

The Teaching of Arithmetic II: The Story of an Experiment

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[This is the second instalment of an article describing an experiment which has been carried out in Manchester, New Hampshire, since 1929. In the [preceding section](#), which appeared in the November Journal, Mr. Benezet explained that: In some schools of Manchester, the only arithmetic in the first six grades was practise in estimating heights, areas, and the like; formal arithmetic was not introduced until the seventh grade. In tests given to both the traditionally and experimentally taught groups, it was found that the latter had been able in one year to attain the level of accomplishment which the traditionally taught children had reached after three and one-half years of arithmetic drill. In addition, because the teachers in the experimental group had had time to concentrate on teaching the children to "read, reason, and recite," these children developed more interest in reading, a better vocabulary, and greater fluency in expression.]

In the fall of 1933 I felt that I was now ready to make the big plunge. I knew that I could defend my position by evidence that would satisfy any reasonable person. Accordingly, a committee of our principals drew up a new course of study in arithmetic. I would have liked to go the whole route and drop out all the arithmetic until we reached the seventh grade, for we had proved, in the case of four rooms, that this could be done without loss, but the principals were more cautious than I was and I realized, too, that I would now have to deal with the deeply rooted prejudices of the educated portion of our citizens. Therefore, a compromise was reached. Accordingly, on September 1, 1933, we handed out the following course of study in arithmetic:

- **Grade I** – There is no formal instruction in arithmetic. In connection with the use of readers, and as the need for it arises, the children are taught to recognize and read numbers up to 100. This instruction is not concentrated into any particular period or time but comes in incidentally in connection with assignments of the reading lesson or with reference to certain pages of the text.

Meanwhile, the children are given a basic idea of comparison and estimate thru [sic] the understanding of such contrasting words as: more, less; many, few; higher, lower; taller, shorter; earlier, later; narrower, wider; smaller, larger; etc.

As soon as it is practicable the children are taught to keep count of the date upon the calendar. Holidays and birthdays, both of members of the class and their friends and relatives, are noted.

- **Grade II** – There is no formal instruction in arithmetic.

The use of comparatives as taught in the first grade is continued.

The beginning is made in the telling of time. Children are taught to recognize the hours and half hours.

The teaching of arithmetic II: The story of an experiment

The recognition of page numbers is continued. The children are taught to recognize any numbers that they naturally encounter in the books used in the second grade. If any book used in this grade contains an index, the children are taught what it means and how to find the pages referred to. Children will naturally pick up counting in the course of games which they play. They will also easily and without formal instruction learn the meaning of "half," "double," "twice," or "three times." The teacher will not devote any formal instruction to the meaning of these terms if the children do not pick them up naturally and incidentally.

To the knowledge of the day of the month already acquired is added that of the name of the days of the week and of the months of the year.

The teacher learns whether the children come in contact with the use of money at all in their life outside the school. If so, the meaning of "penny," "nickel," "dime," and "dollar" is taught. In similar fashion, and just incidentally, the meaning and relation of "pint" and "quart" may be taught.

- **Grade III** – While there is no formal instruction in arithmetic, as the children come across numbers in the course of their reading, the teacher explains the significance of their value.

Before the year is over the children will be taught that a "dime" is worth 10 cents, and a "dollar" 10 dimes or 100 cents, a "half dollar" 5 dimes or 50 cents, etc. They will learn that 4 quarters, or 2 halves, are worth as much as one dollar.

They add to their knowledge of hours and half hours the ability to tell time at any particular moment. The first instruction omits such forms as 10 minutes to 4; or 25 minutes to 3. They are first taught to say 3:50; 2:35; etc. In this connection they are taught that 60 minutes make one hour.

It is now time, also, for them to know that 7 days make a week and that it takes 24 hours to make a day. They are also taught that there are 12 months in a year and about 30 days in a month.

The instruction in learning to count keeps pace with the increasing size of the textbooks used and the pages to which it is necessary to refer. Games bring in the recognition of numbers. Automobile license numbers are a help in this respect. For example, the teacher gives orally the number of a car [of not over four digits] which most of the children are likely to see, and later asks for the identification of the car. Children are encouraged to bring to class their own house numbers, automobile license numbers, or telephone numbers and invite the class to identify them.

The use of comparisons is continued, especially those involving such relations as "half," "double," "three times," and the like.

- **Grade IV** – Still there is no formal instruction in arithmetic.

