105; XXIX (April-May, 1945), pp. 152-163; XXIX (February, 1945), pp. 45-52.

W. Edgar Martin, "A Chronological Survey of Published Research Studies Relating to Biological Materials in Newspapers," School Science and Mathematics, XLV (June, 1945), pp. 543-550.

It must be scientifically true. To satisfy this criterion:

- a. It must be verifiable; i.e. it must be stated so that it suggests directly or indirectly, a definite operation or observations or experiments whereby its truth value can be tested or verified.
- b. It must be consistent with the body of accepted scientific knowledge, and except for a few limiting or singular exceptions, with all the data facts relevant to it."

Using the same reliable technique of Wise who had already devised a list of principles for the physical sciences, Martin emerged with a list of 300 principles related to the field of biological sciences. Thus he completed the task stated by the Thirty-first Yearbook Committee of establishing certain principles of science to be used as teaching goals for general education at all grade levels.

Apparently the textbooks were not keeping up with the new developments in the field for an investigation of elementary science textbooks, grades one through six found in the elementary grades by Reek, <sup>1/</sup> showed that the authors of these books did not treat principles as the Thirty-first Yearbook Committee had suggested. The study also showed that the authors stressed physical rather than biological principles and some authors failed to use any principles at all.

1/Doris L. Reek, A Study of the Principles of Science Found in Four Series of Textbooks of Elementary Science, Unpublished Master's Thesis, University of Michigan, 1943.

However the use of basic principles in science teaching is continuing to be emphasized as indicated by a more recent writing of Martin. <sup>1/</sup>

"The true test of any course in science is the extent to which the understandings developed by the learning experiences of the course are able to bring about permanent and desirable modifications in the behavior of those who study it. The basic understandings of courses in science in terms of which behavior can be modified are to be found in the important generalization and principles of science."

Although not of a recent nature, one of the most forceful arguments for the wider use of principles in science teaching was made by Philip Johnson. <sup>2/</sup> Speaking before the National Education Association, Johnson based his argument on three reasons. He said in part:

"I shall contend....that the emphasis of the science program should be placed on principles. When common dictionary meanings are substituted for the terms 'emphasis' and 'principles' my contention may be stated. The science program should bring out general truths clearly and forcibly. It follows that any plans, methods, techniques, or teaching schemes which tend to bring out clearly and forcibly the general truths about a topic or unit indicate an attempt to emphasize principles.

Principles should be emphasized because they are general. A truth is general if it is related to the

1/W. Edgar Martin, "Chronological Survey of Research Studies on Principles as Objectives of Instruction in Science," Science Education, February, 1945, Vol. XXIX, p. 45-52.

2/Philip G. Johnson, "Emphasis of the Science Program Shall be Placed on Principles," National Education Association Proceedings, 1938, pp. 535-537.

solution of a number of problems. A truth is general to a pupil in a science class when the pupil senses that the idea is related to a large number of the changing situations in which he has found himself. The truth has been developed clearly and forcibly when the pupil can use the idea and bring about an approach to the conditions and changes which are desired.

Principles should be emphasized because they are relatively few in number. The items of specific information about any aspect of our environment are so numerous that no person can achieve complete mastery over such a store of knowledge. Even if we were to master all the facts, we would be faced with few occasions to use many of them and so facts would fall into the realm of the unforgotten. While we fail to remember many specific facts, we are often able to recall many general impressions and ideas.....

Finally we should emphasize principles in science teaching because they represent the product of inductive and deductive thinking of a high order. Much of our science teaching has been and still is, too incidental, too specific, and too much focused on products of learning which are of temporary value....

In conclusion I contend that we should emphasize principles in our teaching of science, because: (a) principles are generally true, (b) principles are relatively few in number, and (c) an emphasis on principles provides excellent opportunities for guidance in the development of scientific thinking and scientific attitudes."

#### Summary of need for principles in science teaching.--

It is clearly evident from the preceding writing that generalizations and principles of science are justified and recognized as objectives of science teaching at all grade levels for general education. Starting with Downing at the University of Chicago there has been a rapid shift

from the study of facts to the use of facts as an aid in making generalizations useful in solving different problem situations.

Robertson through his interest in the elementary school established a list of principles to be used in grades one through six inclusive. The work of Wise and Martin established a definite concept of a principle and later determined the scientific principles to be taught in all fields of science in general education grades one through fourteen.

The big task ahead seems to be that of making more adequate use of scientific principles in the daily classroom. It is to help further this end that this study is conducted.

The field trip as an educational tool.-- The term field trip is only one of several used by various writers in the field. Other terms used are excursion, school tour, school journey, or school jaunt. For the purpose of this study, however, it will be called the field trip.

Since its inception from European sources it has grown slowly but steadily until it now promises to become one of the outstanding procedures in educational practice.

According to McKnown and Roberts <sup>1/</sup> the idea of the field trip has very early beginnings. In their book Audio

<sup>1/</sup>Harry C. McKnown and Olvin B. Roberts, Audio-Visual Aids to Instruction, McGraw-Hill Book Company, Inc., New York, New York, 1949, pp. 246.

Visual Aids to Instruction they write:

"The movement in American education to develop the school trip, field trip, tour, excursion, jaunt, or journey is hardly three decades old but the basic idea is not new. Both Aristotle and Socrates used the trip method;.... Rousseau considered it the chief technique in the education of Emile; Pestalozzi promoted it in his school at Yverdon; and Francis Parker introduced it into his famous Chicago school."

Atyeo <sup>1/</sup> who made an intensive study of the field trip in his doctor's dissertation also claims that we owe the use of the field trip here in America to the wide spread acceptance it has maintained in the European school systems.

"Considerable evidence exists to show that it is the German and English excursion especially the former, which have in large part inspired the adoption of the excursion technique in this country. In Germany a ministerial decree requires that one day a month be used for an excursion in the elementary schools. Sweden makes participation in a stated number of excursions a condition of graduation from the elementary schools. The excursion is not compulsory in England, nor in Japan, but school authorities in both countries not only recommended its use but also have taken steps to provide opportunity for it. In Italy and Russia, where education is definitely under governmental control the excursion is much in favor and is made to serve militaristic and political as well as more purely academic ends, as it is also in Germany."

Some of the values that the field trip holds are expounded by Hoban, Hoban, and Zisman <sup>2/</sup> in Visualizing the Curriculum.

1/H. C. Atyeo, Excursions as a Teaching Technique, Bureau of Publications, Teachers' College, Columbia University, New York, New York, 1939, p. 175.

2/Charles F. Hoban, Charles F. Hoban, Jr., and Samuel B. Zisman, Visualizing the Curriculum, The Gordon Company, New York, 1937, pp. 41-43.

The use of the school journey in connection with instructional and learning procedures has very distinctive advantages, among which are the following:

- a. They offer opportunities to present subjects of study in their natural setting or as they function
- b. They offer the concrete evidences necessary to clarify instruction
- c. They stimulate interest
- d. They blend school work with actual life
- e. They serve as an effective means of correlating the subjects of the school curriculum
- f. They afford opportunities to develop keenness of observation
- g. They involve the consideration and solution of problems arising from individual and group participation in natural social situations
- h. They stimulate narration discussion
- i. They offer rich opportunities for the profitable use of leisure time
- j. They provide actual source materials for study

Edgar Dale <sup>1/</sup> states the theory underlying the field

tip in the following terms:

1/Edgar Dale, Audio-Visual Methods in Teaching, The Dryden Press, New York, New York, 1946, p. 136.

"The educational theory underlying the field trip is that you discover what something means by responding actively to it. You can see it in operation. You cannot learn what it means by looking it up in a dictionary or encyclopedia and then repeating what was said there.

