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NEW ARITHMETIC

EDITED BY SEYMOUR EATON

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WITH PREFACE BY

TRUMAN HENRY SAFFORD
PROFESSOR OF ASTRONOMY IN WILLIAMS COLLEGE

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BOSTON
PUBLISHED BY D. C. HEATH & CO.
1889

PUBLISHERS' NOTE.

THE present work was prepared by Seymour Eaton, Esq., an experienced and skilful common-school teacher. The publishers have requested Prof. T. H. Safford, of Williams College, to prepare a preface for the use of teachers, giving some hints as to the methods which should be employed in teaching arithmetic with its help; and would refer, also, to the monograph by the same author, where the modern principles of all mathematical teaching are laid down on a more extensive scale. The reading of the monograph and that of the preface, in connection, will materially facilitate the use of the present little book in classes.

PREFACE.

THERE are many schools in this country where, as it seems to me, the present work can be used with profit. It requires good, careful teaching; and especially such methods as are in accordance with the natural laws of the development of the boy's or girl's mind. It is rather a book for the higher classes, especially in those schools where pupils are prepared for business, than for primary schools or classes.

Consequently the teacher should not often find it necessary to develop, at very great length, the fundamental principles which the author calls "Hints and Definitions." At the same time, these must be gone over pretty carefully to see that the pupil has already acquired the necessary ground-work, both of thought and practice.

To my mind it seems that more facility in the accurate performance of arithmetical operations is needed than is found in many schools, especially away from the cities. Arithmetic furnishes an excellent mental training; but such training cannot be given unless the classes undergoing it are tolerably at their ease with the numerical operations. A teacher who has not mastered the subject thoroughly often fails in the right results from allowing the use of mechanical processes; and in this case the pupils will later be found deficient in the advanced subjects and in the power of thinking.

The golden mean between doing everything by mechanical rules, but accurately, and thinking out every process with the possibility of mistakes at some one point, is hard to hit; and the successful teacher is he or she who avoids both extremes. Or, better expressed, every process should be present to consciousness until it becomes habitual, not only to perform it, but

to perform it correctly; and the pupil should also acquire the habit of revising and controlling the work of himself or others. It is frequently well to give pupils' work to other pupils for criticism.

In fact, habits of correct calculation are as important in arithmetic as those of reasoning; it was the fault of the earlier teaching of this subject to overlook the necessity that the pupils should reason out the steps; then followed a time in which the latter necessity was recognized, rather to the detriment of accuracy; and now, owing in part to the higher scientific applications of the subject, it begins to be seen that both accuracy and correct reasoning are indispensable. Schoolmasters two generations ago produced good accountants, but did not cultivate the reasoning powers so extensively; those of the last generation were educators rather than trainers, and their results were theoretically better than in practice; and now it is seen that the book-keeper, or the chemist, or the engineer, or the astronomer, cannot compensate for errors in calculation by the brilliancy of his reasoning.

In other words, the real essential difficulty of teaching arithmetic is now better understood than ever before. Even Warren Colburn's Arithmetic, an excellent text-book, has lately been modified to meet the views of the German schoolmaster Grube.

It begins to be seen that arithmetic is a pretty wide subject. As usually defined, it is the science of numbers. It is not ordinarily restricted in definition to that part of the science of numbers which can be treated without the use of letters; so that the definition includes a large part of algebra.

Take the equation

$$(a + b)(c + d) = ac + bc + ad + bd,$$

and we have an arithmetical theorem; for it holds good for any numbers whatever, provided that the necessary substitutions be made.

And so much of arithmetic can be and should be learned while the pupil is studying what is nominally algebra; and the

rules of arithmetic can be ordinarily expressed in a briefer form by algebraic notation. Thus,

$$\frac{a}{b} \div \frac{c}{d} = \frac{ad}{bc}$$

includes a shorter way of writing the common rule for the division of fractions; to make it perfectly definite, then, it may be written as follows:

$$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}.$$

The aspiring teacher will readily find out, by similar considerations, that a thorough knowledge of elementary algebra is a great help to improvement in the art of teaching arithmetic.

Moreover, many concrete examples have relation to ideas of space, length, area, solid contents, measurement. So a knowledge of elementary geometry is needful in the teaching of such branches of our science.

Geometrical demonstration, however, is not all of geometry. The teacher must be more familiar with the definitions, and all that they involve, and with the results of geometrical study, especially the forms developed, one out of the other, than he need be with the logical process of demonstration. The latter he has usually learned for the sake of mental training, and it is no harm to a mathematician to have forgotten some of the steps; but it is a loss to him when he can no longer see the geometrical objects clearly in his mind.

In fact, to teach any branch of mathematics effectively, the instructor must himself know more of the science than is included in that particular portion. The rule most easily laid down is that the grammar school instructor should have gone through the high school; the high school teacher through college; the college professor should have pursued post-graduate studies. For advanced arithmetical teaching, algebra and plane geometry, at least, must be known by the teacher.

But the same person must have a special preparation for each lesson. He cannot rest satisfied with a knowledge of the an-