The Educational Value of Certain After-School Materials and Activities in Science

BY
MORRIS MEISTER

Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in the Faculty of Philosophy, Columbia University.

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CHAPTER I

INTRODUCTION

Educational thought and investigation of the last ten or fifteen years have been focusing the attention of teachers, supervisors, educators, and the thinking public upon certain educative forces that exist quite apart from the activities of the schoolroom. These forces are sometimes so vital and so important in shaping the life of the individual that the failure of the educational system properly to guide and control them has brought upon it a considerable portion of the criticism of recent years. Developments in educational philosophy and psychology have been very emphatic in pointing out that what our pupils do during every hour of the twenty-four in the day—and of every day in the year—is a factor making for education and therefore a legitimate consideration for the school and teacher. Thus, we have begun to investigate such questions as home-study, play, and nutrition. We have gone into the home and made recommendations to parents in matters which have hitherto been looked upon as belonging only to mother and father. We have begun to lay stress upon student organizations of all sorts; seeking in them value in citizenship and habit formation. Clubcraft, scoutcraft, and camping have become pertinent considerations for the educator and, what is more important, for the teacher in the class room. And, as might be expected, this newer element has had its influence upon our schools, their organizations, curricula, courses of study, and methods of instruction. The concept that the school is not a place where we prepare for a life that is to come, but is an integral part of life itself, must necessarily and in a very intimate way relate school procedures with the vital factors of life.

In a sense, we are preparing our pupils for a future life in the most effective way when we teach them to live better their present lives. From considerations such as these, extra-curricular activities have been deriving greater and greater importance. Eventually the line of demarcation between the two phases of activity should fade completely. The school day may start at 9 and end at 3; but its influence will function at all times. And in turn, methods of work, content, and organization within the four walls of the school-room should take their quality and their inspiration from the well-springs of enthusiasm so common to after-school activity.

Needless to say, we are as yet far from so ideal a development. To the pupil, out-of-school time has always been and still is the period of freedom par excellence. We have perhaps progressed beyond the point where he thinks of the school-room as an abode of horrors, of the teacher as an ogre, and of books as instruments of torture; but too often his real life is still essentially distinct from the school. His greatest activity and his greatest enthusiasm still center around the extra-curricular where are to be found problems of his own choosing and ideas born of his own inner urgings.

As for the teacher, he has been reacting to the extra-curricular in many different ways. When seized by the immensity of some teaching difficulty, he may storm at the "distracting influences" which take "their minds off their subjects," or he may feel envious of these rivals to his efforts, or he may welcome them as offering a "whip" with which to lash pupils into submission—by laying punitive restrictions upon their after-school time. Or, he may throw care to the winds, and enter whole-heartedly into the extra-curricular plans of his boys. If he is one who reacts in this last way, he almost always attains a popularity and a sphere of influence that make teaching a joy.

The parent is perhaps the only one who is in a position fully to appreciate the extra-curricular. Most of his problems as a parent, a good deal of his worry, a goodly portion of the cost of child support, and nearly all of his pleasure with his children are tied up with the extra-curricular. If he be the unintelligent parent, he welcomes such a procedure as will relieve him of his problems. Time spent in school is so much less time for his boy to get into mischief. If he be the thinking parent, he will make the effort himself to reconcile for the boy the two distinct claims upon the latter's time. Both types of parents are ready to cooperate and to accept recommendations looking to a better state of affairs.

And society is filled with individuals who look back upon these two phases of their past lives with two quite distinct attitudes: with censure, criticism, and unpleasantness for the one; and with glowing recollections of time profitably spent for the other. It is a very wide-spread reflection upon American college education that it is essentially an extra-curricular training. In some colleges it is frequently a matter of disrepute to have devoted much time to studies. The same condition holds for the high school and in a different sense even for the elementary school. The man of sixty who reviews his life and concludes that his real education was what he got while in contact with the world of actual experience is often paralleled by the high school or college student who regards as his real schooling his experiences of out-of-school life. "He has nine months in which to get his schooling and three months in which to gain an education."

From every point of view possible, extra-curricular activities loom up as immense factors of educational importance. In the field of science there has always existed a body of materials and experiences that were essentially tied up with life out of school. Before the great industrial changes which brought to civilization the "factory," and which herded our masses into congested cities, the home was a center of industrial, social, and intellectual activity. In this activity were found a stimulus and an opportunity for experiences of a physical, mechanical, and manipulatory nature. This stimulus existing quite apart from the systematic education of sixty or seventy years ago, nevertheless made one of the largest contributions to the intellectual development of the individual of that day. As modern industrialism continued in its growth, the home ceased to function in the old sense. Education became more and more "curricular" and systematic, "squeezing the educational juice" out of the home.

Charles W. Eliot in his paper on "Changes Needed in American Secondary Education," comments upon this situation as follows:

"If any one should ask—why has modern society got on as well as it has, if the great majority of its members have had an inadequate training of that sort, the answer is that some voluntary agencies and some influences which take strong effect on sections of the community have been at work to mitigate the evil. Such are, for example, athletic sports, travel, the use by city people of public parks and gardens, the practice of that alert watchfulness which the risk of crowded thoroughfares and of the dangerous industries compel, and the training of the senses which any man who practices well a manual trade obtains on the way . . . The problem now is how to make systematic secondary education support and better these incidental influences, and how to co-ordinate sense-training with accurate reasoning and retentive memorizing."

Clearly Dr. Eliot recognizes certain extra-curricular forces which are supplying a need not met by the schools. In the last ten or fifteen years another of these forces has come into existence, to make up for the lack of manipulatory, sense-experiences that have followed the decadence of the home. A mass of science play materials has invaded the apartment house. The boy spends large portions of his time on them; and the parent often stints himself in order that his boy may have them. In the matter of time expended, effort exerted, interest aroused, and thought provoked, these materials and activities compare most favorably with the subject matter and activities of the same boys in school.

In addition to being socially important and of vital interest to the boy, these materials present problems to the parent and to the science teacher. In the case of the former, there are matters such as safety of the boy, safety to the household furnishings, and interference with the comfort and rights of other members of the family, that are to be carefully considered. Then, too, which are the best things to buy among the countless articles offered for sale as "educational toys?" Are the expensive toys more valuable educationally? Are they really educational? May they not over-stimulate? How often should new materials be bought? What are the most efficient arrangements for the boy's play room or shop? What tools shall he have? There are many other questions which the writer has been called upon to answer by parents of his boy pupils.

The science teacher too is affected by this activity which goes on outside of his class room. Sometimes he uses it for his illustrations, sometimes he makes use of the apparatus, sometimes he cautions against certain projects, and sometimes he opposes the activity and rules against its worthwhileness. Though it must be pointed out that this study does not attempt to treat or solve problems in the teaching of science, it is hoped that any conclusions which are arrived at will throw light upon these curricular problems. These out-of-school materials affect the science teacher's problems in two ways. They cause a change in the reaction that boys will make to the teacher's materials; and thereby tend to change his content, organization, and methods. Two instances of such tendencies may be briefly discussed with profit.

There is no greater problem for framers of courses of study than the proper selection of content. Even when basic principles have been agreed upon, the task of choosing the details that are to be taught is fraught with argument and indecision. Two contending principles are in most cases the cause for this difficulty. On the one hand we have the school of thought which lays maximum stress upon the items of "racial experience" that are proved and of long standing, irrespective of likes or dislikes of the pupils. "This is good for them!" On the other hand we have the group of educators who lay maximum stress upon the interest of the child as the starting point, and will include or exclude each item in the course of study according as it meets or does not meet the criterion of interest. A proper compromise between these two points of view has been proposed by Dr. Kilpatrick in which a weighting of three factors can be used as the criterion: the frequency with which an item occurs in actual life, its significance when it does occur, and the cost of instruction. But whichever criterion is used, our extra-curricular activities, in offering the most effective selection of content on the basis of genuine interest, perform a service for framers of courses of study which is surely of great value.

Another immediate significance that these play materials have for curricular work is in connection with laboratory procedure. There is a growing dissatisfaction with our meaningless bits of high school apparatus, the very quantitative procedure of measuring useless objects for the sake of developing habits of accuracy and the great stress upon performing experiments from rigidly designed manuals which destroy the last bit of initiative in the pupils. The dissatisfaction is not at all with quantitative procedures or with high ideals of accuracy of measurement, but with the attempt to force these things upon pupils of an age and training which make impossible a proper appreciation. Here again extra-curricular activities offer some valuable suggestions by presenting a type of experimenting which possesses more characteristics in common with the activities of great scientists (whatever else they possess) than do our present-day laboratory courses in the high school.

However, solution to curricular problems will not be the immediate concern of this study. It will be quite sufficient if principles and conclusions evolving from this investigation will make for a better development of the mass of materials that is daily increasing its sphere of influence. At the present time, stress of business competition is evolving a science toy which has value in terms of "number of sales." It is true that in the long run manufacturers of these toys and also science-motion-picture producers, popular science magazine editors, etc., will, in their struggle for existence, evolve a type of product which will "survive." But can educators accept as the sole criterion of survival the "number of sales"? Ought not education to make this development of after-school materials less feverish, less hit-or-miss, and more definitely directed toward a worthy goal? That, in a word, is the primary aim of this investigation. Assuming that business competition as it exists today is not conducive to altruistic aims, and that we ought not to wait upon the slow process of evolution, the writer attempts to analyze the problem that these activities raise and establish certain principles and criteria. From these criteria an evaluation will be attempted in terms of objective measurement.*

As for a literature of the subject, almost nothing has been found that deals with a problem that is even remotely akin to this. Of course, there has been a flood of extra-curricular literature in the past few years, all of which might be used in substantiation of the point that these activities are significant and important, but not to throw light on the educational values of the specific activities that are the concern of this study. Then, too, and in a general way, what has been written on such questions as play, interest and effort, self-activity, purposeful activity, concrete vs. abstract, practical vs. cultural, play vs. work, etc., is all

*It might be in place here to state that the leading manufacturers of science toys have all shown a keen interest in this aim. They have devoted days of their busy week to conferences with the writer. They have very generously given of their materials for purposes of study and have put their office staffs at the writer's disposal. More important still they are ready to accept some of the findings of this investigation.

pertinent to this problem. But to my knowledge there has been a total lack of experimentation or investigation in this particular field.* Here and there in some current magazine, we read of some teacher's experience with "science clubs," or of some teacher of science whose hobby it has been to teach science by means of toys. The important experiences of this sort and their contributions to the general problem will be dealt with in the course of this paper.

*In the last few months the *Mother's Magazine* has been reporting regularly on a series of experiments with educational toys in a public school of Chicago. The aims, methods, and organization of the experiment are all very vague. Each month the editor gets back a number of reports from teachers as to how children have reacted, and these are printed as informational material for mothers.

CHAPTER II

THE MATERIALS AND ACTIVITIES LISTED AND DESCRIBED

The aim of this chapter is to set down and describe the materials and activities which are the basis of this study. The writer recognizes four large types of such materials and activities.

I. Toys
  (a) Sets and Outfits
  (b) Specific Toys
II. Reading Materials
III. Educational Agencies Involving Science Materials
IV. The Science Club

I. (*a*) The Toy Outfits

These outfits, of which there are at least forty different makes and types sold to the American boy, group themselves roughly into Mechanical, Electrical, and Chemical Sets, and Sets for Special Purposes.

Of the Mechanical Sets three are worthy of mention: the Meccano, the Erector, and the Structo. The original toy of this type was the Meccano, first introduced in England in 1902 and later in most civilized countries of the world. The remarkable success of the toy everywhere—as a commercial venture—brought into the toy market in but a very short time as many as thirty or forty imitations. Fortunately or unfortunately these imitations were declared by the courts to be infringements of patent rights; so that our present product has evolved from the experimentation of but one company. The Erector, an American innovation, is sufficiently different from the Meccano to have withstood legal attack; but the Structo, after several years of active effort in the field, has been compelled by the courts to withdraw as competitors of Meccano and Erector.

The history of the development of Meccano is typical of a great many of these outfits, and is significant educationally. The inventor is Frank Hornby of England. Born at a time when the possibilities of scientific inventions were beginning to grip the minds of men, he spent his youth and early manhood in dreaming of inventions and mechanical contrivances to do new and wonderful things. Practically all of his efforts in that direction were complete failures, but he carried with him into manhood an appreciation for this great longing of the normal boy to manipulate, to experiment, to "make things go;" so that when his own two boys arrived, it was with keen understanding that he undertook to satisfy their craving to do things.

The derrick has always proved a particularly fascinating object for boys. Hornby conceived the idea of constructing a derrick that would actually lift things, and which could be dismantled and its parts used for other purposes when the boys got tired of the derrick. The first project worked out to the satisfaction of his two boys; it was but a simple step to build with the same parts other objects of interest. Gradually the parts were standardized and perfected so as to be as interchangeable as possible. The ingenuity of his boys and his own ability to play as a boy soon developed an imposing array of different models—all built out of strips of steel, accurately and uniformly perforated, fastened by miniature brass nuts and bolts, and operated by real gears, belts, and pulleys.

Dr. Hele-Shaw, professor of engineering at University College, Liverpool, recognized the educational value of Hornby's toy and assisted the latter in launching the venture commercially. A good many of the original investors in the scheme were men and women who were inspired by the Froebel doctrine and the writings of Horace Mann, and who believed with Herbert Spencer that "Invariably children show a strong tendency to make, to build; a propensity which, if duly directed, will not only prepare the way for scientific conceptions, but will develop these powers of manipulation in which most people are so deficient."

Thus it is important to note that Meccano had its origin in educational ideals. But as with hundreds of other attempts to make money out of education, there soon arose difficulties. Hornby's toy was sold under the title, "Hornby's System of Mechanical Demonstration," in which he endeavored to provide "an economical and yet very effective series of apparatus for demonstrating the main elementary fundamentals of mechanics and mechanical science." To quote further from his avowed purposes, "The scheme is intended to cover the requirements of the ordinary elementary schools; though it is by no means limited to such an application. The present models used in the teaching of mechanical science are very costly. In such models one piece of apparatus is employed to teach a given lesson, and that one only; the consequence being that to cover anything like a proper ground, the cost of the apparatus required is very heavy. . . . Experimental models constructed from 'Hornby' System parts will be found to be of quite as high a degree of accuracy as apparatus costing many times as much. . . . Every care has been taken in designing these models to make each one both simple in construction and effective as a demonstration of some important principle. . . . We need hardly say that suggestions from teachers will be welcomed by us, and are invited. . . . We have introduced three separate outfits to meet the requirements of the three higher standards of elementary day schools. 'A' section relates mainly to constructional work, and is designed to bring out such ideas as bracing, girder construction, the building up of roof-trusses, the joining of plates and so on. 'B' section embodies a series of movable parts in engines, whilst 'C' section is designed to afford scope for the teaching of the elementary laws of mechanics."

And so Hornby begins his "Manual of Instructions" with a series of simple elements. He has the boy make a "diagonal tie bar for a frame;" and when he can do that well, he allows him to apply the "frame" to a "swinging gate."

He has him make an "angle bracket;" and when he has perfected himself in that exercise he can then apply it to a "simple roof-truss" and a "girder." Then the boy makes a "rectangular angle iron framing," after which he applies it to another unit which "might be a braced tower." Following this, the boy is asked to perfect himself in making a "trestle," an "H-girder," "joining plates at right angles," making a "butt joint with a Tee Iron," and making a "lap joint of plates." This completes Section A.

In Section B, Hornby assumes an ability on the part of the boy to manipulate all of the above units, and asks him to construct a series of mechanical devices which involve to some extent the units of Section A. Some of these devices are rather complicated and difficult to construct. There are in all nine such models. The pantograph, the open and crossed belt drives, the crank and connecting rod, tracing a locus, quick-return motion, a beam-engine, a centrifugal, governor, a universal crosshead, and a Hookes' Coupling. His dominant idea seems to be to teach the boy certain important mechanical actions, so that when he meets with these actions in actual engines he will appreciate and understand them.

In Section C he points out to the teacher the applicability of Meccano parts to the traditional type of physics experiment. He very ingeniously illustrates different types of pulley arrangements, block and tackle arrangements, the wheel and axle, a train of gears, a worm gear, the lever, the bell crank, the triangle of forces, the forces acting in a crane, in a roof-truss and in a cross head, and the inclined plane.

It is not necessary to dwell at great length on the merits of the "Hornby System." The greatest criticism and the most severe that Hornby could have received came from the boys of England. They wouldn't play with his toy. It wasn't a toy. He so completely bound up their inner urgings with his rigid procedure, he left so little for them to do, he took away from them so completely the possibility to experiment, that Meccano lost its appeal. It took Hornby about five years to realize that in his anxiety to prove that his device was "educational" he had robbed it of the spirit which had given him the original inspiration. In the parlance of our men of business, the Hornby System did not "pan out." It didn't attract. It was too "educational" to educate.

Hornby, however, persisted. Some of our modern educational theorists might have told him that teaching through play was an abuse of play,* or that he was using play as a means to an end, when play should be an end in itself,** or that his procedure was from general principle to application where it should be the reverse. His own analysis of the difficulty was put in this form: "The boy must have fun; if he learns anything in the process, so much the better." Since 1907 the Hornby System has been

*J. C. Merriam, Child Life and the Curriculum.
**John Dewey.

virtually extinct. In its place has come the toy that millions of boys the world over play with.

Let us contrast with the quotations cited before from the Hornby System Manual the following excerpts from the later series of Meccano Instruction Books:

"MECCANO LAND—THE LAND OF HAPPY BOYS"

"Have you ever heard of the wonderful new country where nearly all the inhabitants are boys—millions of them, the happy land where all is sunshine and joy . . . where all the inhabitants crowd the fleeting hours with enjoyment and fun?

"The young ones are amusing themselves among miniature cranes and bridges; wagons and windmills; trucks and towers—exquisite little engineering models, which they have built and set to work for themselves. The older ones are building and playing with great structures, real giant cranes, big bridges, ingenious looms for real weaving, clocks which keep time, automobiles which actually run; while the thoughtful and serious boys are busily engaged in inventing and creating new and ingenious models and movements for themselves.

"This happy country is called Meccano Land, and boys from every country in the world live there. Meccano language is the universal boy language, and all the inhabitants understand and speak it. . . . Many boys have lived in Meccano Land for ten years, and the longer they live there the happier they are. Every day boys are crowding into the country eager to participate in its wonders. They know they are going to have the time of their lives; more fun than they ever had before—healthy boys' fun; fun which will make them glad to be alive; fun which will strengthen their characters; set their brains working, and teach them something which will make them into big and successful men."

And then, in a somewhat calmer, more subdued tone, and evidently directed at the adult, parent or teacher, "Meccano is sold as a children's toy, to give them fun, interest them, and instruct them in the fascinating wonders of engineering, *but* every day sees a fresh use for it. Engineers and architects use it for designing models and inventing movements. Professors and teachers in technical schools use it to demonstrate mechanical principles to their students. We have received enthusiastic letters from inventors who have designed practical commercial machines with Meccano parts for weaving and other purposes. It is largely used in institutions for the blind for teaching patients, and in very many children's hospitals."

It is hard to say whether Hornby's efforts to surround his toy with "dignity" have been of use to him either to increase the number of sales or to command the respect of educators. This much is certain—that the Meccano Company has been convinced through bitter experience that the *fun* element is by far the dominant contribution of Meccano. And for purposes of this study it is just as certain that we must evaluate Meccano as it functions in the life of the boy.

Meccano as it is sold at the present time consists of about fifty or sixty standardized parts. The materials are in the main of good quality iron and brass. As shown in the accompanying illustrations,* the parts are small and simple. The interchangeability of parts is truly the most ingenious feature of the device.

It is impossible to describe in words the endless variety of uses to which each part can be put. Only one who has built with these parts can appreciate the flexibility of the toy. There are other features about these parts which are worthy of mention from a mechanical standpoint.

1. The strength and elasticity of the parts make for good service and permanency.
2. In the main, each part is very definitely modeled after the same part as it functions in real life.
3. The holes are of uniform diameter and are accurately spaced; so that the boy is not handicapped unnecessarily by fortuitous difficulties.
4. The odd number of holes in each perforated strip make possible a great many balanced structures.
5. The spring motor and the electric motor are efficient mechanisms which stand up well in service.

The boy can buy a Meccano Outfit (No. 00) for $1.00. He can buy No. 00A for 50¢ and turn his No. 00 into No. 0. He can buy No. 0A for $1.50 and turn his No. 0 to a No. 1. No. 1A

*The illustrations have been omitted in this edition.

for $3.00 will turn his No. 1 into a No. 2. And in this way, after a few years, he can own the most complete outfit—No. 6—which costs about $40.00. In the following table the possibilities of each of these sets are listed:

Set Number	No. of Different Parts	Total No. of Parts	Minimum No. of Models That Can Be Built
0	22	78	80
0A	15	28	
1	28	105	105
1A	15	70	
2	35	175	151
2A	21	76	
3	44	251	196
3A	28	126	
4	51	377	247
4A	21	136	
5	55	513	277
5A	42	596	
6	60	1109	325
Inventors' Outfits	..	....	...

The "minimum number of models" listed above represent a bare minimum. Periodically the company has issued new manuals of instruction to supplement the original ones given with the various sets; so that one can safely double the number here given in order to get an idea of the mass of constructive material that the company makes available to the boy. In the past four years the writer has recorded no fewer than 260 models, not found in the manuals and built by about 174 boys. It is to be noted also that the models presented with the more advanced sets are proportionately fewer, but mechanically far more difficult and complex.

In a later chapter the manner in which these constructions were collated will be fully discussed. It will be found that these models came originally, like the writer's 260, from the efforts of boys themselves. Hence an analysis of the types of models becomes significant, since it is indicative of certain interests and tendencies.

For the first five outfits the models group themselves as follows:

Type.	Number.	Per Cent.
1. Vehicles	55	20.2
2. Drills, Presses, Lathes	26	9.6
3. Cranes and Derricks	25	9.2
4. See Saws and other "games"	24	9.0
5. Furniture	17	6.2
6. Ploughs and other farm tools	14	5.1
7. Bridges	9	3.3
8. Windmills	7	2.6
9. Railway signals	7	2.6
10. Weighing Scales	7	2.6
11. Guns and Implements of War	7	2.6
12. Aeroplanes	6	2.2
13. Ladders	6	2.2
14. Circular Saws	5	1.8
15. Railway Systems	3	1.1
16. Lawn mowers	3	1.1
17. Elevator	3	1.1
18. Distance Indicators	3	1.1
19. Miscellaneous Items (occurring no oftener than twice)	45	16.0
	272	99.8

The most striking fact about the above figures is that there does not seem to be any well-marked tendency in favor of one type of construction. Even in the case of the "Vehicles," the comparatively large percentage of 20.2 would dwindle to an insignificant amount if we made but a slight effort to distinguish between different types of vehicles. Included in this category are models ranging from baby-carriages to locomotives. The same might be said of "Drills, Presses and Lathes," and of "Derricks" and of "Games." These figures are borne out by the addition of hundreds of new models in the past few years. It is most certainly true of the writer's own 260 "original" models. In other words, the interest which furnishes the child with motive power to manipulate and construct does not tie itself too closely to any environmental material in particular; but rather seeks an outlet in diverse paths.

Another rather general conclusion regarding these models is that by far the greatest portion of them involve the element of motion. The static model is unpopular and infrequent. Usually this element of motion is bound up with the usefulness of the model. The most popular models are the ones that accomplish a useful purpose and involve moving parts. In this connection the spring motor and the electric motor become indispensable.

The Erector Set is an American product and practically the only competitor of Meccano. The inventor, A. C. Gilbert, is a Yale graduate, who launched his idea as a business venture when still a student in college. It was brought prominently into the market at approximately the same time that Hornby gave up his "System of Mechanical Demonstration" and launched the later development of Meccano previously described. It might be of interest to trace as we did with Meccano the origin of this device, its development, especially in so far as it relates to ideals of education. The following are excerpts from letters and other writings of A. C. Gilbert:

"Three things always interested me — Athletics, Sleight-of-Hand, and Scientific experiments. Outside of my school work, athletics claimed the major part of my time, but a good share was left to learn the secrets of scientific things. This hobby which I had had ever since I was a boy helped me in two ways: first, it helped me earn my way through college, and second, it helped me bring science down to a boy's understanding. The first money I ever made was by giving magic entertainments to private audiences, and while entertaining one of these audiences in this way the thought occurred to me that if these same tricks I was doing could be put up so that boys would understand them easily, they would have a splendid sale. . . . It was not long before Mysto Magic Sets were known pretty familiarly all over the country.

"Manufacturing and selling just magic toys did not satisfy me. I had always felt that toys, besides giving a great amount of fun and enjoyment, also had a big influence on the character of a boy and that they should be considered of great importance by parents. I realized that as a boy I always had a longing to know more about the secrets of nature and to experiment along scientific lines. So I conceived the idea of manufacturing toys of a character and kind that had been such a hobby with me as a boy—real engineering toys."

There is no doubt at all that the growth of Erector was as phenomenal as that of Meccano. In six years the Gilbert plant has grown from a wooden shanty to a modern factory covering acres of ground. Whether because of Hornby's experience or convictions of his own, Gilbert has never strenuously attempted to surround his toy with the "dignity" of the school-room. On the other hand, he very clearly recognizes larger ideals for his product than mere money-making. Again and again he makes the statement that "Toys can be made more than mere playthings—they could be made to mean something to the boy and his parents," and that he "has therefore continued to bring out many engineering toys of the kind and character that will hold the boys' interest because they are full of intensely interesting things and because they provide fun and amusement."

As it is sold at the present time, Erector consists of sixty different parts. The standardization and interchangeability of parts has not been carried to as high a point of development as has the Meccano; but there is nothing inherent in the device which should prevent such development. The material is of a cheaper grade of iron than Meccano, with not as fine a finish. Instead of perforated strips, the unit of construction is in this case a girder type of strip that can fasten at the ends only, by means of a slip-joint or angle iron held by a nut and bolt. This girder strip is wider than Meccano and permits more easily of the building of four-sided columns or pillars; or even three-cornered and diamond-shaped posts. The flexibility of Erector and the possibilities for original construction are extremely large, though not quite up to the mark of Meccano.

Erector is sold in eight sets. The Manuals of Instruction given with each set are fully illustrated and offer a wealth of constructive material for each set. Again the number of models offered does not quite equal the number offered by Meccano. This, however, does not prove a serious handicap. Erector sells individual parts in any quantity, but does not grade its sets, so that a boy cannot feel that he can gradually buy enough material to turn his set of a year ago into the most complete set sold by the company. This does impose a hardship and is a decided disadvantage.

Several interesting points educationally come to light from an analysis of the Erector Manual. On the very first page, the boy is cautioned as follows: "Before attempting to build any models go through the exercise of building each standard detail. This is the most important recommendation we have to make. You will not be successful as a model builder unless you follow these fundamental instructions implicitly." Then, by means of illustrated cuts, thirty-five elementary exercises are described. In some cases detailed word descriptions are given, designed to help the boy build. For example, "To construct a square girder: Commence by placing a long screw through one or both ends of two girders, as in A, then separating the two take another girder, pushing it down into the grooves or channels as in B. Having assembled the three sides, take the fourth girder and likewise insert it into the grooves, as in C, and slide it down until the two are flush; which makes you a square column girder as in D."

Among the thirty-five elementary constructions are many which remind one of the Hornby System. The boy is told before doing anything at all to make a lap-joint, a right-angle connection, an acute connection, a connection for branch girders, a cross-connection using screw, nut and washer, a four-way girder connection, eccentric motion, and interchangeable gear-box, a five-way connection, a double pulley connection, a six-way girder-corner, a brake mechanism, etc., etc.

Having been drilled in the elements, he can then proceed to do what he enjoys. There is a difference between Hornby's "elements" and Gilbert's. The former were fewer in number and truer to actual machinery. The latter to a great extent are peculiar to the inherent characteristics of Erector and are not duplicated very often in actual life. The reaction of the boy to these preliminaries, before he can actually build, varies with the boy. Some will tire very easily and will jump into actual construction at once. Gilbert seems to realize that this tendency exists among boys and attempts to head the boy off by repeated warnings throughout the manual. Thus, on page three: *"Warning:* You must not proceed with your models until you have worked out all the standard details on pages 1 and 2; even if you are an old

Gilbert Model Builder. I find myself, after having built thousands of models, that I frequently refer to the Standard Details for reference and help." And again, a little later on: "The square girder and the triangular girder are the fundamentals of real structural steel engineering. You simply must practice this until you can do it simply and easily. The boy who cannot do this will never become a Gilbert Engineer." Still later on, with more complicated models, he sounds another warning, and this time adds a new note: "*Patience.* This will require some patience, but you will not regret it; and you will enjoy your Erector a good deal more by so doing." My experience has been that the boy as a rule does not heed these warnings. There always are a few who faithfully and painstakingly subject themselves to Gilbert's training; but they are never the brilliant builders. There are, however, a very considerable number who will refer to the Standard Details when they are "stumped." As a reference to be looked up when needed, Gilbert's elementary exercises are a valuable asset; but his toy suffers from this unavoidable complication.

Another interesting feature of the Erector Manual is the attempt to lead the boy gradually to the point where he will build his own original models. Under the caption of *Imagination,* the manual tells the boy that "Nothing but illustrations are shown in these models; because we wish to encourage imagination and resourcefulness and to help you later on in creating your own models." As in the case of the admonishings to practice and to be patient, the boy misses the point completely. As a matter of fact, one boy out of five ever constructs a model exactly as he sees it in the picture; the other four just naturally ignore the illustration and alter it in many small ways. Often (this will be discussed more fully in a later chapter) a boy when half way through with a model will be inspired to alter completely his original plans or design and fashion out of the beginning given him by the manual an entirely new creation. Furthermore, this is just as likely to happen with a boy playing with Erector the first time as with a boy who has had Erector for a year.

For the first six outfits the Erector models group themselves as follows:

Type.	Number.	Per Cent.
1. Vehicles	23	21.9
2. Drill Presses & Lathes	10	9.5
3. Furniture	10	9.5
4. Windmills	6	9.5
5. Games	6	5.7
6. Cranes & Derricks	5	4.8
7. Aeroplanes	5	4.8
8. Boats	5	4.8
9. Railroads	3	2.9
10. Gear Arrangements	3	2.9
11. Railroad Signals	2	1.9
12. Washing Machines	2	1.9
13. Pumps	2	1.9
14. Lighthouses	2	1.9
15. Bridges	2	1.9
16. Telescopes	2	1.9
17. Miscellaneous Items (occurring no oftener than once)	17	16.2
	105	100.1

A comparison with the similar table for Meccano bears out our conclusion as to the wide scope of this type of interest. Note also that approximately the same types of models head the list in both Meccano and Erector. This is especially interesting when we realize that the Meccano models have in the main evolved from the activities of the English boy—and the Erector models from those of the American. Too much importance, however, should not be placed upon this, as there is no way of knowing the extent to which the Erector has copied consciously or unconsciously from Meccano and vice versa. Although the writer's 260 models agree closely with the figures of the two tables here given, it is just as true that the boys under observation have been known to take their inspiration from what they found in the manuals. A similar analysis of the Structo Manual shows roughly the same figures.

One further feature of Erector is worthy of mention. Whenever, in presenting a new model, Gilbert finds it necessary to introduce a new and important part, the manual at once becomes an elementary text attempting to teach the new principles involved. Thus, when he introduces the electric motor, he also offers an explanation of why the motor turns, several wiring diagrams and a simple discussion of volts and amperes. He follows an identical procedure when he finds need to introduce the rheostat, the gear-box, the reversible switch and the transformer. This text-book feature of the manual functions to a greater extent than any of the other teaching devices in Erector; and chiefly because of the strategic places which this material occupies. Just as the boy wishes to automatize a model, the electric motor is offered him; and of course he reads the explanatory material that goes with it. The text, however, is not always clear or readable; and so leaves much to be desired.

As regards the Structo toy, there is not much of value that can be had from as close a study or analysis as has been made of Meccano and Erector. It is perfectly obvious that the toy has no further contribution to make, resembling very closely the Meccano. The only part of its business which has not been affected by the decision of the courts is the manufacture of wheels and gears of rather substantial quality. These they put out in all sorts of dissectible "go-carts," "push-mobiles," and "scooters" which do not fall legitimately within the scope of this study.

Another important and rather popular type of "toy outfit" is the Chemical Set. Of these, three prominent types will be discussed: The Gilbert Chemistry Outfit, the Porter Chemcraft Set, and the St. John Fun with Chemistry.

History and Development of Gilbert Chemistry Outfit

Originally this set was sold as a "Mysto Magic" Outfit. At least, it was the "magic" trade that suggested the idea. Gilbert realized very early in his experience that boys and adults for that matter enjoy the mysterious; but he learned also that to explain the mysterious and bring it within the realm of human understanding in no way detracted from the enjoyment. In fact it enhanced the pleasure and made this sort of play more appealing. Psychologically, this idea is of course sound. Vaudeville performers have long made use of this psychological fact when they do some puzzling, impossible stunt and then let the audience in on the secret. There is usually a laugh, loud applause and quite a general feeling of satisfaction. The magician who attempts to impress an audience with his super-natural powers, is more apt to succeed in classifying himself as a fake, a charlatan, and in eliciting from his audience a host of widely varying reactions in which quite unworthy methods and motives are attributed to him. In other words, to every situation there always is some response. And as Thorndike puts it, "When any conduction unit is in readiness to conduct, for it to do so is satisfying, for it not to do so is annoying." Educationally, the response to a situation which involves satisfaction is the response which will tend to be tied permanently to that situation. In the case of our Chemical Magic, explanations in terms of the laws of chemistry offer a response to a puzzling situation far more satisfying and therefore more educational than the response of being left just mystified.

