AN EXPERIMENT IN MEMORIZING VERSUS INCIDENTAL LEARNING.

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The general problem to be solved is "Is it best (1) to memorize, then use knowledge, or (2) begin at once to follow directions in doing, or (3) use knowledge already acquired in doing?" The more special problem tested by this experiment is, "What is the best way of gaining facility in using a multiplication table?"

The traditional method of the schools is to have the children memorize the multiplication table, then after it is learned and the children have been tested by various drill exercises, they are expected to use it with facility in written multiplication. Another method that might be used would be to place in the children's hands a multiplication sheet which they could use in written multiplication with the hope that after using it a good while they would incidentally learn the combinations and be able to work without the key sheet. A third possible method would be to allow the pupil after learning some of the combinations in addition and learning how to derive multiplication combinations from them to begin written multiplication, figuring out each combination as he needs it.

It would require considerable time and care to test these methods with primary children under ordinary school instruction, so an experiment embodying the same principles was devised for older pupils. All those to be tested were supposed to know the multiplication table usually taught in school, but not to know the products of seven by the prime numbers from 17 to 53, inclusive, and the experiment was conducted to determine the relative advantage of three methods of learning these combinations. A practise or test sheet was prepared containing the prime numbers above named with a smaller figure seven beneath them arranged in 10 lines of 10 such groups of figures each. Another sheet, known as the key sheet, indicated the products that could be substituted for each group of numbers. In two methods of testing the pupils were not informed that the numbers on the key sheet were products, and the majority of them did not discover the fact, and very few of those who did made use of their knowledge.

In the first experiment a class of 20 young men in a normal school were divided according to the position in which they happened to be sitting into two equal divisions, one of which was to memorize the key and the other to begin at once to practise writing the substitutes given in the key. In a preliminary test all wrote the substitutes for one line. After that one group practised while the other group memorized for four and, in most cases, for five days, then began practising (using the key if they needed it). The preliminary test revealed slight difference in the rate of the two groups.

To find the time required to do each line the writer called the time at intervals of five seconds, and the pupils wrote down the approximate number of seconds required for each line. Ten lines were done each day. The total time for each day's test, including the time of folding the paper and getting it placed for the next line, averaged about 10 minutes. Those who were memorizing had therefore studied the key from 50 to 60 minutes before beginning their practise.

The average time per line for the practisers the first day was 25.9 seconds, while the average time of those who had spent four or five days in memorizing was slightly greater, being 26.2 seconds. The memorizers were usually less rapid in doing the first few lines than before memorizing, because they required more time to think of the numbers than to look on the key sheet and see what they were. At the close of the second day of practise, or the seventh day of the experiment, the memorizers averaged 19.4 seconds per line, which was slightly better than the 21.9 seconds per line required by the practisers the second day of the experiment. On the tenth day of the experiment, the fifth or sixth day of practice for the memorizers, their record of 17.2 seconds was slower than the fifth or sixth grade of practise for the practisers by 3.1 seconds.

After an interval of about three weeks, during which nothing was done with the experiment, a final test was given. The subjects first reviewed by doing five lines as before, using the key sheet if they needed it, then they were given the critical test of efficiency in use, under slightly different conditions. In this test they wrote as many products as possible

without the key sheet in two minutes, following the lines down and up instead of from left to right, and not stopping to fold the paper between lines. Five of each group remembered all the products in this test, while the others either drew a line in place of the products which they did not know or figured the product (which they now knew could be done). The memory group wrote on an average of 40.9 answers, and the practising group 46.2.

It appears, therefore, that from every point of view the results averaged better for the practise group than for the memory group. There were two individuals of the memory group who learned the key early, one in three and one in four days, and these were able to use their memory very quickly soon after beginning practise. It is possible that these did as well or better than they would if they had practised without memorizing for the same length of time.

A few individuals of the practise group made very little progress in learning the key. A study of their method of working showed that they did not, like the others, look from practise sheet to test sheet before writing each product, but that they kept their eyes on the key sheet most of the time and soon wrote almost as rapidly as if they were merely copying a set of figures without looking at their writing. They thus attained a high rate of speed in a short time, but did not learn the key so fast as those who gave more attention to the practise sheet and the correspondence between the practise and key sheets.

