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A Comparison of Second and Fourth Grade Children's Multiplicative Abilities

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A COMPARISON OF SECOND AND FOURTH GRADE CHILDREN'S MULTIPLICATIVE ABILITIES

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

The curriculum of American schools has experienced a considerable change since the first Sputnik. This is especially true of the mathematics and science programs. One of the criticisms often heard concerning American schools is that they are not giving pupils the background in mathematics that they could. In an effort to overcome this criticism, educators have recently been introducing many new aids designed to improve and strengthen instruction. Some of these aids are the Catherine Stern materials, and the Cuisenaire Rods. In addition to these materials, groups and committees are very active. The School Mathematics Study Group, Greater Cleveland Study, and the Illinois Study are a few of these groups. The Yakima School District is one of several districts in the state of Washington that want to keep up with the changes that would help elementary children receive a better knowledge of mathematics. With this end in mind, a few experiemental classes started using Cuisenaire Rods in the school year of 1960-61. This led to the use of the rods in the first and second grades during the school year of 1961-62.

After the introduction of Cuisenaire Rods into the Yakima elementary schools, it was deemed desirable to initiate research into their effectiveness. Naturally, much research over a long period of time needs to be done. This study was concerned with one phase of this research.

I. THE PROBLEM

Statement of the problem. It was the purpose of this study to (1) compare the multiplicative abilities of fourth graders using the textbook form of learning to that of second graders using the textbook form of learning supplemented by the Cuisenaire Rods; (2) determine which areas of multiplication might be stressed in the coming years to give the district a better primary arithmetic program; and (3) determine if the rods were as helpful to the slow learners as they were to the fast learners.

Importance of the study. Whenever a new method of instruction is introduced into a system, there will be, in most instances, people completely in favor of it and others who have their doubts as to what the overall outcome will be. This is as it should be since it will keep educators from going too far in the wrong direction.

II. DEFINITIONS OF TERMS USED

Regular primary arithmetic program. This term will be used to define the arithmetic program in the Yakima first and second grades up to the time that the Cuisenaire Rods were introduced in 1960.

New primary arithmetic program. Throughout this study, the term "new primary arithmetic program" will be the program presently being carried on in the first and second grades of the Yakima School District. This is instruction carried on as it was in 1960 plus the use of Cuisenaire Rods to supplement the program.

Slow learners. Throughout this report the term "slow learners" will refer to children who rated 90 and below on the California Mental Maturity Test.

Average learners. The term "average learners" will refer to children who rated between 95 and 110 on the California Mental Maturity Tests.

Fast learners. The term "fast learners" includes children who rated 115 and above on the California Mental Maturity Test.

Areas of multiplication. "Areas of multiplication" will refer to one or all five of the following situations concerning multiplication type processes: story problems, writing an addition problem in a shorter way, factoring, simple multiplication, and fractional parts of numbers.

Tester. In this report the "tester" and writer are the same person.

III. LIMITATIONS OF THE STUDY

This study cannot be taken as the last word on the problem of whether the district should continue with the use of the Cuisenaire Rods or look for other methods of teaching arithmetic in the primary grades. As yet, it is not known what the carry-over of the multiplication concepts will be in the later grades. This study does not include all the schools in the Yakima School District, only a sample from three of the thirteen elementary schools. It does not include all the students in the second and fourth grades, only 45 from each grade level. Moreover, the test was composed by the writer and there could be a question as to its validity. Sometimes the vocabulary was unfamiliar to some of the children. The word "factoring" had not been used very often with the fourth graders and had to be explained before the test could be given. This was true with some second graders also. A spread of 10 points between the different I. Q. groups would be more desirable than the 5 points spread used. In some schools the high and low groups could not have been filled with this arrangement.

IV. ORGANIZATION OF REMAINDER OF THE THESIS

The present chapter will identify and state the problem. Chapter II will contain a review of related literature. The methods and procedure used to collect the data are to be presented in Chapter III. Chapter IV will analyze the findings of the study, and Chapter V will give the summary and conclusions.