The evolution of Mysto Magic into a Chemistry Outfit immediately produced a larger market and a more popular appeal. In 1917 Gilbert issued his first definite effort to "bring chemical science down to the level of the boy's understanding." Although it made its appeal to the fun or play motive it was certainly an advance beyond the collection of magic stunts which preceded it. It is interesting to note that in this later development and in others that followed, Mr. Gilbert has called in experts in the field to assist him with their technical knowledge. In this particular case a research chemist with a PhD from Yale is responsible for the presentation of Chemical laws and facts. Other experts on Gilbert's staff are a radio operator with a degree from Columbia University, an engineer with experience from the General Electric Company, a Worcester Polytechnic graduate, a former mechanic of the Fire Alarm and Telegraph Company, a master mechanic from the Sargent Lock Company, an experimental engineer from the Wireless Division of the United States Army, an official of the Hoyt Electrical Company, and Mr. Gilbert himself who is an M.D.

Educational Aims of the Gilbert Chemistry Outfit

To understand the aims and purposes of the Company it is perhaps best to quote from the Manual:

"Chemistry is, without doubt, the most important of the sciences, but it far outranks them, towering above them like a giant. The reason for this is because of the close relation of Chemistry to our every-day life. Look about you—every object you see has some Chemistry involved in its history. The manufacture of some articles depends entirely upon Chemistry; the manufacture of others only partly. The ink you write with, the soap you wash with, the food you eat; all are in some way or other interlinked with chemistry. Every day wonderful new industries are springing up, built purely upon some Chemical discovery.

"It is difficult to realize exactly how widespread Chemistry is, since it is so broad that it now includes what once were separate sciences. We all know of the part it has played in the European war. Indeed it has been stated that Chemistry is the great weapon of the conflict. We have read of the use of liquid fire, poisonous gases, high explosives—all of these come within the realm of Chemistry. . . . There was a time when Chemistry was regarded as akin to sorcery. It was suppsoed that all chemicals were deadly poisons, that every chemical reaction resulted in an explosion. The men who practiced chemistry had to do so in secret, because they were regarded by the people with superstition and dread as related to the devil. . . . To-day, matters are entirely altered. There is no need for secrecy. The Chemist is looked upon with respect and there is a general desire to know more about Chemistry.

"To satisfy in part this thirst for chemical knowledge and to afford the extreme pleasure derived from the performance of the entrancing experiments is the purpose of this chemical outfit.

"We have aimed to make the subject alive, real and amusing by taking for Chemical explanation the things one sees and uses every day of his life. There is no age limit for this outfit. For the child—because he is intensely interested and derives real pleasure from it—it is a toy. For the grown-up—who realizes the value of the information herein—it is an instructive pastime."

As a statement of aim the above compares very favorably with recent thought among leaders in science teaching. The outfit aims to deal with environmental chemistry and to make its appeal to the genuine interest of the child.

Materials, Activities and Methods of the Gilbert Chemistry Outfit.

The Manual opens with a set of "general directions," covering five important points: Measuring chemicals, dissolving chemicals, using test tubes, heating, and some notes on care of apparatus. Chemicals are measured in an exceedingly rough way. One measure of any dry chemical is defined as "as much as the small flat end of a spoon will hold after lightly tapping it." The success of experiments is, however, very seldom dependent upon a more accurate measurement of proportions. Heating of chemicals is done by means of a candle flame, and is not always satisfactory. Another "general direction" that reminds one very much of the Erector method is this: "It is further suggested that it would be a good idea to read the entire manual before attempting to do any experiments. If this is done you will find many points clearer and mistakes less frequent." One boy in twenty will make an attempt even to follow out this direction.

To do the 75 experiments suggested by the manual, the outfit provides small quantities of about 40 different chemicals, a candle, some filter paper, rubber stoppers, glass tubing, glass funnel, mortar and pestle, measuring spoon, a test tube brush and some test tubes—all contained in a box of not over 300 cubic inches in volume. In the most recent chemical outfit (to be described later) the list of materials are supplied in a box of not over 600 cubic inches. They enable a boy to perform 453 different experiments.

It is interesting to note that a list of 75 chemicals, appended to Williams and Whitman's, Laboratory Exercises in General Chemistry contains 50 of the chemicals supplied in the Gilbert Chemistry Outfit. The chemistry laboratory manual referred to is a typical high school laboratory guide.

As for the experiments themselves, they are of two different types. By far the major portion of them (62 out of 77) are devoted to a series of practical exercises more or less appealing to the boy. The other fifteen are especially adapted to Magical Entertainments and are probably the remnants of the old Mysto Magic.

The following are excerpts from the "Table of Contents":

General Directions.

The Chemical Wet Electric Cell.

How and why it generates current.

Electro-plating.
  How to give an object a coating of metallic nickel and copper.
How to Make a Duplicate of your Medal.
  Process of Electrotyping.
How to Etch Electrically Upon Copper.
How to Petrify the Baby's Shoe.
The Lemon Electric Cell.
The Filter Funnel and Filter Paper. How to Use Them.
  Making a Precipitate.
Testing for Acids and Bases.
  (a) With Litmus.
  (b) With Phenolphthalein.
Beautifully Colored Precipitates with Phenolphthalein.
Testing for Metals by Their Flame Colors.
How to Fire Proof Cloth and Wood.
Making Chemical Soap Bubbles.
The Standard Peroxide Test.
Inserting an Egg into a Bottle by Softening the Shell.
How to Start a Fire Chemically.
Experiments in Crystallization.
  (a) Making Frosted Glass.
  (b) How Rock Candy is Made.
  (c) Nickel Crystals.
Make Your Own Ink.
Disappearing Ink and Why It Disappears.
What is India Ink?
Black Sympathetic Ink.
Lovers' Ink.
How to Make a Weather Barometer.
Baking Powder.
Making Coke from Soft Coal.
Making Illuminating Gas.
Chemistry of the Gas Flame. Tapping a Flame.
How to Make an Acid from Wood.
  (a) Application to Food Smoking Industry.
  (b) How Charcoal is Made.
Carbon—How Diamonds Are Made.
  Graphite.

Hard and Soft Water.
How to Make Your Own Soap.
Chemical Plants.
Manufacture of Soap, Powder and Shaving Cream.
How Glass is Made.
Rust—How It Forms.
How to Bend a Glass Tube.
Explanation of the Hand Fire Extinguisher.
Chemistry of Photography.
Why Silver Tarnishes and How to Remove the Tarnish.
The Incandescent Gas Lamp.
The Electric Lamp.
Manufacture of White Lead.
Iodine.
Vinegar.
How Leather is Made.
Paraffin—What It Is.
Helping Hints for Your Laboratory.
Definitions of Chemical Terms.

MAGIC PROGRAM—WITH PATTER TALK

Change Wine to Water by Passing Hand Over Glass.
Pour Wine from a Glass Pitcher of Water.
Pour Milk from a Milk Bottle Full of Water.
Change Blue Paper to Pink in Your Hand.
Blow the Color from a Blue Handkerchief.
Blow Chalk into Water with Your Breath.
Second-sight. An Amazing Exhibition of Mind Reading.
Write Black with Water.

As can be seen from the above there does not seem to be any definite attempt to marshal this wealth of chemical knowledge under the laws of chemistry or even under a few large categories. It might be said that in the main the organization is psychological rather than logical, were it not for the fact that the organization does not lead on to any larger conceptions. The "definitions of chemical terms" coming at the end of the manual, are a mere glossary designed to enlighten the boy as to certain technical terms. To it the boy seldom refers.

The purpose then of the manual is to introduce the boy to a host of experiences, more or less important and not at all connected one with another. With each exercise is offered a text. Thus, after a description of how one is to go about assembling, testing and using the wet cell, there are found some paragraphs headed, "How The Wet Cell Works," "Chemical Action of the Wet Cell," "Local Action and How to Prevent It," and "Polarization." To the directions for Electrotyping are appended paragraphs on "What it is," "How It Worked," and "Chemical Explanation." "Testing for Acids and Bases" is a presentation of the chemical differences between these two types of substances, interspersed with a manipulation or two, somewhat after the fashion of a high school chemistry text. And so on throughout the manual. As if realizing that this descriptive matter made rather "deep and heavy" reading for most boys, Gilbert has scattered throughout a trick stunt or two, to relieve the tension.

"To make chemical soap bubbles," "To insert an egg into a bottle," and "Lovers' Ink" are a few typical instances. Occasionally Gilbert forsakes the definite effort to "teach" and launches forth into a series of experiments that differ very little from the usual type of recipe book. Taken altogether the manual is a conglomerate mass, now simulating a logical presentation, now making a play for the interest of the boy—and not succeeding entirely in either attempt.

Nevertheless, the manual presents and makes possible a set of novel activities, isolated though they be, that are important in the boy's environment. How he takes advantage of these possibilities and how he reacts to the organization or lack of organization of the manual will be described in a later chapter.

The Gilbert Chemistry Outfit was not long in the market before three or four competitors appeared. One of these, by dint of better advertising, more liberal allowance of chemicals, better organization of materials, and more workable experiments has become the most popular toy of its type.

History and Development

That the Porter Set had its inspiration in the Gilbert set there is no doubt. The manual begins in an almost identical strain with the Gilbert manual, extolling the marvels of chemical science and dwelling upon its importance in our everyday life. "The whole great universe about us from its uppermost heights to its lowest depths is built up of chemicals and chemical compounds. Earth, sky and water are all passing through constant chemical changes. Deep down in the ground coal is being formed from the remains of prehistoric forests. Precious metals and ores are being smelted under the heat and pressure of millions of tons of earth and rock. On the surface of the earth, air and water are constantly producing chemical changes in everything they touch. All nature is but a series of wonderful chemical reactions; plants, forests, birds, animals and people are all complex chemical engines. Chemistry is more closely interwoven with the industries of the world than any other science. . . . Surely a population educated in the science of Chemistry is the greatest asset your country can have."

H. M. Porter, professor of chemistry in a small western college is responsible for the working out and arranging of the materials. His son, also a chemist, is responsible for the promotion of the scheme as a commercial undertaking, and is at present the leading spirit in the movement. The company at the present time sells four Chemcraft Outfits ranging in price from $1.50 to $11.00. The more expensive sets are just as popular as the less expensive ones.

Educational Aims

In the words of the manual, "no matter what profession a man follows, he is greatly handicapped without a knowledge of chemistry. The manufacturer, the farmer, the tradesman, the professional man, the scientist, all have constant need of chemical knowledge. In the home the housewife who knows nothing of the chemistry of the food she prepares or of the materials which she daily uses is seriously handicapped. In *Chemcraft* the various phases of chemistry have been combined into a series of fascinating experiments which will *furnish amusement* for the young people during many profitable hours; and as the experimenter gains in skill and knowledge he can by means of the number three and four Chemcraft extend still further his intimacy with this most fascinating science." The aim of the Porter set then is similar to that of the Gilbert set in that the same two ideas are stressed: fun for the boy and time "profitably" (educationally) spent. The Porter differs from the Gilbert in attempting to grade its experiments so that as the boy becomes older and more familiar with chemical experiences he will be more and more introduced to larger laws, principles and concepts. The Porter set, too, lays far greater stress on the organizing of small boy laboratories. More will be said later on the question of the laboratory in the home.

Materials, Activities, and Methods of Chemcraft

In a box 12" x 18" x 3½", (the No. 4 Set), are supplied 60 different chemicals and 15 different pieces of equipment. The chemicals and equipment differ very little from the list previously given for the Gilbert set and are just as frequently a major part of the regular high school stock of chemicals. The manual offers 607 different experiments, though that by no means exhausts the possibilities of the outfit. For purposes of definiteness and future reference excerpts from the Table of Contents are here given:

PART I

CHEMISTRY AND ITS APPLICATION TO THE INDUSTRIES
How Chemistry Grew From Alchemy
Chemical Elements

(14) Forming Sulphurous Acid
(15) Forming a Salt
(16) Neutralizing a Base with an Acid
(17) Making an Acid
(18) Double Decomposition of Two Salts
(19) Reaction of Calcium Chloride and Sodium Carbonate
(20) Making a Base

Indicators

(23 experiments)

Air—Oxygen

(14 experiments)

Hydrogen

(4 experiments)

Water

(35 experiments)

Testing Water

(13 experiments)

Nitrogen

(111) Separating Nitrogen from the Air
(112) The Properties of Nitrogen

Compounds of Nitrogen

(13 experiments)

The Halogen Group

Carbon—Combustion

Compounds of Carbon

Carbonates

Sulphur

Compounds of Sulphur

Sulphates

Sulphides

Silicon and Silicates

Glass

Boron and Borates

Phosphates

Hydroxides

Sodium and Soda Industries

Potassium and the Potash Industries

Calcium and Calcium Compounds

Strontium and the Fireworks Industry

Compounds of Aluminum

Magnesium

Oxidation and Reduction of Metals

Testing Metals

Alloys

Paints and Pigments

Ink Industry

Textiles and Dyes

Soup and Glycerine

Tanning

Paper Making

Glues—Adhesives and Gums

Fermentation

Starch and Sugar

Perfumes and Flower Oils

Electro Chemistry

Artificial Gems

Household Chemistry

The Chemistry of Farming

Chemistry of Foods

PART II

Chemical Magic, or Magic Inks and Papers

Sympathetic Inks

Magic Changes

Magic Colors
Magic Liquids

Chemical Flags

Chemical Sorcery

Chemical Colors

Chemical Smells

Indicator Tricks

Miscellaneous

Sets 1, 2 and 3 differ from Set 4 in that fewer experiments are offered under each of such categories as "Chemical Elements," "Acids, Alkalies, and Salts," etc.; and sometimes whole groups of experiments are omitted. Thus, Set No. 1 offers 50 experiments, Set No. 2 offers 128, Set No. 3 offers 256, and Set No. 4 offers 607. Apparently Chemcraft carries out its aim of gradually leading the experimenter on to greater understanding of the laws of chemistry, by increasing the quantity of materials. There is no marked gradation in the difficulty of the experiments or in the type of thinking required as one goes from Set No. 1 to Set No. 4. In fact, Set No. 4, because it contains a greater number of exercises and illustrations for each law or principle, is a much more effective presentation—easier to understand and pedagogically more sound. So that the beginner has a more difficult time than the boy who is more advanced. From the point of view of organization, the Porter set swings to the opposite extreme. As can be seen from the Table of Contents, there is a very definite marshalling of materials into groups; generally speaking, a logical ordering of topics. The procedure from "chemical elements" to "composition of elements," to "decomposition," "exchange of elements" and "displacement" reminds one of the average standard text in elementary chemistry. So does the treatment of "Acids, Alkalies and Salts," "Air and Oxygen," "Hydrogen," "Water," "The Halogen Group," etc., etc. Very clearly, then, Porter has the conviction that the conglomerate mass of the Gilbert Set is a mistake. And because his set has outsold the Gilbert, he has maintained and proposes to maintain his present organization. It has been the observation of the writer that the business man, when spurred on by competition, is apt to be extremely conservative when once he has found that his product is an advance over others in the market. It is "sound business" to exploit a "paying proposition" quickly and intensively. Further improvements only interest the average business man when sales are on the decline. It is exceptional to find a manufacturer striving to reach ultimate perfection of his product when the product that he has is sufficiently good to beat its competitors. This purely materialistic criterion is, of course, unacceptable to the educator. Though the business man's criterion indicates tendencies, it would be dangerous to limit progress by means of it.

In the case of Chemcraft the educator is interested in an organization of materials that will be psychological; that is, an ordering of materials that will start with the interest of the child and work gradually toward a scientific organization of the knowledge involved. Not that there is an *a priori* assurance that such a presentation will be more successful either as a producer of sales or as an educational instrument; but that such a trial is necessary before final conclusions are drawn. The situation, however, took quite a different turn. A perusal of the following Table of Contents from the latest Gilbert Chemistry Outfit—brought forth to bolster up the sales of the Gilbert product—will make it quite evident that they have no desire to experiment very much further with the make-up of the Porter Set.

This, of course, may be regarded as "safe and sane" business policy. But it is hard to see how the policy can further educational ends.

PART I

Inorganic Chemistry and Its Commercial Application to the Industries

Matter in Chemistry

Kinds of Matter
The Three Forms of Matter
Division of Matter

Experiment

(1) Division of Matter
(2) Division of Matter
(3) Division of Matter
Molecules are Small Particles of Matter
Difference Between Solids, Liquids and Gases
Properties of Matter
Impenetrability
(4) Impenetrability of Matter
Malleability
Ductility
Brittleness
Elasticity
Flexibility
Hardness
Indestructibility of Matter
Changes in Matter
(5) A Chemical Change and What It Means

Elements

Direct Union of Elements

(6) Union of Zinc with Sulphur
(7) Union of Magnesium with Oxygen
Decomposition or Breaking Up of a Chemical Compound
(8) Decomposition of Sodium Thiosulphate
(9) Decomposition of Sugar
Double Decomposition or the Exchange of Elements
(10) Action of Ferric Ammonium Sulphate on Calcium Oxide
(11) Action of Aluminum Sulphate on Strontium Nitrate
Substitution or the Displacement of One Element by Another
(12) Action of Iron on Copper Sulphate
(13) Action of Zinc on Copper Sulphate
(14) Action of Magnesium on Copper Sulphate
(15) Action of Zinc on Hydrochloric Acid

Air—Oxygen

Hydrogen

Water and Water-of-Crystallization

Testing Water

Acids, Bases and Salts—Indicators

Nitrogen and Ammonia—Ammonium Hydroxide

Sulphur and Hydrogen Sulphide

Oxides and Oxygen Acids of Sulphur

The Insoluble Sulphates

The Halogens—The Chlorine Family

Poisonous War Gases—The Gas Mask

Carbon—Carbonic Acid—Carbonates—Combustion

Explanation of the Hand Fire Extinguisher

Baking Powder in Bread Making

Silicon and Silicates

Glass Making
Hydraulic Cements
Ordinary Clay
Porcelain Clay

Boron and Borates

Phosphorus and Phosphates

The Alkali Metals—Sodium and Potassium

The Alkaline Earth Metals—Calcium, Barium, Strontium

Strontium and the Manufacture of Fireworks

Aluminum—Zinc—Magnesium

Testing Metals by Their Flame Colors

Alloys

PART II

Organic Chemistry and Its Commercial Application to the Industries

The Soap and Glycerine Industry

The Ink Industry

The Paper Industry

The Manufacturing of Gums, Adhesives and Glues

The Tanning or Leather Industry

Fermentation and Ferments

The Manufacture of Paints and Water Colors

The Starch and Sugar Industry

The Dyeing and Textile Industry

The Manufacture of Essential Oils and Perfumes

The Chemistry of Foods

Testing Foods for Proteins

Testing Milk

To return now to the Porter Chemcraft, it must also be pointed out that the material is a good deal more readable than the early Gilbert set. The manual contains considerable descriptive and historical matter that helps the boy to appreciate the significance of what he is doing. The following quotations are typical of the manner of treatment—especially in the earlier portions of the manual:

"Let us go back to the olden days when the human race was still in a semi-savage state and civilization was just beginning to dawn upon the world. Man lived in a primitive manner, taking little notice of his surroundings, intent only upon obtaining food and protecting himself from others. But as his intelligence developed . . . it was not long until he began to experiment with the materials around him."

"In the olden days people were very superstitious; and so the alchemists who had learned to bring about such wonderful changes in materials, came to be regarded as wizards or magicians, who could do almost anything. Now the great desire and ambition of these mediaeval people was to become as rich as Solomon and to live to be as old as Methuselah. It was quite natural. therefore, that the efforts of the alchemists were devoted to fruitless attempts to change the baser metals such as iron, copper and lead into gold, and also to produce the 'elixir of life,' a mythical substance which would prolong their lives.

"About the time that Columbus discovered America the alchemists gave up their search for the 'elixir of life' and abandoned their attempts to change the baser materials into gold, and began to devote their efforts to learning about the materials which were used in the daily life of the people and to make use of their knowledge to improve the products of the industries and develop new materials."

Unfortunately, materials of this type does not pertain throughout the Chemcraft Manual. The high standard of the first 25 pages—in the matter of simplicity of style and interest—is not adhered to in 150 pages or so that follow. Nor is there the same care of presentation or of detailed directions. The author of the manual has apparently experienced what so many writers of texts experience: that the last chapter of a book needs just as much care and planning as the first. And not being able to give this time—due to business stress—there has resulted a hasty compilation of materials of rather inferior quality.

The most recent Gilbert Chemistry Outfit of which the Table of Contents has already been given, is of course modeled very closely after the Porter set. The 453 experiments are set in a frame-work of laws and principles and the arrangement is even more logical than in the Porter set. Before being permitted to experiment the boy is introduced to 27 terms and their definitions. The list of these definitions which is here given is a rather formidable array—definitions that every high school teacher of chemistry can teach successfully only in a year's course and with liberal drill:

Acids
Atom
Atomic Weight
Base
Chemistry
Chemical Change
Chemical Compound
Chemical Equation
Chemical Affinity
Decolorize

Deodorize	Mixture
Dissociate	Molecule
Electrolysis	Physical Change
Element	Precipitate
Evaporate	Salts
Immerse	Solution
Ion	Symbol
Law of Conservation of Matter	Valence
Law of Definite Proportions	

These definitions are followed by some General Directions which are more or less practical aids to the would-be experimenter, and which cover such topics as measuring chemicals; dissolving chemicals; heating liquids or solids in test tubes; use of the test tube rack, stirring-rod, test tube holder, test tube brush, and gas-delivery tube; filtering; gas-generating; measuring liquids or solutions; grinding or mixing substances; and some general notes on apparatus.

Another innovation of the new Gilbert Chemistry Outfit is the chapter on "Matter in Chemistry" which serves as a preface to the study of chemistry proper.

The whole question of organization of materials; manner of presentation and special teaching devices would be of great importance and deserve more space than has been devoted to it, if organization and presentation functioned in any large way in the activity of the boy. But it does not. As will be shown later, only 10% of the boys that the writer has had an opportunity to observe follow the manual in a connected way. The other 90% are practically oblivious of the elaborate effort of the manuals to erect a logical structure.

A third type of chemical outfit that deserves to be ranked with the two already described is St. John's Fun with Chemistry. The peculiar significance of this toy lies rather in its failure as a commercial undertaking than in any marked contribution to this field of educational endeavor. St John was a pioneer in the movement for educational toys. As far back as 1900 or 1901 he put out a complete series of outfits on scientific subjects, basing his materials on his experiences with boys at the Browning School

—a private institution in which he served as instructor. In this respect the origin of the "Fun With" sets was rather unique.

The following is a list of the St. John toys:

Fun With Magnetism.
Fun With Electricity.
Fun With Puzzles.
Fun With Soap Bubbles.
Fun With Shadows.
Fun With Photography.
Fun With Chemistry.
Fun With Telegraphy.

As nearly as one can make out, there were two important reasons for the financial failure of the toy: poor advertising and cheapness of the product. Toy manufacturers twenty years ago suffered from the conviction that a toy must necessarily be a flimsy, breakable, temporary affair. Thus it was that the entire St. John series could be bought for $3.00; which even when we consider the greater purchasing power of the dollar at that time hardly makes possible the quality and workableness demanded by the boy.

In spite of these drawbacks there is very little in these outfits that is inferior to the present-day outfit—when we consider the aim of the author, the type of materials and their organization. In fact there is much that is superior; especially from the point of view of meeting the boy's needs in a boy way. It is strange that the teacher should be the one to ignore completely the "dignity of education." St. John isn't at all anxious to point out at every step the educational possibilities of his experiments; nor to insert his exercises into the logical frame-work of a science. In his rather unpretentious introduction he points out that "Chemistry is one of the most practical of all the sciences," and that "the simple experiments contained in this little book will serve as a start, and the boys and girls who perform them will soon see that they can have Fun with Chemistry and at the same time learn a great deal about *combustion,* which is one branch of chemistry."

His outfit consisted of the following articles: One Book of Instructions, called "Fun with Chemistry;" 1 Adjustable Ring-stand, including Base, Rod Slide with Set-screw, and Wire Ring; 1 Wire Arm; 1 Large Candle; 1 Small Candle; 1 Metal Box with Cover; 1 Test-tube Wire; 2 Test-tubes; 1 Glass Tube; Red Litmus Paper; Blue Litmus Paper; 1 Package of Sawdust (No. L); 1 Box of Wood Ashes (No. 2); 1 Package of Filter Paper; 1 Paper Funnel; 1 Box of Paraffin (No. 3); 1 Box of Slaked Lime (No. 4); 1 Box of Sal Ammoniac (No. 5).

The following is his Table of Contents:

Chemistry—The Outfit

(23) Making Alkali from Wood Ashes—Filtering—Alkali in Ashes—Lye
(24) A Chemical Fight
(25) Through Wall of Flame—Hollow Flames
(26) An Artificial Gas Well—The Candle Flame
(27) Liquid Paraffin
(28) A Candle Without a Wick—Paraffin
(29) Cooled Flames
(30) A Lampblack Factory—Carbon in Flame
(31) Steam from a Flame—Products of Combustion—Water from Combustion
(32) The Death of a Flame—Carbonic Acid Gas
(33) The Flame that Committed Suicide—Air Currents
(34) Chemical Soup—Lime—Chemical Action.
(35) Making Limewater—Milk of Lime—Limewater
(36) A Baby Skating-rink—Limestone Ice
(37) Magic Milk—A Magic Milk-shake—Carbon Dioxide and Limewater
(38) The Wizard's Breath—Animal Heat
(39) A Chemical Curtain
(40) Tiny Explosions Produce Gas—Effects of Explosions
(41) Scrambled Chemicals—Chemical Action Between Solids

All of his experiments are marked by a high degree of simplicity and workableness. The picturesque titles neither enhance nor detract from the appeal that they make to boys. And the directions are not only clear but they show the teachers' insight into the capabilities of young folks. The exercises themselves are ingenious bits of experimentation. It is a pity that these sets are not now being manufactured; so that they could compete upon a fair basis with Gilbert's and Porter's.* At their most popular stage, St. John sets were adopted by the New York City Board of Education as standard pieces of school equipment and received the Board's recommendation as an educational toy.

All efforts by the writer to learn more about the strange history of these outfits have thus far been met with failure. No one seems to know the whereabouts of St. John nor to know much

*The author has just learned that these sets have again been put on the market.

about his aims, ideals, and methods of work except that the Browning School was founded on the idea that there never should be more than five pupils to a class. His contribution does not, however, affect our problem in any large way, since he has left the field clear to others. And it is the materials and activities that function at the present time that is the purpose of this study.

Next in order of importance and popularity among boys are the Magnetism and Electricity Outfits. In this field Gilbert is practically supreme. The Meccano Company is at the present time developing its own Electric Outfit and of course St. John's Fun With Magnetism and Fun With Electricity are efforts along the same line; but the Gilbert business machinery has swept its own product into the field so completely that it is practically the only one worth considering.

Cooperating with Mr. Gilbert in the organization of the magnetic and electrical sets is Hugo Kloysbrunn, PhD, University of Vienna. The manual divides the work into four divisions: Static Electricity, Magnetism, Current Electricity, and Induction Electricity. The boy is introduced to the study by a paragraph on "What is Electricity?" (The answer is, "We do not know. We cannot define the idea electricity but we can turn to advantage the phenomena of electricity. We can produce it and use it and master this mighty force." In characteristic Gilbert style the boy is told at the outset that "to understand the fundamentals of electricity, you must start with the first elements and advance step by step." There are, however, two departures from the usual Gilbert product. First, the emphasis is decidedly upon the "fundamentals of electricity," that is, upon the building up of sound concepts of the science of electricity rather than upon "fun." And secondly, the usual care has not been taken to provide in the outfit all the materials necessary to perform the experiments successfully. The boy is asked to make use of a great many materials that Gilbert assumes are always available. This assumption is not warranted.

Three grades of Electrical Outfits are sold. One for $2.50, one for $7.50 and one for $10.00; with a corresponding gradation in the amount of materials supplied and number of experiments possible. The major portion of the materials is in each grade or set devoted to the parts of a dissected electric motor.

The following lists of experiments will serve to show both the content and method of treatment in Gilbert's text-book; for that is what it virtually is:

I. Frictional Electricity
   1. Hard Rubber Electricity
   2. Glass Electricity
      (explanation of above experiments and some historical material in reference to early discovery of frictional electricity)
   3. Law of Attraction
   4. Paper Electricity
   5. Law of Repulsion
   6. The Carbon Pendulum
   7. Charging by Contact
   8. Carbon "Flies"
   9. Electric Spider
   10. Unlike Electricities
      (Development of idea "positive and negative" and a recapitulation of the three fundamental laws, which are stated thus:
        1. Charges of the same kind of electricity repel each other
        2. Charges of unlike kinds of electricity attract each other
        3. Either kind of electricity attracts, and is attracted by a neutral body.)
   11. Conductors and Insulators
   12. Potential of Electricity (E.M.F.)
   13. The Electrophorus
   14. How to Use the Electrophorus
   15. Equal Potentials
   16. Disruptive Charges
   17. Silent Discharging
   18. Electric Clapper
   19. Electric Density

II. Electrification by Induction
   20. Polarization by Induction
   21. Theory of Neutrality
   22. Theory of Induction
   23. Bound and Free Electricity
   24. Charging by Induction
   25. Dielectrics
   26. Theory of the Electrophorus
   27. Conductive Bodies
   28. Condenser
   29. Theory of Condensers
   30. Discharging the Condenser
   31. Discharges
   32. The Leyden Jar

33. Electroscope
34. Gold-Leaf Electroscope
35. Proof Plane
36. Determining the Electric Charge
37. Electric Machines
38. How the Plate Machine Works
39. Insulating Stool
40. Summary of Electrostatic effects
    (a) Mechanical effects
    (b) Chemical effects
    (c) Heating effects
    (d) Optical effects
    (e) Physiological effects

III. Atmospheric Electricity
41. Benjamin Franklin's Experiment
42. Potential of Lightning
43. Thunder
44. Luminous Phenomena
    (a) Heat Lightning
    (b) St. Elmo's Fire
    (c) The Aurora
45. Lightning Rods

The last five experiments are not experiments that the boy can do himself. They are descriptive statements. The whole 45 experiments are interspersed with a liberal amount of descriptive matter; some of it taken almost bodily from physics text books.

The section on Magnetism is rather meagerly treated. This defect has been recognized by Gilbert; and he has quite recently produced a further development of this subject, which will be described briefly later on.

The materials supplied consist of a few bar-magnets, horse-shoe magnets, iron filings, wire, a compass and some needles.

In much the same manner the manual develops the concepts and laws of Current Electricity. Practically no attention is given to detailed directions for performing experiments.

CURRENT ELECTRICITY

1. Flowing Electricity or "Current" Explained
2. Volts, Amperes, Ohms
3. Units of Measurement Defined
4. How Current is Generated
    (a) Chemically
    (b) Mechanically
    (c) Thermally

5. Galvani's Frog Experiment
6. The Voltaic Pile
7. Simple Voltaic Cell
8. Galvanic Battery
9. Chemical Action Explained
10. Polarization Explained
11. Kinds of Cells
12. Forms of Cells
13. The Dry Cell
14. About Dry Cells
15. Ohm's Law
16. Internal Resistance
17. Connecting in Series
18. Connecting in Parallel
19. Keys and Push Buttons
20. Switches
21. Conductors and Insulators
22. A List of Conductors
23. Insulators
24. Divided Circuits
25. Laws of Resistance
26. Rheostat
27. Effects of the Current
    (a) Thermal Effects
    (b) Chemical Effects
    (c) Physiological Effects
    (d) Magnetic Effects
28. Electric Light
29. The Carbon Lamp
30. Metal Filament Lamp
31. Nitrogen Lamps
32. The Electric Arc
33. Fuses
34. Replacing Fuses
35. Systems of Electric Lighting
36. Wire Connections
37. Different Splices
38. Experiments With Your Lighting Outfit
39. Chemical Effects
40. Decomposition of Water
41. Anode: Kathode
42. Electroplating
43. Physiological Effects
44. Lines of Force
45. Deflection of the Magnetic Needle
46. The Hand Rule

47. Galvanometer
48. Astatic Galvanometer
49. Apparatus For Electric Measurement
50. The Solenoid
51. The Electromagnet
52. The Electro Horseshoe Magnet
53. Lifting Magnet
54. The Electric Bell
55. How the Bell Works
56. Wiring of Bells
57. Telegraphy
58. Morse's Invention
59. The Telegraphic Code
60. Electric Accidents
61. What To Do For Electric Shocks
62. Treatment After Respiration Begins

ELECTRO-MAGNETIC INDUCTION

63. Theory of Induction
64. Faraday's Discovery
65. Induction Through Magnets
66. Induction Through Currents
67. Alternating Currents
68. Primary and Secondary Coils and Currents
69. Theory of Induction
70. Ruhmkoff's Induction Coils
71. How to Build a Ruhmkoff Coil
72. How the Induction Coil Works
73. Experiments With Induction Coils
74. Wireless Telegraphy
75. X-Rays
76. Telephony
77. Transmission of Electrical Current
78. Transformer
79. The Gilbert Transformer
80. Distribution of Current
81. The Dynamo
82. Power Stations
83. The Gilbert Generator
84. Simple Electric Motors
85. Theory of the Electric Motor
86. The Electric Motor
87. The Field Magnet
88. The Armature
89. How to Assemble the Motor
90. The Power of the Motor
91. Reverse Switch

92. **How to Connect the Reverse Switch**
93. **Uses of the Electric Motor**
94. **Gear Box**
95. **How to Use the Gearing**

In practically two-thirds of the 95 sections above listed, the boy needs the use of special pieces of apparatus which the outfit does not supply. These the Gilbert Company will sell as accessories. Examples of this type of equipment are the motors, generators, bells, transformers, and rheostats, all of which the company manufactures so that they can be adapted to the large variety of Gilbert toys.