You can, it is true, get some of the meaning this way, but the richer our direct experience with each of the works used in the definition the more meaningful the definition will be. And the more meaning we can bring to an experience the more meaning we can get out of it. Our richest experiences and thus our richest meanings come only when we respond both physically and mentally to a new situation."

Carleton E. Preston <sup>1/</sup> supports this theory and further emphasizes the need for field trips in education as he writes in his textbook, The High School Science Teacher and His Work.

"It has long been recognized that field work.... has a high educational value. It connects the somewhat theoretical study of the classroom with the practical applications in nature and industry; it enables pupils to see materials and processes in their natural setting; it gives the proper conceptions of size and importance so necessary to establish in the minds of those who for the sake of simplicity have been more often instructed through the use of materials in miniature; it gives opportunity to observe not only scientific processes, but human beings at work and to consider the desirability, from the points of view of health and interest of various industrial and professional occupations."

It is to be noted that the field trip offers a wide range of values. It may be pinpointed for the purpose of observing certain definite procedures yet by its nature it provides a broad cultural experience as well. The most

<sup>1/</sup>Carleton E. Preston, The High School Science Teacher and His Work, McGraw Hill Book Company, New York, New York, 1936, p. 244.

mentioned value however, is that of making the individual familiar with first hand information in a real life situation. Haas and Packer <sup>1/</sup> are talking about this as they write:

"Few teaching programs are complete without a field trip. Not only does a trip make possible close observation of a multitude of natural and man made things, but it also offers an opportunity for planned inspection of administration, organization and procedure in many fields. A trip provides the student with first hand information and real experience in a real life situation."

Also Schwamm, <sup>2/</sup> writing in the Educational Screen, mentions the importance of making teaching meaningful and real by means of field trips.

"There has been a patent renaissance of the concept that techniques which make learning a rich and exciting adventure are worthy of adoption, especially when they result in a type of education that is more meaningful to individuals than is possible through the exclusive use of verbal methods....Schools have long used various visual, auditory, and other sense aids as they have also employed the field trip, the further exploitation of which may prove that it has greater educational possibilities than heretofore realized."

Valuable as the field trip is, it holds pitfalls which must be avoided if the most possible good is to be obtained from the expenditure of time necessary to conduct most trips. Chief among the hazards is the tendency to allow the trip to become a sight seeing tour which offers an exciting outing

<sup>1/</sup>Kenneth B. Haas and Harry Q. Packer, Preparation and Use of Audio Visual Aids, Prentice Hall Incorporated, New York, New York, 1950, p. 179.

<sup>2/</sup>Gerald Schwamm, "Field Trip-Education by Contact," Educational Screen, (November, 1944), Vol. 23, p. 391.

for the individuals participating but fails to accomplish any real purpose. To avoid such a situation it is necessary to plan ahead. Miller <sup>1/</sup> mentions this as she writes, "The value of such field trips can be incalculable, provided the necessary ground work has been carefully laid by the teacher." Emmet <sup>2/</sup> has the same idea in mind. He states, "It is very important that the objectives be clearly in view beforehand. One must know the exact reason for the school journey and what results to expect."

More specifically the field trip has the additional value of aiding the teacher's own development. It widens his interests, enlarges his background, and makes his teaching more dynamic. This viewpoint is supported by Gruver. <sup>3/</sup>

"Nothing has happened during these years to stimulate the growth of teachers more than planning educational excursions, and applying their results to our educational processes. They have given our teachers a much broader point of view, a much more intelligent interpretation of

<sup>1/</sup>Edith F. Miller, "Let's Take a Field Trip," Instructor, (February, 1944), Vol. 56, p. 29.

<sup>2/</sup>Wilbur Emmet, "Panel Discussion....The School Journey," Educational Screen, (October, 1940), Vol. 19, p. 25.

<sup>3/</sup>Harvey S. Gruver, "School Excursions," National Elementary Principal, (October, 1935), Vol. 15, pp. 47-48.

what an educational program should accomplish."

Taggart <sup>1/</sup> is of a similar opinion as he writes: "If teachers are to help children live more abundantly they themselves should be helped and encouraged to live a wide and rich range of experiences from which to draw rather than being prepared only for the one excursion which it might seem profitable for their pupils to take at a particular point in their study."

Much can be done with in service training utilizing the field trip. In Iowa, Hilda Cavanaugh <sup>2/</sup> summarizes the accomplishment of one county in this direction.

"The inservice training program for teachers in our county is based on the principle that education should be and can be made a continuous process. In teacher training institutions there is not enough time to give students all of the information, skills, and abilities which they well need as teachers in the public schools. Then too the curriculum is an emerging one and teaching units are usually planned by children and teachers in the classrooms. But the teachers may easily have an opportunity to learn right on the job. One day most of the pupils in the county had a half holiday while the teacher went to school. The classroom was two farms, and the textbook was by Mother Nature....

In these field demonstrations teachers learned how to make use of the most important kind of resource material, the resources of the community where they work in which their pupils live."

1/L. A. Taggart, "Enriching Teacher Experiences," Childhood Educator, (February, 1938), Vol. 14, pp. 252-255.

2/Hilda Cavanaugh, "Teachers Learn Through Field Trips," Instructor, (May, 1947), Vol. 56, p. 29.

Miss Cavanaugh also brings out another point which is emphasized by many others; the value of field trips in acquainting teachers with their community. Today more than ever teaching is made increasingly more vital and life like as local problems and situations are made the basis for study topics. That the field trip is an excellent means of accomplishing these ends can be illustrated by selections from related literature.

Mitchum <sup>1/</sup> and others in explaining the outcome of a series of field trips for the teachers of Springfield, Missouri, writes in part:

"The most important result, however, [of field trips] was that teachers began to utilize more fully the resources of the community, selecting more dynamic problems for classroom study and taking pupils out into the community to learn through actual first hand contacts and from original data. Topics were chosen for study which involved significant social understandings....The use of first hand community resources helped the children to become more keenly aware of the interrelationships among various social forces and institutions. Thus in studying the conservation of natural resources they discovered that the government was an important factor....Trips into the community were used specifically to build important social concepts to create an increasing awareness of the functioning of a community as an interrelated unit."

<sup>1/</sup>Paul Mitchum and others, "Excursions to Acquaint Teacher with Community Resources," National Elementary Principal, (July, 1942), Vol. 21, pp. 358-362.

The Committee of the Forty-six Yearbook of the National Society for the Study of Education <sup>1/</sup> also recognized this need and urged the thorough exploration of the community by its teachers. They have this to say about the problem.

"All available resources of the community should be surveyed by the teacher of science, individually, or by members of the teaching staff undertaking a cooperative study. Rich as the community may be in resources usable in the study of science, the community will seldom if ever be used as the science curriculum at any level of growth. However the science teacher can link the scientific agencies of the community to the laboratory experiences of his pupils through problem solving activities."

The values of the field trip may be summed up under two main headings. First, it provides an opportunity to obtain first hand information thus making learning more meaningful and second, it offers an excellent opportunity for individuals to become acquainted with their community thus increasing their educational background. Both points are well brought out by Olsen <sup>2/</sup> writing in the Ninth Yearbook of the National Council for Social Studies.

"Schools must relate to life. We teachers press that point, for we know too well how remote from actual living and its dominant needs much of our teaching is. In practice if not in theory most of us are like the traditional teacher who pulled down the window shades

1/Special Problems of Science Teaching at the Secondary Level, Chap. IV, Forty-sixth Yearbook-National Society for the Study of Education, Part I., 1947.

2/Edward G. Olsen, "Acquainting the Teacher with the Community," Ninth Yearbook-National Council for Social Studies, 1938, p. 36.

while the circus parade was passing in order that he might continue his lecture on quadruped zoology without interference from the outside world. Like this naive academician we are often content to remain diligently immersed in verbalized, non functional book knowledge, while we and our students ignore our living dynamic environment....