CHAPTER II

REVIEW OF RELATED LITERATURE AND HISTORY OF THE RODS

Many writers are in agreement concerning the readiness of children to learn the mathematical processes. Bjonerud says that preschool children possess certain arithmetic concepts, and that a planned arithmetic-readiness program for kindergarten should be in effect (1:350).

Cuisenaire and Gattegno take approximately the same stand: "The very large majority of pupils 5 to 7 can study a set of rational numbers up to beyond 100--and it may be up to several hundreds" (4:62).

Noser has said that the first grade is the place to start substituting the letter "N" for a number (14:19).

Near the other end of the scale is the Committee of Seven, who would wait until the last half of the third grade or 8 years 4 months to teach the easy combinations in multiplication and the first half of fourth grade to teach the harder combinations. The combinations in multiplication would not be taught to children who have not attained virtual mastery of the addition facts (3:131).

Brownell and Carper point out that a decade or two ago 100 multiplication combinations were presented in the third grade. More recently, grade three has taught the 4's and 5's, with the fourth grade teaching the harder combinations (3:106). In relation to this, Brownell and Carper report that it can be said with considerable certainty that the postponement of instruction of the combinations to grade four and later cannot be justified on the grounds that children in grade three are incapable of learning them (3:128).

Neuriter and Wozencraft would place the multiplication concepts in the primary grades because they "believe that most elementary curricula overload the third grade with an excess of new topics while the children in the primary grades are not being occupied to full capacity" (10:195).

By using new aids, such as Stern materials and the Cuisenaire Rods, the grade placement for some mathematical concepts has been lowered. The teacher must have a working knowledge of the rods. Howard says:

> One must not give total credit to aids and devices when the role of the teacher is an important factor. What a teacher does with children and how she does it and the way she does these things with the materials she uses constitute the program or pattern of education (10:195).

Brownell, having made a trip to England, Wales, and Scotland to study their mathematics programs, found that the Cuisenaire Rods had been used for three years in England and Wales. He reported, "None of the readily identifiable new experimental programs is being followed extensively" (2:168).

Earlier, in 1957, Howard had investigated the British teachers' reactions to the Cuisenaire Rods and found that they were favorable. The only problem seemed to be that the slower learner showed less interest. Perhaps a new way to present the rods may be needed (10:191-92).

In Scotland Brownell found that the schools using Cuisenaire were spending from 1¼ to 1½ hours a day on arithmetic (2:172). About this time Miller, in an investigation of the amount of time spent on arithmetic in the United States and foreign countries, found that the foreign countries were spending more time on arithmetic than most of the large cities of the United States in the primary grades. Miller reported that 14 per cent of our large cities give 0-9 minutes a day to arithmetic in grade one, while not one of the foreign countries were using less than 10 minutes a day for arithmetic (13:218-19).

The foreign countries were not covering the scope of the elementary curriculum that the American schools were covering. This trip led Brownell to make three statements in respect to our schools:

1. We have seriously underestimated the attention span of school beginners.
2. Likewise, we have seriously underrated the "readiness" of school beginners for systematic work in arithmetic.
3. We can safely ask children in the lower grades to learn much more in arithmetic than we are now asking them to learn (2:173-74).

The use of rods to teach numbers is not new. Seventy years ago Maria Montessori was using rods of different lengths to teach numbers. Miss Montessori, educated in Rome, receiving a medical degree, worked first with the feebleminded and defective children. Later she used much the same method in educating normal children. Her methods were not accepted in this country because of the progressives' distrust of Montessori's "formalism" (12:243;7:404).

The rods appeared again in the early 1930's when Catherine Stern came to America from Germany. Her materials have been revised, with the help of the Carnegie Corporation, and are now being published by Houghton Mifflin (12:243).