The next test was tried with two classes of freshmen normal school students of about 25 each, all of them young ladies, except four. One class practised, using the key as previously described, for eight days, while the other had no key, but multiplied the numbers and wrote the answers as rapidly as possible the same number of days. In the final test the average number of answers written in two minutes by the group practising with the key was 25.4, while the computing group wrote 44.3 answers. The best of those practising with the key were nearly, but not quite, as good as the best in the computing group, but only one wrote fifty or more answers and six not over twenty, while in the group that computed seven

wrote fifty or more and only one less than twenty. Those who had not memorized the key were helpless in the final efficiency test. Only two or three knew they could get the answers by multiplying. Those in the computing group were perfectly at home and only a little slower than those who incidently memorized the final products.

The experiment was also tried in a similar way with children, though an outbreak of scarlet fever kept some pupils and training teachers out of school part of the time and caused slight irregularities in the experiment which it is not necessary to describe in detail. There were about 20 children in each room, but some of them were absent a day or two, and in one there were only 15 that took the final test. One sixth grade, average age $11\frac{1}{2}$ years, practised with the key 10 days; one sixth grade, average age $11\frac{1}{2}$ years, computed for 10 days; one fifth grade, average age $10\frac{3}{4}$ years (said by the supervisor of these rooms to be brighter than the sixth grades), memorized for five days, then practised one day, then memorized three days more, while another sixth grade memorized for four days, then practised for eight days. The results in the final efficiency test of two minutes was that the number of products written by the computers was 27.7; by the practisers, 19.1; by the fifth-grade memorizers, 10.1, and by the sixth-grade memorizers and practisers, 27.4.

TABLE SHOWING THE SIGNIFICANT FIGURES.
NORMAL STUDENTS.

Group of men who memorized four and five days, then practised with key five days:

Preliminary test of one line	33.5
Average the first day of practise.....	26.2
Average the second day of practise.	19.4
Average the fifth day of practise.....	14.2
Average after vacation.....	17.2
Number of answers in two-minute efficiency test, 40.9.	

Group of men who practised with the key 10 days:

Preliminary test of one line.....	Sec
Average first day of practise.	32.0
Average second day of practise.....	25.9
Average fifth day of practise.....	21.9
Average tenth day of practise.....	17.3
Average tenth day of practise.....	13.1
Number of answers in two-minute efficiency test, 46.2.	

Group of women who practised with key eight days:

	Sec.
Preliminary test of one line	26.2
Average per line first day	22.1
*Average per line second day	11.7
Average per line eighth day	12.3
Average per line after vacation	25.4
Number of answers in two-minute efficiency test, 25.4	

Group of women who practised computing eight days:

	Sec.
First line	32.0
Average first day	25.3
Average second day	18.9
Average eighth day	11.7
Average after vacation	13.8
Number of answers in two-minute efficiency test, 44.3	

Group of children who memorized 10 minutes a day for five days, practised one day, memorized three more days, then after three weeks took final test:

	Sec.
Time required for preliminary test of one line	77.4
Average time per line after five days' memorizing	49.5
Average of five lines after vacation	41.6
Number of answers in two-minute efficiency test, 10.1	

Group of children who practised with key for 10 days:

	Sec.
Preliminary time	61.6
Average per line first day	44.4
Average per line sixth day	23.3
Average per line tenth day	19.1
Number of answers in two-minute efficiency test, 18.9	

Group of children who memorized four days, then practised eight days:

	Sec.
Time required for preliminary test of one line	59.4
Average per line first day of practise	35.4
Average per line sixth day of practise	19.4
Average per line eighth day of practise	16.8
Average per line after vacation	16.7
Number of answers in two-minute efficiency test, 27.4	

Group that practised computing 10 days:

	Sec.
First line	64.2
Average first day	45.7
Average sixth day	29.8
Average tenth day	24.1
Average after vacation	25.0
Number of answers, 27.7	

These preliminary experiments are crude and too few in number to settle the whole question of the best method to be used in various lines at various ages and in various stages of

*Omitted because some of the records for this day were mislaid.

progress, but there is so little evidence of any advantage gained by memorizing unassociated with practise and such marked evidence of the efficiency of those who used previous knowledge as they were learning that it is hard to believe that more exact and extensive experiments will give essentially different results. It seems that memorizing apart from use is the poorest method of all, drill in using somewhat better (if there is not so much effort to attain speed that there is little incidental learning), while the method of using previous knowledge as a guide in practise is the best of the three. A still better method would be to practise either with a key or by computing with the purpose not only of doing the work, but also of learning the products so that it will not be necessary to refer to key or to compute while doing the work. Some individuals would probably do best by considerable attention to memorizing as they work, while others would learn almost as quickly without trying to do so.*

The results indicate that in many lines of teaching there has been a tremendous waste of time, energy and interest in first memorizing, then later practising, the use of what has been learned. Also that pupils do better when practise is guided by their own knowledge than when it is directed by authority of book or teacher.

