AN EXPERIMENTAL INVESTIGATION OF THE BOOK, LECTURE AND EXPERIMENT METHODS OF TEACHING PHYSICS IN ELEMENTARY SCHOOLS.¹

This investigation was undertaken to obtain a basis for a judgment on the best method of teaching elementary physics. Three methods were employed (referred to as the book method, the lecture method and the experiment method), and the classes of the seventh and eighth grades of Public School 84—Boys, Brooklyn, were so divided that each lesson in science was taught to each class of the same grade by a different method. Upon the completion of the series of lessons the classes were tested by uniform tests, and thus the effects of each method were noted. Some tests were given after a stated interval in order to ascertain how the impressions left by each of the methods were affected by time.

The series of experiments extended over the first and second school terms of 1911. During the second term many of the experiments of the first term were repeated for purposes of verification. Altogether there were 30 experiments in which the lecture, book and experiment methods were compared. The total number of boys that participated in these experiments was about 500. The average age was 13 years 10 months. The total number of test papers corrected was 3280. To this number the book method classes contributed 1114, the lecture method 1072, and the experiment method 1094. In all, about 18,500 individual question were answered and corrected.

The sum totals of the average per cents that the book, lecture and experiment methods attained are as follows: Book method 1555, lecture method 1891, experiment method 1949 total per cents. On the basis of *average per cent. attainments*, then, the experiment method produced the best results. The lecture method, a close second, is only 58 units below the experiment method, while the book method is far behind.

The experiment method produced the highest average per cents in 16 of the 30 experiments. In four of the experiments the average per cents were the same as in the lecture method. In only one experiment did it take third place. In two experiments it tied with the book

¹Author's abstract of a thesis for the Ph.D. degree at New York University. The original thesis, of which this abstract presents a fragmentary summary, is a typewritten manuscript of 386 pages, and may be consulted for further details at the library of New York University.

method for second place. In the remaining seven experiments the experiment method takes second place.

The lecture method produced the highest average per cents in 10 of the 30 experiments. In four the per cents were the same as in the experiment method. In 13 experiments it takes second place. In three experiments it takes third place.

The book method did not produce the highest average per cent. in any experiment. In one it tied with the experiment method for first place, in three it was distinctly second, and in one it tied for second with the experiment method. In the remaining 25 experiments it produced the lowest average per cents.

Eight of the thirty experiments are repetitions of the corresponding experiments of the term before. In the experiment method four first term conclusions are confirmed and four are not. In the lecture method three are confirmed and five are not. In the book method seven are confirmed and one is not. This indicates that the conclusions (as far as these eight experiments are concerned) regarding the book method are firmly established. The conclusions regarding the experiment and lecture methods (as regards these eight experiments) are open to doubt. Further extended investigation might be profitably undertaken.

Twelve of the experiments are 'interval' experiments, *i. e.*, with the test separated by a stated interval from the lesson. In eight of these twelve experiments the experiment method came out first; in two it tied with the lecture method, and in one with the book method for first place. In one experiment it takes second place.

The lecture method attained first place in one of the 12 interval tests; in two it tied with the experiment method for first place. Seven times it attained second place and twice third place.

The book method tied with the experiment method for first place once, and once it attained second place. In the remaining 10 experiments it was third.

This indicates that the impressions left by the experiment method are the most permanent; those left by the lecture method less permanent, and those left by the book method least permanent.

A "combination method" (experimental demonstration plus notebook work) was compared with the other methods in five experiments. In four of the five experiments its average per cents were far below those of the lecture method, in two experiments its average per cents

were much below those of the experiment method, and in two experiments its average attainment was about as good as that of the experiment method. Although we have only five experiments from which to draw our conclusions, the value of notebook work seems to be seriously discredited. Further experimentation in this direction is highly desirable.

The total time consumed by each method is: Lecture method, 121 minutes; experiment method, 143 minutes; book method, 232 minutes. This would mean that the book method is very wasteful of time; the experiment method less so, and the lecture method least so. An undue proportion of the total time in the book method comes from experiments involving quantitative work, to which three full periods were allowed. Excluding the exceptional cases, we find that, as far as the actual teaching of a lesson is concerned, the time consumed by each method is about the same. This leaves out of consideration the time spent by the teacher in preparing lessons. From the teacher's point of view, the methods in the order of least time consumption are: 1st, book method; 2d, lecture method; 3d, experiment method.