The Cuisenaire materials were invented by George Cuisenaire, a schoolmaster of Thuin, Belgium, to assist his own children to learn mathematics. The Cuisenaire Rods are one square centimeter in cross section and vary in length from one to ten centimeters. The color indicates the length of the rod (5:144). The color and length of rods are as follows:

Color of Rods	Length	Color of Rods	Length
White	1 cm.	Dark green	6 cm.
Red	2 cm.	Black	7 cm.
Light green	3 cm.	Brown	8 cm.
Purple	4 cm.	Blue	9 cm.
Yellow	5 cm.	Orange	10 cm.

Although Cuisenaire invented the materials bearing his name, the credit for introducing the materials in many countries, including Canada and the United States, goes to Caleb Gattegno. Gattegno explains Cuisenaire's theory of the rods as follows:

> The central inspiration of his outlook lay in his recognition that the child must learn by action and will, thereby, acquire confidence. If he manipulates materials, sees how bonds are formed, can correct himself and write down what he now sees and knows, it is clear that he will feel very differently from the child who merely repeats sounds he hears which, however meaningful they may be, mean nothing to him (9:3).

Through this aid a child can discover for himself instead of being told. Dutton and Adams believe very strongly that we are not to point out things but are to let them discover for themselves (6:95).

Gattegno explores the uses of counting to find answers to mathematical questions and has this to say about the Cuisenaire method in connection with counting:

> If counting is restricted to answering the question "How many?" then we shall need new mental operations to meet the challenges of life.
>
> Thus, our purpose in the new method <u>is not to do away with counting</u> but to give it its proper place beside the other activities needed to answer the other questions to which mathematics offers its answers (9:5).

CHAPTER III

PROCEDURE

The Yakima School District was interested in how well their new primary arithmetic program was progressing. The Elementary Curriculum Director for the Yakima Schools and the writer met several times to determine what information the district needed and what would be the best way to proceed. To obtain this information it was decided that the first step in the over-all research project would be a simple experiment involving three schools, one from the east side of town, one from the center of town, and one from the west side of town. It was decided to (1) compare the multiplicative abilities of fourth graders using the textbook form of learning to the multiplicative abilities of second graders using the textbook form of learning supplemented by the Cuisenaire Rods; (2) determine which areas of multiplication might be stressed in the coming years to give the district a better primary arithmetic program; and (3) determine if the rods were as helpful to the slow learners as they were to the fast learners. This would give an indication as to whether second graders taught via Cuisenaire Rods can compare favorably with fourth graders taught traditionally.

The Elementary Curriculum Director and the writer met in each of the three schools with the principals and second and fourth grade teachers. The reasons for the study were presented at this time and the entire support of these people was obtained. The test scores from the California Mental Maturity Tests, given at the beginning of the second and fourth grades, were used as the criterion for determining the students' abilities. The scores of all the children were collected at this meeting. The scores were divided into five groups. Table I shows the number of students in each school, in each grade, according to the five I. Q. groups. Students from three of the five I. Q. groups were used in this study. The study used fifteen second graders with I. Q.'s of 90 and below, fifteen second graders with I. Q.'s of 95-110, and fifteen second graders with I. Q.'s of 115 and above. This same pattern was used in the fourth grade.

The writer composed a test intended to test the multiplicative abilities of the students in five areas of multiplication. The first three problems, story problems, were read to the students by the tester. Each problem was read three times. Three points could be earned in this area. The second area to be tested was the writing of an addition problem as a multiplication problem and getting the right answer, such as 3+3+3 as 3x3=9. Three points could be earned in this area. The next section of the test had to do with factoring of numbers. It was possible to make one point for each correct factor of

