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ABSTRACT

Described is the use by blind persons of the Cranmer abacus, a computational device adapted from the Japanese abacus. Noted is the lack of carefully controlled research on its use. A comparison of calculation by abacus and by paper and pencil is said to indicate that the use of such mechanical devices does not give the blind competitor an undue advantage over sighted competitors. (CL)

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USE OF THE CRANMER ABACUS BY BLIND PERSONS

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SUMMARY

A comprehensive literature review reveals that there has been no carefully controlled research on the use of the Cranmer abacus nor other computational devices for the blind. However, based on the limited information in the literature, it is clear that the use of such mechanical devices does not give the blind competitor an undue advantage over sighted competitors.

This paper is the result of a comprehensive review of the research on the use of the abacus by blind persons. The discussion of this subject is divided into three sections. These are: computation on the Cranmer abacus; significance for blind persons of the Cranmer abacus; comparison of calculation by abacus and by pencil and paper.

Computation on the Cranmer Abacus

The Cranmer abacus, a computational device used by many blind people, is an adaptation of the Japanese abacus, called the soroban. The most important adaptation to the soroban was the addition of layers of felt and sponge behind the beads to prevent them from slipping around too freely. The abacus is only 3" X 5.5", so it can easily be carried in pocket or purse (Nolan, 1964).

The computational operations of addition, subtraction, multiplication, division, and extraction of square roots can be performed on the Cranmer abacus. For thorough instruction in the use of this device, a blind or sighted person can consult F. L. Gissoni's text Using the Cranmer Abacus for the Blind, available in large print and braille. However, some basic principles of computation can be explained here.

Figure 1 is a diagram of the basic parts of the abacus. Thirteen vertical rods are crossed by a horizontal bar. Each rod holds four beads below the bar and one bead above the bar. Each bead below the bar represents one unit, while each bead above the bar represents five units. A bead acquires its value in computation when it is pushed toward the horizontal bar. The abacus in Figure 1 has the value 751 set on it. In the far right column a single-unit bead is pushed toward the bar, in the second column the five-unit bead is pushed toward the bar, and in the third column from the right, the five-unit and two single-unit beads are at the bar.

The abacus therefore uses a decimal system with units, tens, hundreds, tenths, hundreds, thousandths, etc. The user can either keep track of the decimal place mentally or line up the problem on one of the decimal points located on the frame at three-rod intervals.

The operation of addition on the abacus involves "carrying" numbers from one column to another, as does pencil-and-paper computation. However, the abacus user handles this situation slightly differently, by using the principle of complementary numbers. For instance, if you wish to add four to a column that already contains seven (see Figure 2a), you set 1 on the next column to the left and subtract 6 from the column which initially contained 7 (see Figure 2b). The subtraction of 6 is dictated by the fact that 6 and 4 are complementary numbers, i.e., their sum is 10.

A skilled abacus user performs this "indirect addition" automatically, but a child or adult learning to use the abacus must understand the underlying principle (Neumann, 1970).

Figure 1. Diagram of the Cranmer abacus or soroban.