If education is to relate to life in concrete fashion, children must be enabled to learn through first hand personal experience....But before teachers can direct their pupils in the use of the community laboratory, they must themselves become acquainted with it-not casually, as mere sightseers, but as critical observers who come through a wide range of personal experiences to know intimately the community in which they live....

Carefully planned and executed field trips should become a part of every teacher's personal and professional background. These excursions widen the teacher's own intellectual and aesthetic horizon while at the same time they awaken vital interest in community processes and problems and give new life to classroom teaching."

#### Definitions

Field trip--- An organized and planned personal visit for the purpose of gaining first hand information.

Scientific principle--- To be a principle a statement

Must be a comprehensive generalization

Must be true without exception within the limitations specifically stated

Must be a clear statement of a process or interaction

Must be capable of illustration so as to gain conviction

Must not be a part of a larger principle

Must not be a definition

Must not deal with a specific substance or variety  
or with a limited group of substances or species

#### Scope

This study will use approximately twelve teachers from two elementary schools of Little Falls, New York school system. Two tours of local industries will be conducted over a period of three months to observe scientific principles at work. The principles will be those established by Robertson for the elementary school.

## CHAPTER II

Descriptive background.-- Little Falls, New York is a city of approximately 10,000 population located in Herkimer County on the Mohawk River and Barge Canal about twenty miles east of Utica. It is an industrial community supporting a wide variety of manufacturing plants. For the most part the industries are relatively small though two of them have plants in other cities in this country or abroad.

The Cherry-Burrell Company, one of the largest manufacturers of dairy equipment, has plants located in Sheboygan, Wisconsin and Milwaukee, Wisconsin.

The Hansen Food Laboratory, manufacturers of Junket products, in addition to the plant in this city has plants in Milwaukee, Wisconsin in this country and in Toronto, Canada. In addition they have plants abroad in Reading and Bristol, England; Copenhagen, Denmark; Vincennes, France; Munich, Germany; Milan, Italy; and Sidney, Australia.

A summary of other local industries is included later on in the description of the procedure.

Transportation facilities are offered by the New York Central Railroad on which the city is located and by numerous trucking companies which travel New York State Route Five which also passes through the city.

Of historical significance is the Mohawk River and Barge Canal which at one time was part of the old Erie Canal and played such an important role in developing upper New York State and points west. In its beginning Little Falls was an important terminal and portage as the cargoes had to be carted around the falls to complete their journey east or west. Improvements were gradually made in the structure of the canal until in 1917 a single lock with a lift of forty and one-half feet was constructed which enabled the barges to travel through with only one lock operation. To this day the lock has one of the highest lifts of any lock in the world. The cargoes for the most part consist of scrap iron westbound to Buffalo, petroleum westbound to Canada, and grain eastbound to New York City.

The public school system consists of four elementary schools with an enrollment of 925 and a combined junior and senior high school with an enrollment of 560. The faculty of the elementary schools number thirty-five while that of the junior-senior high school is thirty-two.

Procedure.-- At a meeting with the teachers who would participate, the nature and purposes of the trips were explained with the intent of securing their approval of the plan. At first the reaction was mixed. One group was immediately in favor of the idea, while the other group was hesitant. Upon further questioning it was determined that the reason for the hesitancy lay in the fact that the teachers were afraid they would be tested on their ability to recognize scientific principles at work. When it was explained that the survey was entirely impersonal, all agreed to participate in the plan. It was interesting to compare this reaction to that of the teachers while on the trips where their numerous questions to the guides and their curiosity in the details of various operations extended the actual time of the trip considerably beyond the length originally planned.

The approvals of the superintendent of schools as well as those of the principals of the high school and elementary schools included in the study, were readily received and their cooperation was of inestimable value in completing the study.

Principles to be used.-- As Robertson's list of principles was designed for use in the elementary school they were selected for use in this study. Of the one hundred

thirteen principles finally determined by Robertson only fifty-eight will be considered in this study. Eleven of the deleted principles pertain to geology and forty-three of the principles are related to biology. The fifty-eight principles that are to be considered are as follows:

1. All matter is composed of single elements or combinations of several elements and can be analyzed by chemical processes and divided into these units.
2. All substances are made up of small particles called molecules, which are alike in all samples of the same substance but are different in different substances.
3. The materials forming one or more substances, without ceasing to exist, may be changed into one or more new and measurable different substances.
4. Every pure sample for any substance, whether simple or compound, under the same conditions will show the same physical properties and the same chemical behavior.
5. No chemical change occurs without an accompanying energy change.

6. Things happen according to law, effect follows cause and to every action there is an equal and opposite reaction.
7. Matter and energy may be transformed but they cannot be created or destroyed.
8. Certain energy forms travel in waves.
9. Waves travel in straight lines while passing through a uniform medium.
10. Radiant energy travels through space in all directions undiminished.
11. When waves strike an object, any one or more of these results will follow: they will be absorbed, they will be transmitted, or they will be reflected.
12. Ready absorbers of energy are ready radiators; slow absorbers are slow radiators.
13. Dark, rough, or unpolished surfaces absorb or radiate energy more rapidly than do light, smooth, or polished surfaces.
14. Whenever an opaque object intercepts rays of radiant energy, a shadow is cast behind the object.
15. If a beam of light falls on an irregular surface, the rays of light are scattered in all directions.

16. An image appears to be as far back of a plane mirror as the object is in front of the mirror, and reversed.
17. When waves pass obliquely from one medium to a denser one, they are bent or refracted toward the normal, and when they pass obliquely from one medium to a rarer one they are bent away from the normal.
18. Light rays may nearly always be caused, by a convex lens, to converge, and often to focus; and by a concave lens, to diverge.
19. Ordinary light is made up of waves of many different wave lengths and each one is bent, or refracted, to a different degree, so that the various colors of which the light is composed are spread out in a band of colors known as the spectrum.
20. The colors of objects depend on what light rays they transmit, absorb, or reflect.
21. Every portion of matter may change its state by absorbing or releasing energy.
22. The average speed of molecules increases with the temperature.

23. Compression of a confined gas increases its pressure.
24. Heat is liberated when a gas is compressed, and is absorbed when a gas expands.
25. Gases may be converted into liquids by reducing the speed of their molecules.
26. When a liquid is changed to a gas, heat is absorbed; when a gas is condensed to a liquid, heat is liberated.
27. Gases expand when heated and contract when cooled, as do most liquids and solids.
28. Different parts of the same substance will expand by different amounts, according to the amount of temperature change produced.
29. A gas always tends to expand throughout the whole space available.
30. Pressure exerted by a confined gas always increases with the temperature and vice versa.
31. If the same pressure is maintained, the volume of a confined gas varies directly as the temperature.
32. The boiling point of any solution becomes lower as the pressure is decreased, and higher as the pressure is increased.

33. A body immersed or floating in a liquid is buoyed up by force equal to the weight of the fluid displaced.
34. Any substance that will dissolve in water will cause the resulting solution to boil at a higher temperature and to freeze at a lower temperature than that at which pure water boils or freezes.
35. Freezing point depression and boiling point elevation are proportional to the concentration of the solution.
36. The force of attraction or repulsion between two magnetic poles varies directly as the product of the pole strengths and inversely as the square of the distance between the poles.
- Like magnetic poles always repel each other, and unlike magnetic poles always attract each other.
37. An electric current may be produced in three ways; by rubbing or friction, by chemical action, and by using magnets.
38. Like electrical charges repel and unlike electrical charges attract.

