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## Learning Through Purposeful Activities In The Lower Grades

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A REMEDIAL PROGRAM  
IN THE FOUR FUNDAMENTAL OPERATIONS  
IN DECIMAL FRACTIONS

being

A Thesis presented to the Graduate  
Faculty of the Fort Hays Kansas State College  
in partial fulfillment of the requirements  
for the Degree of Master of Science

by

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Date

July 31, 1939

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L. Stern, J. G., and Hoffman, L. H. How to Teach Arithmetic. Chicago, Ill., Rand McNally & Co., 1914. p. 54.

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## CHAPTER I

### INTRODUCTION

Can the results of the teaching of the four fundamental operations in arithmetic be improved? This is an important question that confronts most teachers of arithmetic. S. A. Courtis of Detroit, Michigan, reports that seventy per cent of eighth grade children do not attain an accuracy above seventy<sup>1</sup>. Charles H. Judd makes the statement that there is no subject in the curriculum of the elementary school in which failure is so common as it is in arithmetic; and mathematics in the high school bars the road to intellectual progress more frequently than do all other subjects combined<sup>2</sup>.

How can the teacher eliminate the difficulties which interfere with pupil progress, and reduce the number of failures in arithmetic? At the beginning of a school year, the teacher many times is not closely informed as to the spread in abilities of her pupils. But she realizes that within one grade a wide variation in the range of the achievement of pupils may exist. She is better prepared to deal with the errors and failures of her pupils if these weaknesses in achievement and ability can be located. A group diagnostic test will show not only the level of ability of pupils in the various operations, but will point

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1. Brown, J. C., and Coffman, L. D. How to Teach Arithmetic. Chicago, Row, Peterson & Co., 1914. p. 38.

2. Judd, Charles H. The Psychology of Social Institutions. New York, The Macmillan Co., 1926. p. 338.

out weaknesses so that the teacher may organize her work in such a way as to give time to those who are below the standard and omit deadening drill for those who are above. These statements furnish the incentive and background for the problem of this thesis.

To be more specific, the problem of this thesis is stated as follows: "A Study of the Mathematical Ability and Achievement of Eighth Grade Pupils in the Four Operations in Decimal Fractions". In order to determine what results might be obtained in respect to the problem, a study was undertaken in the Dodge City Junior High School during the year of 1937-1938, to determine specifically where eighth grade pupils are most deficient in the fundamental operations in decimals and to design a special remedial program to eliminate these deficiencies. It is the teacher's task to reduce the number of failures in arithmetic without lowering the standards.

A number of recent studies have been made in this problem. Edna E. Schlegel diagnosed pupils' difficulties in decimals and found that pupils do not have adequate concepts of the numerical value of decimals nor mastery of the basic combinations .

Isabelle Johnston studied the arithmetical errors of eighth grade pupils and concluded that the errors were due to carelessness, lack of ability, and faulty comprehension .

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3. Schlegel, Edna E. "A Diagnostic Study of Pupil Difficulties in the Fundamental Operations in Decimals". Master's 1935. Pittsburgh.

4. Johnston, Isabelle. "An Experiment in Teaching Junior High School Mathematics". Master's 1935. University of Cincinnati.

In 1926, a committee of seven of the Superintendents' and Principals' Association of Northern Illinois, with the cooperation of several superintendents of schools, made an investigation to determine if the standards toward which our schools are working in the fundamental operations in arithmetic conform with social needs and practices. The following statement is taken from their report, "Children graduating from the eighth grade do not possess anything like as much skill in addition and subtraction as social needs apparently demand. On the other hand it is likely that under the spur of social need, the better half of them will acquire the necessary skill. Children graduating from the eighth grade have somewhat more speed and accuracy in multiplication and division than have intelligent adults ."

5

A study of the arithmetical disabilities of high school students was made by Mildred M. Clyde to determine the arithmetical understandings and abilities of the mathematics students of the Stowe Township High

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4. The committee of seven consisted of the following men: Harry O. Gillet, principal of the University Elementary School, University of Chicago; Floyd Goodier, Superintendent of schools, Chicago Heights, vice-chairman; W. J. Hamilton, superintendent of schools, Oak Park; E. E. Lewis, superintendent of schools, Rockford; W. C. Reavis, principal of the University High School, University of Chicago; J. Roy Skiles, superintendent of schools District 76, Evanston; and Carleton W. Washburn, superintendent of schools, Winnetka, chairman.

5. Washburn, Carleton W. "Social Practices in Arithmetic Fundamentals". Elementary School Journal, XXVII (September, 1926), pp. 60-66.