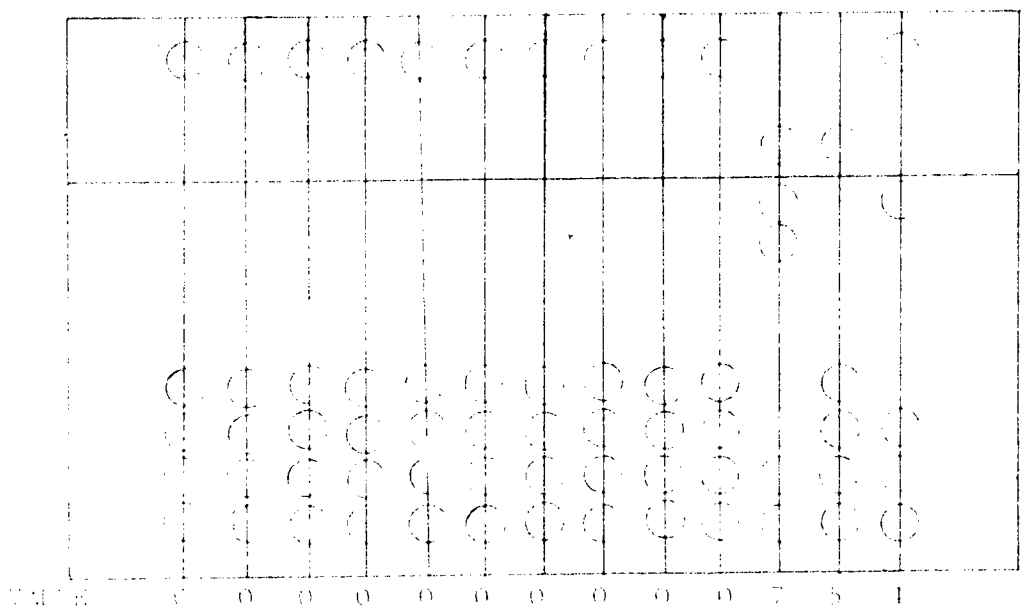
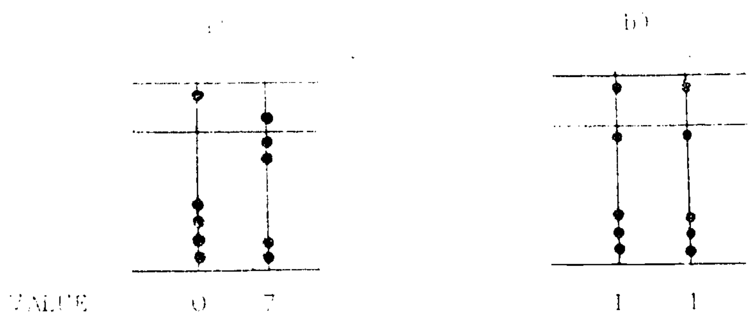


Figure 2. The problem 7 + 4 = 11 performed on the abacus.



Addition on the abacus is performed from left to right, but this does not cause the inconvenience of erasing that would be experienced with pencil-and-paper calculations.

In subtraction, the principle of complementary numbers is again used and has the same effect as "borrowing".

The process of multiplication is much more complex. When numbers with two or more digits are involved, the process consists of a series of additions of the products of multiplications. The user must know the multiplication tables to 9 X 9 = 81. The number of digits in the multiplier plus the number of digits in the multiplicand must equal no more than 12. If multiplier and multiplicand together have more than 12 digits, a second abacus must be used for storing the multiplier.

Long division on the abacus involves a series of divisions, multiplications, and subtractions, in a manner quite similar to the pencil-and-paper operation. The main difference is that each digit of the divisor is divided into the dividend separately. The user must know the division and multiplication tables. A second abacus may be needed in computations involving large numbers.

In problems involving fractions, all numbers must be converted to decimals or to the lowest common denominator. The abacus itself has no provision for dealing with fractions.

Significance for Blind Persons of the Cranmer Abacus

In the past blind children have had difficulty with arithmetic computation. For instance, Nolan and Ashcroft (1959) found that blind children's performance on the Stanford Achievement Test (SAT) computation subtest was 20% below sighted norms. Part of the blame for this poor performance may be due to inappropriate techniques available to the blind child for computation (Nolan, 1964). For instance, the blind child's main writing implement, the Braillewriter, is very awkward to use for computation. Imagine trying to do long division on a typewriter, especially if you couldn't look and type at the same time!

In the early 1960's the Cranmer abacus was developed, and then introduced on a fairly broad scale in schools for the blind. Studies showed that computational accuracy and speed increased in blind children who were trained to use the abacus (Nolan, 1964). Unfortunately there are no carefully controlled studies comparing the computational performance of children using the abacus and children using other methods. There are no studies dealing with blind people beyond ninth grade.