39. All materials offer some resistance to the flow of electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy which, when intense enough, produces light.
40. The given amount of heat which a body acquires when its temperature rises is identical with the amount it gives off when its temperature falls by that amount.
41. As heat tends to diffuse and thus equalize temperatures of all places and objects with which it comes in contact, there is a continuous transfer of heat between bodies of different temperatures.
42. The lower the temperature of a body, the less the amount of energy that it radiates; the higher the temperature, the greater is the amount of energy radiated.
43. The principal cause of wind and of weather change is the unequal heating of different portions of the earth's surface by the sun; thus, all winds are convection currents caused by unequal heating of different portions of the earth's atmosphere, and they

blow places of high atmospheric pressure to places of low atmospheric pressure.

44. The more nearly vertical the rays of radiant energy, the greater is the number that will fall upon a given area, and the greater is the amount of energy that will be received by that area.
45. The atmosphere of the earth prevents the heat of the earth's surface from escaping, and the earth begins to cool only when the amount of heat lost during the night exceeds that gained during the day.
46. The higher the temperature of the air, the greater is the amount of moisture required to saturate it.
47. The pressure of air decreases with an increase in water vapor content, other conditions remaining unchanged.
48. The pull of gravity is proportional to the mass of the body and inversely proportional to the square of the distance between the center of the mass of the body and that of the earth.

49. Movements of air, water, and solids on the earth are due to gravity plus rotation of the earth.
50. Any body of liquid free to take its own position will seek a position in which all surfaces lie in the same horizontal plane.
51. A body at rest or in motion will remain at rest or continue in motion in a straight line until compelled by some force to change its condition of rest or motion.
52. A body in rotation tends to fly out in a straight line which is tangent to the arc of rotation.
53. The amount of momentum possessed by an object depends on its weight and its speed of motion.
54. Whenever one surface is moved over another surface there is always friction (resistance to motion) which always results in the transformation of some of the mechanical energy of the moving object into heat energy and in the wearing away of some of each surface.
55. Sound is produced by vibrating matter and is transmitted by matter.

56. The more rapid the vibrations of a body, the higher is the pitch of the note emitted by it.
57. The greater the space through which a body vibrates the louder is the sound it produces.
58. Musical tones are produced when a vibrating body sends out regular vibrations to the ear, while only noises are produced when the vibrating body sends out irregular vibrations to the ear.

Local industries.-- A listing of the various industries of Little Falls was made using a local directory. Then in consultation with two other teachers of the high school science department, eleven local industries and one from a neighboring town were selected as possessing the best possibilities for visiting for the purpose of observing the application of science principles.

These industries were then reached by telephone to find out if they were agreeable to sponsoring a visitation and to gain other pertinent data necessary in organizing a field trip. Only one out of the twelve selected industries felt that it could not accept a group for inspection.

The results of this survey are recorded in terms of each of the industries.

1. National Automotive Fibers Incorporated, Phone 1070  
West Main Street, Little Falls, New York  
In charge of field trips- Mr. La Deau  
Trips accepted Monday through Friday from  
8:00 A. M. to 3:00 P. M.  
Duration of the trip is approximately one hour  
The operations to be viewed include the laying  
out, cutting, and stitching of upholstery for  
automobile interiors and material for parachutes.
2. The Beechnut Packing Company, Phone 33251  
Main Street, Canajoharie, New York  
In charge of field trips- Mr. Cobleigh  
Trips accepted Monday through Friday from  
8:00 A. M. to 3:00 P. M.  
Duration of trip is approximately one and one  
quarter hours.  
The operations to be viewed include the  
processing and packing of chewing gum and  
baby food.
3. The Burrows Paper Corporation, Phone 589  
East Mill Street, Little Falls, New York  
In charge of field trips- Mr. Palmer  
Trips accepted Monday through Friday from  
8:00 A. M. to 8:00 P. M.

Duration of trip is approximately one hour  
The operations to be viewed include the  
manufacture of various types of paper from  
the mixing of the pulp to the winding on rolls.

4. The Henry Cheney Hammer Corporation, Phone 777

73 West Mill Street, Little Falls, New York

In charge of field trips- Mr. Mulford

Trips accepted Monday through Friday from

8:00 A. M. to 3:00 P. M.

Duration of trip is approximately one half hour

The operations to be viewed include the drop

forging, grinding and polishing of various

types of hammers.

5. The Cherry-Burrell Corporation, Phone 670

503 Albany Street, Little Falls, New York

In charge of field trips- Mr. Wing

Trips accepted Monday through Friday from

8:00 A. M. to 3:00 P. M.

Duration of trip is approximately two hours

The operations to be viewed include the

designing, assembling, and testing of various

kinds of dairy equipment: bottle washers,

pasteurizers, and storage tanks.

6. The Evening Times, Phone 1331

347 Second Street, Little Falls, New York

In charge of field trips- Mr. Weir or Mr. McGuire  
Trips accepted Tuesday or Wednesday from  
8:00 A. M. to 3:00 P. M.

Duration of trip is approximately one and one  
half hours

The operations to be viewed include the  
collection, editing, type setting, and printing  
of a daily newspaper.

7. The Gilbert Knitting Company, Phone 462

151 Elizabeth Street, Little Falls, New York

In charge of field trips- Mr. Vander Gracht

Trips accepted Monday through Thursday, Tuesday  
the most preferable from 8:00 A. M. to 3:00 P. M.

Duration of trip is approximately one hour

The operations to be viewed include the  
carding, spinning, dyeing, and knitting of  
yarn into a variety of woolen goods.

8. Christen Hansen's Laboratory Incorporated, Phone 217

Hansen's Island, Little Falls, New York

In charge of field trips- Mr. Nordgren

Trips accepted Monday through Friday from  
8:00 A. M. to 3:00 P. M.

Duration of trip is approximately one hour

The operations to be viewed include the laboratory where tests are conducted, the mixing and packaging of Junket Products: Rennet Tablets, Fudge Mix, Sherbert Mix, and Danish Dessert.

9. The C. J. Lundstrom Manufacturing Company, Phone 849  
523 East Mill Street, Little Falls, New York  
Field trips not accepted due to the hazards of the machinery.
10. The Little Falls Felt Shoe Company, Phone 53  
West Main Street, Little Falls, New York  
In charge of field trips- Mr. Simpson  
Trips accepted Monday through Friday from  
8:00 A. M. to 3:00 P. M.  
Duration of trip is approximately one and one half hours  
The operations to be viewed include the cutting, assembling, and stitching of felt footwear.
11. The Reed Tissue Corporation, Phone 1021  
East Mill Street, Little Falls, New York  
In charge of field trips- Mr. Cone  
Trips accepted Monday through Friday from  
8:00 A. M. to 3:00 P. M.  
Duration of trip is approximately one and one half hours

The operations to be viewed include the processes involved in converting paper into towels, napkins, wrappers, and novelties.

12. The H. P. Snyder Manufacturing Company, Phone 144  
203 West Main Street, Little Falls, New York  
In charge of field trips- Mr. Snyder or Mr.  
Kidney

Trips accepted Monday through Friday from  
8:00 A. M. to 3:00 P. M.

Duration of trip is approximately one and one  
half hours

The operations to be viewed are welding,  
electroplating, painting, and lath work in  
the construction of bicycles and tricycles.

Organizing the trip.-- At meetings with the teachers the tentative dates and places of the visits were determined. It was decided that two trips could be worked out, without undue hardship on the teachers and that two industries with different processes and products would furnish greater variety and interest. As a result trips to the Hansen Food Laboratory and The Gilbert Knitting Mill were selected.

Interviews with the persons in charge of the selected industries were held during which the following arrangements were made:

1. The date and time of visitation were determined
2. The size of the group was made known
3. The nature and purpose of the trip were explained
4. Guides for the trip were established
5. Arrangements were made for a preliminary tour to prepare a working outline and syllabus for the group.