The appeal of Gilbert's Electrical Outfit is decidedly an appeal to the older and the more capable boy. The average boy finds himself handicapped at every turn; and as a rule is hopelessly discouraged. St. John's sets, on the other hand, are everything which the Gilbert sets are not. Fun With Magnetism and Fun With Electricity are a collection of 120 experiments using the simplest pieces of apparatus, and described so clearly that boys of 10 have been able to follow them with ease. St. John possessed a decided genius for presenting a subject simply and entertainingly. His subjects for experiments are quite as picturesque as are his chemical experiments. The "fun" element is the predominating mood of all of St. John's materials. Again, one has a feeling of disappointment that the St. John outfit is not once more launched to compete with the Gilbert. The two opposing points of view could then receive a conclusive test.

The development of the Meccano Electro Outfit is proceeding along different lines. The aim is to "electrify" Meccano, by adding new standard and interchangeable parts that can be absorbed by the present highly developed mechanical set.

In addition to Mechanical, Electrical, and Chemical Outfits, a few other types of outfits are worthy of mention. These are usually designed to satisfy one type of interest and do not possess the characteristic of almost infinite flexibility and possibility that the other three types possess. The more important sets of this type are:

1. **The Telegraph Set**
2. **The Phono-Set**
3. **The Wireless Set**

4. The Railroad Set
5. The Weather Bureau Outfit
6. The Hydraulic and Pneumatic Engineering Set
7. The Light Experiments Engineering Set
8. The Sound Experiments Set
9. The Heat Experiments Set
10. The Civil Engineering Set
11. The Microscopy Set
12. The Photography Set
13. The Mineralogy Set
14. The Miniature Machinery Outfit
15. The Glass Blowing Outfit

Although some of these sets lack the wide range of activity that is characteristic of the more successful "outfits," they meet the need in a remarkable way of the individual who is given to "hobbies" and to concentration on one line of work.

The Telegraph Set consists of a box of simple materials (costing $2.00) that the boy can put together and operate as a telegraph. The manual that goes with the set is a 24-page booklet written by J. S. Newman, author of "Applied Science and Mechanics for Boys." The following are some of the topics treated:

1. History and Development of the Telegraph
2. The Morse Code
3. Technique of the Telegraph Operator
4. Wiring Diagrams of Telegraph Connections
5. Operating the Telegraph
6. Commercial Telegraphy
7. Batteries

The Phono Set is a $5.00 outfit organized and developed by J. S. Newman for the Gilbert Company. The feature of this set is the very clear and well-written manual. The reeciver, the transmitter, the underlying principles in sound and electricity, are all explained in a simple way and with a great many striking diagrams. The following is an outline of what the set covers:

1. Historical sketch of A. G. Bell and his invention
2. The Receiver
3. The Transmitter
4. Sound

5. The Simple Telephone
6. How the telephone operates
7. The commercial telephone
8. How to assemble the phono-set
9. Making Connections
10. Hints
11. Ringing Systems and long distance lines
12. Outdoor lines—splices

The Wireless Set is one of the most popular science toys; and chiefly because it makes possible the sending and receiving of actual messages. But it requires an equipment that is above the average in cost and an ability on the part of the boy that borders on the exceptional. Hundreds of wireless clubs have been formed by teachers, due to the enthusiasm of a few able individuals who have created a seeming demand for it. The initial interest is in most cases present—they all want the experience of catching a message from a ship at sea—but the equipment and ability exist with the few. The result in nine cases out of ten is a gradual decrease of interest and final failure. The individuals who were the leading spirits go right on, of course, and develop a surprising efficiency. There exist at the present time several leagues or associations of amateur radio experimenters. During the war their activities were prohibited; but in the last two years their number has been continually on the increase. Especially with the coming of the cheap audion bulb which makes possible radio telephony over long distances, has activity with "wireless" been very great. But always this activity is of the concentrated kind—where a boy devotes all his play time to it and adopts it as a hobby which often lasts for six years or more.

The Wireless Outfit is, of course, among the Gilbert products. For $5.00 or $10.00 Gilbert attempts to furnish a complete sending or a complete receiving set of instruments. Unfortunately, his outfit is of low quality and has been proved, in the main, unworkable. Whether his latest improvement will solve the problem or not of furnishing a comparatively inexpensive set that will work remains to be seen.* Until then boys will con-

*The present Gilbert Wireless Sets are more expensive pieces of apparatus, costing anywhere from $15 to $48 per set.

tinue as in the past, to buy their wireless parts one by one in various stores, often picking up second-hand commercial pieces of apparatus that satisfy their needs to perfection.

The Gilbert Wireless Manual, written by an expert radio engineer, is a small text-book on "wireless." The treatment of the subject is not simple enough for the junior high school boy, but extremely helpful to high school seniors and college freshmen. As with others of Gilbert's text manuals, the primary reaction of the boy is to ignore the text and strive for practical results. If he is successful to some degree, thereby maintaining his interest, he does, as he gets older, react more definitely to the theoretical principles of radio engineering. In the case of the Gilbert Set, the unworkable features of the apparatus have made the text worse than useless.

The Railroad Outfit is usually sold in two forms: the "spring" engine and the "electric" engine. The latter type is not only more popular, but better educationally. The track for the railroad is supplied in segments, the boy being able to extend his line indefinitely and around as many curves and turns as he chooses. Miniature railway switches are supplied; and with these he can switch the train at will. Reversing switches permit of turning the train back on its path, and small block signals can be wired to add a final realistic touch to the toy. The chief feature of the outfit is its close parallel to the subways and trolley lines of modern life. Though the number of experimental possibilities with the railroad is not very large in comparison with other "outfits," it cannot be classed as a "specific" toy. The boy's chief source of interest in the railroad is to experiment with various speeds, various loads, various curves and various grades of incline. The problem in wiring, though not always an easy one, especially in the matter of installing the reverse-switch and the system of signals, is productive of a great deal of effort, study, application and enthusiasm. The outfit, too, is rich in physical and mechanical experiences, such as the effect of friction, overcoming inertia, centrifugal force, principle of work, etc., etc.

The most recent development in science outfits for boys have been in the market for but one year. In many cases they represent the final result of the years of experimenting; but many of the sets are new ventures in the field. Though the experimental phase of this study does not deal directly with these newer sets (not having been sold in sufficient quantities for my boys to have them), it will be worth while to devote some space in brief description.

MAGNETIC FUN AND FACTS

The materials supplied are in two sets: one selling for $3.75 and another for $10.00. As shown in the accompanying illustration, the equipment consists of the usual apparatus used to illustrate the fundamental principles of magnetism. With the set goes a well-written and scientifically accurate manual possessing also these characteristics in addition:

(a) Clearness and simplicity of exposition
(b) Wealth of illustration
(c) Historical description
(d) Workable experiments
(e) Careful gradation from simple to more complex

In a word, this manual is one of the best pieces of work yet done by Gilbert. The following is the Table of Contents:

CHAPTER V. HOW TO MAKE MAGNETS

Permanent magnets—Horseshoe magnets—Electro-magnet design—Electric units—Units of power—Short-circuits—Ground—General instructions for connections—Design of an electro-magnet—Moving core magnets.

LIGHT EXPERIMENTS

The aim of this set is expressed in the following excerpt from the Introduction: "What is light? Where does it come from? Where does it go to? What does it mean to us? Those are the questions which would stump you if you had to answer them. You probably don't know because you never thought much about it. But you, as well as every other boy, should understand more about light. You should know how it affects our everyday life. . . . And then this set will tell you how to give shadow shows and exhibitions that will amuse your friends. While you play with this outfit, you will learn about the telescope, opera-glasses, microscope, moving pictures and many other important instruments. You will learn, too, why eye-glasses improve the sight . . . and there's a pile of fun in every experiment of the outfit."

The set sells for $15.00, and furnishes material which makes possible about 132 experiments and stunts. The manual is arranged by C. J. Lynde, Ph.D., Professor of Physics, MacDonald College, Quebec, and author of "Lynde's Household Physics." As was the case with Magnetic Fun and Facts, the organization of the manual is psychological and pedagogical. The procedure is not only from the simple to the complex; but there is a definite preparation made for each large law of the science of light before it is presented to the boy. The wealth of experiment, developed in an appealing manner, gives the boy certain experiences with natural phenomena which he never could obtain in the average laboratory course and which make him far better able to grasp and appreciate the laws of light. For future reference, portions of this type of development of subject matter will here be recorded:

1. Fun with bright sunlight
2. To make your dark-room
3. To make a dark box
4. Something about light
5. Fun at night
6. Intensity of light
7. Shadows—Shadow entertainments
8. Reflection of Light
9. Fun with Sunlight
10. Fun by day or night with one mirror
11. Why the image is as far behind the mirror as the object is in front
12. Experimental Magic
13. The "why" of the Periscope
14. Illusions
15. Fun with the curved mirror
16. The "why" of the curved mirror
17. Refraction of light
18. More fun with sunlight
19. Refraction of spherical waves
20. More fun by day or night
21. Atmospheric Refraction—Mirages
22. Still more fun with sunlight
23. Why objects are colored
24. Complementary colors—Mixing paints
25. What is in the sun and stars
26. The spectroscope
27. The "why" of it, etc., etc., etc.

SOUND EXPERIMENTS

"My sole aim in getting out this set," says Gilbert, "is to bring the Science of Sound down to your understanding and have the kind of fun I liked when I was a boy. It may not make you the smartest boy in your class; but it will teach you a lot of things that perhaps the smartest boy in school does not know."

The set sells for $7.50, and furnishes material for 42 experiments. The organization of the manual attempts to follow the two previously described, but does not quite reach their degree of excellence.

HYDRAULIC ENGINEERING

In this set there are about two dozen different trinkets—all simple, inexpensive and easily replaceable. Though the cost is $10.00, a goodly portion must be for the manual, which is the largest and finest compilation of experiments with water and air ever made. From the accompanying list of experiments, it will be seen that the manual is virtually a combination of laboratory guide and text-book.

1. Water Supply
   Experiments, such as
   (a) Making and operating a city water supply system
   (b) Showing how water is brought from a well, etc.
   Game No. 1—A Naval Battle
2. Pneumatic Tank System of Water Supply
   Two experiments, and
   Game No. 2—Rapid Fire Water Gun
3. Water and Air
   Two experiments
   Game No. 3—Trench Gun
   Game No. 4—Height and Distance Contest
   Game No. 5—Pop Gun
4. The Siphon
   —How the siphon is used in water supply systems
   —How to start a large siphon
   —Other uses of the siphon
   —Velocity of flow
   —Other siphons
   —How to start a small siphon
   —An enclosed fountain
5. Atmospheric Pressure
6. The "Why" of the Siphon
   —Pumps
   —Game No. 6—Water Gun Shooting
   —Game No. 7—Big Gun Battle
   —Game No. 8—Machine Gun Battle
   —Game No. 9—The Diablo Whistle
   —Lift Pump
   —Force Pump Contest—Game No. 10
7. Hydraulic Appliances
   —Pascal's Law
   —Hydraulic Press
   —Hydraulic Elevator
   —Canal Locks
   —Pressure exerted by water
   —Hydrostatic paradox
   —Explanation and calculations

8. Pressure Under Water
   —Depth Bomb, Torpedo, Submarine
   —Buoyancy
   —Law of Archimedes
   —Raising Sunken Ships
   —Floating Dry Dock
9. Running Water
   —Friction
   —Nozzles
   —Velocity of Flow
   —Air locks

PNEUMATIC ENGINEERING

1. Atmospheric Pressure
   —Barometer
   —How airmen know their altitude
   —Altitude Gauge
   —Water Barometer (5 experiments)
   —Air Lift-Pumps
   —Laws of Pascal and Archimedes
   —Balloons
2. Compressed and Expanded Gases
   —Boyle's Law
   —Air Brake
   —Flame Thrower
   —Fire Extinguisher
   —Air Pump
   —Bicycle Pump
   —Air Compressor
   —Sand Blast
   —Pneumatic Paint Brush
   —Diving Bell
   —Pneumatic Caissons

WEATHER BUREAU OUTFIT. This set develops the science of meteorology in a series of experiments that the boy can easily perform with the material supplied him. The various instruments used in making weather forecasts, the making of weather maps, and a general study of atmospheric conditions and the laws according to which these conditions change, are the features of this set.

In this outfit and in those that follow it, as also in some of those already described, Gilbert shows an increasing tendency to omit the appeal to "magic," "fun" and "sport." Although he introduces a great many sources of entertainment, this entertainment comes from what might be called "purposeful activity."

MINERALOGY OUTFIT. This set represents a new line of advance in the field of science toys. William J. Horn is responsible for the working out of this outfit, which, according to the manual, deals with the following:

I. Chemical Properties of Minerals
II. Physical Properties of Minerals
III. Description of Minerals and Means of Identification
  (a) Minerals of Economic Importance
  (b) Important Rock Making Materials

Eighteen different minerals are supplied with the outfit, and the boy is directed to experiment with and learn to recognize each one.

In a similar manner sets and manuals have been worked out on the following subjects:

Heat Experiments
Surveying
Machine Design
Glass Blowing
Through the Telescope
Through the Microscope
Signal Engineering
Soldering
Tin Can Toys
Carpentry
and The Magic Series

II. (b) SPECIFIC TOYS differ from the outfits in that they are built for one purpose only. In almost every case they permit of no other use than the one they are made for: taxing the ingenuity of the boy to adapt them to his ever-changing needs, and ending in either total ruin or disuse. The place of these toys in the play life of the boy is discussed in a subsequent chapter. With the exception of the camera, electric motor, batteries and magic lantern, they provide for very transient interests and no far-reaching activity. A partial list of such toys is here given:

1. Steam Engine
2. Fire Engine
3. Electric Motor
4. Dynamo

5. Magic Lantern
6. Moving Picture Machine
7. Spring Motor Toys
8. "Tank"
9. Shocking Machine
10. Aeroplane
11. Submarine
12. Phonograph
13. Batteries
14. Camera
15. Rubberband Motors
16. Battleship
17. Piedometer, etc., etc.

II. SCIENCE READING MATERIALS

(a) *Popular Science Books*

There is a type of science book which boys read as they do novels. Such books were very much more in vogue a few generations ago than they are today; and the better ones are still to this day among the most popular. Jules Verne is an example of the highly imaginative type of science story writer, and Sir E. Ray Lankester's "Science From an Easy Chair" is an example of the "science reader" type of book. In recent years there have been many attempts along this line. Very few of the books, however, possess, in addition to their wealth of science material, the literary merit which marks a book as being popular after-school material, read for its own sake. In the following list the needs of the boy interested in science are met; not as a school assignment, but as an extra-curricular activity. There may be other books than are here listed; and each month a new book appears. The ones listed are the ones that comprise the Science Club library* and have been studied by the writer:

Book	Author	Publisher
1. Wonder Book of Light	E. J. Houston	F. A. Stokes & Co.
2. Wonder Book of Magnetism	E. J. Houston	F. A. Stokes & Co.
3. Wonder Book of the Atmosphere	E. J. Houston	F. A Stokes & Co.
4. How It Works	A. Williams	T. Nelson & Sons
5. How It Is Made	A. Williams	T. Nelson & Sons
6. How It Is Done	A. Williams	T. Nelson & Sons

*The Science Club is described in Chapter 9.

Book	Author	Publisher
7. The Romance Series (12 books)		Lippincott
8. The "All About" Series (6 books)		Funk & Wagnalls
9. Boys' Book of New Inventions	Maule	Doubleday-Page
10. Boys' Book of Modern Marvels	Clarke	F. A. Stokes & Co.
11. Boys' Play Book of Science	Pepper	E. P. Dutton & Co.
12. Submarines	F. A. Talbot	Heinemann
13. Modern Chemistry & Its Wonders		Heinemann
14. Boys' First Book of Inventions	Baker	McClure
15. Boys' Second Book of Inventions	Baker	McClure
16. The Boy Electrician	Morgan	Allyn Bacon
17. "I Wonder Why?"	Goldsmith	Sully
18. Harpers' Electricity Book for Boys	Adams	Harpers
19. Harpers' Everyday Electricity	Shafer	Harpers
20. Books by	F. A. Collins	

The greatest amount of after-school reading is done in connection with experiments and other practical work.

(b) *Popular Science Magazines*

The following is a list of the more popular boy magazines that feature science:

1. Popular Science Monthly
2. Popular Mechanics
3. Science and Invention
4. Illustrated World
5. Scientific American
6. Every-day Engineering
7. Boys' Life
8. The American Boy
9. Saint Nicholas
10. Youth's Companion

Many of these magazines encourage boy correspondents, answer questions, suggest experiments and carry on competitions. The magazines are practically the only extra-curricular activity that have thus far been applied to or correlated with curricular work. The Popular Science Monthly was the first to recognize the use to which these magazines could be put in the school science work and has been publishing for the last five years a Teachers' Service Sheet to go with each month's issue. During the last year the writer has been editing these Sheets for the Popular Science Monthly. There are in all about 10,000 teachers who subscribe to the Service Sheets and make use of them either as a direct aid in developing their course of study in general science, physics, chemistry or biology or as a means of stimulating, guiding, and controlling the after-school reading of their pupils. It is the aim of the writer to develop these Sheets according to the type of demand which exists for popular science reading material. To this end questionnaires were distributed among the subscribers and their reactions to the Sheets were obtained. Although full figures are not yet available, there is a general consensus of opinion that the use of science magazines is chiefly for extra-curricular time. Where a rigid course of study is in force, as is the case in the senior high school sciences, the magazines have no place at all. There is no time. In the junior high school and in the elementary or general science course, these magazines are most valuable assets in arousing interest, supplying readable information, and suggesting experiments with tools and apparatus. It is also one of the large aims of the Service Sheet to discriminate and lead the pupil to discriminate between the worthwhile and the purely puerile and vacuous matter with which the magazines unfortunately abound. It is the feeling of the writer that to develop power of discrimination is more valuable than to eliminate the magazines because of their faults.

III. EDUCATIONAL AGENCIES INVOLVING SCIENCE MATERIALS

There are three forces in the after-school life of the boy that are rich in science stimulation. These are in connection with the popularization of science on the moving picture screen, the science lecture, and the Boy Scouts of America.

It is not necessary in the present study to list the hundreds of science films that have flooded the market, nor to describe the activity of producers and visual educators in this field. It is also true that the present stage of motion picture education does not warrant any large assumptions as to "value." But a number of the better films, especially one on the automobile which is being treated experimentally by the writer according to the same procedure as was used to measure the activities and materials of this study, shows a very favorable comparison between what pupils can get from a period of instruction and from an equal period of just seeing a movie.

As for the program of the Boy Scouts of America, nearly two-thirds of it is activity which can legitimately be classified in the field of science. That Scouting is a potent force is generally recognized. That its aims and ideals as well as its social, moral, and ethical programs are intimately bound up with their content material is not so generally understood. In England the Meccano Guild program (described fully in Chapter 3) is being accepted by the Boy Scout organization. In America it is already possible for Scouts to attain their higher degrees and win their merit badges for showing certain scientific knowledge and skills. All the propaganda of toy manufacturers designed to monopolize the play time of the boy for their particular toy—their Gilbert Institutes and Meccano Societies—their engineering degrees and their prizes and awards—should be controlled by a movement such as is the Boy Scouts of America. Otherwise the taint of commercialism endangers the whole future of the boy science movement in this country.

IV. THE SCIENCE CLUB as that particular type of organization which the teacher can use to guide and control after-school activities in science will be described fully in Chapter 9.

CHAPTER III

EDUCATIONAL PROPAGANDA OF THE MANUFACTURERS OF AFTER-SCHOOL MATERIALS IN SCIENCE

The advertising methods of the producers of the materials described in the previous chapter are the finest illustration that we have of the importance for the welfare of the boy of time spent outside the classroom. When a parent buys a child one of these toys, he at the same time puts the child at the mercy of the sales manager of the company. The boy gets more than the toy and the manual. He gets literature of many different kinds; he is told in a very entertaining manner of hundreds of other boys; and in many ways his emotions are played upon by those in charge of this phase of the toy business. Generally speaking, the men who head these departments show a profound understanding of boy psychology. They seem to be attuned to the spirit of boyhood. They know what the boy likes; what he will work for; what he will fight for; what he will dream about; what he will worship; and what he will save and spend his money for. These men are among the highest paid employees; they are men who would undoubtedly have made splendid teachers.

There is considerable difference in the methods employed by the different companies. In general, there are four types of propaganda used to grip the interest of the boy and weave around and into his life an element possessing large educational possibilities. Each of the four methods will be treated in turn.

The Magazine and Booklets

Every boy who owns a Gilbert Set can subscribe to "Toy Tips," "the official organ of the company." Every boy who owns a Meccano Set can receive regularly the "Meccano Magazine." Every boy who owns a Chemcraft Outfit can subscribe to the "Chemcraft Chemist." And so on. The important aim and function of the magazine is to keep in touch with the boy customers, keep alive their interest, and thus advertise their product.

That this method of advertisement pays is indicated by the fact that more and more effort and money are being spent upon these magazines. It is interesting to see that these magazines are developing along lines rather remote from pure advertising. Originally, literature of this type was published by the companies at irregular intervals in order to announce some new toy or part of a toy—a new price or a new store where their materials could be bought. Gradually material that was but indirect advertisement was interspersed. Then letters written by boys were published and "boy stories" very remotely related to their product, but full of the enthusiasm for experimentation, began to appear. Soon question departments were started and boys were encouraged to correspond with the editor. At the present time there is barely a page in any one issue devoted to direct advertisement. A special editorial staff is provided to do this work; and in nearly every case the director of the company himself employs this means of guiding the fortunes of his product and of keeping in close touch with his boys. The average publication is a bi-monthly issue; and has a circulation equal to one-half of its annual sales. In recent years the quality of paper, print, and photography has been of the very highest. A wealth of illustration and entertaining readable matter is quite the rule. In short, the magazine, itself interesting, and centered around a concrete activity that is highly significant in the life of the boy, finds it very easy to tie thousands of boys together, giving them a common interest and develop a "Gilbert Spirit" or a "Meccano Spirit" or a "Chemcraft Spirit." This "spirit" furnishes but another outlet for the "gang" instinct or tendency among boys of a certain age.

Some of the methods used to build up this spirit are both interesting and significant. First, a prominent place is given to pictures of models built by boys; descriptions of how they work; how they came to be built; and pictures of the builders themselves. Periodically the name and address of each subscriber is published. All types of boy contributions are encouraged. Then the magazines are full of stories of great inventions and inventors. They compare some particularly able boy with Edison or with Franklin and stimulate both his imagination and his ambition. Boys will put forth tremendous efforts to get their model, their picture, and their story into print. A third method is the use of fiction and poetry based on some scientific idea or plot. Though never of the calibre of a Jules Verne story, that type of story always has an appeal. The magazines have always been ready to print our Horace Mann Science Club News. It has proved a great incentive and a valuable aid in stimulating our activity.

Competitions

The vice-president of the Meccano Company in discussing with the writer the various reactions of boys to these after-school materials, expressed himself in somewhat the following manner:

"There are four stages in the boy's reaction to Meccano. In the early days of his play, he is bent on getting the mere *experience* of manipulating real and workable things. In the second stage he is essentially imitative, duplicating what he sees in the manual. In the third stage he tends to be original, to invent, and to innovate. And in the fourth stage he emulates the accomplishments of others. Furthermore, there is no fourth stage unless there is something he can compare himself with, something he can strive for."

All of the manufacturers have recognized to some degree the above analysis; and we find especially in the fourth stage of the boy's reaction, that they all arrange for elaborate competitions.

There is no better way of describing the appeal that is made to boys to enter these competitions than by quoting from "Toy Tips," from "Meccano Magazine," and from "Chemcraft Chemist."

"Big Toy Engineering Prize Contest!

"Think of This!

"$1500 in prizes for you!

"Remember this big contest is always running and any boy can compete.

"Prizes are awarded once a year.

"This contest is to encourage leadership in boys in building original models; new models; imitations of great engineering feats, etc.

"Think of it, boys—500 fine prizes! A real boy's automobile or Shetland pony!

"You can enter models built from Erector, or any other Gilbert toy.

"We do not want to have you send in models. Send in drawings, sketches or photographs of the model, giving us a complete description.

"No restriction is placed upon the material out of which you make your model.

"You can submit as many designs as you wish.

"The names of the winners will be published in 'Toy Tips.'

"Copies will be mailed to every competitor.

"Every boy who wins a prize will be awarded an honorary Diploma in the Gilbert Engineering Institute for Boys."

"Meccano boys are keen, inventive boys, and every year thousands of them design new models, entirely different from those in our big Manual of Instructions. and both they and their friends get a lot of pleasure from them. We want to know all about these good models, so that we may bring them out of their obscurity and publish them for the benefit of all our Meccano boys, many thousands of whom reside in far-away countries and are glad to see what American boys can do. Don't forget that we collect their models also, from Europe, Asia, Africa, and in fact from every civilized and uncivilized country in the world, and bring their novel ideas over here for the American boy to enjoy. Moreover, we want to encourage the Meccano boy to invent. It is the thinkers and inventors who have placed this great country in the front rank among nations, and in Meccano, the American boy has the finest possible means of developing his inventive and thinking facilities.

"Competitors may be of any age or sex, and there are no restrictions or entrance fees. The ingenuity and originality shown will guide the judges in their decision, and no preference will be given to large, elaborate or complicated models. A small model well constructed, and demonstrating an ingenious idea, stands just as good a chance of winning a prize as a large and intricate one.

"In making the awards, the judges will pay special attention to the following points:—

"ORIGINALITY.—Special points will be given to those models which show initiative and originality and are not simply variations of those already published.

"CORRECT CONSTRUCTION.—Models which in their details are constructed on correct mechanical and engineering principles will receive higher marks than those which are built incorrectly or carelessly. No special knowledge is necessary.

"GENERAL INTEREST.—Preference will be given to those models which are likely to prove most interesting to build and demonstrate. We shall publish the best models in all civilized countries.

"This year our big Contest is divided into sections as follows:—

"Section A.—For Competitors under 10 years of age on May 1st, 1921.

"Section B.—For Competitors over 10 years and under 14 years of age on May 1st, 1921.

"Section C.—For Competitors over 14 years of age on May 1st, 1921.

"A competitor may enter any number of models for competition, but only in the Section for which he is eligible.

"Entries must be in the form of Sketches or Photographs which should show clearly how the model is constructed. Written instructions for building need not be attached unless they are necessary to explain the working of the model. ACTUAL MODELS MUST NOT BE SENT IN. The Photographs or the Sketches need not be the work of the competitor.

"There is no restriction as to the number of parts or make of toy which may be used in the construction of a model for the competition.

"The judge will be Frank Hornby, the inventor of Meccano, and his decision will be final.

"Competitors must enter with the distinct understanding that the sole copyright of the photos, sketches or models which win prizes, is vested in Meccano Company, Inc.

"If considered necessary, winners of prizes may be called upon to furnish proof that they have complied with the conditions.

"The results of the competition will be annnounced about June 30th, 1921, or as soon after as possible.

"A specially printed list of prize winners will be sent to each competitor, or to any address on application.

GRAND PRIZE CONTEST

"Open to all members of The Chemcraft Club, Junior Members and All Boy Chemists.

"The Chief Chemist is glad to announce the second grand prize contest. The prize contest last year was a great success, and more than 500 experiments were entered. This year we expect several times that many. So all you Chemcraft Chemists get busy.

RULES

"1. Experiments can be performed with any of the chemicals listed in the Hand Book and Catalog, or furnished with any CHEMCRAFT Outfit, or any other chemicals, provided no dangerous, poisonous or explosive substances are used.

"2. The experiment must be original with the amateur chemist who sends it in. Stock experiments copied from books or magazines will not be accepted.

"3. A Contestant can enter any number of experiments he desires.

MASTER CHEMISTS

"The degree of 'Master Chemist' will be awarded by the Chief Chemist to all whose experiments are exceptionally good. A list of those receiving the degree of Master Chemist will be published in the Chemcraft Chemist Magazine as soon as possible after the contest closes."

The extent to which prize competitions are in vogue as a means for advertisement is not realized by many teachers. The method is not at all new in school activities; but it has in recent years been severely criticized from an educational point of view. Whether such stimulants to industry and aplication on the part of the pupil is worth while or not does not matter much. For when our boys leave our classrooms they are attracted by these competitions and yield in a very human way to these dazzling prizes. On the average, 20% or 30% of my boys are at all times planning or preparing some sort of an entry for a prize. These competitions are not limited to the boy manufacturers. Practically every boys' magazine or popular science magazine of any size offers prizes of some sort. The Popular Science Monthly for example gave away $5000 in scholarships last year and about $500 more for various minor competitions.

Degrees and Awards

By far the most striking and effective means employed by the companies to maintain their hold on the boy are what might be called the Boy Universities. It is hard for adults to appreciate what the International Society of Meccano Engineers can mean to a boy or to regard with a boy's mind the Gilbert Institute of Engineering or the Boys' Chemcraft Chemist Club of America. To receive the degree of "Erector Master Engineer" means quite as much to a boy as the LL.D. or Ph.D. will mean later on—perhaps more. This is how Gilbert broaches the question to his boys:

"I know that everyone of you is full of ambition—chock full of a determination to be a 'big' man in the affairs of the world when you grow up. And so, knowing this, I have decided to do another big thing for you that will encourage and inspire you—that will enable you to prove to your mother and father and friends that you have the 'stuff' that the real mean of the world are made of.

"Listen! In addition to offering valuable prizes for the best models, I am going to give boys whose models of Erector or the Erector Electrical Set show that they deserve it, free membership in the Gilbert Institute of Erector Engineering. What is this Institute? Well, I'll tell you. Instead of awarding only prizes for the best models built by boys, the 'Board of Erector Engineers,' which will meet every Thursday of each week, will confer upon boys degrees just like the big colleges do. These degrees will bring with them handsome diplomas, suitable for framing, and will testify to your ability as a toy engineer.

"The First Degree is that of 'Erector Engineer.'

"The Second Degree is that of 'Erector Expert Engineer.'

"The Third Degree is that of 'Erector Master Engineer.'

"If you succeed in winning any of these diplomas, you will be proud of them all your life—because they will be issued only to boys who show real ability and promise of developing into men of brains and character."

In addition to diplomas, Gilbert also presents his "engineers" with gold fraternity pins and gold enamel lapel buttons. The Master Engineer also gets a gold watch, and a recommendation for a position with the "Gilgert Demonstration Department" of a local store, which pays a salary of $10 a week for three weeks during the Christmas Holiday Season. A boy can win the First Degree by—

(1) Sending Gilbert a photograph or drawing of an acceptable Erector Model.

(2) Sending Gilbert a photograph or drawing showing that you know how to put together a motor.

According to Gilbert, "only a few hundred boys in the whole United States win the Third Degree in any one year."

Speaking to the parents, Gilbert advises them to "interest your boys in this movement, because it will afford them a great deal of wholesome fun, and cannot fail to aid in making better boys of them, and admirable types of men later on. Also, because Gilbert Toys direct a boy's thoughts and actions along constructive lines while he plays—his imagination, ingenuity and skill are encouraged — and his impressionable mind learns that real pleasure comes through *creating* and *not destroying.*"

Quite recently the Gilbert Company has made a few significant changes in their system of awards and degrees. Instead of Erector Engineer, has been substituted Gilbert Engineer. Every boy upon purchasing any Gilbert toy gets a "credential of membership" which entitles him to several privileges among which is the privilege of taking examinations for higher degrees. These examinations may be taken in one or more subjects in the Gilbert Study Series. This series comprises the following toy outfits:

1. **Engineering Series.**
   - **—Erector (A)**
   - **—Civil Eigineering (A)**
   - **—Hydraulic and Pneumatic Engineering (B)**
   - **—Signal Engineering (C)**

2. Natural Science Series.
   —Industrial and Recreative Chemistry (B)
   —Mineralogy (A)
   —Astronomy (B)
   —Microscopic Research (B)
   —Sound Experiments (B)
   —Light Experiments
   —Heat Experiments (B)
   —Weather Bureau (C)
   —Telescopic Research (B)
3. Electrical Series.
   —Elementary Electricity (B)
   —Magnetic Fun and Facts (B)
   —Wireless (C)
   —Telegraphy (C)
   —Telephony (C)
4. Manual Training Series.
   —Designer and Toymaker (A)
   —Carpentry (A)
   —Picture Framing (A)
   —Soldering (A)
   —Wheel Toy Construction (A)
   —Glass Blowing
   —Tin Can Toy Making (A)
   —Machine Design (A)
5. Recreative Series.
   —Mysto Magic (B)
   —Chemical Magic (B)
   —Knots and Splices
   —Coin Tricks (B)
   —Handkerchief Tricks (B)
   —Photo-Phads (B)
   —Card Tricks (B)
   —Puzzle Parties (B)
   —Air Kraft (A)
   —Briktor (A)

Items marked (A) refer to constructions and models of various sorts. The examination in these consists of submitting photographs and other proofs. Items marked (B) refer to "researches." Descriptions of inventions and new experiments must be accompanied by parent statements to be acceptable as fulfillment of the examination requirements. Items marked (C) refer to "examinations" where explanations of phenomena are required. The Institute stands ready to assist the boys in their studies through correspondence.

The International Society of Meccano Engineers is of course a rival institution to the Gilbert Institute. This society also awards three degrees: Membership, Junior Engineer, and Senior Engineer.

MEMBERSHIP.—"Send in your name and address to headquarters. We will then enroll you in the Society as a member and send you a copy of the next issue of the Meccano Magazine, so that you can get acquainted with it and hear what other boys are doing. For six months you are to continue model building and do all you can by talking about the Society to increase its membership."

JUNIOR ENGINEER DEGREE.—"After you have been a member of the Society for six months, you can become a Meccano Junior Engineer. Write us, giving full name and address, date you were registered as a member of the Society, and state what you know about Meccano and what models you have built. The degree is an award for merit, that is why it is so greatly prized.