In manual lines there has been considerable change recently from systematic manual training to less systematized work in the practical arts, which means that learning is being more closely associated with practise and with practising for a purpose.

In language the alphabet is now almost universally taught incidentally while learning to read, instead of being memorized separately, as formerly. Rules of speech and pronunciation are still separately taught in many schools, but there is a growing tendency to put more emphasis upon practising and more or less incidental teaching while reading, talking and writing. Spelling is also taught less by separate drill than formerly. There are also in use methods of teaching facts of geography and history that involve a more or less incidental learning of facts that were formerly memorized separately. In general, however, tradition and examination tests

*See supplement

have made these changes toward more interesting and efficient methods of learning slow and incomplete. This is largely because teachers do not believe that incidental learning is as sure and rapid a method as the method of direct memorizing.

In arithmetic, especially, memorizing and drill methods still hold their places, in spite of the introduction of various innovations. Most teachers will be horrified if told that the sacred multiplication table need not be made a subject of special memorizing and drill, yet such appears to be the case. After children have learned to count they can learn to compute all the addition, multiplication and other useful tables. After they know how to compute they can learn products incidentally by computing, whenever this is necessary in working written examples and problems. To illustrate, after learning to count by ones they can easily learn to count by twos, then by threes. The knowledge of the twos will help them to get that of the fours, and of the threes to get that of the sixes and the nines. The tens are almost learned in learning the ones, and the fives, as half way between, are easily gained. The child then has a basis for computing all additions except the sevens, and these he can get from the three and four combinations. From the addition table he readily gets the subtraction and multiplication tables, and from them the division tables. It is true that these things are now recognized to a considerable extent, but emphasis is still placed upon *memorizing* the tables rather than upon learning to compute them, and much time is spent in drilling on them before the children are given written multiplication and problems with large numbers in which tables are needed. It is probable that at least a year in numbers is wasted in special drill on the various combinations beyond what would be necessary if emphasis were first placed on learning how to compute tables, then upon working examples and problems with larger numbers, computing products till they were learned incidentally.

This last statement has, of course, not been proved experimentally, but is merely an opinion based on inference from general principles and on a good deal of personal observation. Just how much time could be saved by the use of computation and incidental methods in number work as compared with memorizing and special drill methods is not known, but there

can be no doubt that there is no need to have children *memorize* any tables.

It is hoped that such experiments as the above will encourage superintendents to try the method of incidental learning in some of their schools through a course of years. In doing so, tests should be used to determine the efficiency of this method as compared with that of separate memorizing and drill. The Curtis Tests may be used in arithmetic, while in other subjects drill exercises may be modified so as to serve a useful purpose as tests. Occasional tests should be used not merely for experimental investigation, but as a means of helping teachers and pupils to judge the progress that is being made.

SUPPLEMENT.

After this paper was sent in two divisions of normal students, numbering 27 each, practised computing, one with the idea of gaining in speed and the other with the idea of learning the products while practising. The records made for each line naturally emphasized speed in both divisions, while mention of the fact that they need not take time to compute any products that they knew, called some attention to memorizing. The idea of learning was emphasized in one division by asking them to keep that purpose in mind and by having them not compute answers for any line each day, but instead think of all the answers they knew. Those practising for speed gained rapidly at first and three of them learned all of the products, while those intending to memorize were slightly slower at first, but nine learned all of the products. In the final efficiency test given as described above there was no significant difference (60.1 and 60. being the average number of answers written). Three weeks later the average time for the two divisions was practically the same. When, however, a two-minute test was given in which they were not to write products, but to make horizontal marks in place of all products they remembered, and vertical lines when the products were not remembered, the number of lines of both kinds made by those who had practised for speed only averaged 77.8, while those who intended to memorize averaged 86. Evidently one division had gained more in rate of writing products and the other in rate of thinking them.