"Interest is the mother of attention." Without interest there is no attention and without attention intelligent work cannot be done. The book method of teaching elementary science did not prove interesting to the boys. Only in rare cases was curiosity aroused on account of the novelty of the method.

On the other hand, the lecture method proved to be most interesting. It seems that the element of personality is the important feature of this method. Not one case is recorded where this method failed to arouse and hold the attention. In experiments where the work was largely quantitative in nature the lecture method far excelled the other two. This was largely due to the ease of grasping clear explanations. The boys were not aroused to superior thinking, but merely remembered and imitated the explanations given them.

It is hard to say whether or not the experiment method was as interesting as the lecture method to the boys. Certain it is that in the lecture method attention and interest were directed to the essentials of each lesson, while in the experiment method such interest and attention were necessarily divided between the lesson, itself, and the apparatus that was used.

Of the three methods, the book method was the most fatiguing. Mind-wandering, yawning, staring, stretching, inattention and list-

lessness were invariably noted. The lecture and experiment methods had about an equal share in reducing fatigue to a minimum.

It was demonstrated, again and again, that not only are boys of elementary school age unable to get the thought by means of symbols from the printed page, but that even simple diagrams did not prove of much benefit. If the pupils remembered anything, they remembered words, and not ideas. In several cases a simple diagram was reproduced without the slightest conception of its significance. On the other hand, the concrete and detailed presentation in the experiment method proved of great aid in reproduction. In other words, concrete memory images were reproduced more readily than verbal or auditory memory images.

The book method failed to produce good results either in thought or in memory work. It cannot be said, however, that the experiment method and lecture method were particularly successful in arousing the boys to original thought. Judging from the character of the answers that were given by the classes, it is safe to say that the book method class depended too much upon memory. If the exact statement of the book was forgotten, the answer was usually incorrect. There was no attempt to reach an answer through a process of sound reasoning. The ingenious "inventions" that the book method class frequently resorted to are not indications of sound reasoning. On the other hand, the lecture and experiment method classes, especially the latter, showed more power of independent thought and self-reliance.

Further points emphasized by various aspects of the experiments were that repetition of subject-matter, with an extended intervening period for study, results in a marked increase in efficiency as indicated by the tests; that the use of books in connection with science work helps the boys in the power of expression and has a wholesome effect upon the spelling of scientific terms, both new and old; that poor experimental demonstration is detrimental to efficient teaching, and that a teacher's judgment regarding a class with which he is familiar is usually correct.

The vote of the eighth-year boys showed that the experiment method was by far the most popular, receiving a total of 88 votes. The next in popularity was the lecture method, 23 votes, while the book method received only 11 votes.

CONCLUSIONS.

1. On the basis of efficiency as measured by percental attainments, by lasting impressions on the minds of elementary school pupils, by persistence in memory, by encouragement of independent thought and self-reliance, and by popularity among the pupils the three methods rank as follows: First, experimental method; second, lecture method; third, book method.

2. On the basis of minimal time consumption in the actual teaching of the lessons, of arousing and holding interest and attention, and of the minimal expenditure of mental and physical energy they rank as follows: First, lecture method; second, experimental method; third, book method.

3. On the basis of minimal time consumption by the teacher in the preparation of the lessons, they rank: First, book method; second, lecture method; third, experiment method.

4. The amount retained in thought work, as well as in memory work, in elementary science is inversely proportional to the length of time elapsing between the presentation and the test.

5. No particular hour of the day or position in the general program need be reserved for elementary science.

6. Carefully-written notebook work and neatly-drawn diagrams of science apparatus do not increase the pupils' knowledge of elementary science.

7. The work in elementary science must be concrete, and must be based on the daily experiences and observations of the pupil.

8. Elementary science in elementary schools should be largely, if not entirely, qualitative, and not quantitative.

9. As regards elementary science, elementary school pupils cannot get the thought from the printed page. Simple diagrams are of no material aid.

10. The book method of teaching elementary science might be used with fairly good results, provided the class were exceptionally bright.

11. Pupils who are taught by the book method show superior ability in the power of expression, and in the spelling of new scientific terms, as well as of familiar old terms.

12. Since the experiment and lecture methods approach each other in so many respects, either one may be profitably used. Each produces good results. An ideal method might result from a combination of the two.

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