The preliminary tour.--- On the preliminary tour the various operations were observed and applications to the fifty-eight selected principles by Robertson were noted. At the conclusion of the preliminary tour a syllabus for the teacher's use was prepared. In the syllabus the purpose of the trip was restated and a general summary of the processes and products of the plant was made.

An outline was then prepared for each step in the manufacturing process and in the order that they would be viewed on the trip. After each step the various principles that could be readily observed in the process were stated with a blank space provided for the teacher to check. A copy of the outline for both trips is included in the appendix. If a principle was once found to apply to a certain process it was not repeated each time that it might recur in succeeding processes unless it was particularly significant. The reason for this was that it would have made the syllabus unduely long and cumbersome, and it was

felt that greater benefit could be derived from an observation of as wide a number of principles as possible rather than a repetition of a few principles.

Also the principles were selected on the basis that they be readily observed. The syllabi were not designed to include all the principles that might have application for a trained observer. Unless their nature and operation were easily grasped, the principle was excluded. In this way it was felt that the teacher would have an instrument that could be used with ease and understanding.

At the end of each syllabus a list of general considerations was included that pertained to the industry visited. These were intended to familiarize the teacher with some of the overall features that the trip provided in the way of furnishing additional background material.

These syllabi were placed in the hands of the teachers at least two days in advance of the date on which the trip was made so that the teachers would have ample time to read the syllabi over and prepare questions of their own that they would like answered while on the trip.

Conducting the trip.-- As the trips were started during the school day and only a few teachers of the entire system were to attend, it became an administrative problem to properly supervise the children until dismissal time. The

principal of the elementary schools involved and the high school principal were most cooperative.

As all the teachers did not attend there were at least two experienced teachers in each school. In addition the high school principal arranged for two eleventh or twelfth year girls to supervise each of the classrooms that had no teacher in one of the elementary schools. In the second elementary school two fifth-and-sixth grade pupils were placed in the kindergarten, first, second, and third grades. The principal also remained until after dismissal.

The plan worked out exceptionally well and provided the high school girls with an interesting experience.

Transportation for the participating teachers was provided by private automobiles. At the plant the teachers were greeted by the guide and welcomed to the plant. The group proceeded on the tour of the industry.

Obtaining results of the trip.-- The teachers were afforded ample opportunity to ask questions concerning any of the processes observed. At the end of the trip a short discussion period was arranged. The teachers were asked to turn over their syllabus with the principles each had checked together with any notations of their own made while on the trip, to their principal within two days. It was felt that the additional time would give them a chance to

think over all that they had seen and tie together the processes of the plant with the application of principles and thus make for a more complete report.

After the syllabi were turned in a personal interview was conducted with each teacher in an attempt to find out specifically their reaction to the experience and any criticism they had of it.

The results from these syllabi tabulated and summarized are included in the next chapter of the study. In addition record is made of the comments obtained as a result of the interview.

### CHAPTER III

Explanation of Table 1.-- In the foregoing chapter the field trip to the Hansen Food Laboratory will be referred to as Trip I and the field trip to the Gilbert Knitting Mill will be referred to as Trip II.

Nine teachers attended Trip I. The preliminary survey shows that twenty-two principles were observed in operation once and one principle was observed in operation three times for a total of twenty-three different principles. Thirty-five principles from the adjusted list by Robertson were found not to apply to the operations viewed on this trip. No principles were written-in by any of the teachers. The twenty-three principles in the order of the percentage with which they were observed are included in Table 1.

Table 1. Principles Observed on Trip I

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
1. Every portion of matter may change its state by absorbing or releasing energy.....	9	9	100.00
2. Sound is produced by vibrating matter and is transmitted by matter...	9	9	100.00
3. A body at rest or in motion will remain at rest or continue in motion in a straight line until compelled by some force to change its condition of rest or motion.....	8	9	88.88
4. A gas always tends to expand throughout the whole space available...	7	9	77.77
5. The higher the temperature of the air, the greater is the amount of moisture required to saturate it.....	7	9	77.77
6. Any body of liquid free to take its own position will seek a position in which all surfaces lie in the same horizontal plane.....	7	9	77.77
7. Every pure sample for any substance, whether simple or compound, under the same conditions will show the same physical properties and the same chemical behavior.....	6	9	66.66

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Table 1. (continued)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
8. Matter and energy may be transformed but they cannot be created or destroyed.....	18	27	66.66
9. Certain energy forms travel in waves.....	6	9	66.66
10. Compression of a confined gas increases its pressure.....	6	9	66.66
11. All materials offer some resistance to the flow of electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy which, when intense enough, produces light.....	6	9	66.66
12. As heat tends to diffuse and thus equalize temperatures of all places and objects with which it comes in contact, there is a continuous transfer of heat between bodies of different temperatures.....	6	9	66.66
13. The pull of gravity is proportional to the mass of the body and inversely proportional to the square of the distance between the center of the mass of the body and that of the earth.....	6	9	66.66

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Table 1. (continued)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
14. Waves travel in straight lines while passing through a uniform medium.....	5	9	55.55
15. Radiant energy travels through space in all directions undiminished.....	5	9	55.55
16. Whenever an opaque object intercepts rays of radiant energy, a shadow is cast behind the object.....	5	9	55.55
17. Any substance that will dissolve in water will cause the resulting solution to boil at a higher temperature and to freeze at a lower temperature than that at which pure water boils or freezes.....	5	9	55.55
18. The lower the temperature of a body, the less the amount of energy that it radiates; the higher the temperature, the greater is the amount of energy radiated.....	5	9	55.55
19. Whenever one surface is moved over another surface there is always friction (resistance to motion) which always results in the transformation of some of the mechanical energy of the moving object	5	9	55.55

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Table 1. (concluded)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
20. into heat energy and in the wearing away of some of each surface... The materials forming one or more substances, without ceasing to exist, may be changed into one or more new and measurable different substances.....	5	9	55.55
21. When waves strike an object, any one or more of these results will follow: they will be absorbed, they will be transmitted, or they will be reflected.....	4	9	44.44
22. If a beam of light falls on an irregular surface, the rays of light are scattered in all directions.....	4	9	44.44
23. Light rays may nearly always be caused, by a convex lens, to converge, and often to focus; and by a concave lens, to diverge.....	2	9	22.22

Explanation of Table 2.--- Eight teachers attended Trip II. The preliminary survey shows that seventeen principles were observed in operation once and four principles were observed in operation twice for a total of twenty-one different principles. Thirty-seven principles

from the adjusted list by Robertson were found not to apply to the operations viewed on this trip. No principles were written-in by any of the teachers. The twenty-one principles in the order of the percentage with which they were observed are included in Table 2.

Table 2. Principles Observed on Trip II

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
1. Matter and energy may be transformed but they cannot be created or destroyed.....	16	16	100.00
2. When waves strike an object, any one or more of these results will follow: they will be absorbed, they will be transmitted, or they will be reflected.....	8	8	100.00
3. If a beam of light falls on an irregular surface, the rays of light are scattered in all directions.....	8	8	100.00
4. Movements of air, water, and solids on the earth are due to gravity plus rotation of the earth...	8	8	100.00
5. A body at rest or in motion will remain at rest or continue in motion in a straight line until compelled by some force to change its condition of rest or motion.....	8	8	100.00

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Table 2. (continued)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
6. A body in rotation tends to fly out in a straight line which is tangent to the arc of rotation.....	8	8	100.00
7. Certain energy forms travel in waves.....	7	8	87.50
8. Waves travel in straight lines while passing through a uniform medium.....	7	8	87.50
9. Whenever an opaque object intercepts rays of radiant energy, a shadow is cast behind the object.....	7	8	87.50
10. The colors of objects depend on what light rays they transmit, absorb, or reflect.....	7	8	87.50
11. Compression of a confined gas increases its pressure.....	7	8	87.50
12. All materials offer some resistance to the flow of electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy which, when intense enough, produces light.....	7	8	87.50