"During the six months period of building you will have learned something of the history of Meccano and its inventor, and the names and uses of Meccano parts. You will also have learned the importance of the Meccano system of standardized strips and girders with holes one-half inch apart. So it will be easy to write us a letter telling all you know. In this letter add a list of the models you have built and any you may have invented. Be sure to write clearly and use one side of the paper only. As soon as you have been awarded the Engineer Degree you will get a beautiful blue enamel button and a letter certifying that you have been admitted to rank in the Society.

SENIOR ENGINEER DEGREE.—"After you have obtained the first degree and have worn your button for six months and continued to use your building Outfit, you have the opportunity of obtaining a further honor called the 'Senior Engineer Degree.' You obtain a second certificate and a silver bar with the word 'Senior' on it. The latter is to be worn above the blue enamel button. The two have been designed to match.

"To obtain the second degree, send full name and address, date on which you obtained the Junior Degree and what you have done to earn the higher rank. A Senior Engineer is supposed to know how different kinds of girders are built, to be acquainted with the Meccano 'standard details' given at the end of the Manual, and the scientific value of Meccano as illustrated in Manual No. 2."

A third institution of the same type is that of the Porter Company—the Chemcraft Chemist Club. A few quotations from the Articles of Constitution will serve as a description of this organization:

"There are thousands of Amateur Chemists in America. In fact, almost every boy and girl who has a Chemcraft Outfit is an Amateur Chemist. All these boys and girls have lots of real good times, perform all kinds of wonderful chemical experiments and learn a lot of the elementary principles of chemistry at the same time. Many invent new experiments of their own. So many have become Amateur Chemists, and so many have new things to tell about that we decided to get all owners of Chemcraft into one big happy family; so that they could all know what the other fellow is doing, and each could benefit by the experiments and tricks invented by all the others. So the Chemcraft Chemical Club was started.

"Another object of the club is to promote good fellowship and friendship among all boys and girls who are interested in Chemistry and to further the study of Chemistry among them.

"National Headquarters is the central place from which the activities of the Club are directed. The Club is made up of boys and girls in every part of America who have Chemcraft Outfits. There are no offices at National Headquarters except the Chief Chemist, who directs the affairs of the Club, and the Secretary, who keeps the records of membership and such things. The entire membership is made up of boys and girls.

"National Headquarters is the place where the new experiments, tricks and general chemical information furnished by the members is collected, classified and distributed to all members; where the charters for Local Chapters are issued (I'll tell you more about them later); where the questions relating to chemistry are answered and suggestions are furnished which will help members understand the subject better.

"National Headquarters also arranges for prize contests among members, furnishes the prizes, acts as judge in the contests and awards the prizes to the winners.

"The official magazine of the Club is also published at National Headquarters and mailed to each member. National Headquarters also furnishes the membership equipment which is given to each Full Member when he joins.

"In fact, National Headquarters is the guiding hand that runs the Club and keeps the whole organization in harmony and running smoothly.

"Any owner of the Chemcraft Outfit can join the Club upon payment of the yearly dues. All members are furnished with the following equipment and granted the following rights:

"(1) Membership Card
"(2) Membership Button
"(3) The Official Club Magazine
"(4) Catalogue of Supplies
"(5) The right to compete without charge in the Prize Contests.
"(6) The right to conduct correspondence with the editor and to contribute to the magazine.
"(7) The right to apply for and receive a Charter for a Local Chapter.

"A Local Chapter is a branch of the National Club, located in any part of the country and run by the Full Member who starts it, with the assistance of the other boys he gets into his Local Chapter.

"When you have joined the Club, and so become a Full Member, you can make application for a Charter for a Local Chapter. This Charter grants you the right to organize, supervise and conduct a Local Chapter of the Chemcraft Chemical Club under your own name. Your name will be written into the Charter and no other boy can use it. The Charter also appoints you Chief Chemist of your Local Chapter. You can apply for your Chapter at the same time you send in your Membership Application so you will get all your equipment and your Charter at the same time.

"After you have received your Charter, you will then proceed to organize your Local Chapter. The first thing to do is get together two or three other boys and explain the scheme to them and get them to join your Local Chapter. You will first need a set of by-laws that will be the guiding rules of your Chapter. The following is an example of the best form to follow:"

The Boy Departments and Letter Bureaus

The magazines of the various toy companies devote considerable space to the answering of boys' questions, the printing of their stories and communications and the encouraging of the boys to correspond. In all three magazines these "boy departments" have been highly developed. In a subsequent chapter will be given an analysis of several hundred of such letters and their significance treated fuly.

The educational propaganda described in this chapter is all the development of the past four years. Obviously this is too short a period to warrant any definite conclusions. The companies are feeling their way, trying one device after another; but they are firmly convinced that the idea is sound. Their conviction is based upon more than the mere advertising value, though that is a most prominent feature; for most of them as has been shown, have at heart the ultimate worth of their product as educative material. To bring the boys of the whole country together in this common pursuit, with this common interest and in cooperative effort is an ideal which can take the shape of a real boy movement in the field of science. The men who are directing this propaganda have already commenced to feel, just as the pioneers of the Scouting movement felt, that there are certain very real difficulties in attempting to guide boys through a program of activities at long distance. However wonderful the personalities of men like Hornby, Gilbert, Porter and St. John, their influence cannot be efficiently transmitted to the thousands of boys all over the country through their magazines, booklets, societies, fraternities, letter bureaus, and the like. Most likely, the companies will continue to engage in this propaganda, so long as it remains a "paying proposition," and there is every indication that it will do so. But it is not likely that they will develop their work to a point where money will be sacrificed for the sake of the ideal. One prime need, for example, is for the three or four agencies working independently in this field to get together. Another need is to provide for proper personal leadership in the place of the leadership through printed matter alone. Can anything be done in this respect?

In a later chapter, the writer will describe his experiences with the Science Club—an organization which like the Gilbert Institute or Meccano Society guides, inspires, aids, and keeps tab of after-school activities in Science; but through direct personal contact between a director and a comparatively few number of boys. In England, the Meccano has organized a scheme, known as the Meccano Guild; which resembles in its program and activities the writer's Science Club; and which has practically monopolized the science toy field. Thus we have a starting point and at least one experiment by which to go.

And because the Meccano Company in America is now taking the lead in developing a boy science movement, it will be of value to devote some space to a description of the operation of the Meccano Guild of England, after which their attempt along this line will be modeled.

The Meccano Guild of Great Britain was organized in its present form about two years ago. For years, boys had been corresponding with the Meccano editor, telling him of Meccano Clubs that they had formed on their own initiative. This became so common that the company finally decided to take a hand in furthering this club idea. In less than two years, there seem to be 300 cities and towns in England where there is at least one Meccano Club. The movement is steadily growing.

Before proceeding with a detailed description of the methods of the Guild, it will help to keep before one's mind a few important features.

1. The objects of the Meccano Guild are:
   (a) "To make every boy's life brighter and happier."
   (b) "To foster clean mindedness, truthfulness, ambition, and initiative in boys."

(c) "To encourage boys in the pursuit of their studies and hobbies, and especially in their development of their knowledge of mechanical and engineering principles."

2. The Meccano Club is a science club in everything but name.
3. Advertisement of a direct commercial character is entirely absent from the movement. One need not own a Meccano or limit himself to Meccano activities to be eligible for membership. He can even neglect Meccano for other science activities.
4. No Meccano Club can exist (officially) without an adult "Leader" and a capable boy "Secretary."
5. The Guild reaches the boy through his leader and his secretary. Special pamphlets are prepared and given to the leader and to the secretary.
6. A great many Scout Masters have become Meccano Guild Leaders as well.
7. A definite program of activities for the Clubs has been and is being developed by the Meccano Company. Latest methods and new devices are supplied to the "Leaders."

From the pamphlet, "Notes for Club Leaders:"

"Those fortunate individuals who are brought in frequent and close contact with boys and youths, and who have the power, the will and the ability to guide them in their work and in their play, to encourage and help the lagging ones, to stimulate and encourage the ambitious and clever ones, to open their minds to all that is pleasurable in life . . . are doing work which, from a moral and national point of view, is of value beyond estimation.

"Meccano Limited and its officials have worked amongst boys for more than twenty years.

"The number of Meccano boys at the present time runs into the millions. We have corresponded with them and interviewed them on all subjects; we have been the confidants of their hopes, ambitions, difficulties and fears; and we have realized how much they stand in need of guidance. They have formed little clubs and coteries amongst themselves, and repeatedly and persistently they have asked us to found a central club to which they could all look for guidance.

"Realizing the immense responsibility and work of such an organization we delayed any action until we felt that the call was a clear one, and until we had all the means and facilities to carry it through successfully.

"You as a Club Leader have now become an important member of the Guild organization; have approved and accepted its principles, and we desire to inspire you with the same ideals and aims. You have under you, looking to you for guidance, a number of Meccano boys, and your influence among them is great. You will come to look upon your association with them as the brightest and most useful part of your life.

"The Headquarters of the Guild are attached to the Meccano factories in Liverpool. Their function is to co-ordinate the work of the Meccano Clubs in various parts of the country; to assist officials of clubs in the arrangement of the Winter's syllabus; to furnish all available information and help to make each club meeting successful; to provide badges for the members; and special certificates and awards for boys who show special aptitude; to insure interchange of ideas between all clubs, and to issue an official magazine regarding the work of the Guild.

"A Meccano Club has a Club Leader, Secretary, Committee and the usual officers. It has a Guild certificate of affiliation, and each member has accepted the objects of the Guild. Each club manages its own affairs entirely, draws up its own rules, arranges programs, competitions, demonstrations, club outings, etc. Each member wears the official badge on all occasions, and undertakes to acknowledge any other member of the Guild he may meet, and recognize him as a friend with interests and work in common.

"The fate of a club depends wholly and absolutely upon how the boys spend the 100 odd minutes of each evening they meet together. All schemes and policies, or aims and ideals depend for their fruition upon the success of the weekly meetings. A boy who is bored or made uncomfortable once will not allow it to happen again if he can help it. He goes to a club meeting to gain knowledge, to be entertained and to enjoy himself, and if he is disappointed he will drop out. It is the work of the Club Leader to make each meeting successful, and to do this, it is necessary for him to plan out the work beforehand, and to carefully and tactfully insist upon his plans being carried out. For a sense of order and method makes unruly behavior impossible, whilst something interesting to do is the finest disciplinary code yet conceived."

In general the Meccano Guild suggests four types of programs:

(a) Lectures and papers by the boys themselves or by adult outsiders.
(b) Working at and demonstrating Meccano inventions.
(c) Competitions among the members.
(d) Concerts and Exhibitions.

Another pamphlet is issued to the Club Secretaries. In this a great many practical suggestions are set forth designed to help the boy to form his club, secure a leader and a club room, and stage the preliminary meeting. Typical programs for the year are submitted and a great many activities suggested. A wide range of subjects are set down as being among the legitimate interests of a Meccano Club. Under the head of Engineering, the following are listed: bridges, roads, railways, canals, cranes, steam and electric locomotives, motors, ships, aeroplanes, air-ships, mechanical labor-saving devices, tunneling, coal apparatus, agriculture, elevators and transportation. Under the head of Scientific, the following subjects are listed: Electricity, electric bells, lighting and wiring, electric traction, electrical heating apparatus, electrical instruments, wireless, telephony, electro-plating, optics, astronomy, hydraulics, photography, gardening, bee culture and nature study.

The following is also adopted as the Guild Science Library:

Author	*Book*
Clandy, C. H.	Tell me why! Stories about Great Discoveries.
Smiles	Self Help.
Williams, A.	Victories of the Engineer
	Romance of Modern Inventions.
	How it is Made.
	How it Works.
	Romance of Modern Mechanism.
Frith, H.	Triumphs of Modern Engineering.
Holmes, F. M.	Great Works of Great Men.
Doubleday, R.	Stories of Inventors.
Johnson, V. E.	Modern Inventions.
Baker, R. S.	Boys' Book of Inventions.
Hall, H.	The Young Engineer.
Adams, J. H.	Harper's Electrical Book for Boys.
Onken, W. H.	Harper's How to Understand
Baker, I. B.	Electrical Works.
Bonney	Electrical Experiments.
	Electro-platers' Handbook.

In a word then, the Meccano Guild is in reality a movement for the proper kind of after-school science. Though its methods, organization, materials and even aims may be criticized, their motives are not ulterior. They look upon the increase of Meccano sales only as a remote and very indirect outcome of this propaganda.

CHAPTER IV

BOY REACTIONS TO AFTER SCHOOL ACTIVITIES AND MATERIALS IN SCIENCE

Chapters II and III have aimed to describe certain forces in the after-school time of the boy. They have not attempted to indicate the potency of these forces or the various reactions that they call forth. If we are to evaluate educationally the mass of materials and activities hereto described, we must very definitely determine what boys actually do with these materials. Not the elaborate structures erected by the manufacturers, but their functioning in the life of the boy is the important consideration of this study.

In this chapter the writer will present experiences and observations that throw light on the question of how the boy reacts. The basis for the facts presented are four years of experimentation in the Speyer Junior High School and in the Horace Mann School with about 500 boys ranging in age from nine years to fifteen. Wherever possible statements will be given in quantitative terms; the figures have been compiled from various sources, such as the minutes of the five Science Clubs (both the secretaries' and the writer's own), letters written by the boys, compositions written as class assignments for other teachers, records kept by the writer over a period of four years, and other sources that will be mentioned in the course of the chapter.

The most fundamental reaction of all is the extent to which boys possess these outfits. To ascertain this the following questionnaire was devised and distributed among 764 boys as follows:

270—5th and 6th grades—Horace Mann School

494—7th, 8th, and 9th grades—Speyer School

Questionnaire

Name

Age (last birthday) Grade

If you ever had any of the following toys or have them now place a check to the left of each one that you have or have had:

Meccano Set	Batteries
Erector Set	Wet Battery
Structo Set	Storage Battery
Chemical Set	Dynamo
Electrical Set	Motor
Fun With Electricity	Train (winding)
Fun With Magnetism	Cannon
Wireless Set	Electric Dog and Kennel
Telegraph Set	Camera
Telephone Set	Piedometer
Railroad Train Set	Galvanometer
Steam Engine	Rubberband Boat
Fire Engine	Winding Boat
Electrical Engine	Sail Boat
Stereopticon	Motor Boat
Magic Lantern	Battleship
Moving Picture Machine	Blinker
Automobile (winding)	Recko
Tank	Tool Chest
Aeroplane	Lathe
Shocking Machine	Pistol
Transformer	Rifle
Submarine	Skates
Phonograph	Bicycle

In the following space put down any toy which you have or have had and which you cannot find in the above list.

Of the toys you have checked, put another check next to the two you like or liked best.

Put a cross next to each toy in the above list that you play with at the present time.

Put two crosses next to the toys you like best right now.

TABLE I

AVERAGE NUMBER OF TOYS PER BOY (HORACE MANN)

Age	Number in group	Average number of "Outfits"	Average number of specific toys
8 to 9*	21	2.3	10.0
9 to 10	45	2.8	11.2
10 to 11	75	3.6	11.6
11 to 12	78	4.3	14.3
12 to 13	39	4.8	16.7
13 to 14	12	6.2	19.3
Totals	270	3.86**	13.27**

*By "8 to 9" is meant past the 8th birthday but not yet 9.
**Weighted average.

TABLE II

AVERAGE NUMBER OF TOYS PER BOY (SPEYER SCHOOL)

Age	Number in group	Average number of "Outfits"	Average number of specific toys
10 to 11*	22	3.91	11.64
11 to 12	84	3.92	12.97
12 to 13	141	3.21	11.97
13 to 14	158	3.29	11.73
14 to 15	65	3.09	10.11
15 to 16	24	3.08	9.58
Totals	494	3.163**	11.688**

*By "10 to 11" is meant past the 10th birthday but not yet 11.
**Weighted average.

The answers to more than three-quarters of the questionnaires were obtained during the fall of 1920, six weeks before the Christmas holidays, so that the flood of presents which occurs at this time does not enter into the figures. The other one-quarter of the answers were taken during 1918 and 1919, and also before or long after the Christmas holidays.

Tables I and II indicate a few significant facts:

1. Assuming that Horace Mann parents are wealthier on the whole than Speyer parents, the boy of means shows a diminishing interest in toys at a later age than the boy of lesser means. Or, if the gradual and slight decrease

with age in the average number of "outfits" and of "specific toys" in Table II cannot, in the light of the small number of cases, be considered as being probably true, the table might still be regarded as showing that parents of lesser means will cease to buy additional toys sooner than will more wealthy parents. Perhaps this is due to the injunction of the poorer parent to his boys to conserve and take care of his toys.

2. Though Table I does not go far enough to show when, if ever, the increase in the number of toys ceases, correspondence and conversations with Horace Mann Elementary School graduates tend to show that 14 years is the peak in the matter of number of toys. At 14 the boy's interests show a decided change. This fact is clearly evident in Table II.
3. This decrease in interest shows itself more markedly in the case of "specific toys" than in the case of "outfits."
4. Comparing the weighted averages in the case of the two schools, there seems to be a far smaller difference than one might ordinarily expect between the two types in the matter of what they will each do for their boys in the way of toys. The difference would undoubtedly be greater if amount of money, instead of number of toys, were taken as the criterion. Educationally, however, the expensive toy, as will be shown later, holds very little advantage over the cruder and less expensive one. That the difference above referred to is probably very small is also borne out by a great many statements of toy manufacturers at a recent convention and in hundreds of letters printed in toy journals such as "Playthings" and "Toys and Novelties." According to the editor of the former periodical, "In every economic crisis, when parents have had to pinch in every way in order to provide essentials, they have seldom neglected to include toys in the list of essentials." It is also a matter of common experience with firms like A. C. Gilbert Co. to find that "the department stores that cater to the middle class and to the poor show relatively as great a number of sales as in stores of the John Wanamaker type."

TABLE III

The Twenty Most Frequently Possessed Toys

Order of Frequency according to boys of all ages	Rank (order) of these toys according to various ages 10 to 11(a)	11 to 12(b)	12 to 13(c)	13 to 14(d)	14 to 15(e)	15 to 16(f)
1. Skates	1	1	1	1	1	1
2. Erector-Meccano	3	4	2.5	3	7.5	3.5
3. Rifle	10	10	6.5	2	3	9.5
4. Bicycle	16	8	4	4	2	13.5
5. Pistol	10	2	2.5	7	5	9.5
6. Camera	10	4	13.5	6	4	3.5
7. Electric Motor	5	4	6.5	10	7.5	2
8. Railroad Outfit	16	12	5	5	6	6
9. Tool Chest	10	6.5	13.5	12.5	10.5	6
10. Phonograph	5	14	11	8	13	9.5
11. Cannon	16	16	10	12.5	10.5	17
12. Steam Engine	16	6.5	8	11	14	13.5
13. Wireless	10	10	13.5	15	18	23
14. Batteries	22	19	17.5	14	16	6
15. Telegraph	10	13	9	9	10.5	9.5
16. Magic Lantern	20	16.5	16	17	18	19
17. Submarine	2	19	13.5	19	22	17
18. Chemcraft	10	10	20	20	10.5	17
19. Aeroplane	20	21	17.5	17	17.5	13.5
20. Moving Picture Machine	5	16.5	20	16	15	13.5

Table III shows a difference in the kind of toys possessed by boys of different ages, but the difference is not great enough to indicate any particular toy or particular type of toy as being peculiar to any age. The actual differences that exist can be seen from the following set of correlation coefficients:

$$\rho\ a.b = .384$$
$$\rho\ b.c = .664$$
$$\rho\ c.d = .850$$
$$\rho\ d.e = .851$$
$$\rho\ e.f = .602$$

These are Spearman coefficients, calculated from the formula—

$$p = 1 - \frac{6 \Sigma D^2}{N.(N^2-1)}$$

It is apparent from these coefficients that the differences between the different ages are slight. The largest difference occurs between the ages 10 to 11 and 11 to 12. That, however, is an unreliable coefficient, due to the very small number of cases upon which the ranks in the 10 to 11 column were based. The same might be said of the ranks in column "f."

TABLE IV

Toys in the Order of Popularity

Order of Popularity according to boys of all ages	Rank (order) of these toys according to various ages: 10 to 11(a)	11 to 12(b)	12 to 13(c)	13 to 14(d)	14 to 15(e)	15 to 16(f)
1. Bicycle	2.5	1	1	1	1	2
2. Skates	1	4.5	2	2	3	3.5
3. Chemcraft	2.5	2	5	4	2	1
4. Erector-Meccano	6.5	3	3	3	10	8
5. Electrical Set	6.5	8.5	4	5	4	5
6. Camera	4	6.5	6.5	6	10	3.5
7. Railroad Outfit	6.5	4.5	9	10	6.5	8
8. Wireless	6.5	11	8	9	5	8
9. Batteries	14.5	6.5	6.5	7	17	12.5
10. Dynamo	10	8.5	11	8	17	8
11. Telegraph	10	16	10	11	17	12.5
12. Magic Lantern	10	14	12	13	17	21
13. Electric Motor Engine	14.5	13	13.5	21.5	10	12.5
14. Phonograph	14.5	16	16	12	17	12.5
15. Steam Engine	14.5	12	13.5	17.5	35	28
16. Shocking Machine	26	28	19	21.5	17	21
17. Train (winding)	26	28	26	27.5	10	21
18. Rifle	20	28	26	27.5	10	21
19. Moving Picture Machine	20	20	19	15.5	35	28
20. Sail Boat	26	28	19	21.5	17	21
21. Tool Chest						
22. Submarine						
23. Aeroplane						
24. Tank						
25. Pistol						
26. Battleship						
27. Cannon						
28. Telephone						
29. Motor Boat						
30. Rubberband Boat						

In order to determine the differences due to age in the popularity of the twenty more popular toys, the Spearman coefficients can again be calculated:

TABLE V

Coefficient	*For First* 15 *Boys*	*For First* 20 *Boys*
p a.b	.660	.782
p b.c	.812	.786
p c.d	.801	.702
p d.e	—.421	—.375
p e.f	.509	.551

Table V shows a surprising change in the interests of the boy at 14 years of age. The order in which he likes the toys after 14 is not at all the order in which he prefers them before he is 14. Various explanations of this phenomenon are, of course, possible. Perhaps the most probable explanation is the tremendous growth and development of the boy at this age, which is at the very beginning of the adolescent period. Toy manufacturers have reached the same conclusion through bitter experience in trying to sell their toys. They find that they cannot appeal to the boy of 14, 15, or 16 as they can to the younger boy. This has become so well established that manufacturers now speak of "the toy age"; by which they mean "anywhere from 4 to 14 years." It must not be thought, however, that boys of 15 and 16 cease their activity with this type of material. They do not. They usually find a special interest which becomes all absorbing, and they adapt the materials they can buy to their particular interests. In general, it is true, that at 15 and 16 only those "toy materials" which he can make do a useful thing will interest him.

In this connection it is significant to again point out the decrease after 14 of the number of "outfits" possessed by the boy (Table III) and especially of the number of "specific toys." Perhaps if parents consulted the boy more before purchasing his toys, this decrease would be even more marked. On the other hand, if a distinctly new type of toy were put in the market, which toy was better adapted to the adolescent boy, this decrease might not be evident at all.

Another consideration, next in importance to the number of these toys possessed and played with by the boys, is the time actually spent on this activity.

An examination of 92 diaries kept by as many boys over a period of three weeks shows the following:

1. The fourteen hours of the average school day during which a Horace Mann boy is awake is spent in five main activities:
   (a) In the classroom, 4 hours.
   (b) Exercise and athletic games, 2 hours.
   (c) Doing lessons (music, etc.), 2½ hours.
   (d) Time for meals and going to and from school, 2½ hours.
   (e) Play or free time, 3 hours.
2. On Saturdays, Sundays, and holidays outdoor games and "free time" divide between them the entire day.
3. Forty-eight of the diaries expressed their greatest enthusiasm in describing activities occurring during "free time." Thirty diaries centered their enthusiasm around physical games and outdoor sports. The other 14 gave the most prominent place to school or class work.
4. Though "free time" spent on toys is seldom a regularly occurring activity, it comes in protracted periods, ranging from one hour to four hours. Also there are weeks of intense application and weeks of comparative neglect.
5. After a period during which little toy activity has taken place, some problem or query will bring the boy back; and then one thing or another will keep him at it for several days until the enthusiasm dies out. Usually the initial problem that brought him back to his toys will be very quickly forgotten in a host of new ones.
6. Forty-three of the diaries make mention of dreams about toys.
7. Forty boys tell of how they lie in bed and think about how they can make some toy work better or how they can perform some stunt with toys or what they will do with them the next day.

8. More than a hundred times the fact is mentioned that a parent has compelled the boy to leave his toys for some other activity—much to the regret of the boy.

As regards these diaries, the writer feels that they are subject to error in that they were kept for the "science teacher." Nevertheless they agree so closely with the observations of teachers and of about 46 parents with whom the writer has had an opportunity to go into the details of these diaries, that it seems safe to offer the above facts for what they are worth. All things considered, it appears to be true that the "free time" is the period most looked forward to by the boy, the period that calls forth his greatest enthusiasm, enters more than any other period into his thought processes, and is the period where his initiative and originality find their fullest opportunity. It is also true that until he is thirteen or fourteen this so-called "free time" divides itself nearly equally between physical play (sports) and "toy" materials of one sort or another.

The writer was very fortunate in enlisting the aid of the three largest toy producers, and has been able to get from them several hundred letters written by boys. In these letters the boys describe their activities and ask for help. Together with many letters the writer himself has received, there are in all 432 letters which will be analyzed in the following paragraphs.

First, it must be remembered that these letters are encouraged by the various magazines, pamphlets, and letter bureaus previously described; but that no definite idea is given the boy as to what he is to write about. The result is that he will write when he has something real to say—when he has a motive. That it is practically impossible to get boys to write letters on subjects of someone else's choosing was shown very clearly when the author of this study published a little story in the Meccano Magazine that ended in an appeal to the readers to write a letter answering a few specific questions. Not more than six replies were received by the editor of the magazine. The editor then told me that that had been his own experience over and over again.

Second, the proportion of letters received to the number of sets actually sold each year is surprisingly high. In the case of the Porter Company, for example, 68,202 sets of all types were sold during the year 1920 and a total of nearly 14,000 communications received. A. C. Gilbert Co. reports an average of 2,500 letters a day during November, December, and January and an average of 200 a day throughout the year. (The Gilbert "Boy Letter" office holds a prominent place in the plant.) The Meccano Company offers the only evidence at all contradictory to the above. Their vice-president makes the statement that the English boy is a real letter-writer—that he will "talk his little heart out and explain his little difficulties. Not so the American boy. The American boy cannot and does not write letters." The difficulty of the Meccano Company in getting as large a correspondence in America as they do in England may be due to an entirely different cause or set of causes. For one thing, the movement has been developed in England and has been designed to meet specifically the needs of the English boy. Then, too, Mr. Hornby is in England. Boys must send their letters there if they wish personal attention. Mr. Gilbert and Mr. Porter are not only Americans who have designed their toys from their knowledge of the American boy, but they aim to answer all communications personally. This means a great deal. On the average one boy in about four or five who owns a set will correspond.

Third, the letters divide themselves into four classes. There are letters of complaint (about 5 per cent), letters desiring information as to price, etc. (about 5 per cent), letters desiring scientific information (about 40 per cent), and letters describing new activities, inventions, new experiments, and interesting occurrences (about 50 per cent).

Fourth, the set of letters which the writer is using as basis for these figures are as nearly a random collection as one could get. Care was taken not to choose letters that were published in the magazines nor the "type" letters that manufacturers use for advertising purposes. In nearly every case they came from a folder out of the companies' index files. Finally, though the letters are very crude, they are also very genuine.

To the question, "Just what is there in these materials and activities which interests a boy?" the letters give the following typical replies:

(a) "I like to do things, make experiments, make things work and invent."	120	letters or	37%
(b) "I want to win a prize and get a Gilbert diploma."	76	" "	23%
(c) "I want to become an engineer (an inventor)"	64	" "	20%
(d) "I like to fool my friends and show them magic tricks"	31	" "	9%
(e) "I want to learn how to earn money"	11	" "	3%
(f) "I want to learn how to use tools and learn how things work"	6	" "	2%
(g) Miscellaneous specific ends	18	" "	6%
(h) Letters lacking in this information	106		
	432	"	100%

To the following question, "What are the usual difficulties that confront the boy while working with these materials?" the letters offer the following:

(a) Difficulties due to lack of knowledge	184	or	54%
(b) Difficulties due to lack of ability or technique	60	"	18%
(c) Difficulties due to "wild-cat" schemes	85	"	25%
(d) Difficulties due to pure accidents	11	"	3%
(e) Letters lacking this information	92		
	432		100%

To the question, "How does the boy usually overcome his difficulties?" the letters offer the following:

(a) By reading in books	30	or	11%
(b) Through parent or other help	21	"	8%
(c) Through hints from other boys' experiments	34	"	12%
(d) By "perseverance and experimenting"	91	"	33%
(e) Failures	101	"	36%
(f) Letters lacking this information	155		
	432		100%

In corroboration of the figures above, let us see how the 500 boys with whom the writer has had close contact, divide as to the three points for which the letters were analyzed:

First, as to type of motive or interest:

(a) Number who just liked to handle things and make things work	227	or	55%
(b) Number whose chief motive was some definite reward such as the Science Club medal, parent approbation, or Gilbert or Meccano prize	74	"	18%
(c) Number whose chief motive was some large ultimate end; such as becoming an engineer, an inventor, learning a good trade, etc.	66	"	16%
(d) Number whose chief urge was a very immediate end; such as mystifying their friends with some stunt, etc.	45	"	11%
	412		100%

Item (a) above is similar to item (a) in the analysis for the letters and the percentages in the two cases are 55 and 37. In each case this motive is the most frequent one.

Item (b) above is similar to item (b) in the first analysis and the percentages are 18 and 23. Item (c) above can be compared to items (c), (e) and (f). The percentages in each case are 16 and 25. Item (d) above shows a percentage of 11 as compared with 15 per cent for items (d) and (g) in the case of the letters.

Second, as to the type of difficulty:

From the minutes of four science clubs and from records of conferences with boys, the difficulties that boys usually encounter group themselves as follows:

(a) Difficulties due to lack of knowledge	177	or	62%
(b) Difficulties due to lack of ability or technique	66	"	23%
(c) Difficulties due to "wild-cat" schemes	37	"	13%
(d) Difficulties due to pure accidents	6	"	2%
	286		100%

Again it is interesting to note that more than half the difficulties that boys encounter in carrying out some of their projects are due to lack of knowledge or information. Lack of ability or lack of technique (it is hard to determine which it is in most cases) accounts for about one-fifth or one-quarter of the difficulties. About an equal portion is due to the highly imaginative type of boy whose wild, impractical schemes involve him in all sorts of difficulties that eventually discourage him, in 99 cases out of every 100. There was not included in this class of difficulties the type that confronts the very exceptional boy (the near-genius or genius) which difficulty may be caused by a problem which though essentially sound, is far beyond his present comprehension or his available means.

Third, as to how these difficulties are overcome:

(a) Needed information supplied through reading	41	or	15%
(b) Needed information supplied by parent, teacher, etc.	28	"	10%
(c) Inspiration from other experiments, such as teacher, friend, the book, etc.	52	"	19%
(d) Success through repeated experimenting	85	"	31%
(e) Failures	69	"	25%
	275		100%

Note that three-quarters of the cases recorded here, and two-thirds in the case of the letters, were cases of successful solutions to difficulties; successful, that is, in the eyes of the boys themselves; and in the sense that the boy felt that he had accomplished what he had set out to do. The figures also point to the large possibilities for the influencing of reading and of thinking which are offered by these self-initiated problems.

One other thing comes out very strikingly in a large proportion of the letters and also in the problems that the writer has recorded. Every time the boy solves a problem successfully he almost always has a new problem to tackle. Statements such as this occur very frequently. "Having made my motor operate my small crane and my grindstone, I am now going to turn my mother's sewing machine with it." Or, "Yesterday I tried out the suggestion you sent me about boiling the soap chemicals a long time, and it worked fine. Now I am going to make perfumed soap," etc., etc. When the boy is successful he not only enjoys himself thoroughly but keeps right on seeking new activities. When he fails, he is discouraged and his interest lags. To keep him interested and with their "long distance" method of reaching him, the companies have but one recourse, to make things so simple and so workable that even the less capable boy will feel that he is successful. The companies have as yet not developed any means of utilizing for educational purposes the many situations in which the boy is confronted by a very great or insurmountable difficulty. Perhaps that should not be expected of a commercial undertaking; and yet these situations offer just as great possibilities for the progress of the boy as his successes.

In addition to the major reactions hereto described, the writer wishes to list a great many minor reactions which are nevertheless quite important.

(1) According to the records kept, 212 boys performed the Chemcraft experiments in a random order, picking experiments from the last few pages before attempting to do the earlier experiments, and skipping around wherever their fancy led them. Only 32 boys were recorded as giving evidence that they were doing the experiments as listed in the manual. The large majority were oblivious of the effort of the manual to teach them the principles of chemistry.

(2) Quite a large number of boys tire very easily of the too-overt effort of the manuals to teach. This is true of all the manuals that are logically organized and that lay stress on the laws "which must be remembered." This does not interfere very long with their activity, however, for they soon learn that they can ignore the organization and do what they choose. Mr. A. C. Gilbert and men of his type are continually on the horns of a dilemma. Shall they make their appeal to the vast majority of their customers—the boys—who care only for workable experiments that they can enjoy? Or shall they surround their experiments and models with textual material (which will be read only by adults), thereby adding "dignity" to the outfit, and giving it an educational flavor?