6. Clyde, Mildred M. "A Study of the Arithmetical Disabilities of High School Students." Master's 1934. Pittsburg.



School by means of a standardized diagnostic test. She discovered the nature and extent of the disabilities existing, and compared the arithmetical performances of grades 9-12 to obtain the measure of improvement found in successive grade levels in this school.

Marion Ellen Bowdren traced the causes of failure of five children in the fifth and sixth grades in a school in a suburb of Boston, and showed specific work done with each child in overcoming his failure and renewing his sense of ability .

8

Sister M. Leonardilla, in a study found that the various types of pupil difficulties can be eliminated by means of proper attention and instruction, and that pupils of low intelligence are capable of improving when given individual attention as needed.

9

Margery Lucile Settle made a study of the errors in the eighth grade in forty-two schools in McLean County, Kentucky, and an analysis of six arithmetic work books to determine whether or not pupils who use them could obtain adequate drill to meet the difficulties found in eighth grade arithmetic.

The general procedure employed in carrying forward the project in

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7. Bowdren, Marion Ellen. "Five Case Studies of Arithmetic Failures." Master's 1934. Boston University.

8. Leonardilla, Sister M. "Third Grade Diagnostic and Remedial Work in the Four Arithmetic Fundamentals." Master's 1932. Indiana State Teachers College.

9. Settle, Margery Lucile. "The Difficulties in Eighth Grade Arithmetic and the Frequency of Their Appearance in Work Books". Master's 1934. Kentucky.

the Dodge City Junior High School eighth grade may be described in terms of four steps, namely, (1) the measurement of mental ability, (2) the diagnostic test of the arithmetical ability in decimals, (3) the program of remedial instruction, and (4) the tests used to determine the improvement, if any, resulting from the remedial instruction.

This testing program began at the end of the first month of school. By then the "warming up process" or review work which was necessary to overcome the retrogression in ability in arithmetic which occurred during the summer vacation was completed. A more reliable picture of the conditions was secured then by a test given immediately after the opening of school.

On September 27, 1927, the Henmon Nelson Test of Mental Ability, <sup>10</sup> Form A (see page 100) was given to the pupils of the eighth grade to determine the mental age and the intelligence quotient of each pupil.

On September 28 and 29, 1937, the Compass Diagnostic Tests in <sup>11</sup> Arithmetic: Test IX, Form A, Addition, Subtraction, and Multiplication of Decimals (see page 101), and Test X, Form A, Division of Decimals (see page 102), were given to determine the weaknesses of each pupil so that the remedial instruction could be given to those below standard.

Forms B of Tests IX and X of the Compass Diagnostic Tests in Decimals were to have been given later, but since these tests were not

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10. Henmon, V. A. C., and Nelson, M. J. The Henmon Nelson Tests of Mental Ability. Chicago, Houghton Mifflin Co., 1931.

11. Ruch, G. M. and others. Compass Diagnostic Tests in Arithmetic. Chicago, Scott, Foresman and Co., 1925.

available at that time, the Forms A were given again on March 23 and 24. Then, on March 25, the Brueckner Diagnostic Test in Decimals (see page 103) was given to obtain a more accurate result of the achievements of the pupils in the remedial program in decimals.

All specified directions for administering the tests were carefully followed. Since the quality of children's responses depends upon a favorable attitude, one of the important items of this testing program was to make certain the children were at ease before starting the tests.

After the tests were checked the data were assembled in the form of tables. Only very simple statistical methods were applied to the data secured from the testing program.



C H A P T E R II

A PRELIMINARY SURVEY OF THE PUPILS TESTED

Dodge City, located in southwestern Kansas, has a population of ten thousand. It is a commercial, distributing and retail center, and is the primary market for grain, poultry, and dairy products of southwestern Kansas, eastern Colorado, and northwestern Oklahoma.

The leading industries of Dodge City include Santa Fe railroad shops, flour milling, creameries, canvas goods, bakery products, concrete products, electrical power, bottled beverages, processed sheet metals, general machine shops and foundry. A large wholesale business is done in agricultural machinery, building materials, hardware, auto supplies, automobiles, furniture, and groceries.

Dodge City has five grade schools, a junior high school, a senior high school, and a junior college. The people take much pride in the school system.

About six per cent of the parents of the eighth grade pupils belong to the business and professional class, while about fifteen per cent of the pupils come from homes dependent upon the W.P.A. or direct relief for support. The majority of the pupils are from the middle walks of life. Many of these pupils will graduate from high school, but will not complete their college education. A few will quit school before completing their high school work, and for this reason, it is desirable to diagnose and remedy the deficiencies in arithmetic.