(continued on next page)

Table 2. (continued)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
13. Any body of liquid free to take its own position will seek a position in which all surfaces lie in the same horizontal plane.....	7	8	87.50
14. Sound is produced by vibrating matter and is transmitted by matter.....	7	8	87.50
15. When a liquid is changed to a gas, heat is absorbed; when a gas is condensed to a liquid, heat is liberated.....	13	16	81.25
16. The higher the temperature of the air, the greater is the amount of moisture required to saturate it.....	13	16	81.25
17. Radiant energy travels through space in all directions undiminished.....	6	8	75.00
18. A gas always tends to expand throughout the whole space available.	6	8	75.00
19. The lower the temperature of a body, the less the amount of energy that it radiates; the higher the temperature, the greater is the amount of energy radiated.....	6	8	75.00

(concluded on next page)

Table 2. (concluded)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
20. Whenever one surface is moved over another surface there is always friction (resistance to motion) which always results in the transformation of some of the mechanical energy of the moving object into heat energy and in the wearing away of some of each surface.....	11	16	68.75
21. Every portion of matter may change its state by absorbing or releasing energy.....	5	8	62.50

Explanation of Table 3.--- Combining the results of both trips the preliminary surveys show that twenty-seven different principles were observed on one or the other of the trips. Six principles were observed on Trip I and not on Trip II. Four principles were observed on Trip II and not on Trip I. Seventeen principles were observed on both trips. Thirty-one principles from the adjusted list by Robertson were found not to apply to the operations viewed on either trip. The twenty-seven principles in the order of the percentage with which they were observed are included in Table 3.

Table 3. Principles Observed on Trip I and Trip II

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
1. Movements of air, water, and solids on the earth are due to gravity plus rotation of the earth...	8	8	100.00
2. A body in rotation tends to fly out in a straight line which is tangent to the arc of rotation.....	8	8	100.00
3. A body at rest or in motion will remain at rest or continue in motion in a straight line until compelled by some force to change its condition of rest or motion.....	16	17	94.12
4. Sound is produced by vibrating matter and is transmitted by matter...	16	17	94.12
5. The colors of objects depend on what light rays they transmit, absorb, or reflect.....	7	8	87.50
6. Every portion of matter may change its state by absorbing or releasing energy.....	14	17	82.35
7. Any body of liquid free to take its own position will seek a position in which all surfaces lie in the same horizontal plane.....	14	17	82.35
8. When a liquid is changed to a gas, heat is absorbed; when a gas is condensed to a liquid, heat is liberated.....	13	16	81.25

(continued on next page)

Table 3. (continued)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
9. The higher the temper- ature of the air, the greater is the amount of moisture required to saturate it.....	20	25	80.00
10. Matter and energy may be transformed but they cannot be created or destroyed.....	34	43	79.07
11. Certain energy forms travel in waves.....	13	17	76.47
12. Compression of a con- fined gas increases its pressure.....	13	17	76.47
13. A gas always tends to expand throughout the whole space available..	13	17	76.47
14. All materials offer some resistance to the flow of electric current, and that part of the electrical energy used in over- coming this resist- ance is transformed into heat energy which, when intense enough, produces light.....	13	17	76.47
15. Waves travel in straight lines while passing through a uniform medium.....	12	17	70.59
16. When waves strike an object, any one or more of these results will follow: they will be absorbed, they will be transmitted, or they will be reflected.....	12	17	70.59

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Table 3. (continued)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
17. Whenever an opaque object intercepts rays of radiant energy, a shadow is cast behind the object.....	12	17	70.59
18. If a beam of light falls on an irregular surface, the rays of light are scattered in all directions.....	12	17	70.59
19. Every pure sample for any substance, whether simple or compound, under the same conditions will show the same physical properties and the same chemical behavior.....	6	9	66.66
20. As heat tends to diffuse and thus equalize temperatures of all places and objects with which it comes in contact, there is a continuous transfer of heat between bodies of different temperatures.	6	9	66.66
21. The pull of gravity is proportional to the mass of the body and inversely proportional to the square of the distance between the center of the mass of the body and that of the earth.....	6	9	66.66

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Table 3. (continued)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per Cent
(1)	(2)	(3)	(4)
22. Radiant energy travels through space in all directions undiminished.....	11	17	64.71
23. The lower the temperature of a body, the less the amount of energy that it radiates; the higher the temperature, the greater is the amount of energy radiated....	11	17	64.71
24. Whenever one surface is moved over another surface there is always friction (resistance to motion) which always results in the transformation of some of the mechanical energy of the moving object into heat energy and in the wearing away of some of each surface.....	16	25	64.00
25. Any substance that will dissolve in water will cause the resulting solution to boil at a higher temperature and to freeze at a lower temperature than that at which pure water boils or freezes.....	5	9	55.55

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Table 3. (concluded)

Principle	Fre- quency	Possible Opportunities to Observe Principle	Per. Cent
(1)	(2)	(3)	(4)
26. The materials forming one or more substances, without ceasing to exist, may be changed into one or more new and measurable different substances.....	4	9	44.44
27. Light rays may nearly always be caused, by a convex lens, to converge, and often to focus; and by a concave lens, to diverge.	2	9	22.22

Summary of Tables.--- From a study of the three tables it would seem that three observations might be made.

First, that in general the ability of the teachers to recognize the application of scientific principles appeared to improve. This observation is evidenced by the higher percentages found on Table 2 as compared to Table 1.

Second, the tables would indicate that there is a wide difference in the ability of teachers to recognize various principles, as some principles were seen to apply by all the teachers while others were seen to apply by only a few teachers.

Third, the application of all principles found on the preliminary surveys was observed and checked by at least two teachers.

Results of personal interviews.-- The outstanding comments resulting from the interviews are grouped under two headings; results of the trips in terms of recognizing the application of scientific principles and results of the trips in terms of enriching the teacher's background.

Results of the trips in terms of recognizing the application of scientific principles.-- The majority of the teachers definitely felt that the trips gave them a better understanding of the scientific principles included in the preliminary survey and the trips also served to draw to their attention the important role that science principles play in the operation of industrial processes.

Second, the teachers felt that the syllabi were an invaluable aid to helping them recognize and understand the application of science principles. The major criticism raised by the teachers was the inability to hear the guide because of machinery noise. The syllabi partially helped to overcome this difficulty.

Third, the teachers felt the syllabus for Trip II had a greater value than that of Trip I because more of an

attempt was made to explain the principle as it pertained to the process. Actually the syllabus for Trip I came off of the printing process faint and somewhat difficult to read. As the first syllabus also contained explanation, it may be that because it was difficult to read, the full value of the explanation was not obtained.

Results of the trips in terms of enriching the teacher's background.-- All of the teachers felt that the trips were worthwhile in giving them much information which they had not before possessed concerning the nature and processes of two local industries.

In regard to Trip I one of the outstanding contributions was the role of the intricate machinery used in the packaging department where the packages were formed, filled, and sealed without the direct use of the workers' hands. Some teachers had visited this same plant years previously and they were amazed at the number of operations now completed by machinery that at one time was completed by hand.

Second, the cleanliness of the entire building and well-lighted work spaces for the workers appealed to the teachers for it gave a friendly atmosphere to the plant and added greatly to the enjoyment of the trip. Of course,

the nature of the product dictates that high health and sanitation standards must be maintained.

Finally, in the mixing room the teachers were impressed by the large amount of materials that went into the various batches of food products. It was a completely new experience for them.

In regard to Trip II one of the outstanding contributions was the complicated nature of the knitting machines that prepared the material from spools of yarn. The teachers frequently remarked about the time and thought that must have been used in developing and perfecting such a device.