(3) That the manuals do not function as they are intended to by the companies is strikingly illustrated in the Erector Manual, where it is quite essential for proper construction of the four-sided girder (the most important construction element in Erector) to follow instructions carefully. Mr. Gilbert complains bitterly that his boys are losing the real value of Erector by failing to learn from his directions how to construct a four-sided girder. With this type of girder he feels he can compete successfully with the Meccano.

(4) The average standing in the Science Club Point scheme (to be described later) of the 212 boys who did not follow the organization of the manuals was considerably higher than the standing of the 32 careful boys who rigidly observed instructions in the manuals. The average score for the former was 102 points and for the latter 76 points. The former were also richer in "inventions" and original experiments. The latter excelled to some degree in class assignments and written tests on class work.

(5) There are a considerable number of boys who find a new kind of interest in their outfit (particularly the Chemical and the Electrical) after they have played with it for six months or a year. By that time the alluring, sensational experiment has not its old appeal and there commences to develop a sounder interest in the whys and wherefores of phenomena. New relationships between experiments and phenomena to which he was oblivious during his early activity begin to appear; and he enjoys this newer knowledge quite as much as he did the old. Unfortunately the number of such boys is not large in comparison with the number who fail completely to react to the organization of the manual. But proper guidance at critical periods goes a long way to increasing the number who really develop an appreciation and understanding of the larger principles of science.

(6) The most popular type of construction for Meccano and Erector is an electrically operated derrick that can also ride on wheels. The element of motion has perhaps the greatest appeal to boys up to the age of 12. The whole

toy industry has up to a few years ago been built up on this psychological reaction of children to motion and to color. At the last annual Toy Fair held in New York City, 536 of the 1,000 companies exhibiting sold a product that sought to attract children by mere moving of wheels, etc., or by brightly painted objects. At the Toy Fair a year previous to the last one, there were more than 650 of such products out of an exhibit of about 900. It is encouraging to note from the above figures, and also from a perusal of toy trade journals, that manufacturers are beginning to apply this sensational appeal to "meaningful toys" instead of exploiting this reaction so peculiar to childhood. The movement toward science toys has perhaps been the greatest factor in this newer tendency. It was the most enlightening thing to toy manufacture to discover that although the rainbow colored pin-wheel was a great "seller" during the first few months of its business career, it was apt to "peter out" very soon, whereas the Gilbert type of toy, though it needed greater advertisement and a more educated buying public, tended to create a steady, stable, and permanent market—something that these manufacturers had never enjoyed. It became a paying proposition, then, to educate the public up to their product. As for the boy, he would much rather have a toy that will move something than one that will just move. He likes to take things apart, but enjoys a thousand times more to put them together again so that they work.

The topic of all-absorbing interest in all toy trade journals is the remarkable demand for mechanical and educational toys. Their conception of "educational" leaves a great deal to be desired, and a good deal of what is said is just advertisement talk; but a decided swing in the direction of toys with a meaning certainly exists. To a questionnaire sent out to toy dealers by one trade journal, more than 60 per cent. of the letters that came in reply contained some statement such as this: "There was a great demand for mechanical toys and parents show considerable interest in practical educational toys." More than half of the exhibitors at the last annual Toy Fair showed what might be classed as "scientific toys"; and more than half of the advertisements in the two leading toy journals are of toys based on a law or principle of science.

(7) In this connection it might be worth while to devote some space to recent developments in the toy industry in America. With the coming of the World War, German competition in this country was entirely removed. In 1913 toys were our second largest German import. After 1913, American manufacturers had practically a free field in which to develop. The same was true in England, France, Japan, Switzerland, and Italy. In every country of the world the opportunity was welcomed (in some cases by the government itself) to develop an industry which would not be dependent on Germany. To use the words of the brief filed with the United States Senate Committee by the Toy Manufacturers' Association in their plea for a high tariff rate on toys, "In closing, we ask you to put aside the volume of production, the invested capital, the number of employees, and to turn to the real reason for protecting American toys—their place in American homes, and their effect during the impressionable years on growing children. Toys are more than gifts for Christmas and birthdays. Childhood is impossible without play. Under modern conditions toys have become the means for play to most children. American toys must stay in American homes. There they will teach American ideals from the earliest years." In presenting the argument for American toys, the toy manufacturers point to their greatest value in contrast with the German toys. "Our most successful manufacturer today makes it a rule never to produce a toy which is only a 'jim-crack' and attracts because of its novelty. He requires that every toy he turns out shall bring joy to the kiddies who play with it and also leave upon the impressionable mind of the child something greater than the pleasure of the moment." The brief unfortunately does not tell what that "something greater" is, but it certainly leaves no doubt as to the difference in type of toy. In the last two years it seems that Germany has been flooding American markets with toys manufactured before the war,

which have been lying on wharves and in the holds of ships. American toy buyers have been taking the goods, much to the consternation of our manufacturers who are endeavoring to secure tariff legislation. No congressional action has as yet been taken, but already there are signs that the American boy has been educated away from the flimsy toy, and that high duties may not be needed to protect the American product. As far as can be discovered by the writer, there is no German toy that is analogous to the materials described in Chapter II, with the exception of a series of physics experiments, a description of which will be utilized to point out another very interesting reaction to these materials.

(8) It was mentioned before, in discussing Tables I and II, that the boy tires very quickly of a "specific toy" such as the fire engine, the "tank," or the battleship. They offer very little for the initiative of the boy, and very often cannot even be put together again if taken apart. They offer a very limited scope for the "original" activity of the boy; and although some are better than others, they do not compare with the "outfits" in the enthusiasm, effort, and thought they call forth, or the time spent on them. Furthermore, a good many of them, like the steam-engine, the battleship, and the phonograph, are rather expensive—especially the more workable kinds. Two notable exceptions to this reaction, both in the matter of expense and possibilities for activity are the camera and the electric battery, which rank very high in the estimation of the average boy.

Now the German physics experiment as a toy is similar to the "specific" toy of the American type. About 16 sets have been examined and tried out by the writer. Each set is contained in a box of ten compartments, with a little trinket in each compartment. With the set goes a manual, which describes in great detail just what the boy is to do with each trinket. There are sets on Light, on Sound, on Electrostatics, on Electric Induction, on Magnetism, on Hydraulics, etc., etc. Some subjects require two or more boxes of ten compartments each. The material is so designed that it is almost impossible for the boy to do very much else than what has been detailed out for him in the manual. The apparatus is very ingenious from the point of view of reducing school science apparatus to a miniature size, but it is extremely frail and breakable. It is also entirely lacking in the "fun" element. The German boy must be a much more serious animal than the American, because the writer has failed completely in getting his boys to "play" with it, even when the fact that they are German toys is kept a closely guarded secret. They are a source of amusement and keen interest when the teacher demonstrates the workings of the miniature apparatus, but the materials in themselves possess very little power to draw the boy or to make him handle them for any length of time. In fact, boys tend to class this type of apparatus with the steam-engine, the fire-engine, and the battleship, as being very "nice and interesting for a little while."

(9) The most popular type of chemistry experiment is that which has to do with gunpowder, flash-powder, and colored lights. The companies are making a concerted effort to discourage the boy from this type of activity, fearing that one fatality might ruin their business. Their efforts, however, have been unsuccessful. As yet no case approaching seriousness has been recorded. Page upon page of the Chemcraft Manual is devoted to subjects like Food Analysis, but boys will "pass them up" and concentrate on experiments with "sparklers," "explosions," and other startling effects. As nearly as the writer has been able to estimate, 60 per cent. of Chemcraft experimenters will react in this manner; the other 40 per cent. will show varying degrees of interest in Food Analysis, Paint Industry, Glass Manufacture, etc., etc., and varying degrees of lack of interest in "fireworks." It must also be pointed out that of the 60 per cent. there are a considerable number who eventually tire of this sensational type of experiment; and if they then do not leave Chemcraft entirely, they begin to show an increasing interest in other parts of the manual. Even if they desert Chemcraft, about half of

them return to it later on, with a much healthier interest in the toy.

(10) A most interesting toy reaction to some of the more recently developed sets and outfits of the Gilbert Co. is the readiness of the boy to criticize the impractical and unworkable features of the toy. In order to seize the market and be the pioneer in the movement, Gilbert put out in very rapid succession a whole array of new science sets that were not fully worked out; did not supply the boy with a full equipment and were not designed to meet conditions that confront the boy. The result has been a flood of complaints and what almost amounted to a boycott. The Gilbert Co. has recently appropriated $100,000 with which to improve their new products, but are finding it hard to overcome the prejudice against the few outfits which had been hastily developed. Thus the boys' reaction acts automatically to further continual improvement. Unfortunately there is as yet no control, automatic or otherwise, on the improvement of the strictly educational features.

CHAPTER V

THE PROBLEM ANALYZED

The great boom in mechanical and scientific toys which came in this country as one phase of the development of the toy industry, in the absence of German competition, brought with it a good deal of talk and literature on the subject of "Educational value." It was and is the chief "selling point" of every new development of the last five years. And it has proven to be a most lucrative method of advertisement. Men like Hornby and Gilbert have worked themselves into a frame of mind where they see in their products a great "boy movement" of untold educational possibilities. In Chapter II we quoted rather fully from the aims and ideals of Meccano, Erector, and Chemcraft. In each case the material was presented as a vehicle for educative entertainment. It is inherent in the nature of commercial advertisement to over-state, exaggerate, and make extravagant claims. It is unfortunately only too true that an unthinking public will accept these over-statements and exaggerations.

It is the purpose of this chapter to establish certain principles or criteria according to which these educational values can first be analyzed, and then measured.

First, let us see what the manufacturers feel to be the value of their toys—not the value of their product over that of someone else, but the intrinsic value of this material. Two types of statements are usually forthcoming; one emblazoned in their advertising circulars to parents and adults, and one to teachers, educators, and the sharply inquiring individual. "Meccano," says Hornby in one of his magazines, "is valuable because a knowledge of mechanical principles gained early in life is an asset that will count strongly in favor of the boy when he rubs against the real problems of later life." And again, "No boy can play with Meccano without being trained in the principles of mechanics and engineering." But talk to Hornby or his representative and ask him what he feels to be the value of his toy and he will tell you that he does not *know* whether all boys can learn the principles of mechanics, or whether all the principles of mechanics are involved, or how many boys actually learn some of these principles, or even whether they learn any at all. He will talk very assuredly about some things, and will preface most of his statements with "It is my profound belief," or "It is my positive conviction," etc. From the concrete evidence and personal experience which he does possess, he has ventured one positive statement: "The boy is interested, he is enthusiastic, and he is getting *real* experiences with things."

Gilbert is even more non-committal on the value of this type of toy. To a convention of toy buyers and manufacturers he will point, among other things, to the following basic ideals of his product:

(a) To instill into boys the spirit of leadership.
(b) To bring science down to a boys' understanding.

But Gilbert in a private conference will hasten to confess that he does not know what the *real* values of his toys are. He "feels" that they are worth while. He enjoys helping his boy correspondents. It keeps them out of mischief. They and also he are having lots of fun. And he proposes to go right on perfecting his toys, making them still more popular and in still greater demand.

Perhaps the most definite statement yet made as to educational value was made by H. M. Porter. In answer to a very direct question he says: "I believe that the principal educational value of Chemcraft lies in the fact that it makes chemistry interesting instead of a dry text book subject. It connects chemistry with tangible things which the boy and girl use and see every day of their lives. It tells them how to make many things; and by getting them thoroughly interested, they go ahead of their own accord and dig out the reason. A boy or girl who has used a Chemcraft outfit will take up a high school or college chemistry course from an entirely different standpoint than the boy or girl who knows nothing about the subject."

Without going into further details, it is clear that parents are being flooded with vague, exaggerated, and baseless claims for values that may or may not exist, or values that may or may not be values. It must be very emphatically pointed out that we have not yet been educated to the point where we will look upon the activities of the child when he is out of school with as critical a mind as we regard what he does while within the school walls. Furthermore, it is not quite clear how the various studies and researches which have developed our conception of curricular values can be applied to extra-curricular activities. So that even the parent who keenly awakes to the need of marshalling proper influences around the child at all times, has no criteria by which to judge or control the type of materials which are here considered. It is not uncommon to find the chief value of a toy to be the fact that it "helps keeps my boy out of mischief," or that it is "the safest and sanest thing I have yet bought," or "It is very inexpensive and absolutely noiseless." These expressions do not always bespeak unintelligence or lack of parental interest in the welfare of the child. It is a far greater indication of the failure to utilize for the development of the child certain forces that are as important as its "schooling."

Play, as a factor in education, is of course not new. Some of our leading educators throughout the ages have given it special thought. Plato was the first to give it prominence. And since Froebel wrote his "Occupations" we have had a long list of experimenters and writers on the subject. Spencer found as the chief function of play the fact that it furnished an outlet for the "surplus energy" of the human organism. Groos and Fiske looked upon play as "nature's method of education," as activity peculiar to "infancy" and of value in preparing for adult life. Later the above theories gave way to G. Stanley Hall's "race recapitulation" theory, and even this theory has been successfully attacked by writings of men like Dewey, who look upon play as being just one phase of the normal life of the child—important in its own right and worthy of being an end in itself. As Merriam puts it in his book on Child Life and Curriculum, "Education through play is a misconception and an abuse of play Play through education is a more valuable concept."

The tendency then among educational thinkers is to establish values for play activities that are in a different sphere or on a distinctly separate plane from curricular values. This may ultimately be developed in as detailed and thoroughly applicable a set of criteria as we have for curricular studies, but in the absence of these newer standards there can be no more valuable evaluation of the materials, activities, and reactions of Chapters II, III and IV than to compare and contrast them with activities of the classroom. Whatever the standards are that we apply to school work, how will the Meccano boy and the Gilbert boy measure when the same standards are applied to them? Obviously an answer to this question will orientate our problem, and is the very first question to settle, because it will determine to a large extent whatever else may follow.

The science activity that most nearly parallels play with science toys, especially for the boy of the age that we are considering, is the course in elementary or general science. A close study of the recent trend toward a first course in science brings to light one large aim from which the values of the study are to be derived. There has been considerable discussion and in many cases even bitter disagreement as to choice of content, its organization and method of instruction, but there has now evolved almost unanimous agreement that General Science or Elementary Science or the First Course in Science should aim to acquaint pupils with their environment. Other aims and especially their relative importance and desirable emphasis are still very much mooted questions, but that environmental science is the starting point for all writers of texts and framers of courses of study, there is now general agreement. In substantiation of this statement we have the expressed aims (as stated in their prefaces) of sixteen out of twenty authors of general science texts, studies such as that of Howe,* in which the opinions of teachers and educators are tabulated, opinions of hundreds of teachers with whom the writer has been in personal contact, and the recent N. E. A. Report on the Reorganization of Science in Secondary Schools. The chief worth of classroom science activity is the increased knowledge, appreciation, and control of the environment that it gives the boy. Environment is here taken in a very broad sense. The school environment, the home environment, the street environment, the newspapers, the theatre, etc., are all analyzed for the elements of science that they contain and materials and activities of the classroom take their origin in them.

Next to environmental knowledge and environmental control, there is greatest agreement on the proposition that we should

* Published in the General Science Quarterly for May, 1918.

teach science so as to enable our pupils to appreciate the method of science and to use this method and the thinking procedure of science in their every-day lives. Obviously there are several aims involved in the proposition. Some of our leading educators in science teaching, who realize the limitation of a beginner's course in science, are content if this course but serves to inspire boys and girls to further study of science. Eventually the value or values sought are the habituation of the individual to the greater use of scientific thinking and experimenting, and possibly the development of those individuals who can contribute to the advancement of science in the way of discovery and invention.

To these two groups of major aims from which evaluation proceeds, there are usually put forward other aims which, though very important, have not received the same degree of general approval. General or Elementary Science is taught for its civic value, for its vocational value, for its avocational or cultural value, and for the enthusiasm and interest which it arouses in a large proportion of any class: civic value, because of the large number of commercial, city, state, and national functions that are intimately tied up with the practical applications of scientific laws and principles; vocational value, because of the inspiration that frequently comes to a boy or girl to choose some field of science as a life work due to the discovery of an "original" talent. This discovery usually comes through contact with the materials and activities of the science course. Avocational value is claimed because of the larger applications which are made possible by a study of science. The universe, the heavenly bodies, the forces of nature, all offer real esthetic experiences that are heightened by a keener understanding of them. And, of course, science has been the source of the greatest proportion of life hobbies of the more genuine kind. Finally, the mere enthusiasm evoked by well-conducted courses in science is always a desirable characteristic about a pupil because it furnishes a hold on him which can be utilized in many ways to further the general efficiency of instruction.

Accepting the above analysis of aims and their corresponding values for curricular science—especially that science which is commonly given to a boy during his "toy age"—it is proposed to also adopt the analysis for extra-curricular science. To recapitulate, and in terms of our after-school materials, the criteria which give a science activity value are these:

(a) Does it make for an effective increase in the knowledge of the science of our environment and of its control? That is, does playing with toys help a boy to know better—

what things are
why things happen
how things work
how things are made and
how things are used?

Does it also give one greater skill in—

using things and
making things?

(b) Does it increase his ability to construct? That is, does it make him more adept at manipulating things, and does it increase his ability to fashion raw materials into usable things?

(c) Does it make for experimentation and inventiveness? That is, does it inspire the boy to experiment, to try out new things, new ideas, new combinations, and to test these ideas in experience?

(d) Does it have vocational value? First, will it inspire one to further study of science? And, second, will it inspire one to take up a certain vocation?

(e) Does it have civic value?

(f) Does it have avocational value?

(g) Does it involve an attitude or spirit of work? That is, in accord with—

(i) Dewey's "Interest and Effort"
(ii) Thorndike's "Mental Set or Attitude"
(iii) Kilpatrick's "Purposeful Activity"?

In setting up what are virtually curricular standards for extra-curricular activities, we must keep in mind that we cannot expect to measure all the value or values that the latter activities may have. There are a whole sphere of values that we cannot begin to measure with our criteria. It is also within the realms of possibility that what possesses value according to one set of standards is decidedly lacking in value according to the other set. If a German subject in the year 1913 were measured as to his qualifications for American citizenship, he would most likely be scored low in some characteristics in which he scored high as a German; and he would possess some qualities in which America would have no interest, and others of keen interest to her in which he would be lacking. On the other hand, if the same individual be measured for his qualities as a "human being," the criteria set up would certainly be different, but not at all the same as the German criteria set up for the same purpose. Obviously the German concept of "human being" would be a German human being, and that of the American, an American. Without forcing the analogy, it must be pointed out that our evaluation of the second sphere of activity in terms of the first does not necessarily imply that such measurement will determine completely its worthwhileness or even indicate lines of improvement or of development. Only in so far as both types of activity can adopt similar criteria will our analysis furnish conclusive tests. To what extent the criteria previously outlined satisfy this condition it is difficult to say; but even if their origin lies in curricular activity, they involve to a large extent certain general forces making for the development of the boy. The analysis adopted offers more promise than would a set of criteria evolving from considerations of the extra-curricular level alone.

Once having established values according to our set of measures, it might then become profitable to inquire whether science play materials

(a) enable boys to "play" better
(b) give him more "fun"
(c) offer him more "wholesome" activities
(d) solve successful certain home-parent problems and any other criteria on this same level of evaluation.

In previous chapters were described four types of Toy "Outfits" (Mechanical, Chemical, Electrical, and Sets for Special Purposes), Specific Toys (about seventeen), certain propaganda of the manufacturers, and there were briefly mentioned, the after-school activities with Reading Materials, agencies involving science materials and the Science Club. In all, we have nine large types of materials or activities. In this chapter eight criteria were proposed, which, if applied to each of the nine above mentioned, would result in 72 conclusions, as numbered in the following table:

Materials and Activities	Environmental Knowledge (a)	Control (b)	Constructive Ability	Experimentiveness	Vocational Value	Civic Value	Avocational Value	Attitude
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
I. Meccano-Erector	1	10	19	28	(37)	(46)	(55)	64
II. Chemcraft, etc..	2	11	20	29	(38)	(47)	(56)	65
III. Electrical Outfits	3	12	21	30	(39)	(48)	(57)	66
IV. Special Outfits..	4	13	22	31	(40)	(49)	(58)	67
V. Specific Toys ...	5	14	23	32	(41)	(50)	(59)	68
VI. Propaganda Activities	6	15	24	33	(42)	(51)	(60)	69
VII. Reading Materials.	(7)	(16)	(25)	(34)	(43)	(52)	(61)	(70)
VIII. Educational Agencies	(8)	(17)	(26)	(35)	(44)	(53)	(62)	(71)
IX. Science Club	9	18	27	36	(45)	(54)	(63)	72

As has been mentioned before, this study has, as yet, not been extended to include row VII or row VIII*; nor has it dealt with

* As regards the value of reading materials, the writer has been able to collect a large list of books that are read to a greater or less extent as novels are read—after school. A rough evaluaton was found possible from the judgments and experiences of about 100 teachers. In the case of magazines, the writer has been editing for one of the magazines (*The Popular Science Monthly*) a monthly Service Sheet for Teachers in which sheets the science material is so organized as to be applicable to (and to function in) the curricular and extra-curricular phases of the general science course.

In the case of the educational agencies that involve science materials and actvities, only the moving pictures were investigated to any degree. And in this case a typical film was tested objectively by the procedure which is described in Chapter Six.

None of this, however, is being submitted in this report.

the criteria of columns (e), (f), and (g). These imposed limitations will reduce our possible conclusions to the items numbered and not enclosed in parenthesis. Other limitations inherent in the study concern themselves with the procedure used in applying the criteria. It has not always been found possible to treat all items experimentally and with objective measurements. This was the case in all the items of columns (d) and (h) and in all the items of row IX. The details of procedure are described fully in the chapter that follows.

CHAPTER VI

THE PROCEDURE USED

In the Speyer School experiment of 1916 to 1918 the science teachers found themselves in the unfortunate position of having to teach their subject without either laboratory facilities or equipment of any sort. It is a fact hard to believe but only too true. Not even a piece of glass tubing graced the shelves of the former cooking pantry which had been turned over to the science department. This almost unheard of condition necessitated heroic measures. The exceptional circumstances brought about exceptional methods of procedure, with the result that all recognized "curricular" principles of teaching had to be abandoned. Force of circumstance focused the attention of the teachers on the activity that was going on among the boys out of school. In order to keep from drowning in a sea of difficulties they grasped at a solution which the boys themselves offered, as for the proverbial straw. It took two years to build an equipment and a makeshift laboratory. And what an equipment it was! Dozens and dozens of junk rooms were despoiled of their discards; old broken toys that boys donated; crude apparatus built by pupils at home out of tin cans and cigar boxes, and shelf upon shelf of scientific toys and outfits, loaned to the teacher for a term or two by enthusiastic and generous boys.

It was the most enlightening two years the writer has ever spent. Long afternoons devoted to planning and preparing for the work of the next day brought to light the inner urgings of the boy; for the latter took full part in these plannings and preparations. Gradually a program evolved, based on what might be termed the "extra-curricular" spirit.

The method of class instruction was a form of socialized recitation which has been described at length by the writer in articles printed in the General Science Quarterly for May 1918, and May 1919. The content of the course was virtually the materials of Chapter II. The two years were a period of enforced experimentation with science activities of all types, originating in the after-school interests of the boy. Though no organized effort was made to measure the actual value of this activity, it was carefully watched and studied. In the beginning the situation compelled a liberal amount of freedom for the pupils in their choice of subject matter; and as the work developed no cause appeared for withdrawing this freedom in any large way. When guidance and control became necessary it was found that an after-school organization—a science club—was very effective. The net result of the two years was a crystallization of a class procedure that correlated with a program of after-school activities in science, a discovery of the well-springs of the boy's enthusiasm and a realization that what goes on outside of our classroom walls under the guise of "play" is of tremendous significance in the development (education) of the boy.

In the year which followed, this time in the Horace Mann School, the experiences of the Speyer School were checked up and verified. In the main the problems were the same, with the "extra-curricular" activities more predominant, if anything. The analysis of the foregoing chapter and the necessity for objective measurement came at this stage and concerned itself with the last two years in the Horace Mann School.

In measuring the extra-curricular in terms of the curricular we are comparing an activity about which we know relatively little with an activity about which we know a good deal. Thus, in the case of class-teaching, we know accurately the amount of time spent, the materials used, the nature of the reviews, the questions asked, the reaction produced, the effort evoked and a fairly reliable measure of accomplishment. In the case of the extra-curricular we know of these things in a vague way, if at all. The whole of Chapter IV was devoted to a description of the variable nature of "after-school" reactions to science materials. Furthermore, we have no way of knowing the extent to which other factors, in addition to the boy and his materials, enter into the problem. How much parent control is there? What is the effect of the back and forth questioning and suggesting that may go on between father and son or brother and brother? What influence has the physical environment of the home? And other factors of a similar nature.

The first essential, then, was to bring this activity under as close observation as was the class-work in science and yet not deaden its spontaneity in any way. This was accomplished by means of a well-organized science club with a program of activities that brought the boys into the school for some of their "play."

A second essential was a common ground; that is, a common body of content, so that the comparison would be a fair one. This raised a serious problem. To teach the things that boys will play with is to introduce a control on teaching that may work to its disadvantage. To make boys play with the things they are taught (if that were possible) would be to destroy completely the "play." To solve the problem two procedures were adopted. During 1919-1920 the play was permitted to go on uncontrolled, as was the teaching. At the end of the year a good deal of overlapping was found to exist. Tests based on this overlapping material were used as a means of measurement. During 1920-1921 a series of play units were chosen on the basis of the most popular toys as determined in Chapter IV, and the entire course of study for the year's teaching was developed from these play units. Thus the teaching was "controlled," as was also the play to a lesser extent and the tests given were entirely on an identical body of content.

During the two years the comparisons drawn were among four groups of almost equal mental age and I. Q.* Group A in both cases had not only the teaching but also the play. Group B had only the teaching. Group C had only the play, and Group D had neither. The last group was introduced as a control group. A peculiar arrangement of the school program facilitated the selections of these different groups. The sixth grade boys have science and industrial arts scheduled as a regular subject. About half of them join the club and half of them do not. Thus Groups A and B were obtained; for they both had science instruction and only the one had play activities. Also, most of the 5th grade boys do not have science and industrial arts scheduled regularly. From those who joined the club Group C was formed and those who did not, Group D. It is to be noted, also, that Groups A and B

*Groups C and D were drawn from the 5th grade, whereas Groups A and B were drawn from the 6th grade. Thus the former were on the average one year mental age younger than the latter.

received identical instruction, most of them coming as one class; and Groups A and C received their play together, all of them attending club at the same time.

During 1920-1921 the total amount of time spent on teaching was twenty periods of 30 minutes each and twenty periods of 15 minutes each, allowing forty-five minutes during each week of the school year up till the end of March. The time allotted to play was a thirty-five to forty-five minute period a week for 20 weeks.

The character and method of both the play and the teaching are significant. First as to the play. A large chart was prepared listing the club members vertically and the twenty play units horizontally. By the end of March each square in the chart was checked, indicating that each member of Groups A and C had participated in at least these twenty units of activity. There being about 50 boys in the two groups, it was impossible to permit them all to work or rather play at the same time. Fifteen was usually the maximum number that were present at one time in the Science Play Shop. No bonus or reward was offered for this activity. They came on practically every afternoon of the week and of their own volition. When a boy came into the shop to "play" he was asked to choose any particular unit he wished, that he hadn't already played with before. The choice being made, he was handed a card and a box of materials to play with. Now, it was found that to throw a piece of equipment in the way of a boy brings forth reactions that of course vary with the boy; but when the things ten or twenty of them will do with a given toy are all listed there are always about four or five manipulations that are common. These common manipulations or stunts—the minimum number of essential reactions—were previously determined by closely watching and recording what fifteen boys would do with each of the 20 units. These minimums were suggested to the boy on the card that went with his box of materials. The card then served two purposes. First, it listed the materials which he was to find, and second, it suggested certain possibilities (without telling him how to accomplish them) and also gave him a stimulus to work some original "stunts" with the apparatus. The chief function of the card was to prevent floundering and waste of time.

As regards the kind of equipment, most of it was taken from the commercial toy outfits; so as to try out the workableness of the material. In a few cases commercial apparatus was used; but always where there were no essential differences between the apparatus used in the Play Shop and the kind bought from Gilbert, for example. Also, in a few cases the apparatus was "home-made."

The spirit of the play was genuine throughout. Not only did the boys come of their own volition and for no further rewards than the activity itself, but they would stay as long as they could before being put out.

One of the greatest difficulties encountered by the instructor was the tendency for the play period to become a laboratory period in the high school sense. In this situation the teacher or the manual issues orders and the boys follow blindly. Occasionally they run up with a question and go back to their apparatus for more study. The teacher, too, supervises very closely, criticizing, admonishing, lecturing, and helping. In our case we can not, of course, object to the laboratory method; but if it is to be play as it occurs at home, the boy must be left pretty completely to his own resources. It was for this reason that the instructor made no attempt to answer questions, give suggestions, or aid in any way. He sat in the room, of course, and made sure that the dozen boys did not interfere with each other, did not attempt any dangerous procedure, and saw to it that necessary materials were forthcoming. The boys understood that sometime during the week they could see their instructor during recess and discuss with him any of their problems and proposed projects, just as they could bring to him problems and projects arising out of their class work, their home study, or any other source.* This procedure was strange in the beginning; but the boys soon became habituated to it and oblivious to any person or thing in the room not connected with their immediate task.

The card became very important in the successful carrying on of these play periods. It will be of interest to print some of them in brief form, omitting from all except the first everything but the "Things to Do."

PLAYING WITH BATTERIES AND LIGHTS

"You need the following list of materials. You will find them in a labelled box in the large cabinet. If all the materials are not there ask the sergeant-at-arms or Mr. Meister."

1. Two batteries
2. Two small bulbs
3. Two small sockets
4. A spool of wire
5. A push-button
6. A small screw-driver
7. A pair of pliers

"In the list below are some things which other boys before you have done with this material. You might try to see if you too can do them. But there are many other things possible than just the ones listed below. If you can think up and work out some new 'stunts' or 'inventions' you will be allowed to present them at the next meeting of the Club."

Things to Do:—

1. Light a bulb with the two batteries connected in series.
2. Light a bulb with the two batteries connected in parallel.
3. Light the two bulbs connected in series.
4. Light the two bulbs connected in parallel.
5. Press the button and light both lights dim.
6. Press and light them bright.
7. Connect so that pressing button makes one lamp dim and the other bright.
8. Connect so that pressing button puts lights out.

PLAYING WITH A MOTOR

Things to Do:—

1. Run the motor, using a bar magnet.
2. Reverse the motor.
3. Take it apart and put it together again.
4. Make new brushes.*
5. Make the motor do some work.

*In the Play Shop there are always kept a number of helpful books on science. When a boy is "stumped" he is encouraged to "dig out" the necessary help from the book, if possible.

PLAYING WITH A CHEMICAL BATTERY

Things to Do:—

1. Break open an old used-up battery. (Save the zinc cup and the carbon rod.)
2. Dissolve the sal-ammoniac in the cup and make a new battery.
3. Ring bells, light lights and run motors with the battery made.
4. If it doesn't last long, increase its length of life.
5. Bring an old battery to life.

PLAYING WITH WIRELESS

Things to Do:—

1. Get sparks from the induction coil.
2. Wire up the sending set.
3. Wire up the receiving set.
4. Send code messages.
5. Let your partner put faults in the wiring and you discover them and fix them. Do the same for your partner.

PLAYING WITH THE TELEGRAPH

Things to Do:—

1. Make the sounder work.
2. Make it work with the key.
3. Stretch the wires and connect.
4. Learn the code and send and receive messages.
5. Fix up faults that your partner puts into the connections and then do the same for your partner.

PLAYING WITH THE DYNAMO PLANT

Things to Do:—

1. Generate enough current to ring a bell, and light a light.
2. Wire up a five-room house and supply it with current.
3. Short-circuit the dynamo.
4. Generate current which will turn a motor and attach belt from motor to dynamo.

PLAYING WITH MAGNETS

Things to Do:—

1. Make the compass needle spin around by bringing a bar magnet near.

*In all cases where a boy does not know the meaning of some technical term or the name of a part, he can ask the instructor.

2. Lift nails and iron filings through paper and through glass.
3. String as many nails as you can on the end of a magnet.
4. Make a needle into a magnet.
5. Make an iron nail into an electromagnet.
6. Make a floating needle compass by sticking a magnetized needle through a piece of cork.
7. Destroy the magnetism which the needle has.

PLAYING WITH THE RAILROAD OUTFIT

Things to Do:—

1. Run the engine alone.
2. Reverse it.
3. Attach the cars and run the engine.
4. Reverse the engine.
5. Carry the heaviest load possible.
6. Climb the steepest hill possible.
7. Go as fast as you can around the curves.

PLAYING WITH THE CAMERA

Things to Do:—

1. Take the lenses out and put them in again.
2. Focus the room electric light on a sheet of paper with the camera lens.
3. Take the finder apart and put it together again.
4. Take a picture of your work bench.
5. Make a pin-hole camera.

PLAYING WITH THE STEAM ENGINE

Things to Do:—

1. Get up steam by using a candle flame as the source of heat.
2. Get up steam by using a bunsen burner.
3. Operate the engine.
4. Blow the steam whistle.
5. Run the drive-shaft with the engine, thereby operating a motor, a generator, a grindstone and a pump.

PLAYING WITH A MAGIC LANTERN

Things to Do:—

1. Assemble the different parts of our cardboard slide-machine.
2. Operate the small post-card projector which uses a battery lamp as the source of light.
3. Connect up the real machine.
4. Get the proper focus at different distances.
5. Show pictures as small as possible and as large as possible.

PLAYING WITH SPRING MOTOR TOYS

Things to Do:—

1. Operate the "Tank," the Battleship, the Motor Boat, the Automobile, the Railroad Engine and the Submarine.
2. See how long each runs with one winding.
3. Try to put a brake on the different engines by holding back each gear-wheel in turn.
4. Count the number of gears and the number of teeth in each.