TABLE I

NUMBER OF STUDENTS IN EACH SCHOOL, IN EACH GRADE, ACCORDING TO THE FIVE ABILITY GROUPS

School Number	Below 90 I.Q.	91-94 I.Q.	95-110 I.Q.	111-114 I.Q.	115 I.Q. & Above
Second Grade					
1	5	3	37	9	29
2	12	6	52	12	32
3	15	12	31	0	6
Fourth Grade					
1	5	4	23	16	51
2	13	9	31	10	32
3	19	9	24	2	12

the number the student was able to give. Eleven points were possible in this area. The fourth area to be checked had to do with such simple problems in multiplication as $2x3=6$. There were four possible points in this area. The final area to be checked had to do with the fractional concept of multiplication. This included such problems as $\frac{1}{2}x8=4$. Four points were possible in this area. Each student had the opportunity to score 25 points if the test was correct in all areas. The test can be found in the Appendix.

On a prearranged date the writer took one and one-half days to administer the test. The number seventeen was used to determine the five students in each group that would be tested. Seventeen names were counted and that student was picked to take the test. Not more than eight students were tested at any one time. The test was administered in the mornings and early afternoons when the children would supposedly be at their best.

CHAPTER IV

FINDINGS OF THE STUDY

It was the purpose of this study to (1) compare the multiplicative abilities of fourth graders using the textbook form of learning with those of second graders using the textbook form of learning, supplemented with the Cuisenaire Rods; (2) determine which areas of multiplication might be stressed in the coming years to give the district a better primary mathematics program; and (3) determine if the rods were as helpful to the slow learners as they were to the fast learners.

To test the null hypothesis that the population mean is the same for both programs, a statistical technique entitled analysis of variance was employed. The particular design employed was a treatment X levels design, a complete description of which can be found in Lindquist's _Design and Analysis of Experiments in Psychology and Education_ (11:121).

The conditions under which a F-test for such a design is valid are listed below:

1. Each treatment group was originally a representative sample from a specified population.
2. The distribution of criterion measures for the subpopulation corresponding to each treatment subgroup is a normal distribution.
3. Each of these distributions has the same variance.

4. The means of the hypothetical populations corresponding to the various treatments are identical (the null hypothesis) (11:133-34).

It will be recognized that condition four is the hypothesis tested. The data have been analyzed and the results summarized in Table II. The test of significance for the hypothesis is based on the ratio of mean squares for programs and within-programs (ms_p/ms_w). This ratio was 8.83, statistically significant at the 1 per cent level. A significant F indicates that one of the conditions was not satisfied. Assuming that the first three conditions were fulfilled, the writer therefore rejects the hypothesis.

In a treatment X levels design, it is necessary to reject the hypothesis of no interaction before one can turn attention to identifying significant differences for individual pairs of treatment means.

The appropriate test for interaction is the ratio of mean squares for programs X levels to within-programs. This gives a F of 5.77, larger than the .01 F for 1 and 60 degrees of freedom which is 4.98. Therefore, the hypothesis of no interaction is rejected. This allows us to look at the individual means.

A t-test is appropriate to test individual pairs of means. Following is the formula used to test individual means:

$$t = \frac{M_{ij} - M_{ij}}{\sqrt{msu\left(\frac{1}{n_{ij}} + \frac{1}{n_{ij}}\right.}}$$

Table III includes the individual means of the six groups, the differences between means for each level, and the *t* corresponding to each difference. The only significant *t* is that for the lowest level of ability.

Table IV includes the findings of this study that were considered by the areas of multiplication.

In problems 1-3, dealing with story problems, the fourth graders were able to answer more questions correctly than the second graders in the low, average, and high groups.

In problems 4-6, having to do with writing addition problems as multiplication problems and getting the right answer, the fourth graders were able to answer more problems correctly than the second graders in the low and average groups. The second graders in the high group were able to answer the problems better than the same group of fourth graders.

Problems 7-9 had to do with factoring. In this area the second graders in the low group were not able to match the fourth graders in their ability to solve the problems. The average and high groups of second graders were able to surpass the fourth graders in this area.

Problems 10-13 dealt with problems in simple multiplication. The fourth graders were able to answer more problems than the second graders in all groups.