Second, the teachers were impressed in the cutting room by the ease with which the electric knife so accurately cut the many layers of cloth as easily as a housewife cuts out a single pattern with a pair of shears.

Third, the teachers were concerned with the types of jobs using women and the accompanying working conditions. They were constantly comparing their own work with the jobs observed on the trip. In most cases they were satisfied to be teaching school particularly when undesirable working conditions were encountered.

Lastly, one of the contributions received from both trips was the realization of the immense amount of money

for machinery, materials, and labor that is represented in a modern industry, yet the product must be priced at only a few cents in some cases to meet the competitors' prices. The trips enabled them to see private enterprise in action and observe the value of modern technology that makes success possible.

In Chapter I the purpose of the study was stated as follows: to organize, conduct, and summarize a series of field trips to local industries for some of the elementary teachers of Little Falls, New York so that they may have an opportunity to observe certain scientific principles at work. Furthermore, it is felt that this study may serve as an incentive for other teacher groups to employ similar means of benefiting from the contributions that industry possesses in the teaching of science. The trips were organized and conducted and from the tabulations of the completed syllabi and comments obtained by personal interviews it may be concluded that the teachers observed the application of scientific principles at work. Furthermore, the trips enabled the teachers to appreciate more fully the role of scientific principles in industry, and enabled the teachers to reach a better understanding of the scientific principles used in the study.

Finally, the teachers received valuable information about the manufacturing processes of two local industries as well as receiving a new outlook on some of the problems of labor and management in maintaining production in a highly competitive market.

APPENDIX

## Syllabus for Field Trip to Hansen's Food Laboratory

The purpose of this field trip to the Hansen Food Laboratory is three fold.

The first is to better acquaint you as classroom teachers with a local industry and how it operates so as to enrich your background as a teacher in the local schools.

Second, you will have an opportunity to observe in actual operation the application of various scientific principles that you include in your science program.

Third, it is hoped that it will encourage you to take your pupils on a similar trip so that they may gain new understandings and new experiences.

The enclosed outline is a resume of the various steps that you will see. It is designed to help you understand the various processes as they are viewed. It is suggested that it be studied beforehand so that you will be better acquainted with the general procedure. Check the various principles as they are observed and don't be afraid to ask questions concerning the nature of any operation not understood.

As we enter the plant notice the presence of odors.

Principle:

- \_\_\_\_\_ (1) A gas always tends to expand throughout the whole space available.

### Fourth Floor

In the laboratory at least three important duties are performed (1) The raw materials are checked for purity (2) Each batch of prepared food is tested to maintain standard conditions before it is packaged (3) Research is carried on for new products.

Principles:

- \_\_\_\_\_ (2) Every pure sample for any substance whether simple or compound, under the same conditions will show the same physical properties and the same chemical behavior.
- \_\_\_\_\_ (3) The materials forming one or more substances without ceasing to exist may be changed into one or more

new and measurable different substances. (The work of the laboratory is based on these principles).

In the mixing room the various ingredients of the powdered foods are blended together in large mixers and the mixture is sent through a granulator where it is broken up into fine particles.

Principle:

- \_\_\_\_(4) Matter and energy may be transformed but they cannot be created or destroyed (electrical energy changed to mechanical energy to turn mixers).

The mixture is then placed in shallow pans and rolled into driers where the moisture is removed. The temperature in the driers is maintained to about 120 degrees Fahrenheit.

Principles:

- \_\_\_\_(5) Every portion of matter may change its state by absorbing or releasing energy (water absorbs heat changing to water vapor and enters the moving air).
- \_\_\_\_(6) The higher the temperature of air the greater is the amount of moisture required to saturate it. (The warm air readily absorbs the water vapor).

After drying, the mixture is placed in bins for storage until the next step.

In the fudge making department the solid ingredients are mixed with liquid sugar and boiled at a temperature of 250 degrees Fahrenheit. Note the warmth coming from the cooker compared to the one not operating.

Principles:

- \_\_\_\_(7) Any substance that will dissolve in water will cause the resulting solution to boil at a higher temperature than that at which pure water boils. (Water normally boils at 212 degrees).
- \_\_\_\_(8) The lower the temperature of the body the less the amount of energy it radiates; the higher the temperature the greater is the amount of energy radiated.

The mixture is then poured on long tables to be cooled. The tables have cold water circulating inside of them.

Principles:

\_\_\_\_(9) Any body of liquid free to take its own position will seek a position in which all surfaces lie in the same horizontal plane.

\_\_\_\_(10) As heat leaves a body and thus equalizes the temperature there is a continuous transfer of heat between bodies of different temperature.

After cooling, the mixture is placed in beaters and beaten until hard. The fudge is then crushed and sent to a drier. Notice the movement to the drier is mainly by gravity which is characteristic of many other moving processes in the plant, particularly where the movement is between floors.

Principle:

\_\_\_\_(11) The pull of gravity is proportional to the mass of the body and inversely proportional to the square of the distance between the center of mass of the body and that of the earth.

### Third Floor

The driers for the fudge operate on the same principle as the driers viewed previously. Notice the noise of the vibrating belt.

Principle:

\_\_\_\_(12) Sound is produced by vibrating matter and is transmitted by matter.

An electromagnet at the end of the drier removes particles of metal worn off the machinery and mixed with the food.

Principle:

\_\_\_\_(13) Whenever one surface is moved over another surface there is always friction (resistance to motion) which results in the transformation of some of the mechanical energy of the moving object into heat energy and in the wearing away of each surface.

The dried fudge mixture is screened and ready for packaging. (Note the use of gravity in the screening process).

The other powdered foods are sent through a commutating machine where they are ground to the right size particles. The food is then screened and ready for packaging. (Note the noise of the machinery caused by vibrating parts and the role of gravity in the screening process).

### Second Floor

The packaging process is fundamentally the same for all goods. The role of intricate machinery is very evident here. Compressed air is used to remove empty containers.  
Principle:

\_\_\_\_(14) Compression of a confined gas increases its pressure.

The wrappings of some of the packages have special paper and are sealed by electrically heated blocks.  
Principle:

\_\_\_\_ Transfer of energy

\_\_\_\_(15) All materials offer some resistance to the flow of electric current, and the electrical energy used in overcoming resistance is transferred into heat energy.

The wrapping paper is held in position by an electric eye. There are several principles at play here.  
Principles:

\_\_\_\_(16) Certain energy forms travel in waves. (Light)

\_\_\_\_(17) Waves travel in straight lines while passing through a uniform medium (light passing through air).

\_\_\_\_(18) When waves strike an object any one or more of these will follow: they will be absorbed, they will be transmitted, or they will be reflected. (We see the reflected rays as a bright spot. Some rays are transmitted through the paper and operate the controlling mechanism).

\_\_\_\_(19) Light rays may nearly always be caused, by a convex lens, to converge, and often to focus. (Such a lens is found in the eye).

In the room where the rennin capsules are prepared there will probably be no processes going on, but several general principles may be observed.

Principles:

- \_\_\_\_\_ Transfer of matter from one form to another (The plates on the machines are greased to prevent their rusting. The oxygen of the air combines with the iron plate to form rust).
- \_\_\_\_\_ (20) Radiant energy travels through space in all directions undiminished. (The light from the sun causes day and helps illuminate the room).
- \_\_\_\_\_ (21) If a beam of light falls on an irregular surface, the rays of light are scattered in all directions. (The light rays from the windows are reflected off the floor, walls, ceiling, and machinery to light the room).
- \_\_\_\_\_ (22) Whenever an opaque object intercepts rays of light, a shadow is cast behind the object. (Shadows behind the machinery)

#### First Floor

The boxes of finished products are sorted and stacked ready for delivery to the warehouse. (Note the difficulty of getting the stacks in motion and the relative ease of keeping them in motion).