One hundred seventy-two pupils took part in this experiment. In planning this program, it was decided to exclude the scores of those pupils who moved away before the testing was completed, and the scores of those who entered school after the testing program was started. The scores of seventeen pupils were excluded. There were one hundred fifty-five pupils who took part in the entire experiment, seventy-eight girls and seventy-seven boys.



Table I                      The Chronological Ages to the Nearest Third Month

Years - Months	Number of Pupils
16 - 6	1
16 - 3	0
16 - 0	1
15 - 9	1
15 - 6	1
15 - 3	4
15 - 0	2
14 - 9	10
14 - 6	8
14 - 3	11
14 - 0	10
13 - 9	17
13 - 6	20
13 - 3	33
13 - 0	15
12 - 9	17
12 - 6	2
12 - 3	1
12 - 0	0
11 - 9	1
Total	155

The pupils' chronological ages, to the nearest third month, ranged from eleven years nine months to sixteen years six months. The median chronological age to the nearest month was thirteen years seven months.

Table II

## The Mental Ages of the Pupils

Years-Months	No. of Pupils	Years-Months	No. of Pupils
17 - 4	1	13 - 6	5
17 - 3	0	13 - 5	0
17 - 2	0	13 - 4	0
17 - 1	0	13 - 3	4
17 - 0	4	13 - 2	7
16 - 11	0	13 - 1	0
16 - 10	0	13 - 0	3
16 - 9	0	12 - 11	0
16 - 8	3	12 - 10	5
16 - 7	0	12 - 9	3
16 - 6	0	12 - 8	6
16 - 5	0	12 - 7	5
16 - 4	5	12 - 6	0
16 - 3	0	12 - 5	3
16 - 2	0	12 - 4	3
16 - 1	0	12 - 3	1
16 - 0	7	12 - 2	2
15 - 11	0	12 - 1	0
15 - 10	0	12 - 0	2
15 - 9	0	11 - 11	0
15 - 8	4	11 - 10	1
15 - 7	0	11 - 9	2
15 - 6	0	11 - 8	1
15 - 5	0	11 - 7	0
15 - 4	3	11 - 6	2
15 - 3	0	11 - 5	1
15 - 2	10	11 - 4	1
15 - 1	0	11 - 3	3
15 - 0	5	11 - 2	2
14 - 11	0	11 - 1	1
14 - 10	6	11 - 0	1
14 - 9	0	10 - 11	0
14 - 8	7	10 - 10	1
14 - 7	0	10 - 9	0
14 - 6	4	10 - 8	3
14 - 5	0	10 - 7	0
14 - 4	0	10 - 6	1
14 - 3	5	10 - 5	0
14 - 2	0	10 - 4	1
14 - 1	0	10 - 3	0
14 - 0	7	10 - 2	0
13 - 11	0	10 - 1	0
13 - 10	8	10 - 0	0
13 - 9	5	10 - 11	0
13 - 8	0	9 - 10	0
13 - 7	0	9 - 9	1
		Total	155

The pupils' mental ages, as found by the results of the Hemmon-Nelson Test of Mental Ability, ranged from nine years nine months to seventeen years four months. The median mental age to the nearest month was thirteen years ten months.

Table III The Intelligence Quotients of the Pupils

I.Q.	No. of Pupils	I.Q.	No. of Pupils
136	1	99	4
135	0	98	5
134	0	97	4
133	2	96	5
132	0	95	4
131	2	94	3
130	0	93	2
129	0	92	4
128	4	91	0
127	0	90	1
126	1	89	1
125	3	88	3
124	0	87	2
123	2	86	1
122	0	85	2
121	6	84	6
120	0	83	1
119	3	82	0
118	2	81	0
117	0	80	4
116	4	79	3
115	2	78	2
114	3	77	2
113	1	76	1
112	5	75	3
111	8	74	1
110	5	73	0
109	1	72	0
108	9	71	0
107	2	70	1
106	3	69	3
105	0	68	0
104	3	67	0
103	1	66	1
102	7	Total	155
101	2		
100	4		

The pupils' intelligence quotients ranged from 66 to 136, with a median of 102.36.