TABLE II

SUMMARY OF ANALYSIS

SOURCE OF VARIATION	df	ss	ms
PROGRAMS	1	141.88	141.88
LEVELS	2	1162.06	581.03
(cells)	(5)	(1489.31)	
PROGRAMS X LEVELS	2	185.37	92.69
WITHIN PROGRAMS	84	1349.59	16.07
TOTAL	89	2838.90	

$.01\ F_{1,60}=7.08$

TABLE III

INDIVIDUAL MEANS OF THE SIX GROUPS

ABILITY	SECOND GRADE MEANS	FOURTH GRADE MEANS	DIFFERENCE	t
HIGH	19.8	19.0	-.8	.55
AVERAGE	15.8	17.9	2.1	1.44
LOW	7.7	13.9	6.2	*4.42
TOTAL	14.4	16.8	2.4	

$.01t_{60}$ 2.64 *significant at 1% level

TABLE IV

FINDINGS OF STUDY BY AREAS OF MULTIPLICATION
IN MEAN SCORES

		Prob. 1-3	Prob. 4-6	Prob. 7-9	Prob. 10-13	Prob. 14-17	Prob. 1-17
Below 90 I.Q.	Second Grade	.7	.3	5.4	.8	.4	7.7
	Fourth Grade	1.8	1.0	6.4	3.3	1.2	13.9
95-110 I.Q.	Second Grade	1.1	1.4	8.5	2.7	1.9	15.8
	Fourth Grade	2.1	1.9	8.1	3.9	1.8	17.9
115 I.Q. Above	Second Grade	2.4	2.5	9.0	3.7	2.1	19.8
	Fourth Grade	2.6	1.9	8.6	4.0	1.7	19.0
Total I.Q.	Second Grade	1.4	1.4	7.6	2.4	1.5	14.4
	Fourth Grade	2.2	1.6	7.7	3.7	1.6	16.8

In the area of fractional parts of numbers, problems 14-17, the fourth graders were able to do better than the second graders in the low group only. In the average and high groups the second graders were able to outscore the fourth graders.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to (1) compare the multiplicative abilities of fourth graders using the textbook form of learning to those of second graders using the textbook form of learning, supplemented by the Cuisenaire Rods; (2) determine which areas of multiplication might be stressed in the coming years to give the district a better primary arithmetic program; and (3) determine if the rods were as helpful to the slow learners as they were to the fast learners.

I. SUMMARY

Since the Cuisenaire Rods had been in use for a year in the Yakima School District, it was decided that a study was in order to determine their worth. A simple experiment involving three schools, one from the east side of town, one from the center of town, and one from the west side of town was started. The object was to check the multiplicative abilities of the second graders who had been using rods with the fourth graders who had not been using the aids. The cooperation of the principals and second and fourth grade teachers was obtained. A test was composed to check these abilities. The second and fourth graders of these schools were divided into three groups. The low group consisted of the children that rated 90 and below on the California Mental Maturity Test. The children that rated 95-110 made up the average group. The high group was made up of students that rated 115 and above. The tests were given in the mornings and early afternoon so as to catch the students at the best time. The test was given to 45 second graders and 45 fourth graders. It was never given to more than eight students at one time. From the findings presented in Chapter IV, it was noted that there was not a significant difference in the average and high groups but that there was in the low group.

In the area of story problems, the fourth graders were able to answer more questions than the second graders in the low, average, and high groups.

When it cameto writing addition problems as multiplication problems and getting the right answer, the high group of second graders were able to answer correctly oftener than the fourth graders but fell behind in the low and average groups.

In the area of factoring, the low group of second graders was not able to answer as many problems as the fourth graders, but the average and high second graders were able to surpass the fourth graders.

In simple multiplication, the fourth graders were able to answer more problems correctly in every instance.

In the area of fractional parts of numbers, the fourth graders were able to do better than the second graders in the low group only.