PLAYING WITH MECCANO AND ERECTOR

On this card the boy was told to make at least three Meccano models and three Erector models. One of each he had to do in the shop; the other four he could do at home and bring to club. It was not difficult to get boys to construct models which involved the principles of

(a) the wheel and axle
(b) the pulley
(c) the lever
(d) the screw
(e) the crank
(f) belt drives
(g) gear arrangements for special reduction

PLAYING WITH CHEMCRAFT

The manual served in the place of a card. Typical units were chosen which in addition to being among the more popular and more workable experiments were also illustrative of

(a) factual chemistry; that is, chemical knowledge and information and first-hand experiences with chemical phenomena.

(b) larger principles; that is, certain relationships existing between many of the phenomena and experiences that might eventuate in the laws of chemical science.

In the first group, the play exercises consisted of the following:

1. Oxygen and Burning
2. Hydrogen
3. Carbon Dioxide
4. Glass
5. Soap
6. Fireworks

In the second group, the play units consisted of experiments 1 to 20, in which are treated the general ideas of neutralization (acids, bases and alkalis), combination of elements, decomposition and displacement of elements.

To recapitulate, the extra-curricular training for 1920-1921 consisted of the following:

1. Batteries and Lights
2. The Electric Motor
3. The Electric Battery
4. Wireless
5. The Telegraph
6. The Electric Power Plant
7. Magnets
8. The Railroad Outfit
9. The Camera
10. The Thermometer
11. The Steam Engine
12. The Magic Lantern
13. Spring Motor Toys
14. The Phonograph
15. The Shocking Machine
16. Meccano and Erector
17. Chemcraft
18. Chemcraft
19. Chemcraft
20. Chemcraft

Upon these items was based the year's course of study. Groups A and B, who received the instruction, met with their teacher forty times. The organization of the material was necessarily different from the list above. The material was first graded for difficulty and then grouped; so that oft-recurring principles could be presented early in the course. The units, however, were not merged. The sequence of topics was roughly as follows: Batteries, magnets, the telegraph, the electric light, the motor, the railroad engine, Faraday's experiment (dynamo), the shocking machine, wireless, the magic lantern, the camera and photography, the thermometer, the steam-engine, oxygen, hydrogen, carbon dioxide, and the mechanical principles involved in Meccano and Erector constructions. Each lesson was a fully developed teaching unit, involving apparatus, demonstrations, class discussions, pupil reports, home assignments, reviews, note-book work and quizzes.

The class-work, in every way but one, was typical of the usual curricular situation. The tendency to digress into other related topics and fields of science was carefully checked so that there would be time enough for all twenty units. As it was, several of the play units were omitted because of lack of time. In the ordinary teaching situation there would be less mechanism; that is, with children of this particular age. In the case of the average high school science course, however, there is just as much if not greater adherence to a rigid program. It is significant to note that more content was covered per unit of time by the extra-curricular than by the curricular.

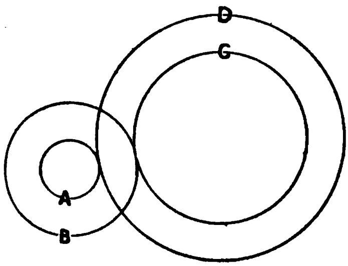
During the year 1919-1920 there were in all ten units of overlapping content between the curricular and the extra-curricular. These ten were the telegraph, the telephone, magnets, oxygen, carbon dioxide, the camera, the phonograph, the battery, pulleys and gearing arrangements. At the end of the year four types of uniform tests were given to Groups A, B, and C. (The schedule did not permit of giving these tests to Group D.) There was first the traditional type of test that teachers usually give to find out what knowledge their pupils have carried away. Second, a test was arranged in which a series of phenomena were enacted before the class. Twenty phenomena were chosen (roughly two from each of the ten units) which involved the essential knowledge or appreciations of the overlapping material for the year. By means of apparatus the examiner performs, one after another, each of the twenty experiments. After each experiment the class is given two minutes in which to write their explanation and understanding of what they have seen. A third type of test was a practical or manipulatory test. In this each pupil is asked to do ten tasks with actual apparatus. Again, these tasks were based on the ten "overlapping" units. Finally, as a measure of constructive ability, the Stenquist Box Test was used both at the beginning of the year and at the end.

FINAL TEST—TRADITIONAL TYPE—1919-1920

1. Who invented the telegraph?
2. Name the important parts of the telegraph.
3. Explain how each part you have named above works. (Use a diagram, if you wish, to help you explain.)
4. Make a diagram showing how the different parts must be connected in order to send a message from one city to another.
5. Explain what is meant by using "a ground" as one of the wires.
6. Who invented the telephone?
7. Name the important parts of a simple telephone.
8. Explain how each part you have named above, works. (Use a diagram, if you wish, to help you explain.)
9. Make a diagram showing how the different parts must be connected in order that two persons may talk to each other over a short distance.
10. Why does the simple telephone fail over very long distances?
11. What improvement has been invented which enables us to use the telephone for long distances?
12. Explain why two telephone receivers when connected together, can be used as a telephone (to talk through and to listen to) over short distances.
13. What is the purpose of the "receiver-hook"?
14. What is a lodestone?
15. What is the difference between a permanent magnet and a temporary magnet?
16. What is the advantage in bending magnets into a horseshoe shape?
17. What is there in a compass which enables us to tell directions? Explain.
18. Explain how you would make a magnet out of a piece of iron.
19. How would you increase the strength of a soft-iron magnet?
20. Why does it hurt a watch to keep it in the presence of strong magnets?
21. How could you make a permanent magnet lose its magnetism?
22. What portion of the air is oxygen?
23. Where do we get our supply of oxygen?
24. Give all the reasons you can why oxygen is so important in our lives.

25. Describe how we made oxygen. (Make a diagram to show how we collected the oxygen.)
26. What happens when a piece of wood with a glowing spark is thrust into a bottle of pure oxygen?
27. What would happen to a human being if confined in a room full of pure oxygen?
28. Explain what happens when a piece of iron rusts.
29. Make a drawing showing how a pin-hole camera can form a picture.
30. How can the picture made by a pin-hole camera be made larger or smaller?
31. How does a lens instead of a pin-hole improve the camera?
32. What serves as the film in the case of the pin-hole camera?
33. Name the important parts of a kodak folding-camera.
34. Make a drawing showing how the "finder" works.
35. Explain the purpose of the "M-F" scale.
36. Explain the purpose of the "25-50-100-B.T." scale.
37. Explain the purpose of the "4-8-16-32-64" scale.
38. What differences are there between the camera and the human eye?
39. Name the important parts of the phonograph.
40. Explain how a song is recorded.
41. Has every phonograph a horn? What is the purpose of the horn?
42. What furnishes the power to turn the platform?
43. What keeps the platform turning steadily?
44. Explain why it is necessary to keep the platform turning steadily.
45. Explain why long needles are called "soft needles" and short ones "loud."
46. Why can Edison records not be played on all machines?
47. What do you find in a used-up battery when you break it open?
48. What differences, if any, would you find inside of a battery that is not used-up?
49. Explain how the current in a battery is made.
50. What happens inside the battery when all the current is used up?
51. What is meant by "short-circuiting" a battery? Explain what happens inside the battery.
52. What is the voltage of a battery?
53. How many amperes can a new battery give?
54. What are pulleys? How are they used?
55. With one pulley fixed to the ceiling and one attached to a table weighing 100 pounds, how much pull will it take to keep the table moving upwards?
56. With two pulleys attached to the table and two to the ceiling, what would the pull be?
57. How far up would the table go in the case of the double pulleys when 12 feet of rope lay coiled at your feet?

58. How could one man by means of pulleys hold his own in a tug-of-war against ten men each as strong as himself?



A and B turn together
A=10 teeth
B=36 teeth
C=12 teeth
D=40 teeth

59. If B turns around 10 times a minute, how fast does C turn?
60. How fast does D turn?
61. Which wheel gives the greatest power?
62. How would you gear a motor that you wished to use as an electric fan?
63. How would you gear a motor that you wished to turn a grindstone with?
64. What portion of the air is carbon dioxide?
65. Where does the supply of carbon dioxide come from?
66. Where does this supply go to?
67. What happens when a burning piece of wood is thrust into a bottle full of carbon dioxide?
68. Describe how we made carbon dioxide. (Make a diagram to show how we collected the carbon dioxide.)
69. How does the fire-extinguisher put out a fire?
70. How is this gas used in the process of making bread?

Time Allowed: 3 periods of 1 hour and 5 minutes each
An average of 3 minutes on each question

FINAL TEST—VISUAL TYPE—1919-1920

1. A wire is wound around a large iron nail. The nail is stuck down into a box of tacks. It is brought out again without any tacks sticking to it. Then a battery is connected to the coil of wire and it exhibits strong magnetic properties when stuck into the box of tacks.
2. A magnet is allowed to pick up a nail. To the nail another nail is touched. The second nail is held fast. To the second a third is attached, and so on until the magnetic induction effect becomes too weak to hold any more nails.
3. Faraday's experiment, of generating electricity by moving a magnet in the presence of a coil of wire.
4. A transmitter and a receiver are connected without a battery.
5. A pivoted compass needle is caused to jump away when a magnet is brought near.
6. A knitting needle is rubbed on a magnet.

7. A burning candle, placed in a shallow pan in which there is about one inch of water, is extinguished by covering it with a glass. The water rises up into the glass to a higher level than in the pan.
8. A glowing ember is inserted into a bottle of oxygen.
9. The windows of the room are focussed on the wall by a large reading glass.
10. A camera is focussed as for taking a picture.
11. While a phonograph is playing the speed of the platform is altered.
12. A phonograph record is played by inserting the sharp corner of a large sheet of tin.
13. A battery is short-circuited.
14. A totally used-up battery is exhibited.
15. A pulley arrangement is shown in which one weight balances two weights equal to its own weight.
16. To start the above pulley arrangement moving a small additional weight is added to one side.
17. A grindstone is exhibited showing the gear arrangement.
18. A Meccano distance indicator is exhibited.
19. Carbon Dioxide gas is poured over a lighted candle.
20. Breathe into a jar of lime-water through a glass tube.

Time Allowed: One Hour.

FINAL TEST—PRACTICAL TYPE—1919-1920

1. Boy is told to repair a telegraph set which has been put out of order.
2. Ditto with a telephone system.
3. He is given two magnets, one with poles marked and one blank. He is told to determine which end of the blank magnet is north and which is south.
4. He is presented with five bottles containing different gases: air, illuminating gas, illuminating gas and air, carbon dioxide and oxygen. He is to determine the contents of each bottle.
5. He is told to adjust a camera for taking a time exposure of a certain object.
6. He is told to put together a phonograph which has been taken apart.
7. He is told to make a battery. The necessary parts are available.
8. He is told to arrange a set of pulleys so that one weight will lift four times its own weight.
9. He is given the gears that control the motion of the hands of a clock and told to arrange them so as to obtain the 12 to 1 ratio in speeds.
10. He is told to make a bottle of carbon dioxide. The necessary materials are available.

Time allowed: One hour and fifteen minutes.

During 1920-1921 similar tests were devised on the basis of the larger number of units common to both the play and the teaching. The number of questions per topic was reduced somewhat in order to avoid making the written examination last too long. In all there were three to five questions for each unit, making in all eighty questions. Three periods were used for the test, allowing, as before, two to three minutes for each question. The questions were as follows:

FINAL TEST TRADITIONAL TYPE—1920-1921

1. Make a diagram showing how you would connect six batteries in series. Make another, connecting them in parallel.
2. How many volts would the first connection give you? The second?
3. Make a diagram showing how you would connect six 3-volt lamps so that they burn properly on ten batteries.
4. Which wire will get hottest, a copper wire one-sixteenth inch thick and two feet long, or an iron wire one-sixteenth inch thick and three feet long, or a nichrome wire one-eighth inch thick and 100 feet long?
5. On what three things does the resistance of a wire depend?
6. Describe Faraday's experiment.
7. Name the parts of a dynamo.
8. Make a drawing showing how these parts are connected.
9. What change would you make in a direct current dynamo if you wished it to generate alternating current? Why?
10. What is the difference between a dynamo and a motor?
11. What would you need to do to make a motor generate electricity?
12. Why is it impossible for a motor to be driving a dynamo and the current thus generated to be used to drive the motor?
13. Explain why a motor turns.
14. Make a list of all the necessary steps to be taken in making a thermometer.
15. Why must the mercury or kerosene be boiled in the process?
16. 68° F. is equal to what temperature on the C. scale?
17. What do you find in a used-up battery when you break it open?
18. What differences, if any, would you find in a battery that is not used up?
19. Explain how a battery is made.
20. What happens inside a battery when all its current is used up?
21. What is meant by "short-circuiting" a battery? What happens inside?
22. What is the voltage of a battery?
23. How many amperes can a new battery give?
24. Make a drawing showing how a pin-hole camera can form a picture.
25. How does a lens instead of a pin-hole improve the camera?
26. What serves as the film in case of the pin-hole camera?
28. Make a drawing showing how the "finder" works.
29. List all the necessary steps in snapping a picture. Give reasons for each step.
30. Explain how pictures are developed.
31. How are wireless waves sent out?

32. How are wireless messages received?
33. Name the important parts of a telegraph system.
34. Make a diagram showing how the different parts are connected so that the complete system can operate.
35. Explain what is meant by using a "ground" as one of the wires.
36. What is the difference between a temporary magnet and a permanent magnet?
37. Explain how a compass operates in enabling one to tell where "north" is.
38. Give two ways in which a piece of steel can be magnetized.
39. Give two ways in which a steel magnet can be destroyed.
40. Why does it hurt a watch to keep it in the presence of a strong magnet?
41. What portion of the air is oxgyen?
42. Where do we get our supply of oxygen?
43. Describe how we made oxygen. (Make a diagram to show how we collected the gas.)
44. What happens when a glowing spark on a piece of wood is thrust into a bottle of oxygen?
45. What would happen to a human being if confined in a room full of pure oxygen?
46. Explain what happens when a piece of iron rusts.
47. Where does hydrogen come from?
48. What is it used for?
49. When will hydrogen burn?
50. What is formed when hydrogen burns?
51. How is hydrogen made?
52. What is "peroxide"?
53. Where does the supply of carbon dioxide come from?
54. How can it be made?
55. What happens when a burning piece of wood is thrust into a bottle of carbon dioxide?
56. How is this gas used in bread-making?
57. How is it used in vichy or other soft drinks?
58. How is it used by plants?
59. What are pulleys? Why are they used?
60. With one pulley fixed to the ceiling and one attached to a table weighing 100 lbs., how much pull will it take to keep the table moving upwards?
61. With two pulleys attached to the table and two to the ceiling what would the pull be?
62. How far up would the table go in the case of the double pulleys when twelve feet of rope lay coiled on the floor?
63. Show in a diagram how, by means of pulleys, one man can hold his own in a tug-of-war against ten men each as strong as himself?
64. See questions 59 to 63, inclusive, of the 1919-1920 list.
65. See questions 59 to 63, inclusive, of the 1919-1920 list.

66. See questions 59 to 63, inclusive, of the 1919-1920 list.
67. See questions 59 to 63, inclusive, of the 1919-1920 list.
68. See questions 59 to 63, inclusive, of the 1919-1920 list.
69. Why do trains slow down when going round curves?
70. Make a diagram showing a dynamo, trolley tracks, trolley-wire, trolley car motor, and how they are all connected.
71. Why are not birds shocked to death when they alight on the bare trolley wire?
72. What supplies the energy with which a "tank" can climb a hill?
73. Why is it easy to wind up a spring-motor railroad engine with a key and almost impossible to do so without it?
74. Describe briefly how steam drives the steam-engine.
75. Why must water be pumped into the boiler when the engine is operating?
76. What protects the boiler against explosions? Explain.
77. How is the waste steam coming from the exhaust pipe sometimes used?
78. Why are the pictures in a magic lantern inserted up-side down?
79. Why do slides show so much brighter than post-cards on the screen?
80. What is the purpose of the inside lens or set of lenses (the condenser)?

FINAL TEST—VISUAL TYPE—1920-1921

1. Rotating a pivoted compass needle with a magnet.
2. Stringing nails on the end of a magnet.
3. Stroking a steel needle on the end of a bar magnet.
4. Making an electromagnet.
5. Focusing the windows on the wall by means of a large reading glass.
6. Exhibiting a photographic negative.
7. Focusing a camera for taking a picture of a near object.
8. Exhibiting batteries connected in series.
9. Exhibiting four 3-volt bulbs connected in series. The boys are asked to tell how many batteries are necessary to light them properly.
10. Exhibiting batteries connected in parallel.
11. The same question is asked of 3 similar bulbs in parallel.
12. Heating a wire to the glowing point by means of an electric current.
13. Varying the length of the above wire so as to make it glow more brightly.
14. Operating a St. Louis motor; and then taking the magnets away so as to make it stop turning.
15. Reversing one magnet in the above motor so as to have two north poles or two south poles as a magnetic field.
16. Moving a magnet in the presence of a coil which is connected with a milli-voltmeter.
17. Making a bulb grow dim and then bright by increasing the speed of a hand-turned generator.

18. Expanding the air in a flask by heating. The flask has its only outlet submerged under water so that the bubbles of air are clearly seen.
19. Allowing the air to cool and therefore contract, so that the water can be seen rising in the flask.
20. By closing with one's fingers the air holes of a bunsen burner, and then opening them again, the flame is turned yellow and then blue again.
21. Extinguishing a candle, burning at the bottom of a pan in which there is an inch of water, by covering it with a glass or jar.
22. Throwing a piece of chalk into a beaker of hydrochloric acid (so labelled).
23. Breathing through a tube into a glass of lime water.
24. Exhibiting a pulley arrangement in which one weight balances two weights each as heavy as itself.
25. Exhibiting the gears of a grindstone.
26. Short-circuiting a battery.
27. Exhibiting a vertical section of a dry cell.
28. Operating the "cartesian diver" experiment, using for the "diver" a small inverted flask, in which the changing water level can be seen.
29. Operating an induction coil to get a large spark across the secondary terminals.
30. Operating a telegraphic sounder.
31. Operating a magneto to ring a bell.
32. Inserting a glowing spark on a piece of wood into a bottle of oxygen.
33. Exploding a mixture of illuminating gas and air.
34. Exhibiting a floating balloon filled with hydrogen.
35. Exhibiting a hanging balloon filled with air.
36. Striking a tuning fork and placing its base aganst the blackboard.
37. Operating a siphon.
38. Inverting a bottle filled with water. The mouth of the bottle is covered with a piece of cheese cloth.
39. Rubbing a hard-rubber rod with a piece of fur and picking up pieces of paper with the electrically charged rod.
40. Blowing into a wide glass tube while changing the length of the latter by lowering it into a jar of water.

Time Allowed:—80 Minutes

FINAL TEST—PRACTICAL TYPE—1920-1921

1. Connect two bulbs so that one is on all the time and the other goes on when you press the button.
2. Make the bell ring (the vibrator screw is put out of adjustment).
3. Make the motor run (2 defective brushes are put in, which can be fixed by bending them down so as to touch the commutator).
4. Make a wet battery.
5. Fix up a wireless sending and receiving outfit.
6. Detect a fault in a telegraph system.

7. Make a dynamo generate enough current to light a bulb. (The field magnets are disconnected.)
8. Which end of a given magnet is north and which south? (He is given a marked magnet and a blank one.)
9. Make an electromagnet.
10. Make the electric train run. (The tracks are short-circuited.)
11. Adjust the camera for taking a time exposure of an object in the room.
12. Blow a thermometer bulb.
13. Make a drive-belt for the governor of the steam engine.
14. Connect the magic lantern and focus on the screen the picture of a post card.
15. Arrange a set of pulleys so that one pound will lift about four pounds.
16. Fix up the gears controlling the hands of a clock so that the minute hand moves twelve times as fast as the hour hand.
17. Make and collect a bottle of carbon dioxide.
18. Make and collect a bottle of hydrogen.
19. Make and collect a bottle of oxygen.
20. Collect a bottle of illuminating gas.

Time Allowed:—Two hours.

The examinations extended over a period of two weeks, the Practical, Visual and Stenquist tests interspersing the periods of written examinations.

In the case of the Stenquist Box Tests, an unfortunate accident caused the interchanging of three models between Series I and Series II. In the original series the ten models of each box are so grouped as to give a sequence from easiest to hardest, with the average difficulty the same in the two series. Although the mixed series used by the writer were grouped in a progressive sequence, the following tables show how the average difficulty of Series II differed from that of Series I:

THE CORRECT STENQUIST SERIES I

Model	Difficulty
A. Cupboard Catch	.462
B. Clothes Pin	.523
C. Paper Clips (Hunt)	.554
D. Chain	.572
E. Bicycle Bell	.579
F. Rubber Hose Shut-off	.590
G. Wire Bottle Stopper	.602
H. Push Button	.608
I. Lock No. 1	.627
J. Mouse Trap	.645
Mean=	.5762

(Average S. D. equivalent) (obtained from 500 6th, 7th and 8th grade boys.)

THE CORRECT STENQUIST SERIES II

Model	Difficulty
A. Pistol	.491
B. Elbow Catch	.503
C. Rope Coupling	.503
D. Expansion Nut	.518
E. Sash Fastener	.573
F. Expansion Rubber Stopper	.602
G. Calipers	.610
H. Paper Clip	.630
I. Double Acting Hinge	.657
J. Lock No. 2	.683
Mean=	.5770

SERIES I—ACTUALLY USED

Model	Difficulty
A. Cupboard Catch	.462
B. Pistol	.491
C. Rope Coupling	.503
D. Expansion Nut	.518
E. Paper Clip (Hunt)	.554
F. Sash Fastener	.573
G. Expansion Rubber Stopper	.602
H. Lock No. 1	.627
I. Paper Clip	.630
J. Double Acting Hinge	.657
Mean=	.5617

SERIES II—ACTUALLY USED

Model	Difficulty
A. Elbow Catch	.503
B. Clothes Pin	.523
C. Chain	.572
D. Bicycle Bell	.579
E. Rubber Hose Shut-off	.590
F. Wire Bottle Stopper	.602
G. Push Button	.608
H. Clippers	.610
I. Mouse Trap	.645
J. Lock No. 2	.683
Mean=	.5915

It can be seen that the difference in "mean difficulty" between the series actually used is not very much greater than the corresponding difference between the two correct series as organized by Stenquist. It is also fortunate that the slightly more difficult series was used at the end of the year.

The writer recognizes the fact that the Visual Tests and the Practical Tests are not standardized. In the former type of test, the writer, in order to obtain a guide for scoring the answers, gave the test to children of various grades and teachers of general science. This furnished for most of the phenomena listed a range of answers from worst to best. Though extremely rough, it facilitated the scoring and enabled two scorers to vary an average of seven per cent for any given paper. In the case of the practical tests, any given exercise was marked either right or wrong. In the written tests the best arbitrary standards in the judgment of the writer were used.

The standardizing of the Visual type of test is a task which lies just ahead of the writer. It promises a consistently high correlation with the written test and a high degree of reliability. It involves in the main inexpensive test materials that can be found in the average high school laboratory; it can be given to large numbers at once, and it is unique in that it does not tire the class to any appreciable degree. Boys are intensely interested in these phenomena that are enacted before them. The writer has been able to show thirty and forty phenomena at a time without noticing a diminution in the interest of those being tested.

CHAPTER VII

EXPERIMENTAL RESULTS AND DATA

In tables I, II, III and IV are given the results of the different tests and measures for 1920-1921 that were described in Chapter VI. Table I deals with the group of boys (Group A) who received both types of training: the instruction and the play. Table II deals with those who received but the instruction (Group B). Table III deals with those who engaged in only the play (Group C). Table IV deals with the controlled group (Group D), who received neither form of training.

The I. Q. measurements were obtained from Dr. Chassel, psychologist for the Horace Mann School. They were calculated from the National Intelligence Tests; and are not, of course, as significant as the Terman quotients would be. Also, it has developed that the norms from which the "mental ages" were obtained are not as reliable as they were first thought. More reliable norms will soon be available, and also a table by means of which the N. I. T. quotients may be transmuted into Terman quotients. These corrections will be made. It must be noted, however, that the indications are that the effect of these corrections will be to raise I. Q.'s several points. Thus, the average Terman I. Q. for the Horace Mann School is 116, whereas the average N. I. T. I. Q. is about 106. There is no reason to believe that these transmutations will act differently on each of the four groups.

The column listed "Chronological Age" is for ages on February 1, 1921, whereas the N. I. T. tests were given on November 1, 1920. This will account for the apparent discrepancy between the quotient of each "mental age" divided by each "chronological age" and the intelligence quotient listed. These quotients are correct if three months be subtracted from each chronological age listed.

In Table V the means and the variabilities of the four groups are compared.

TABLE I

Individuals Group A	Age Chron.	Mental	I Q.	Stenquist I.	II.	Visual	Practical	Written
A	12.3	12.7	105	60%	85%	67%	50%	50%
B	12.0	12.0	103	45	50	70	40	71
C	12.0	15.9	135	70	78	85	70	80
D	11.2	12.7	117	50	48	89	85	74
E	10.9	13.1	124	40	32	80	85	72
F	13.6	12.3	93	70	73	84	85	75
G	11.2	13.9	127	55	86	64	80	56
H	12.6	15.3	124	50	70	absent	absent	absent
I	11.0	11.7	109	25	43	absent	70	30
J	11.5	11.25	101	35	40	55	65	52
K	11.9	10.4	90	60	72	56	70	68
L	12.5	12.3	101	50	87	77	100	49
M	12.6	12.2	99	40	58	37	60	49
N	13.6	11.0	83	45	48	90	80	79
O	11.2	11.6	106	30	49	60	80	71
P	13.7	9.3	70	65	75	82	55	64
Q	12.6	15.4	125	80	84	93	90	82
R	11.4	12.6	114	60	65	80	95	72
S	12.5	14.0	115	75	66	56	75	62
T	11.9	14.7	126	65	72	82	90	66
U	11.6	13.9	123	50	53	82	40	72
V	11.6	11.6	103	80	80	71	95	73
W	11.9	15.7	134	40	78	58	80	64
X	12.7	15.3	123	70	80	absent	80	36
Y	13.8	10.8	80	65	60	84	75	79
Z	10.9	14.1	132	55	41	88	45	87
Mean	12.10	12.91	110.5	55.0	64.4	73.5	73.6	65.3
S. D.	.88	1.75	17.1	14.7	16.2	14.0	16.95	14.0

TABLE II

Individuals Group B	Age Chron.	Mental	I Q.	Stenquist I.	II.	Visual	Practical	Written
A^1	11.1	10.4	97	60%	83%	49%	35%	25%
B^1	12.1	14.1	120	50	75	68	40	59
C^1	11.8	11.4	99	40	absent	absent	absent	absent
D^1	12.3	13.6	113	70	59	65	25	61
E^1	10.5	11.6	114	20	70	51	30	54
F^1	11.0	13.75	129	25	41	49	40	32
G^1	11.8	11.4	99	50	47	65	45	64
H^1	13.1	11.2	88	50	58	60	25	44
I^1	9.7	13.3	143	30	28	42	30	50
J^1	12.0	13.5	116	40	30	62	55	45
K^1	11.2	16.0	148	100	81	91	55	65
L^1	12.0	10.9	93	35	withdrew from school			
M^1	12.0	10.8	93	80	40	66	30	68
N^1	12.1	8.4	71	80	61	58	65	56
O^1	11.25	13.75	125	50	68	48	40	50
P^1	10.5	15.7	153	50	55	54	45	58
Q^1	10.3	16.0	159	65	41	absent	40	51
R^1	14.0	13.3	97	65	62	57	80	31
S^1	11.3	12.5	114	25	26	64	35	54
T^1	11.9	11.2	94	30	19	34	25	46
U^1	11.5	12.25	110	35	40	43	20	55
V^1	12.25	12.3	104	85	65	67	40	76
W^1	12.2	11.0	93	60	44	68	20	61
X^1	11.4	14.25	127	35	55	55	70	37
Y^1	12.3	15.2	125	35	14	42	35	24
Mean	11.66	12.71	112.96	51.7	50.5	57.2	40.2	50.7
S. D.	.90	1.87	14.8	20.3	18.9	12.1	15.42	13.4

TABLE III

Individuals Group C	Age Chron.	Mental	I Q.	Stenquist I.	II.	Visual	Practical	Written
a	10.2	11.0	111	15%	46%	57%	60%	46%
b	9.9	9.6	99	80	75	46	65	27
c	10.9	9.3	95	70	68	31	55	34
d	10.9	11.3	106	20	56	37	40	16
e	11.25	12.7	115	35	47	48	50	48
f	10.5	8.75	85	30	40	47	50	44
g	11.2	11.75	108	20	45	43	80	39
h	10.3	11.0	109	60	70	63	65	55
i	11.25	11.1	101	60	54	42	70	39
j	10.6	10.7	103	75	50	37	60	35
k	9.8	14.0	146	35	45	53	50	44
l	8.9	11.25	130	20	25	36	30	20
m	9.9	8.9	92	5	9	36	15	22
n	11.25	12.4	113	25	32	45	40	38
o	11.0	11.6	108	55	53	51	65	56
p	10.25	11.4	114	25	31	31	55	28
q	9.75	10.25	108	25	48	46	70	42
r	10.3	10.7	104	20	47	27	60	26
s	9.9	12.8	132	20	39	48	40	54
t	11.2	9.25	85	30	58	32	55	34
u	11.75	10.9	95	40	46	24	50	33
Mean	10.52	10.98	107.6	36.4	46.9	41.9	53.6	37.1
S. D.	.68	1.32	14.5	21.0	14.8	9.8	13.62	11.1

TABLE IV

Individuals Group D	Age Chron.	Mental	I Q.	Stenquist I.	II.	Visual	Practical	Written
a¹	10.4	11.1	109	40%	51%	28%	50%	9%
b¹	10.1	12.0	122	45	49	46	40	20
c¹	11.8	9.5	82	25	34	12	10	4
d¹	10.9	9.7	91	30	61	19	15	4
e¹	10.5	14.5	141	30	51	24	5	7
f¹	10.8	9.2	87	20	20	32	0	7
g¹	10.25	9.9	99	50	46	31	30	3
h¹	10.1	8.6	87	35	20	9	5	3
i¹	9.75	12.7	133	50	45	15	15	0
j¹	9.8	10.1	105	40	48	absent	absent	absent
k¹	10.9	10.25	96	40	44	40	20	13
l¹	9.9	11.9	123	45	47	25	40	10
m¹	8.75	10.3	121	30	27	15	15	0
n¹	10.7	10.6	102	15	13	33	20	18
o¹	9.7	11.5	122	55	64	35	10	12
p¹	11.4	9.6	84	55	29	28	20	0
q¹	10.1	11.9	121	35	34	37	5	25
r¹	10.25	10.5	105	70	45	23	20	2
s¹	10.7	16.0	154	40	50	26	60	3
t¹	10.4	9.2	90	25	27	23	5	3
u¹	10.75	10.75	103	absent	..	..	..	..
v¹	9.7	9.8	105	absent	..	..	..	..
w¹	9.8	12.25	128	30	36	38	30	10
x¹	10.0	12.0	123	25	35	31	5	7
y¹	8.8	12.1	137	35	45	33	15	21
Mean	10.25	11.04	110.8	37.6	36.8	27.4	19.8	8.2
S. D.	.68	1.67	19.09	12.6	13.2	9.3	15.53	7.11

TABLE V

Group	Chron. Age M	Chron. Age S.D.	Mental Age M	Mental Age S.D.	I Q. M	I Q. S.D.	Stenquist I. M	Stenquist I. S.D.	Stenquist II. M	Stenquist II. S.D.	Visual M	Visual S.D.	Practical M	Practical S.D.	Written M	Written S.D.
A	12.1	.88	12.9	1.75	110.5	17.1	55	14.7	64.4	16.2	73.5	14.0	73.6	16.95	65.3	14.0
B	11.7	.90	12.7	1.87	112.96	14.8	51.7	20.3	50.5	18.9	57.2	12.1	40.2	15.42	50.7	13.4
C	10.5	.68	10.98	1.32	107.6	14.5	36.4	21.0	46.9	14.8	41.9	9.8	53.6	13.62	37.1	11.1
D	10.3	.68	11.04	1.67	110.8	19.09	37.6	12.6	36.8	13.2	27.4	9.3	19.8	15.53	8.2	7.11

It is correct to state that Groups A and C were not selected groups as far as I. Q. or initial ability in Stenquist is concerned. In the case of I. Q., the slight difference between A and B and between C and D favors groups B and D. Also, if any comparison is to be made between the final accomplishments of those that had play activities alone (C) and those that had instruction alone (B), the I. Q. difference again favors group B.

It may be regarded as a strange fact that boys who join the Science Club (from which Groups A and C were constructed) always tend to a slightly lower intelligent quotient than do boys who do not join the club. Table VI shows this for three different years:

TABLE VI

Year	Average I. Q. of those that join the Club	Average I. Q. of those that do not join Club
1918-1919	132.6 (Pressey)	136.2 (Pressey)
1919-1920	121.8 (Terman)	129.8 (Terman)
1920-1921	109.6 (N. I. T.)	111.9 (N. I. T.)