By means of foot rules and yard sticks, the children are taught the meaning of inch, foot, and yard. They are given much practise in estimating the lengths of various objects in inches, feet, or yards. Each member of the class, for example, is asked to set down on paper his estimate of the height of a certain child, or the width of a window, or the length of the room, and then these estimates are checked by actual measurement.

The children are taught to read the thermometer and are given the significance of 32 degrees, 98.6 degrees, and 212 degrees.

They are introduced to the terms "square inch," "square foot," and "square yard" as units of surface

The teaching of arithmetic II: The story of an experiment

measure.

With toy money [or real coins, if available] they are given some practise in making change, in denominations of 5's only. All of this work is done mentally. Any problem in making change which cannot be solved without putting figures on paper or on the blackboard is too difficult and is deferred until the children are older.

Toward the end of the year the children will have done a great deal of work in estimating areas, distances, etc., and in checking their estimates by subsequent measuring. The terms "half mile," "quarter mile," and "mile" are taught and the children are given an idea of how far these different distances are by actual comparisons or distances measured by automobile speedometer.

The table of time, involving seconds, minutes, and days, is taught before the end of the year. Relation of pounds and ounces is also taught.

- **Grade V–B** – There still is no formal instruction in arithmetic except that the children are asked to count by 5's, 10's, 2's, 4's, and 3's. This work is done mentally at first with no written figures before them, either on paper or on the blackboard. This leads naturally to the multiplication tables of 5's, 10's, 2's, 4's, and 3's which, in this order, are given to the children before the end of the semester.

With toy money, or with real coins if available, the children practise making change in amounts up to a dollar, involving, this time, the use of pennies.

The informal work of previous grades in the estimating of distance, area, time, weights, measure of capacity, and the like, is continued. The ability to guess and estimate by games is developed. Each child in the class writes his estimate before these are checked up by actual measurement.

The children compare the value of fractions and discover for themselves that $\frac{1}{3}$ is smaller than $\frac{1}{2}$ and greater than $\frac{1}{4}$; i.e., that the larger the denominator the smaller the fraction. This is illustrated concretely or by pictures.

Toward the end of the semester the children are given the book, *Practical Problems in Mental Arithmetic*, grade IV. The solution of these problems involves a knowledge of denominations which the children have not had and the use of tables and combinations which have not yet been taught to them. Nevertheless, children with a natural sense of numbers will be able to give the correct answers. The teacher will not take time to explain by formula or tables the solution of any problem to those who do not grasp it quickly and naturally. The purpose of the mental arithmetic book is to stimulate quick thinking and to get children away from the old-time method of using the fingers to do the work of the head. If some of the children do not grasp the problems easily and quickly, the teacher simply passes on, knowing that the power to reason will probably develop in them a year or two subsequently. The one thing which is avoided is that children shall get the idea that a fixed method or formula can be used as a substitute for thinking. The problems listed under September, October, and November are covered before the end of the semester.

- **Grade V–A** – The children are asked to count by 6's, 7's, 8's, and 9's. This work is done mentally without written tables before them, either upon paper or on the blackboard. After a time this leads naturally to the multiplication tables of 6's, 7's, 8's, and 9's. The attention of the children is called to the fact that in the table of 9's the second digit is always diminished by one [18, 27, 36, etc.] and the reason is explained that adding 9 is the same as adding 10 and taking away 1. In similar fashion it is shown that adding 8 is the same as adding 10 and taking away 2, so that in the table of 8's the second digit of each successive product is 2 less than the second digit of the product above it [48, 56, 64]. In

The teaching of arithmetic II: The story of an experiment

similar fashion it is shown that adding 7 is the same as adding 10 and taking away 3. After the tables have been learned the teacher makes sure that the children know the products in any order; i.e., that it is not necessary for the child to start at the beginning of the table and run through until he reaches the product which he is asked to give. They learn that 2 times 3 is always equal to 3 times 2.

Children are given a little idea about the relative value of the fractions $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{5}$, and $\frac{1}{10}$. Concrete examples assist in this; e.g., when the children remember that 2 quarters are worth one half dollar, it is easy to show them that twice $\frac{1}{4}$ equals $\frac{1}{2}$, or that twice $\frac{1}{10}$ equals $\frac{1}{5}$.

The problems listed under December to June, inclusive, in the book *Practical Problems in Mental Arithmetic*, grade IV, are covered in the course of the semester. If the children do not grasp the problem quickly and easily, the teacher does not stop to explain the method or prescribe any formula for solution. Of course as new terms occur in the problems [pecks, gallons, etc.] the teacher explains, incidentally, what they mean.