Principle:

- \_\_\_\_\_ (23) A body at rest or in motion will remain at rest or continue in motion in a straight line until compelled by some force to change its condition of rest or motion.

#### General Considerations

1. The use of various types of labor saving machinery is evident throughout the entire plant. Few of the operations require the direct use of workers' hands. Their job for the most part is to watch the machinery and insure a steady supply of necessary materials.
2. The use of glass brick and fluorescent lights in insuring well lighted working areas adds materially to the ease and efficiency of the workers.

3. The choice of paints for the various rooms was based on the results of psychological studies which showed that worker morale and output is improved by selected color schemes.
4. Power transmission by complicated systems of gears and pulleys is evidenced in the various machines.

## Syllabus for Field Trip to the Gilbert Knitting Mill

The purpose of this field trip is two fold.

The first is to better acquaint you as a classroom teacher with a local industry and how it operates so as to enrich your background as a teacher in the local schools.

Second, it will afford you the opportunity to observe in actual operation the application of various scientific principles that you include in your science program.

Because of the nature of the machinery it would be undesirable to bring a group of children on a similar trip.

The following outline is a resume of the various steps that you will see. It is designed to help you understand the various processes as they are viewed. It is suggested that the outline be studied beforehand so that you will be better acquainted with the general procedure. Check the various principles as they are observed and don't be afraid to ask questions concerning the nature of any operation not understood.

### Nature of Product

The Gilbert Knitting Mill carries on two separate functions.

First, it prepares the yarn for knitting using both the raw fibers and used fibers. The bulk of the yarn is woven from cotton fibers although wool is used in some of the garments.

Some types of yarn are sold outright to other factories for use as lining in other articles of clothing. Most of the yarn is knitted into material that is used to form the various garments produced at the plant.

The finished products include men's work socks and woolen athletic socks of various descriptions, athletic sweat suits, cardigan knitted jackets of both wool and cotton, and assorted knitted outside jackets.

### I

Because of the limit of time we will not take in the processes of preparing the yarn but will start in with the knitting processes and carry on through to the finished products. The knitting process consists of two types. The

first is preparing material for use in sweaters and the like; the second is the knitting of hose.

In the knitting room the cones of prepared yarn are woven into tubes of material that are formed into rolls for easier handling. These will eventually be used in making various forms of sweaters and sweat pants.

The knitting machines are very intricate devices but may be stopped instantaneously when flaws in the work are discovered. Needles, when they become broken, are removed from their lead bases and new ones molded into place.

- \_\_\_\_\_ (1) Matter and energy may be transformed but they cannot be created or destroyed. (The energy of the steam drives the belts which operate the knitting machines).
- \_\_\_\_\_ (2) Every portion of matter may change its state by absorbing or releasing energy. (The lead absorbs heat and melts to a liquid).

The woven material is transferred to the dyeing vats where it is dyed to the selected colors. The inclined plane is used to transfer the material to the lower level.

- \_\_\_\_\_ (3) Movements of air, water, and solids on the earth are due to gravity, plus rotation of the earth. (Rolls move down the ramp)
- \_\_\_\_\_ (4) The colors of objects depend on what light rays they transmit, absorb, or reflect. (Red cloth reflects red rays).
- \_\_\_\_\_ (5) Any body of liquid free to take its own position will seek a position in which all surfaces lie in the same horizontal plane. (Dye in the vat)

The material is spun dried in machines similar to that of the home laundry.

- \_\_\_\_\_ (6) A body in rotation tends to fly out in a straight line which is tangent to the arc of rotation. (Centrifugal force)

The rolls are then placed on hot air driers which complete the process.

- \_\_\_\_\_ (7) When a liquid is changed to a gas, heat is absorbed; when a gas is condensed to a liquid, heat is liberated. (Water absorbs heat from air and evaporates).

- \_\_\_\_\_(8) The higher the temperature of the air, the greater is the amount of moisture required to saturate it. (Hot air insures quick evaporation).

Next the material is run through the knapping machine where one side of the material is fluffed out.

- \_\_\_\_\_(9) Whenever one surface is moved over another surface there is always friction (resistance to motion) which always results in the transformation of some of the mechanical energy of the moving object into heat energy and in wearing away some of the surface. (Responsible for the fleecing effect)

The rolls are then carried to the cutting room where they are rolled out on long tables into many layers ready for marking and cutting. Light is shone through the material to spot imperfection. Note how the cloth remains in place as the knife cuts through it.

- \_\_\_\_\_(10) A body at rest or in motion will remain at rest or continue in motion in a straight line until compelled by some force to change its condition of rest or motion. (Inertia)

\_\_\_\_\_  
Matter and energy may be transformed but they cannot be created or destroyed. (Electrical energy is changed to mechanical energy to operate the knife).

- \_\_\_\_\_(11) Whenever an opaque object intercepts rays of radiant energy, a shadow is cast behind the object. (The light shines through the imperfection).

The various pieces of the garment are sent to the sewing room where the parts are stitched together. Each operator has a separate process and the various machines are designed for the job they have to do. (More examples of energy transfer in operating the machines) Note also the effect of light on the work.

- \_\_\_\_\_(12) Certain energy forms travel in waves. (The light to illuminate the work)

- \_\_\_\_\_(13) Radiant energy travels through space in all directions undiminished. (Light from the sun lights the room through the windows).

The completed garment is then inspected, folded, and boxed ready for shipment. Note here also the lighting effects.

\_\_\_\_\_ (14) When waves strike an object any one or more of these results will follow: they will be absorbed, transmitted, or reflected. (We see the garments because of reflected light).

\_\_\_\_\_ (15) If a beam of light falls on an irregular surface, the rays of light are scattered in all directions. (The floor does not have as much glare as the polished table tops).

## II

The manufacturing of hosiery starts with the knitting of the yarn into the complete sock except for the toe. Again the machinery is very intricate and constant care must be taken against imperfections. Lint is removed from the machines by compressed air.

\_\_\_\_\_ (16) Compression of a confined gas increases its pressure. (Blows away the lint)

After the socks are knitted they are sent on to the looping department where the hole in the toe is sewed up. From here they are sent downstairs to be washed. Note how the light beams through openings in the machinery.

\_\_\_\_\_ (17) Waves travel in straight lines while passing through a uniform medium.

After washing they are dried in the spin drier and shaped in the boarding rooms by completely drying them on heated forms. Feel the heat from the forms in use compared to those not in use.

\_\_\_\_\_ Principles seven and eight repeated.

\_\_\_\_\_ (18) The lower the temperature of a body, the less the amount of energy it radiates; the higher the temperature, the greater the amount radiated.

After shaping, the socks are sent through the brushing machine where the fibers are fluffed out. Notice the presence of odors from the dye and yarn.

\_\_\_\_\_ Principle nine repeated.

\_\_\_\_\_(19) A gas always tends to expand throughout the whole space available. (Odors arise from diffused gases).

Next the socks are paired and labeled. Note the noise of the labeling machine.

\_\_\_\_\_(20) Sound is produced by vibrating matter and is transmitted by matter.

Next the socks are inspected and stamped with the percentages of cotton and wool in the materials. The heated plate places the dye on the socks. The plate is electrically heated.

\_\_\_\_\_(21) All materials offer some resistance to the flow of electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy which, when intense enough, produces light.

Finally the socks are packed in boxes which are placed in cartons ready for addressing and shipping.

#### General Considerations

1. In spite of the use of intricate machinery the operators must be alert and skillful in their work to insure a perfect garment.
2. The use of belts and pulleys in the operation of the various machines are evidenced throughout the plant.
3. The initial power is from three sources. We will not see them except for the electric motors but the other two sources are a water wheel driven by river water and steam power from an engine located in the basement.

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