In this connection it is also significant to note the correlation that exists between I. Q. and standing in the Science Club. (See Chapter IX as to the Club Point Scheme.) Table VII shows this:

TABLE VII

Year	Corelation Coefficient between I. Q. and Club Standing For Group A	For Group C
1918-1919	.11	—.25
1919-1920	.14	—.01
1920-1921	.003	—.08

In comparing Groups B and C, the difference in age must be taken into account. Groups C and D, coming from the fifth grade, as compared with Groups A and B, who come from the sixth grade, are, on the average, one and a half years younger (1.5) (chronological age) and 1.8 years younger (mental age). In order to determine what such an age difference would mean in each of the final tests given, Group B was divided into two parts: one whose average age was approximately that of Group C and the other whose average age was 1.5 years higher. The same procedure was adopted to get the approximate equivalent difference for 1.8 years of mental age. The following were the results:

TABLE VIII

A difference of	Is Equivalent to a Difference of		
	Visual	Practical	Written
1.5 years chronological age	9.79%	3.38%	4.90%
1.8 years mental age	2.49%	7.45%	4.45%

Thus, in Table V we note that Group B scores 15.3% higher than Group C in the Visual Test. In Table VIII we note that for boys in Group B to be as young as boys of Group C is to score about ten per cent lower. For "mental age" this difference is about three per cent. Hence it may be concluded that instruction alone was better than play alone in the case of the visual test; but that this difference must be discounted to some extent by the difference in age existing between the groups compared. In the case of the practical test, the younger group does considerably better than the older, in spite of the difference of age which might have increased their score another 4% or 5%. (See Table VIII.) In the case of the written test, we must again allow about 5%, as due to the age difference. This would decrease the 13.6% difference between Groups B and C to about 8% or 9%.

In the case of the Stenquist Tests, Group A was a little better than Group B to start with; but Group D was better than Group C to start with. Group A shows an increase of 9.4 points at the end of the year, whereas Group B suffers a drop of 1.2 points. Group C goes up 10.5 points, whereas Group D drops .8 points. Group C almost reaches the ability of Group B in Stenquist Test II. Clearly, then, after-school activities improved this particular type of constructive ability.

It is interesting to note here that a score of 64.4 (Group A) on Stenquist Series II is reached or exceeded by only 5.4% of twelve-year-olds, only 11.3% of thirteen-year-olds, only 21% of fourteen-year-olds, only 26.9% of fifteen-year-olds, and by only 41% of adult men (Army). These figures are obtained from tables prepared by J. L. Stenquist from the scores of 1,361 cases to whom this test was given.

In addition to noting the gross increases or decreases in averages from one group to another, it would be well to note certain correspondences that exist between the various tests and measures of Tables I, II, III and IV. In Table IX are listed some coefficients of correlation which the writer feels are significant.

TABLE IX

Correlation of	A		B		C		D	
	p	P.E.	p	P.E.	p	P.E.	p	P.E.
I. Q & Stenquist I ..	.03	.147	—.26	.140	.24	.145	.18	.146
I Q. & Stenquist II .	.09	.146	—.013	.151	.36	.134	.51	.111
Stenq. I & Stenq. II.	.59	.096	.51	.111	.66	.087	.42	.124
Visual & Practical ..	.22	.140	.19	.145	.21	.147	.24	.142
Visual & Written ...	.82	.049	.68	.081	.83	.048	.77	.062
Practical & Written	.13	.145	—.09	.150	.35	.135	.092	.149
I. Q. & Practical	.07	.147	.32	.135	—.132	.152	.27	.140
Sten. I & Practical ..	.28	.136	.26	.140	.42	.126	.51	.111

To save time and because highly accurate coefficients were not needed, the formula

$$\rho = 1 - \frac{6 \Sigma D^2}{N. (N^2-1)}$$

was used; and the reliability coefficients calculated from

$$P.E. = .706 \frac{1-\rho^2}{\sqrt{N}}$$

Of course, the small number of cases upon which these results are based make the low coefficients very unreliable. But the unreliability does in no case make doubtful the following conclusions:

1. The intelligence quotient and Stenquist ability show very little correspondence. Stenquist himself has never been able to get a higher coefficient than .4 between I. Q. and ability in his test. Results of this study show even less correlation. If the Stenquist test measures a desirable trait, the generally accepted I. Q. is to this extent a less valuable general criterion.

2. There is just as small a correspondence between I. Q. and the "practical" test. In the latter test we again have a type of ability which involves what might be termed "manipulatory intelligence."

3. There is practically no correspondence between "joining the club" and I. Q., or between "standing in the club" of those that join and their I. Q. (See Tables VI and VII.)

4. Stenquist ability, on the other hand, is but a slightly better measure of performance in the practical tests.

5. The visual tests and the written tests show the only real and reliable correlations of the entire series.

6. Both the visual and the written tests show an exceedingly low correlation with the practical test.

Tables X, XI and XII give the results of the tests given to the groups of 1919-1920. During that year no Group D was obtainable nor any Stenquist measures. As noted in Table VI, the I. Q.'s were approximately 121.8 (Terman) for Groups A and C, and 129.8 (Terman) for Group B. Again there was a difference of about one year in age between B and C.

TABLE X

Gr. A	Written	Visual	Practical
A	282	85%	60%
B	180	65	70
C	260	80	70
D	140	40	70
E	272	75	60
F	192	65	50
G	184	60	40
H	248	80	80
I	202	40	70
J	222	85	80
K	284	75	90
L	162	55	60
M	186	75	90
N	210	70	70
O	192	70	80
P	188	60	80
Q	178	50	40
R	216	70	90
S	228	80	90
Mean ...	212	67.4	70.5
or	60.6%		

TABLE XI

Gr. B.	Written	Visual	Practical
A^1	135	30%	10%
B^1	166	50	25
C^1	152	35	25
D^1	90	10	5
E^1	174	45	35
F^1	158	55	30
G^1	202	70	75
H^1	198	60	40
I^1	92	30	20
J^1	202	70	30
K^1	102	30	30
L^1	102	40	80
M^1	112	40	40
N^1	178	70	30
O^1	140	60	50
P^1	214	70	30
Q^1	200	65	60
Mean ..	154	48.8	36.2
or	44%		

TABLE XII

Gr. C	Written	Visual	Practical
a	200	60%	80%
b	182	50	45
c	132	25	70
d	62	5	50
e	98	25	60
f	188	35	45
g	120	50	35
h	100	35	70
i	146	55	80
j	128	45	10
k	68	20	30
l	84	25	20
Mean ...	126	35.4	49.6
or	36%		

Table XIII shows a comparison between the means for the different groups in the various tests.

TABLE XIII

	Written Test	Visual Test	Practical Test
Group A	60.6%	67.4%	70.5%
Group B	44.0%	48.8%	36.2%
Group C	36.0%	35.4%	49.6%

Again we find the tendency of after-school play, whether controlled (as in 1920-1921), or uncontrolled (as in 1919-1920) to cause greatest improvement in practical, manipulatory tasks; but with a marked improvement in other lines as well. Here, too, a comparison between Groups B and C shows that play activities alone are almost on a par with class activities alone when measured by the same tests—especially when allowance is made for the difference in age between groups B and C. The most happy combination of all with these groups, as with the 1920-1921 groups, is a type of work that combines the out-of-school work with class work.

In Table XIV we have a set of correlation coefficients that substantiate the results of Table IX.

TABLE XIV

	Written and Visual	Written and Practical	Visual and Practical
Group A	.73	.24	.15
Group B	.86	.233	.479
Group C	.77	.338	.228

In Table XIV Pearson coefficients are used.

CHAPTER VIII

CONCLUSIONS AND DISCUSSIONS

Let us examine the data of the previous chapter in terms of our analysis of Chapter V, in which were developed a set of aims for judging value. In the results of the visual and written tests we have a partial answer to the question of environmental knowledge. In these tests the questions and phenomena were so organized as to cover the whole range of the term's work, rather than a more or less random selection of the term's topics, as is usually the case in the recognized type of teacher's examination. Thus the boys had an opportunity to express themselves on practically everything that had been included in the curricular work. But we cannot be sure if the material represented in the test comprises all that our club boys had met with in their after-school play. Indeed, there is every reason to believe that Group C and surely Group A could have done well on many other questions that could not with fairness be included, because they had not come up in the class work.

The visual test is so designed that it focuses the attention of those that are examined on the five queries which we adopted as definitions of environmental knowledge.

What things are?
Why things happen?
How things work?
How things are made?
How things are used?

As each of the forty phenomena were presented to all four groups, assembled in a large lecture room, there were some striking contrasts between the reactions of the different groups. Almost the first question that popped into the minds of the Group D boys, and to a lesser extent in the minds of the Group B boys, was, "What is it?" The question was evident in their facial expressions and often they spontaneously gave it vocal expression. The club boys were, in general, never at a loss for a reply as to what things were; and they showed it not only in their readiness to write immediately after the phenomena were presented, but also in their test results. Having replied to "What is it?" the next important step was to answer "Why?" or How?" A good many of Groups B and D never got to that stage in their replies. Let us take an illustration. With rapt attention, the 100 boys watch the examiner going through the motions of sending current through a high resistance wire. He unrolls a piece of the wire from a spool and stretches it horizontally between two clamps. He then takes two wires that had been previously connected to a source of current (and through a rheostat) and brushes one wire-end on the other so as to produce a large electric spark, visible to all. Then he ties one wire-end to one clamp and after a short pause and glance at the group touches the other wire-end to the other clamp. The thin resistance wire which was barely visible before becomes a glowing streak of fire. The examiner taps the bell as a signal for them to write.

Some typical replies:

Group D:

(a) "You made a fire."
(b) "You made a fire with electricity."
(c) "The wire got hot."

Group C:

(a) "You must have had the same kind of wire a reducer has; because the reducer gets hot when I use it."
(b) "Any wire will get warm when you make a short circuit."

Group B:

(a) "The resistance of the wire was too great and it got hot."
(b) "The wire was too thin to stand the electricity. The heat depends on two things, the length and the thinness."

Group A:

(a) "Any thin, long wire cannot carry a lot of current without getting hot; especially if the material of the wire has a high resistance."

(b) "The wire must have been nichrome wire, and very thin and long. The longer and thinner, the greater the resistance. The greater the resistance, the more heat. This is how an electric bulb works."

The task of grading the answers is not a difficult one if they are graded for the presence or absence of essential ideas. Thus, in the above case any answer that made mention of "Resistance" and the three things upon which "Resistance" depends, was scored correct. It is conceivable that finer distinctions in answers can be made; but in the absence of a standardized scale, these distinctions would not be safe.

To return to our point, the visual test offers a means of discovering certain types of information and appreciations of phenomena. To some extent, too, it measures ability to observe quickly and correctly, though only the very poor observers will be affected in this respect. But primarily it demands a familiarity with, and a recognition of, natural phenomena and an ability to interpret these phenomena either in terms of their own experiences or in generalizations of experiences that might be termed the laws of science. One further question remains. Are the phenomena dealt with by the test, or the course of study from which they were derived, or the play activities from which the course was derived, such as actually function in the environment of the child? A perusal of the materials listed in Chapter II permits of but one answer. These materials and activities have the hold on boys that they have because they have their origin in the environment. The models and mechanical arrangements of Meccano and Erector are taken from life. Chemcraft experiments, especially the more popular ones, deal with soaps, inks, paints, oxygen, carbon dioxide, cleaning agents, dyeing, foods, etc., etc. The electric outfits, the telephone, the telegraph, wireless, railroad systems, motors, steam engines, and the thousands of experiments in sound, light, heat and with water, air, gas, and minerals, represent most important phases of modern life. If play activity with scientific outfits can increase our understanding and appreciation of these elements in our everyday lives, they justify themselves educationally. And, indeed, our results show that not only can these play activities enhance the value of curricular science, but in and by themselves they compare favorably with curricular science.

It is in our second general aim, environmental control, that the value of our play materials becomes marked. In the type of ability represented by the "practical" test, Groups A and C are far superior to the rest. In a sense, environmental control is more important than mere knowledge or information, for it involves the functioning of this knowledge in life situations. How often do we remark upon the vast chasm that exists between being able to explain to the physics teacher how an electric bell works and the ability to repair the house door-bell! The utter helplessness of the average individual who is confronted with a balky vacuum cleaner or an electric socket that won't work or a blown fuse or a leaky water faucet is regarded by many as a sad phase of modern city life. We rely too much upon the mechanical expert who weaves around himself the autocratic halo of the physician and who regards poor ordinary mortals as incapable of understanding what ails them or rather their house appliances. Just as in medicine, so in things mechanical and electrical we ought to encourage and train individuals to care for their physical belongings intelligently. The ounce of prevention maxim holds just as truly in this field as in medicine. If the course in hygiene aims to make the doctor a less necessary commodity, so after-school activities in science can serve to make less necessary the plumber and the electrician. The most interesting result of the practical test is the small amount of carry-over or transfer which there was between the class-work and the ability to do the actual tasks with materials. It is clear from the tables of the previous chapter that the curricular work did not help Group A in getting their high score in this test, for Group C, without the curricular work, did better than the much older boys of Group B. In this connection we might mention again the common criticism of modern society as expressed in the writings of Dr. Eliot and others, in which the loss from the home of opportunity for sense-experiences is very much regretted. The writer wishes to point out that this opportunity still exists, but in a different form. In a sense, there are more of these experiences possible; they are more interesting, and involve a greater amount of intelligence and knowledge. The stimulation to such experiences is furnished to a great extent by after-school activities in science.

Our third general aim dealt with ability to construct—the ability to manipulate and to fashion out of raw materials usuable things. That this ability is somewhat different from that of doing well in the practical test is indicated by a low correlation coefficient between the two. An explanation perhaps lies in the different content with which the two tests deal. Also, it must be pointed out that the Stenquist materials are more generalized than the practical test materials and do not involve specific preparation, either curricular or extra-curricular. According to Stenquist, ability in his test is very highly correlated with the estimates of shop-teachers of abilities in manual work. That bears out the writer's own experience with Groups A and B in the shop. As the year progressed the club boys became the most efficient in the use of tools of all sorts; and in adaptations of materials to useful ends. The shop foremen were in nine cases out of ten club boys. Groups C and D, who took shop work with another teacher, showed the same influence of after-school activity. Those of Group C were usually the leaders in manual, constructive work of all kinds.

A value of after-school activities which the data of the previous chapter do not uncover is the extent to which these activities make for experimentiveness and inventiveness on the part of the boy. It is in the development of this trait that our play materials are in sharp contrast with curricular science. By some, the only value sought in any science course is training in scientific method—a training which will make the average individual a less gullible, more inquiring, and better-reasoning citizen, and a training which will discover scientific talent that might devote itself to research. To that end all of our laboratory procedure has been organized. It is generally recognized that only through contact with materials and first-hand experiences with natural phenomena can scientific methods be developed. But our curricular attempts to achieve this end have strangely been very barren of accomplishment, chiefly because we have lost sight of the nature of the boy of the "toy age." No better criticism of this condition has ever been written, in the judgment of the writer, than G. Stanley Hall's chapter on "Adolescent Feelings Toward

Nature." Hall's views are significant because they have evolved from an intimate knowledge of the urgings that furnish the motive power of all that the adolescent boy does, and because one of the strongest manifestations of early adolescence is experimentiveness.

"Modern pedagogy of Science," says Hall, "is threatened with an alienation from the love of nature . . . Teachers in this field have a sense that mathematics is the only proper language of physical science. The topics are no doubt admirably chosen, their sequence, the best from a logical standpoint, and they are such models of condensation and enrichment that it seems to the organizer and to the specialist alike almost perversion that the youth pass it by. But boys of this age want more dynamics. Like Maxwell, when a youth, they are chiefly interested in the 'go' of things . . . The high school boy is in the stage of beginning to be a utilitarian . . . He would know how the trolley works, how wired and wireless telegraphy work and the steam-engine, the applications of mechanics in the intricate mechanisms, almost any of even the smaller straps bucklers in the complex harnesses science has put upon natural force, charm him. Physics in the street, the field, the shop, the factory, the great triumphs of engineering skill, civil, mining, mechanical inventions in their embryo stage, processes, aerial navigation, power developed from waves, vortexes, molecules, atoms, all these things which make man's reaction to nature a wonder book, should be open to him . . . for it is the heart that opens up the way for reason . . . Toy museums, exhibitions, and even congresses in Europe are very instructive here. Bugs that flutter and creep, birds that fly, peck and sing; monkeys, soldiers, boats, dolls, balloons, engines that move are often, especially in Germany, masterpieces of mechanical simplification and cheapness, illustrating fundamental principles. Many of these things could be made as manual training adjuncts, and the best boys' books like Cassell, Baker, Beard, Routledge, Peper, and also books on magic, like Hoffman and Hopkins, would be helpful in teaching problems of the lever, balance, wedge, pulley, pump, monochord, whistle, prism, small lenses easily ground by boys, magic lanterns, kaleidoscopes, telegraph, etc., which the normal boy will approach with a full-head pressure of interest. Glass work, the equipment of which with a little stock of tubes, blow-pipes, bellows, tools, and annealing oven, occupies no more space than a sewing machine, including the making of thermometers, all this gives a manual discipline for hand and eye comparable to learning the piano. Tops of many kinds are an open sesame into the very heart of science and suggest and illustrate some of the profoundest principles from ions and electrons to stellar systems . . . Where work that the boy has made with his own hands goes, there his interest follows. An inner eye opens, skill with fingers is harnessed to the development of cerebral neurones, and we work in the depths and not in the shadows of the soul. In Europe photography is often curriculized . . . Suffering as school physics is from lack of concreteness, application and appeals to the motor element, and still more maimed as manual training is for lack of intellectual ingredients, the present divorce of the two is a strange and surely transient anomaly."

As Hall points out, these play materials supply an outlet for the inventive genius of the boy. The writer has gathered records of hundreds of toy "inventions." Some of them were described in Chapter IV; but a few instances set forth in detail will serve to point out the factors making for originality.

Boy inventions run the gamut from simple, naive improvisations to real constructions involving new applications of principles. On the boy level we must think of an invention as a new arrangement of parts to do a new thing or an original use of some old process or mechanism. In 82 out of 126 "inventions" that the writer has recorded the invention came in response to a known need. Necessity is indeed the mother of invention. Thus, a cousin of one boy was blind. The unfortunate fellow would walk along tapping a stick to feel his way. Once or twice the point of the stick would catch in a crack and the blind boy would fall. The invention consisted in splitting open the end of the walking stick and inserting a small Meccano wheel on a shaft so that the blind boy could roll the stick along.

Again, the water pan under the ice box overflowed in one boy's house so that a good deal of damage was done. The boy thought that some scheme to announce the fact that the pan was full would solve the problem. An electric bell was the best announcer he could think of. If only the water could be made to push a button when it got to the top! Well, why couldn't a wooden float make a contact? And there he had it! The scheme worked to perfection.

Or, another boy in adjusting the gears of a Meccano model was forcibly impressed with the reductions in speed obtainable by various combinations. Also, his car having to move in a limited floor space, it was necessary to know exactly what gear arrangement to use. This led him to try out various combinations until he found that a certain wheel would turn around once for every ten feet the car moved. Then the idea "struck" him! A distance indicator! And it was. The very scheme our automobile speed indicators use.

The writer recently had the pleasure of listening to Sperry, inventor of the famous gyroscope. According to the inventor, tops were his hobby. He and his boy would play with hundreds of different kinds. He does not know just how and when the idea came; but the toy began to take on practical significances until today dozens of highly valuable uses have been found by his top by both his boy and himself.

Edison as a boy sat on eggs to see if he could hatch them. Newton as a boy played with his own ingeniously constructed toys and amused himself by running with and against the wind to measure its velocity. Galileo was fascinated by a swinging pendulum and he received a great deal of pleasure from dropping stones and timing their fall. Faraday, Davy, Maxwell, Eli Whitney, Watt, Fulton, Franklin, Pasteur, Stevenson, Lake, Holland, Maxim, and almost every other inventor of prominence has the same story to tell of his youth and early manhood. In a study that the writer made some years ago* of the lives of some of our great scientists and inventors, the experimenting instinct during their early adolesence was found to have had many outlets for development. Of course, our boys are not all Newtons; but what endowment nature has given them needs careful nurture in our hands. The teacher who has watched a boy with his Meccano and Chemcraft will be less likely to remark that only a few boys ever show original thought or inventiveness.

As has been noted in Chapter IV, few boys do the outfit experiments as they are told to by the manual. They start with the picture of the derrick, let us say, and when one third of it is up, an idea is sure to come which will start them on a series of original changes.

*The Method of the Scientists, School Science and Mathematics for November, 1918.

Sometimes they fail and have to go back. Sometimes a problem that the situation presents will urge them to seek information. Sometimes they get discouraged. But in the majority of cases (and here lies the great value of these materials) a successful accomplishment results which brings on new problems and new tasks more enjoyable than those which preceded it.

In conducting a year's work in science as the writer did during 1920-21, there was an opportunity to observe the difference in amount and quality of the "original activity" which the work inspired. We might again tabulate groups A, B, C, and D and record the amount of inventiveness which the year's work produced. Unfortunately, no test is available that measures this trait. But some records kept by the writer might be of value in showing certain tendencies.

Thus, out of 122 conferences with boys who came after school to find out about how something would work, or for help of some sort 97 were with boys of Groups A and C, only 25 were with boys of Groups B and D. It appeared from these conferences that the after-school work in school was stimulating more thought and activity than the class work, especially activity involving original planning and execution. As the year progressed, a decided change was noted in the kind of help wanted by boys. Their schemes became less impractical. They began to show a better appreciation of the possible and the practical. Perpetual motion schemes were soon regarded with contempt by the majority of the boys. A tendency for getting more "information on a subject" became noticeable. Little tricks and useless stunts became less popular. Larger projects were attempted. A demand for more and better equipment arose. A greater number of reports came in of boys tinkering with the mechanics of the household. A tendency arose on the part of parents to come to the writer for advice as to what to do with these newly aroused interests and a greater number of home play shops were installed.

It must not be thought that the boys of Groups B and D did nothing along these lines, for they too possessed many of these play materials; but their play was not guided and in most cases was very much restricted. In trying to discover why boys of Groups B and D did not join the club it was found that

18 had to practice on the piano or violin every afternoon;
16 spent most of their free time in playing ball;
5 had no interest in toys;
4 did not wish to join after the club had once been organized;
6 had no particular reason to offer.

Thus, because of parent restrictions or greater interest in physical activities boys of Groups B and D did not have or take the opportunity to play extensively with the outfits which they possessed.

To return to our discussion of inventiveness and experimentation as organized, encouraged, and developed by after-school activities in science, let us compare these activities with the laboratory methods of scientists. It should first be noted that scientific reasoning or any other kind of reasoning involves an attitude of mind that is typical of the scientist in his laboratory. Therefore, any value that we see in a course in science for developing reasoning ability and inventiveness in pupils must be dependent upon genuine laboratory procedure. Analysis of the thinking process such as that of John Dewey have focused attention on the scientist at work rather than the work of the scientist. Scientific methods viewed from this standpoint becomes a vital process instead of a cold and inert body of logic. Commencing in a perplexity and a well-defined need, the scientist proposes a solution—a hypothesis—which he then takes to the laboratory. There he follows each implication of his hypothesis by arranging conditions which will eliminate some of them, throw light on others, perhaps cause a revision of the hypothesis in the light of new facts and finally lead to adoption or rejection of the hypothesis.

It is needless to dwell on differences in the above conception of a laboratory and present-day curricular laboratories, but it is significant to point out that the free activity which goes on with science play materials has many points in common with this conception. In particular, the spirit of "trying things out," the gaining of first-hand experiences and the arranging of conditions with a vital purpose in mind are elements that parallel the genuine laboratory situation.

To sum up, after-school materials in science have value in developing ability to reason soundly by

1. Offering a wealth of sense-experiences and first-hand contacts with natural phenomena which are the basis of all reasoning;
2. Inducing an activity which is whole-hearted and purposeful because it takes advantage of a very strong instinct of the boy of the "toy age," and which takes place according to a procedure that parallels closely the scientist at work;
3. Stimulating and habituating experimentiveness with elements in the boy's environment.

Quite as great a value as there is in these after-school materials of providing opportunity for embryo Newtons and Edisons is of value that they have in furnishing real, manipulative experiences for the large number of just average boys.

Chapter V went further in its analysis and pointed to other broader values of the study of science. Among them were cultural or avocational values; civic and vocational values; and an attitude or spirit of work. The contribution which after-school activities make to these aims is considerable. These materials are inextricably bound up with efficient and proper use of leisure. Dr. Eliot has pointed out how the conception of the cultivated man has changed in the last century from an emphasis of the literary and poetic imagination to that of the scientific. Leisure time is essentially extra-curricular time, though training for leisure should be a part of curricular activity.

The arousing of an attitude of work, needs perhaps a word of explanation. Already we have discussed from the point of view of the thinking process the attitude of experimentiveness; and from the point of view of the psychology of the adolescent, the enlisting of certain instincts for whole-hearted purposeful activity. From the point of view of Thorndike's psychology, these science play materials create an attitude or a mental set which facilitates the learning process. From the point of Interest and Effort as conceived by Dewey, our materials again hold a strategic place in the life of the boy. It is significant that in our experiment the play activities came at the end of a busy school day, without suffering in enthusiasm or in quality. The play was an active expression and not a "diversion." Finally there is the distinctly adolescent attitude to natural phenomena. To quote from Hall, "Phenomena are a veil to a great mystery, like a curtain to be rung up. Youth feels itself moving about in a world unrealized." Perhaps this feeling toward nature comes a little after the period of greatest "toy activity;" but its beginning can be seen at 11 and 12. This attitude is undoubtedly the basis for not only science, but art, literature, and religion as well.

Among many significances that these conclusions have for curricular science problems, two have been given application by the writer. One is to be described in Chapter XI and deals with a series of exercises and projects, in which the best values of the "toy" have been combined with the use of tools and the applications of science principles. The organization is adapted to curricular work. The other application consists of some experiments with very young children and their reactions to science play materials as part of a school curriculum. The latter experiment is still being carried on by the writer in the Play School of the Bureau of Educational Experiments (New York City).

CHAPTER IX

THE SCIENCE CLUB AND THE SCIENCE PLAY SHOP

It is a most important fact that the period in a boy's life which we have designated as the "toy age" corresponds very closely with the so-called "gang age." Even before Hall's epoch-making book on Adolescence the gregarious instinct of youth has been dwelt upon and emphasized. In recent years the tremendous growth of settlements, social houses and recreation centers has served to bring the "club" to the attention of the boy, the parent, the teacher, and society as the safety valve for this boy tendency of getting together for a common purpose. William B. Forbush in his book The Boy Problem reports upon 862 boy societies which he has studied, with a statement that "the period of greatest activity of these societies is between 10 and 15; over 87% being formed during that period." G. Stanley Hall in discussing the "gang instinct" in early adolescence says that "American children tend strongly to institutional activities only about 30% of all not having belonged to such organizations." In Chapter 3 we saw how the manufacturers of science toy materials vied with each other in tying boys to their own particular products, by means of an appeal to the club instinct. Their attempts are still in the early stages of development; but already they are awaking to the need for a better understanding of boy nature and a more effective utilization of the motives which grip the lad of 10 to 14. A perusal of the quotations from the Meccano Guild handbooks (Chapter 3) will make clear that Hornby appreciates the wonderful opportunity that lies ahead of Meccano as an institutionalized activity of the English boy. In a measure he has already succeeded. So much so that here in America a very serious attempt is about to be undertaken to organize a similar Meccano Guild. A. C. Gilbert and H. M. Porter regard their propaganda activities as their most important asset. A. C. Gilbert states that the greatest need in the field of science toys at the present time is to develop a central, unified, boy movement that will utilize the tendency of boys to "join a club" and apply it to science activities. He just as frankly states that the task of getting the various commercial agencies together on a unified program is nigh impossible. The great growth of the Boy Scout movement is only another instance of the tremendous power that lies dormant in this social instinct. But great as this growth has been we hear on all sides suggestions bordering on criticism for a revision of the content program of scouting which will include a large and better utilization of science. Inevitably the scouting program will absorb the worthwhile features of the propaganda of the manufacturers, because it offers the only way of ridding this movement of commercialism.

Not only the toy producers but editors of popular science magazines as well have been awakened by a demand for help and guidance, coming from groups of boys all over the country who seek to carry on joint activities in science. (In the case of the Popoular Science Monthly the writer has been called in conference on this matter, to offer suggestions as to how this help which the boy science clubs are asking can best be supplied. One possible development may be a change in the scope and aim of the present Teachers Service Sheet which the writer edits for the magazine.)

Widespread boy movements are not new in America. G. Stanley Hall lists eleven such movements of more or less significance in his chapter on Social Instincts and Institutions. Among these we find the "Captains of Ten," an organization promoting a belief in Christ through manual activities such as whittling, mat-weaving, etc., the Catholic Total Abstinence Union, the Princely Knights of Character Castle, some 3,500 Bands of Mercy, the Coming Men of America, the Epworth League, and others. Our present Y. M. C. A. is another instance of the utilization of the social instinct during adolescence; and at the present time we have organizations like the Winchester Rifle Clubs of America and the salesmen clubs of the Curtis Publishing Co., who are exploiting this instinct extensively for more or less altruistic purposes. G. Stanley Hall lists another national boy society that has peculiar significance to the problem of this study—the Agassiz Association, founded in 1875 "to encourage personal work in natural science." Writing in 1904, Hall states the membership of the Association to be 25,000, "with chapters distributed all over the country." According to some authorities of the day, it included the largest number of persons ever bound together for the purpose of mutual help in the study of nature. "It furnished practical courses of study in the sciences; had local chapters in thousands of towns and cities in this and other countries; published a monthly organ, The Swiss Cross, to facilitate correspondence and the exchange of specimens, had a small endowment, a badge, was incorporated, of specimens had a small endowment, a badge was incorporated and was animated by a spirit akin to that of University Extension; and although not exclusively for young people was chiefly sustained by them." Another example of a similar movement is our present day Audubon Societies.

In short, the question of the club in its relation to after-school activities in science holds forth great promise as an instrument for education. Three factors arise from some of the sad experiences in this field of endeavor, which should act as a guide for all further attempts:

(a) Workable Materials,
(b) A definite program,
(c) Intelligent leadership.

The purpose of this chapter is briefly to present a type of club which the writer has developed in the attempt to meet the three factors above mentioned*. The Science Club is the most effective vehicle that he has found upon which extra-curricular materials and activities can be carried; and the Science Play Shop, whether in the school or in the home, offers the best physical environment for facilitating the activity.

(*a*) *Types of Science Clubs*

Almost every wide-awake teacher of science has in one form or another attempted to enhance the interest in his subject by organizing after-school special study groups of some sort. Educational magazines abound in descriptions of such groups and their methods. In 90 per cent. of the cases that the writer has read or known about, these groups or clubs tied themselves to one

*The writer has had considerable experience in club work. He was connected with a Settlement for nearly ten years, having been the director of boys' club work for three years.

very specialized interest. Sometimes it is a Radio Club. Sometimes it is a Field Trip Club, or a Photography Club or an Aero Club, or an Automobile Club, or a Chemistry Club; or a club for the study of some other special subject. The experience of these specialized clubs is almost always short-lived. The chief sources of difficulty are two. First, the prime movers in the group lose their influence on the majority; because they advance so rapidly that the rest feel hopelessly outclassed. Second, the progress of the very few leaders in the club soon exhaust the knowledge, ability and equipment of the average teacher of science. Where the latter is not the case the group continues; but it becomes very limited and select, establishing an "aristocracy of scientists." This of course is of immense value to the "aristocrats," but it doesn't at all utilize the possibilities along these lines that the mass of individuals possess.

In contrast to this type of club, we have the "General" Science Club, which adopts no special hobby for its exclusive program. Obviously it is this type of club to which we must look for extensive educational values; and in the organization and conduct of which we can find suggestion of a "boy science movement," or for the popularization of a real science interest, etc.

(*b*) *The Organization of the Club*

The club each year adopts a constitution. It is not exactly within the sphere of this paper to dwell upon the technical point of constitution-framing, but a good deal is dependent upon the adoption of a document that will actually function. The constitution must be brief, simple and both written and adopted by the boys. At the first meeting of the club, it is well to point out the need for a set of rules, and then with the aid of the group to organize the material that that particular group wishes to put into its constitution, thus:

1. What shall be the aim and purpose of the Science Club?
2. What shall be its name?
3. Membership:
   (a) Who can become a member?
   (b) What must a boy do to become a member?
4. Meetings:
   (a) When shall they be held?
   (b) Where?

(c) How often?
(d) Who shall call for special meetings?

5. Money:
   (a) Shall we pay dues?
   (b) How much?
   (c) Can we levy taxes?
   (d) How? How much?
   (e) For what shall the money be used?
6. Expelling members:
   (a) For what reason or reasons?
7. The Business Program:
   (a) How long shall it last?
   (b) What shall be the procedure?
8. The Science Program:
   (a) How many different activities shall the club have?
   (b) Who shall decide upon and arrange these programs?
9. Officers:
   (a) When shall elections take place?
   (b) How often?
   (c) What officers shall we have?
   (d) What shall be the duties of each officer?
   (e) How can an officer be impeached?
   (f) How can an officer resign?
   (g) Shall officers filling positions left vacant be appointed or elected? And how?
10. Any other regulations you think it important to put into the constitution.

The outline decided upon, a committee is appointed to present answers to the questions raised by the outline. In the meantime a set of temporary officers are elected. At the next meeting the constitution is discussed, altered and finally adopted by a majority vote. It is typewritten and pasted into the secretary's book. The chief value of the constitution is to create an "atmosphere." Often this procedure is the first of its kind that the boy has ever experienced. It appeals to him and makes for solidarity of the group.

The officers of the club usually consist of a president, a vice-president, a secretary, a treasurer, a sergeant-at-arms, a librarian, and two scouts. Their duties are those that usually devolve upon such officials. The sergeant-at-arms is custodian of apparatus, arranges seats, collects and distributes materials, and in general maintains order. The librarian is in charge of all books, pamphlets, magazine articles and pictures owned by or contributed to the club. He organizes a system by which members can draw books, etc., from the library. The scouts discover and investigate interesting places to which the club can make excursions. The club, however, has the power of decision as to whether these excursions shall be arranged. The president and the director arrange the science program for each week and the vice-president acts as assistant to lecturers and demonstrators at the club programs.