Nolan and Morris (1964) studied the performance of 42 junior high school students before and after eight months of instruction on the abacus. The students showed 33% improvement on the SAT (considered to be of medium difficulty) and 66% on the Madden-Peck Arithmetic Computation Test (considered to be of greater difficulty). The authors concluded that the improvement was due to the use of the abacus, rather than to normal improvement during the school year. Unfortunately there was no control group in the study, so this conclusion could not be confirmed.

Lewis (1970) surveyed residential schools and resource room programs to determine what computational aids were used. Eighty-seven percent of the responding residential schools and 35% of the resource rooms used the abacus, although the age at which it was introduced varied from program to program. The abacus was the aid most often selected by teachers as being "of greatest value".

Brothers (1972) in a study similar to Nolan and Ashcroft (1959), surveyed achievement in arithmetic computation in residential schools for the blind. He found that as a group the students performed 27% below sighted norms. However, eighth-graders who used the abacus performed significantly better than those who used mental computation or the Braillewriter. The abacus users were eight months below the sighted norm, the users of mental computation were one year and six months below the norm, and users of the Braillewriter were two years, four months below. This effect is not due to IQ differences because the abacus group had the lowest mean IQ and the Braillewriter group the highest. Only 38% of the eighth-graders in the survey used the abacus, but it was the most popular device or technique.

This study indicates that the abacus can greatly improve a blind person's ability to perform computations. However many factors are uncontrolled or unknown in the survey. The survey included 12 schools which had some differences, perhaps great differences, in their mathematics instruction programs. There was no information about the students' history with particular computational techniques. In taking the test, the children were allowed to choose whichever computational technique they preferred. Only nine of the 12 schools reported students using the abacus.

It is possible that in a more controlled study, the abacus might prove itself to be of even greater value. It would be valuable to study abacus use by high school students and adults to assess what importance the abacus can have in the long run.

Comparison of Calculation by Abacus and by Pencil and Paper

It is necessary to consider the differences between computation by abacus and by the familiar pencil-and-paper method. The most important difference seems to be relief from lengthy mental calculations on the abacus. For instance, even if a long column of numbers must be summed, the abacus user never adds more than two numbers at a time. This saves the user from the necessity of remembering an ever-increasing number while adding another number to it. The main effect, then, seems to be a reduced dependence on memory capacity. However, the pencil-and-paper user in most situations after elementary school is free to reduce the strain on his or her memory by adding the numbers in pairs if desired. Adding the entire column of numbers at once serves mainly to save time that would be lost in writing the sums of all pairs.

The user of the abacus seems to need as basic an understanding of computational principles as does the pencil-and-paper user. In performing multiplication and division, the abacus user would seem to require a greater understanding in order to keep products, additions, and subtractions in the correct columns. The principle of complementary numbers, by which addition and subtraction is performed, seems to be no less basic than the principles of "carrying" and "borrowing".

Even though a skilled, sighted abacus user can attain great computational speed (Kojima, 1954), the use of the abacus cannot be considered analogous to the use of an electronic calculator. The user of the abacus must understand arithmetic principles, while the user of the calculator need only learn to press a few buttons.

It may be argued that if blind persons are allowed to use the abacus when taking tests, then sighted persons should be allowed to do so as well. This argument is only valid if it is true that blind persons are given an unfair advantage when they use the abacus. In fact it seems that the abacus merely helps them to overcome the disadvantage that is imposed on them by their blindness. The abacus takes the place of the visual stimulus that sighted people rely on when calculating. As data from the Brothers (1972) study show, the abacus does not confer automatic superiority in calculation to the blind user. The eighth grade abacus users were eight months retarded in arithmetic computation, although they were superior to peers who used other methods of computation.

The blind user of the abacus is not as speedy as the sighted user, because the Cranmer abacus is especially designed to prevent rapid movement of the beads. Unfortunately there are no good data which will allow us to compare the speed of the blind abacus user, Braillewriter user, and the pencil-and-paper user, so we cannot assess the affect the abacus would have on speed tests.

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