II. CONCLUSIONS

For many reasons it is difficult to draw conclusions at this time about the use of Cuisenaire Rods in the Yakima School District. The rods have been used in the district only about a year and a half. Therefore, the carry-over to higher mathematics will not be known for some years.

The fourth graders were able to complete this test with a higher mean score than the second graders. This is as it should be because of the difference in ages (if we are to assume that the fourth graders have been taught mathematics in their four years in school).

The areas of writing an addition problem in a shorter way, factoring, and fractional parts of numbers were the strongest areas when compared with the fourth graders. The weakest areas were story problems and simple multiplication combinations.

It is felt that although the slow learners did benefit from the use of the rods, they did not profit as much as the average and fast learners.

III. RECOMMENDATIONS

First of all the writer recommends that the Yakima School District continue to use the Cuisenaire Rods in the primary grades until either a better aid for teaching numbers is found or until further study proves that the rods are not doing the job that they were intended to do.

With the slow learner, it is recommended that a different method be tried. This might be handled in a number of ways. There could be a grouping of the slow learners for individual help. Another method might be to pair the slow learner with a fast learner and give him a chance to see how others manipulate the rods. It might be accomplished by grouping slow learners to play a "show me" game. The teacher might ask them to make as many patterns for nine as they can. They would then check each other's patterns to see which ones they have that their friend doesn't have.

In reference to this slow group it would have been better to have checked them against a third grade group because of the difference in ages. To get a more complete picture of the slow learners' abilities it would be advisable to administer the test to other second graders who had not had the rods and then make the comparison to see just how much had been accomplished by the use of the rods.

It is recommended that the teachers spend more time on story problems and simple multiplication combinations. These two areas were the only ones in which the second graders were lower than .2 on the mean score than the fourth graders. This is true when the second grade groups were put together as a grade level and the same pattern was followed for the fourth grade group. In story problems the second graders were .8 below the fourth graders on the mean score. On the simple multiplication combinations, the second graders were 1.3 below the fourth graders.

Further research is recommended to determine the carry-over into higher mathematics. A check of these second graders by the same test when they reach fourth grade would measure the gain in their multiplicative abilities. Further testing of these second graders in the eighth grade would give an indication as to the worth of the rods in higher mathematics when compared with previous eighth graders.

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APPENDIX

TEST IN MULTIPLICATION

1. ☐
2. ☐
3. ☐
4. Can you write the problem 3+3+3 in a shorter way and get the right answer?________________
5. Can you write the problem 2+2+2+2+2 in a shorter way and answer it?________________
6. Can you write the problem 4+4+4+4 in a shorter way and answer it?________________
7. 4____________
8. 10___________
9. 14___________
10. 2x3 = ☐
11. 10x1 = ☐
12. 4x2 = ☐
13. 3x2 = ☐
14. $\frac{1}{2}$x8 = ☐
15. 1/3x9 = ☐
16. 3/4x12 = ☐
17. 5/8x16 = ☐

I. INSTRUCTIONS

Write your name at the top of the paper.

Put your pencils down.

The first 3 problems are story problems. I will read each problem 3 times and that is all. Be sure to cover your paper after you have answered each question.

II. PROBLEMS

1. If I give away $\frac{1}{2}$ of the apples I have, I still have 5 left. How many did I have at first?
2. Let's say you are going to have a party at your house and there are going to be 6 children present. If you wanted each child to have 3 cookies, how many cookies would your mother have to bake?
3. I have 9 pencils in my hand. If I ask you to take 2/3 of them, how many would you take?

4, 5, 6. Can you write the problem 3+3+3 in a shorter way and get the right answer.

7, 8, 9. have to do with factors. Can you write all the factors for 4 on the line beside 4, for 10 on the line beside 10 and for 14 on the line beside 14?

The rest of the problems are multiplication. Work them and turn your paper over as soon as you have finished and I will pick them up.