Dues are usually five cents a week and occasionally a tax of not more than ten cents is levied in order to purchase a special piece of apparatus or the club insignia (buttons or arm-bands) or to pay for the awards and prizes.

A business meeting of no more than fifteen minutes precedes the main program, during which time the members act on the reports of the scouts, the librarian, or any committee which may have been appointed, and passes on the applications for membership of new applicants.

Though qualification for membership varies with any particular group, it is usual to expect every member to prove his right to join by showing an ability to earn fifteen points of merit. (The Point System is described below.) To remain a member in good standing it behooves a boy also to score at least fifteen points each semester, in addition to his initiation points.

Sometimes when the club grows too large for efficient work, as in the case of the Speyer Science Club, it becomes necessary to recognize two types of membership. Grade A are the very active boys who give up practically all of their extra-curricular time to science club activities. Grade B are the boys who because of the demands made upon them by athletics, other clubs, and home chores, cannot assume an equal share of the club's activities with boys of Grade A. They come to the meetings, are very much interested in its doings, and participate to the extent of their ability. Sufficient admission requirements and membership standards are imposed to avoid a "floating membership." In the Horace Mann Science Clubs it never became necessary to adopt the two-grade scheme, so that the data of Chapter 7 is free from the complication which this would introduce.

GROWTH AND MORTALITY OF MEMBERSHIP IN THE HORACE MANN SCIENCE CLUBS

	1918-19	1919-20	1920-21
Number of members, end of October ..	16	34	45
Number of members, end of December .	28	35	50
Number of members, end of February .	30	38	49
Number of members, end of April	26	36	46
Number of withdrawals	2	1	3
Number of expulsions	3	7	3

The total number of boys to whom is open the privilege of membership varies from 85 to 95. Roughly then, half the boys will join a club of the type we are here describing.

Of the six boys in three years who resigned from the club, one withdrew from the school, two lost interest, and three left because other extra-curricular interests were making too great a demand on their time. Of the thirteen boys who were expelled during three years, nine failed to meet the standards, two were too far in arrears in the matter of dues, and two had failed to behave on some occasion as gentlemen.

The success of the club is of course more dependent upon the director than upon any other one factor. The director should take no active part during meetings, except where it is necessary to carry the boys over what is to them an insurmountable difficulty. As was mentioned before, the director and the president confer upon and arrange each week's program. In all matters he should act as adviser. His frame of mind should be that of a man behind the scenes, who, having set the stage, stands by watching the performance, ever ready to step into a situation and set things right. The ability to do this properly comes with practice. It does not demand exceptional ability or personality. The writer has often absented himself from meetings, arranging for a student-teacher to take his place. In some cases women teachers took charge of the club, but in no case did any disorder result. The most necessary characteristics that the leader should possess is a familiarity with the interests of the boy, a well-organized program of activity, and ability to handle tools and to improvise apparatus, and a good knowledge of practical science. In other words, the qualities that go to make a good teacher of science are also essential for science club leadership. In some ways it is even easier to lead a club than to teach. The club leader can with greater safety confess ignorance on some subjects and work together with his boys in the solution of a problem. A class-room situation is usually not adapted to such a procedure.

(*c*) *The Program of Activities*

Next to efficient leadership, the successful club depends upon its program. In a sense, a well-organized program can make up for inexperience or poor leadership. There are in all five types of activities that merit description.

1. Lectures.

Boys like to imitate. They like to regard themselves a body of great scientists who are assembled to listen to and pass on great discoveries and inventions. With great seriousness they will introduce their speakers and sit back to listen critically to what is being presented. These lectures may be given by their own members, by former members who return with newer and richer experinces, or by adults. It is not very difficult to get science teachers, professors of science, or engineers to come before the club. They enjoy talking to youngsters. The Horace Mann Science Club has entertained some very distinguished people at its meetings. Representatives from the New York Telephone Co., from the Sinclair Valentine Ink Co., from the Slawson-Decker Milk Co., two Columbia professors of Physics and six science teachers are some of the speakers who have come before the boys, often with slides, films, and apparatus. Occasionally the director presents a talk or a demonstration. More often the members themselves give these lectures, and stand the fire of dozens of questions which usually wind up their talks. The extent to which this activity is popular will be cited later.

2. Trips.

The excursion is now a recognized form of instruction. As an activity of the club it presents quite a different problem. Excursions too often become a pleasant means of killing time. As a curricular activity it is subject to several difficulties. It cannot always be arranged to meet a classroom need at a crucial time. The teacher is handicapped by discipline problems, by limited time, by lack of information of the plant or factory visited. The engineer or person in charge is very seldom a teacher or one who can patiently answer the questions that boys will ask. The teacher must be ever conscious of a definite teaching unit and provide for reactions when the trip is over, which make the class too conscious of the fact that they are being taught. In the club, the boys must decide by a two-thirds vote whether to make the trip or not, and the dissenting one-third need not come. The result is an attitude which automatically provides for reactions that make the time spent educationally valuable. Those who have come to feel that excursions are always interesting and productive of enthusiasm, will surely revise their opinions after some experience with boys who are permitted to arrange their own excursions. The writer does not wish to go on record as being opposed to this means of instruction. The contrary is true. He does wish to point out the elements which make the trip successful. When the scouts interview the manager of a plant, they assume a responsibility which insures good order and respect for the company's property. Also, they seem to possess a strange faculty for discovering men who can talk to boys. Then, too, the club leader plays the role of visitor with the boys. And finally the original interest which motivated the trip calls forth lasting reactions that not only supply a fund of information but inspire thought. It is not at all uncommon to find a good many boys making a second and a third trip to the same plant, on their own hook, in order to learn more about some machine or process. It is to be noted that one of the secretary's duties is to write up the excursion in full detail. This account is read at the next meeting. No such account has ever gone uncorrected or unsupplemented. Often the compositions throughout the school for that particular month will abound in descriptions of the excursion.

3. School Assemblies, Exhibitions, Bazaars, Etc.

The social life of any school is highly important. It produces that much-desired thing: "School spirit." There is no surer way for a teacher and his subject to become popular and respected than by entering into the social activity of the school. One of the activities of the Science Club is to arrange periodically for events to which the school at large can be invited. This has in the past taken many forms. Sometimes the school assembly period is devoted to an exhibition of "science magic" or a demonstration of some boy inventions or the presenting of a playlet that has a science plot, etc. The necessary talent is never-failing, for the standards are not high. One or two experiences of this sort may be valuable in pointing out what science club leaders may expect in this phase of activity.

A play was to be presented at a Saturday afternoon gathering of boys, girls, teachers, and parents. The plot, written by a boy, was briefly as follows: The Science Club sergeant-at-arms catches a small fellow tampering with the wireless aerials belonging to the club. He hauls him before a meeting of the club, where he is put on trial. It develops that the culprit had been urged by mere curiosity and a deisre to understand what the thing was. After some very wild suggestions by members as to punishments, one boy makes a plea for the offender's life, proposing that he be permitted to join the club where he could learn all about it. His eloquence wins the club over and they then proceed to initiate him "scientifically" into the club; after which the president ties the club insignia around his arm. When the "drama" commenced some of the leading actors became stage-struck to the extent of forgetting their lines. Fortunately the movement of the plot, being of their own origin, was very clear in their minds. First one and then another they all abandoned their memorized lines and rose to the occasion spontaneously. In parts it was crude, but months of rehearsing could not have produced the spirit and genuineness of the acting. It was a great success.

On another occasion the club held a bazaar to raise money for the Red Cross. Samples of the club work were exhibited and people were urged to leave orders for any scientific toy that struck their fancy. The boys were carried away by their enthusiasm and obtained a great many orders for which they collected in advance. At the meeting that followed, they were confronted with the dilemma of either refunding some of the money or working for three weeks in order to fill the orders. The lesson in responsibility was a good one. They met their obligations.

In many other ways the Science Club can become a leader in the school's activities. The school newspaper, the school library, and certain parts of the school plant can all be made to function in the club program.

4. THE WORK PERIOD.

About every other week it is well to spend part or all of the program in actual working with tools and apparatus. This at once makes essential that there be not more than twelve or fifteen boys at a time. In Chapter 6 we describe in detail how these work periods (play periods) were conducted. During 1920-1921 these periods were a major portion of the club activity because they were demanded by the conditions of our experiment. In order that the forty-five club members have an opportunity to work (play) at least once a week, it was necessary to arrange for three afternoons during the week, with another period for a general meeting for all, spent in a demonstration or lecture program to be described in the next paragraph. Ordinarily the work period can come once a week, the boys taking their turn in this activity. The purpose of this period is to give them an opportunity to try out their ideas and to experiment with their toys. During the demonstration programs there are many things presented that stimulate them to "try out" and to "invent." The periods are designed to give outlet for these stimuli. Although, during the last two years the writer refrained from entering into this activity in any large way (in order to meet a condition of experiment), these work periods present a golden opportunity to direct a boy's thoughts into the proper channels. "Wild-cat" schemes can be quickly discouraged; information can be supplied; proper books put in his way, and in many other ways the boy can be helped to develop in scientific concepts and methods.

5. THE DEMONSTRATION PROGRAM.

This is the most popular activity of the club next to the work period. The demonstrations center around a system of awards known as the Point System which is printed here in full. Each boy receives a copy.

REQUIREMENTS FOR THE PRIZE OFFERED BY THE HORACE MANN SCIENCE CLUB

	Points
(250 points which will be awarded according to the following list.)	
1. For constructing a piece of apparatus or toy	10
2. For demonstrating a piece of apparatus or toy	10
3. For performing an experiment	10
4. For demonstrating a new Meccano or Erector construction	10
5. For demonstrating and explaining a Chemcraft experiment	10
6. For discovering, demonstrating and explaining a new Chemcraft experiment	15
7. For demonstrating and explaining a construction or experiment with an Electrical Set	10
8. For demonstrating and explaining a new Electrical Set construction or experiment	15
9. For making a great discovery or invention (so recognized by the club)	25 to 50
10. For proposing an original idea in science	1
11. For working out that idea, or anyone else's idea in practice	5 to 50
12. For duplicating any of the experiments, devices, or phenomena described in any of the Popular Science Magazines	10
13. For rendering a report or lecture to the club on some important article in any of the magazines or newspapers	5
14. For keeping a well-organized Science Scrap Book. (For every 50 important magazine or newspaper articles.)	10
15. For a collection of magazine diagrams and pictures on some important idea or topic in science	5
16. For entering any of the Popular Science Magazine competitions	5
17. For winning a prize	25
18. For being able to calculate the gas, water and electricity bills	5
19. For being able to regulate a clock	2
20. For being able to do simple wiring of bells and batteries	5
21. For being able to wire up a desk lamp	3
22. For being able to regulate and take care of a player piano or victrola	2
23. For being able to replace a burnt-out electric socket	5
24. For being able to run a small electric motor	5
25. For being able to run a lantern slide machine	5
26. For being able to repair a bicycle, skates, window pulleys, window shades, etc.	5
27. For being able to take good pictures	5
28. For being able to print and develop pictures	10
29. For being able to take apart and put together again a phonograph, vacuum cleaner, or sewing machine	10
30. For being able to measure a person's blood pressure	5
31. For being able to measure humidity	5
32. For delivering a lecture before the club	5

33. For taking a trip to some industrial plant and reporting to the club	5
34. For reading a book on science and reporting to the club	15
35. Ror reading a science story and telling it to the club	5
36. For being able to explain 10 of the things, mechanisms or processes listed on the club list	10
37. For being able to explain 10 of the phenomena listed on the club list	10
38. For knowing the names of 20 great scientists	5
39. For knowing what great thing or things each is remembered for	5
40. For being able to give some important facts about the lives of 10 of them	5
41. For being an officer, scout, or librarian of the club	5
42. For helping in the Science Shop	5
43. For helping some boy in working out his project	5
44. For excellence in Shop	5
45. For excellence in class work	5

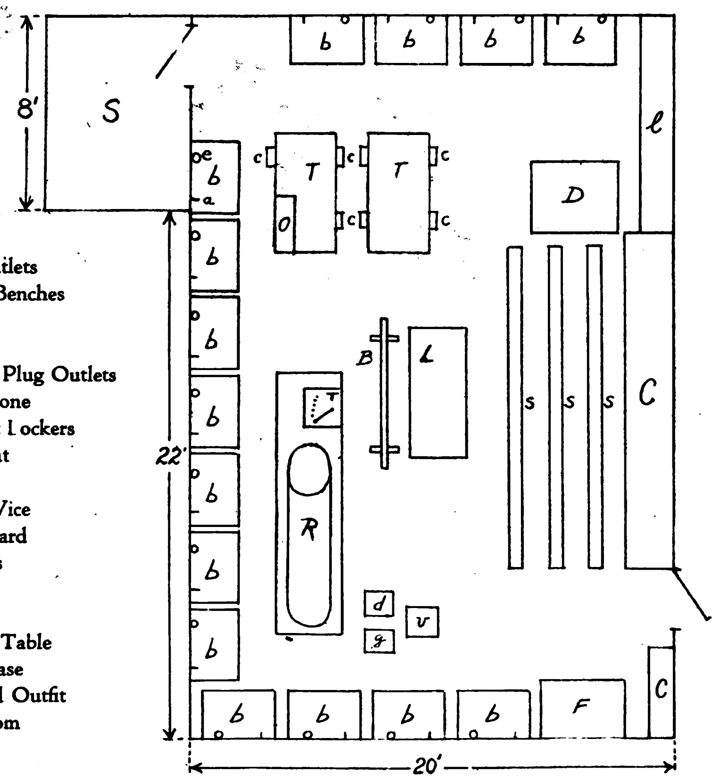
When a boy wishes to claim points he fills out a slip of paper which he drops into the Program Box. The day before the meeting, the president takes out all these applications for numbers on the program and brings them to the director. Together they look them over, arranging them in the best order and making a list of equipment which will be necessary. It is understood that all special apparatus will be supplied by the demonstrators themselves, who are also expected to prepare and set up the apparatus they will need. The program consists of calling the boys up in the order arranged. Each number is followed by questions and discussion. One of the most interesting reactions that this activity produces is in connection with the presenting of so-called inventions. The inventor, after explaining and demonstrating his device must then meet a flood of questions. The originality of the work is sometimes contested; the feasibility of the scheme and its practical value criticised. He is required to test the device thoroughly and often to carry on these tests over a long period of time before he is granted the points. One of nearly one hundred "inventions" of this kind was a wiring scheme by means of which a person instead of knocking on a door could turn the knob and thus close a contact which would ring a bell. Certain features of the device were doubted by the members, who made the inventor install the device in his home to see how long it would stand usage. A committee was appointed to report on its practicability.

The club minutes are crowded with such instances. There is greater difficulty in preventing the standards from becoming so rigid that they discourage activity, than there is of allowing work of poor quality to pass. It has been the writer's experience that boys can be more severe with each other than can a teacher with a boy. One of the things the director must be ever-watchful for is the doing of an injustice to some boy by his fellows. In this connection it is well for the director to keep for himself the authority of granting or not granting the points; although it should be a common practice to call for a vote where there is assurance that a judgment thus arrived at will be fair.

The pressure of the group can be utilized by the director in various ways. In the case of the boy described in Chapter 4 who is interested only in the "fire-works" of his Chemcraft Outfit, the club can very easily bring about one or two results by insisting each time he claims points for a new experiment on a thorough explanation of what happens. Either he becomes entirely discouraged and ceases his Chemcraft activity or he is stimulated to master the "whys" and "wherefores" of what he is doing. The minutes of the different clubs show that in 67 cases of this kind, 42 of the boys appeared at a later meeting and presented an explanation of the experiment that satisfied both the director and the boys. In the case of 32 "inventions" that were given tests of practicability, 21 were eventually perfected. Of 212 cases where boys were "stumped" by questions involving knowledge which they did not possess, 40 tried to "bluff it out," 128 asked the director for help or resorted to books, and the rest were never again heard from on those particular questions. It is not new to those who have had intimate experience with boys to say that the boys value more the respect and affection of their fellows than the reward in "points." It is also to be noted that, although a competitive system was set up, the competition was of the individual with himself; for each boy who scored 250 points for the year received the same prize. On the average, eight or ten boys reached their goal each year.

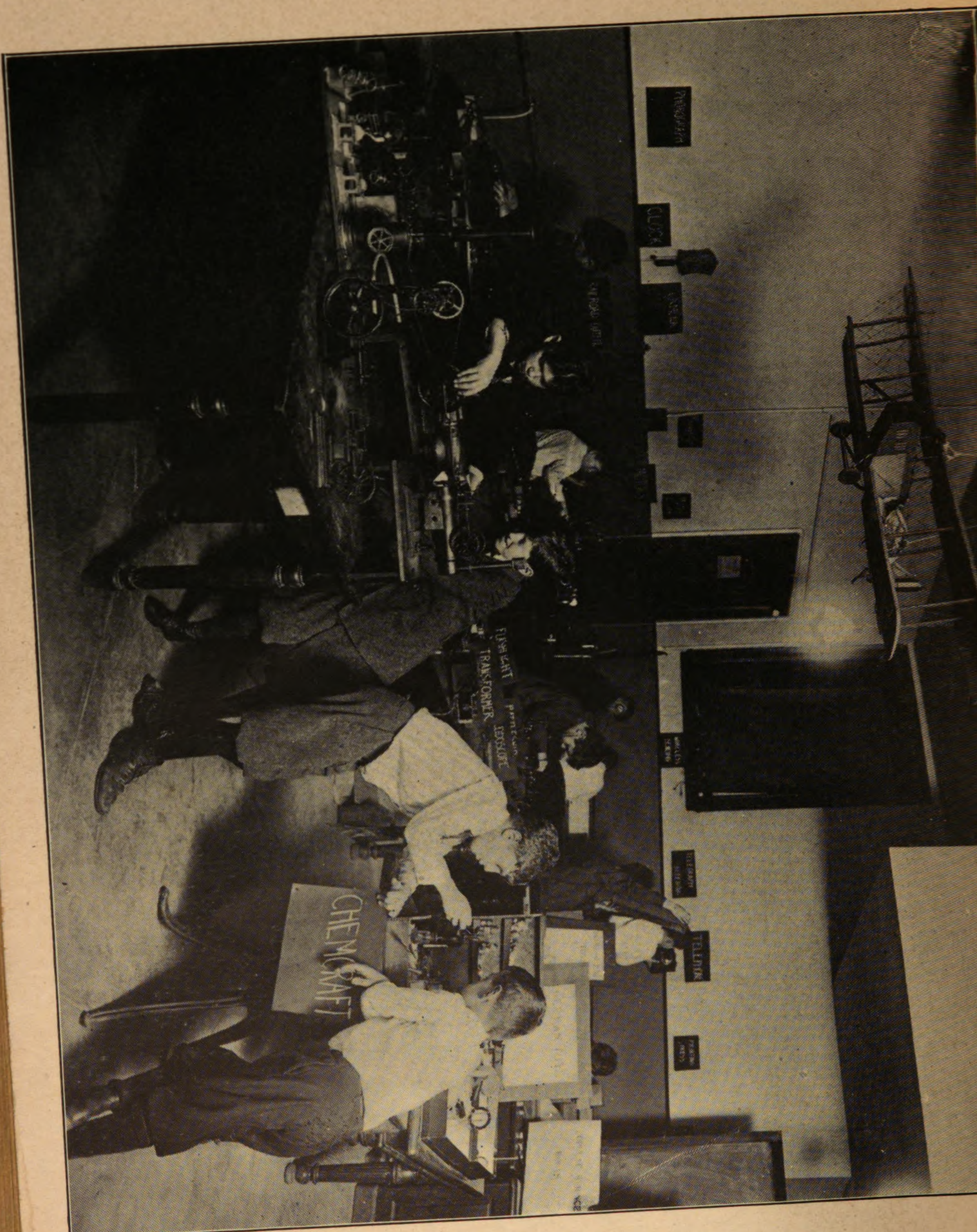
In the following table we can get an idea of the relative popularity of the different items of the point scheme. Next to each item numbered is given the total number of points scored by means of it during three years.

Floor Plan Science Play Shop



SCALE 1-8 in. = 1 ft.

a. Gas Outlets
b. Work Benches
c. Chairs
d. Drill
e. Electric Plug Outlets
g. Grindstone
l. Student Lockers
r. Rheostat
s. Seats
v. Metal Vice
B. Blackboard
C. Cabinets
D. Desk
F. Sink
L. Lecture Table
O. Book Case
R. Railroad Outfit
S. Storeroom
T. Tables


CHEMCRAFT
CLOCK
FLASHLIGHT
TRANSFORMER

Item	Points	Item	Points
1	1260	23	84
2	2210	24	246
3	1070	25	186
4	1810	26	325
5	750	27	110
6	615	28	30
7	920	29	20
8	255	30	10
9	2820	31	65
10	234	32	250
11	610	33	1705
12	190	34	225
13	205	35	25
14	90	36	....
15	60	37	256
16	25	38	105
17	50	39	90
18	245	40	65
19	326	41	145
20	750	42	205
21	120	43	65
22	302	44	....

(*d*) *The Science Play Shop*

Another essential to the success of a science club is a room where these after-school activities can be carried on efficiently. The Horace Mann Science Club of 1920-1921 has been the most successful in the experience of the writer for one reason more than any other; and that was the building of a Science Play Shop. An old junk room was cleaned out for the purpose, and at very little expense fitted up to meet the needs of science work. Some of the experiences with this room might be of value to someone else; and to this end a floor-plan and description are here submitted. (See illustration and diagram.)

The arrangement of the pupils around the sides of the room permits the director of the club to command a good view of the whole group. It also economizes space, leaving the center of the room for large apparatus demonstrations. In this way the director or any boy can walk to the center, hold something up, and it will be seen without the craning of necks. Going from workbenches to seats is also a much simpler matter than with the benches arranged in rows. An essential part of the room's equipment are the two library tables with the books and magazines. Boys are encouraged to go from apparatus to book, from book to apparatus, and back again. The work benches are of the simple type that can be bought for $60 at Hammacher-Schlemmer & Co. Usually a set of these benches are part of the equipment of every school shop. It is not necessary to have individual benches. A long table running around the three sides of the room will quite suffice. A few vises can be provided either as part of this table or attached to a separate bench. At about six or eight places around the room plug-switches should be supplied. This meets most of the demands for electricity that are made. There should be a main switch that controls all the current in the room which though visible to all should be manipulated by the director or a chosen few. To minimize short-circuits, it is well to put a variable rheostat in series with the main-supply, so that the boy cannot get more than a given number of amperes no matter what sort of connection he makes. Where alternating current is available instead of direct current a low-voltage transformer can be used with safety. At each place, too, there should be a gas outlet to which a bunsen burner can be attached. The equipment at each bench should consist of the following: Back Saw, Try Square, Ruler, Plane, Hammer, Brush, Bunsen Burner, Screw Driver, Pliers, Knife. Other general equipment not kept at the individual benches might be a set of chisels, some large rip and cross-cut saws, a set of mallets, a set of files, a set of braces and bits and some bench hooks. A grindstone, a hand-drill and a metal vice should be kept on small movable tables so that a boy can move them to convenient parts of the room. There should be a movable black board that can rotate so as to present either side to view. A small closet for chemicals should be placed close to the sink. By using small chairs or stools fastened in rows of tens and mounted in three gradually rising tiers, thirty boys can be accommodated in a surprisingly small space and so seated that everything that is being done at the demonstration table in front of the black board is perfectly visible. Gas is obtained for the demonstration table by means of a long piece of rubber tubing attached to one of the wall outlets. Electricity is of course brought to the table by means of wires from one of the wall plugs. The controlling rheostat is close to the demonstration table. Other features such as a wireless and a telegraph from one end of the room to the other, and a railroad system, are all very easily installed as shown in the diagram and very accessible to everybody in the room. Exclusive of cabinets and plumbing, the science play shop here described can be installed for slightly over $250.

(*e*) *The Science Play Shop in the Home*

Closely related to the question of providing adequate facilities for the club in the school is the question of what should be done with these activities in the average apartment house. The task at the outset looks hopeless. There is no space to spare. Furnishings can be too easily damaged. The rest and quiet of other members of the family and of neighbors is too easily disturbed. And there are any number of legal restrictions that interfere with the ideal laboratory situation. But the need is great. In this form of play we cannot fall back upon the play ground which is the modern institution that has usurped many of the functions of home and farm. Neither can we rely on the school or the school shop until the latter are organized to provide for this type of activity. What is the result? The boys do the best they can under the circumstances. The experimenting and manipulatory instincts of early adolescence are far too strong to be inhibited by even the close confines of the apartment house, whether the latter be on the East Side or on Riverside Drive. Boys will invade the kitchen, the bathroom, the engine room in the cellar, the elevator shaft, the tank on the roof, tamper with the telephone, the light switches, blow fuses and replace them, and examine critically the gas and electricity meters. The gas range, the vacuum cleaner, the electric fan, the electric percolator and toaster are all objects that excite his curiosity, his interest and his manipulatory instinct. As a general rule, the writer has found Horace Mann parents to be awake to the educative possibilities of these tendencies on the part of their youngsters. Only occasionally does one come across the parent who discourages the boy from these activities, developing in them the "Call the mechanic" habit for each small mechanical emergency of life. The above being the case any suggestions that might help in a difficult situation may be of value. To that end the following experiences with the home-play problem are cited:

1. The most efficient method of storing science play materials is a large and flat case, box, or trunk that can be slid under a bed or sofa, or placed on a shelf. It seems a perfectly feasible thing to develop a special cabinet for this purpose, which when opened up will present a top on which to work, some shelves, test tube rack, ring stand, and even vice. As a matter of fact Chemcraft Set No. 4 and a good many of the containers of the Gilbert materials are already utilizing a fold device which is but a flat box when closed and a type of laboratory bench when opened. The ingenuity that has been applied to the building of compact traveling trunks that contain literally hundreds of articles and clever fixtures, might also be pressed into service for the boy. There are signs that this development is coming. Some of the recent competitions of the toy manufacturers and editors of science magazines have given prizes for the most efficient and most ingenious boy-home-laboratories. A study of some of the winning photographs leaves one with the thought that the boy himself will play a great part in bringing about this development.

2. The boy is not particular as to where his "laboratory" is put as long as he has accessible the three essentials to his work: water, gas and electricity. The traditional nursery in the attic is a failure if it hasn't these three essentials. That there are elements of danger in the use of gas and electricity cannot be denied but that they present any more danger than does the crossing of a busy New York street is also denied. In both cases, careful instructions are necessary, and complete trust given when proper habits are made. A small asbestos mat will minimize greatly the danger from fire.

3. In a number of cases the writer has supervised the installation in the homes of boys of a wiring circuit, which tapped the main supply and brought current to the boy through a set of two ampere fuses. This makes impossible the "blowing" of the house fuses. The boy can "blow" his two ampere fuses and replace them at will. Regular house current is recommended as an economy (batteries are expensive and easily worn out) and as a means of greater experimental possibilities. Where there is alternating current a low voltage transformer is an ideal piece of equipment, and in all cases a "reducer" or rheostat is valuable.

4. The tools a boy will need are surprisingly few in number. A saw, a plane, a hammer, a knife, a screw-driver, a pair of pliers, a brace and bit, a ruler, a try-square, a chisel and a file, are almost all he will ever wish to use. A metal vice is of great value. In this connection the Gilbert Carpentry Outfit offers a rather inexpensive set of essential tools.

5. Out of 50 Speyer boys and 191 Horace Mann boys whom the writer has spoken to on the question of a special place at home where they could play with their toys, 45 of them had special rooms fitted up for that purpose, 72 were permitted to fit their bedrooms up as laboratories, 32 had corners in the kitchen, 22 had corners in the bathroom and 70 had no place at all for this work (play).

CHAPTER X

SUMMARY OF IMPORTANT FEATURES AND FINDINGS OF THE DISSERTATION.

1. An intimate description of a set of after-school materials and activities in science; involving a discussion of historical development and of the aims, methods and advertising propaganda adopted by the manufacturers of these materials.
2. A critical examination of the various "manuals of instruction" that go with the outfits or sets; emphasizing methods of presentation, logical vs. psychological organization, and the most popular experiments and manuals.
3. The kind of science toys most frequently possessed by boys. (See list, Chapter 4.)
4. The average number of toys per boy in the Horace Mann School is 3.9 outfits and 13.3 specific toys. The average number per boy in the Speyer School is 3.2 outfits and 11.7 specific toys.
5. The poorer parent buys his boy almost as many toys as the richer parent buys his; but the toys are not as expensive.
6. In general the very expensive toys are not more educational or more fun-producing than are the less expensive ones.
7. The number of toys a boy possesses increases until he is 11 or 12 years of age. The number stays constant until he is 14; when it begins rapidly to decrease.
8. The kind of toys that are most popular. (See list, Chapter 4.)
9. At 14 years of age there is a marked change in the type of interest that a boy has in toys. Though after-school science activities do not diminish appreciably, there are no toys sold which meet his needs completely.
10. The toy outfit is far more popular than the specific toy. (An outfit is distinguished from a specific toy chiefly by a greater wealth of experimental possibilities and original adaptations.)

11. Of the five hours of each day that the average Horace Mann boy has free to do with as he chooses, roughly three hours are devoted to science toy activities of various kinds; the other two to athletic games.

12. Activities with science toys come at irregular intervals and for long and protracted periods. They are usually accompanied by great enthusiasm and often by dreams at night and by day.

13. A large proportion of boys who own science outfits carry on correspondence with the manufacturers of their toys. As many as 2500 a day has been received by one firm during the months of November, December and January.

14. An analysis of several hundred letters shows the chief interest (37% of the boys) in these toys to be a desire to "do things, make things work, make experiments and invent." The interest that ranks next (23%) is in the winning of a prize or a diploma. The interest that ranks third (20%) is in being a great engineer or inventor.

15. Most of the letters are written because the boys wish help. The chief source of difficulty (54% of the letters) is due to lack of knowledge. The difficulty next in importance (25%) is due to highly impractical schemes. Lack of ability or technique accounts for 18% of the difficulties.

16. As shown by the letters, two-thirds of the boys succeed in overcoming their difficulties. One-third fails. Half of those that succeed do so because of continual experimenting—trial and error. The other half succeeds through help or hint from parent, teacher, or friend.

17. The companies do practically nothing for the one-third that fails.

18. The chief characteristic about a boy who succeeds in overcoming a difficulty is that he almost always finds a new problem arising out of the old one.

19. The analysis of the letters is corroborated by the minutes which were kept of the activities of hundreds of boys in after-school science.

20. For every boy who follows the order of the experiments as found in the manual, there are seven who skip around throughout the manual performing experiments at random. The manuals do not function as they are intended to by the companies.
21. The "random" boys are superior to the others in inventiveness and originality (as measured by their standing in the Science Club).
22. Many of these "random" boys develop a steadier interest in the manuals later on; that is, they pay more and more attention to larger ideas and concepts as developed by the manual. Guidance and control at these critical stages is of course important and is furnished to some extent by the Club.
23. The mechanical toy of greatest appeal is the electrically operated derrick that moves and lifts.
24. There is a growing tendency among manufacturers to abandon the type of toy that appeals merely to the two elementary sensations of motion and color, and to produce a toy that is "meaningful." This tendency is the correlate of a great demand for this sort of toy, that is world-wide.
25. The German science toy is of the specific type—not an outfit. The manuals allow for little flexibility or originality. Boys show an initial interest in them, but the interest seldom lasts. As a rule the German toy is flimsy and frail.
26. A set of curricular criteria are proposed for judging the value of extra-curricular activities. (See tests used and devised.)
27. Extra-curricular activities in science make for almost as good a knowledge and appreciation of environmental phenomena as do curricular activities.
28. Extra-curricular activities in science make for better control of the physical and chemical elements in our environment.
29. Extra-curricular activities in science make for better constructive ability; that is ability to fashion raw materials into
30. Extra-curricular activities in science encourage and stimulate activities that give the boy first-hand experiences with natu-
usable things.

ral phenomena. Their activities agree closely with the youthful activities of great scientists, and they contain elements in common with the laboratory procedure of great scientists.

31. Extra-curricular activities in science represent a type of purposeful activity which encourages originality and inventiveness, and habituates boys to the experimental procedure.
32. Boys who participate in both curricular and extra-curricular activities excell all others in the abilities mentioned in 27, 28, 29, 30 and 31 above.
33. The average IQ of boys who join the Science Club is always slightly smaller than the IQ of those that do not join the Club.
34. There seems to be very little correlation between IQ and standing in the club, or between IQ and Stenquist ability, or between IQ and score in the "Practical" test.
35. Clubs and societies for boys of the ages 11, 12, 13 and 14 take advantage of an instinct that is very dominant during those ages. The propaganda of the manufacturers, the different toy institutes, etc., utilize this instinct essentially for their own purposes.
36. Experiences of large organizations of this type in the past show the need of three things: workable materials, a definite program, and intelligent leadership.
37. The Science Club is an organization which may serve as a medium through which after-school activities in science may be stimulated, guided, controlled, and developed. The organization found to be very workable by the writer is described; including a discussion of types of clubs, methods of organization, control of membership, range of activities and programs and the technique of leadership.
38. The Science Play Shop offers the proper physical facilities for the efficient carrying-on of after-school activities in school.
39. The Science Play Shop in the home is described and discussed from the point of view of offering a way out for parents in crowded apartment houses.
40. Another application of some of the findings of this study (not yet included) is a series of exercises organized into a course of study and correlating principles of science with industrial arts work.

VITA

The author of this dissertation was born near Bielostok, Russia, October 20, 1895. He came to the United States at the age of seven and entered the New York City Elementary Schools, from which he was graduated in 1909. In 1912 he completed the course in the preparatory school of the College of the City of New York, and in 1916 received from that institution the B.S. degree, cum laude, and initiation into Phi Beta Kappa. In 1917 he was granted the M.A. degree from Columbia University.

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