- **Grade VI–B**[20 to 25 minutes a day] – At this grade formal work in arithmetic begins. The first 108 pages of the Strayer–Upton *Arithmetic*, book III, are used as a basis.

The processes of addition, subtraction, multiplication, and division are taught. Care is taken to avoid purely mechanical drill. Children are made to understand the reason for the processes which they use. This is especially true in the case of subtraction. Problems involving long numbers which would confuse them are avoided. Accuracy is insisted upon from the outset at the expense of speed or the covering of ground, and where possible the processes are mental rather than written. Before starting on a problem in any one of these four fundamental processes, the children are asked to estimate or guess about what the answer will be and they check their final result by this preliminary figure. The teacher is careful not to let the teaching of arithmetic degenerate into mechanical manipulation without thought.

Fractions and mixed numbers are taught in this grade. Again care is taken not to confuse the thought of the children by giving them problems which are too involved and complicated.

- **Grade VI–A**[25 minutes a day] – The work of this grade is based upon Chapter II [pages 109 to 182] of the Strayer–Upton *Arithmetic*, book III, and the first 50 pages of book IV.

Multiplication tables and tables of denominate numbers, hitherto learned, are reviewed. The teacher keeps in mind that the objectives to be gained are first of all reasoning and estimating, rather than mere ease in manipulation of numbers.

Again, as in the previous grade, the children before beginning any problem make an estimate [individually] as to what the answer ought to be and check the final result by the preliminary guess.

- **Grade VII–B**[25 minutes a day] – The assignment in the text is the latter part of Strayer–Upton, book IV, beginning with page 51.

Tables of denominate numbers, including United States money, found in the rear of book IV are reviewed. In addition to the table of linear measure, as given, it is taught that there are 1760 yards in a mile, 880 yards in a half mile, 440 yards in a quarter mile, etc.

The teacher will omit any problems in the book which, because of the length of numbers involved, cause the child in using the four fundamental processes to lose sight of the reasoning process which, after all, is the main purpose of the problem.

The teaching of arithmetic II: The story of an experiment

There is a great deal of work in mental arithmetic, involving the solution of problems without reference to paper or blackboard. This is far more important than accuracy in the four fundamental processes.

- **Grade VII–A** [30 minutes a day] – The assignment in the text is the first one hundred pages of Strayer–Upton, book V, omitting the following pages: 1–10, 28, 71–77. Wherever possible the work is done mentally.

Note that most of the pages omitted in this grade reoccur in book VI.

The practise of estimating the probable answer and checking the result with this preconceived estimate is constantly followed.

Again the teachers remember that ability to reason the problem correctly is far more important than errorless manipulation of the four fundamental processes.

- **Grade VIII–B** [30 minutes a day] – The assignment in the test is the latter part of Strayer–Upton, book V, beginning with page 101 [omitting pages 127–34] and the first 32 pages of book VI.

The practise of making a preliminary estimate or an approximation at the answer before attacking the problem is continued. The ability to guess closely and promptly what the answer will be is one of the most important objectives to be gained from the study of arithmetic.

Tables of denominate numbers are kept fresh in the minds of the children. The practise of estimating lengths, heights, and areas of familiar objects and the checking up by actual measurement is constantly kept up.

- **Grade VIII–A** [30 minutes a day] – The text for the grade is book VI of the Strayer–Upton series, beginning with page 35 and omitting the following pages: 36, 46–8, 57–9, 80–2, 92–3, 104, 158–188, 194, 203–4, 206–8.

The work of this grade must necessarily be a summary of everything that has been learned in arithmetic, but, above all, the ability to approximate and estimate in advance the probable answer is kept as the important objective.

The children are shown reasons for the various processes employed; why it is that a correct answer is obtained in the division of fractions by inverting the divisor and multiplying, etc. The ability to read problems intelligently and explain how they should be attacked is far more important than the ability to add large columns of figures without an error.

The teacher will bear in mind that a great deal of work in mensuration [pages 88 to 100 inclusive] will be difficult for some pupils to understand. Of course this work is really using geometrical formulas without giving the geometrical reasons why they work, and some children will be unable to grasp the meaning of it all. It will be found worthwhile to have models in class and to perform experiments like filling a cylinder with water from 3 times the contents of a cone of equal base and altitude, etc.

Again as much of the work as possible is done mentally. Problems are chosen to illustrate principles and give practise in reasoning rather than practise in the manipulation of large figures or complicated fractions.

[Part I](#) | [Part III](#)
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