Table IV

Compass  
Additional  
of Dec

Score	No. of P	ipile
183	1	
182	0	

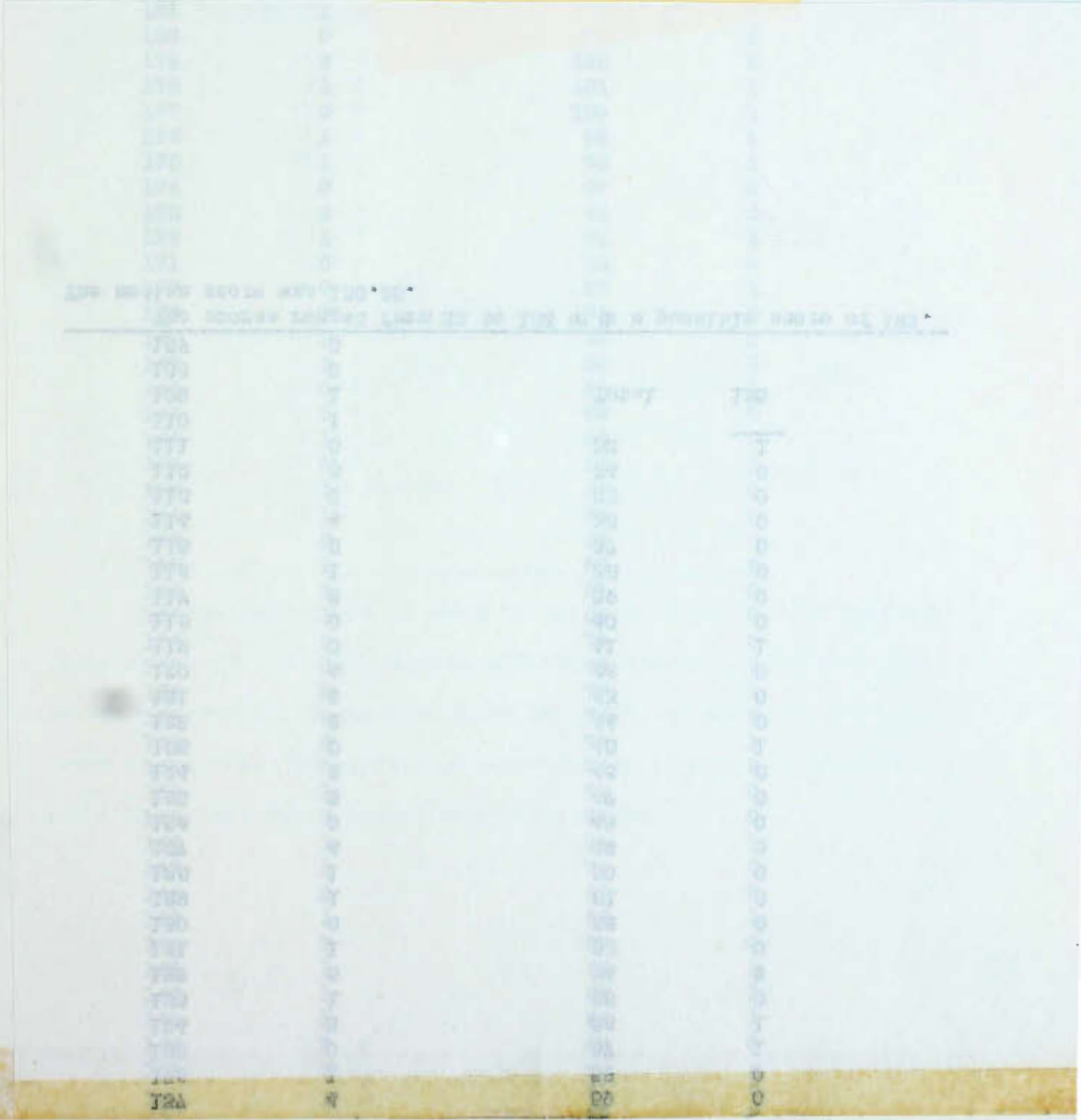


Table V            Age Equivalents as Found by the Compass  
 Diagnostic Test: Test IX, Form A, Addition,  
 Subtraction, and Multiplication of Decimals  
 (September 28, 1937)

Years - Months	No. of Pupils
14 - 6	29
14 - 3	5
14 - 0	2
13 - 9	4
13 - 6	8
13 - 3	5
13 - 0	7
12 - 9	11
12 - 6	8
12 - 3	12
12 - 0	9
11 - 9	11
11 - 6	7
11 - 3	11
11 - 0	8
10 - 9	8
10 - 6	4
Below 10 - 6	6
Total	155

The Age equivalents as shown by the norms given for the Compass Diagnostic test: Test IX, Form A, Addition, Subtraction and Multiplication of Decimals, ranged from below ten years six months to fourteen years six months. The median age equivalent to the nearest tenth of a month was twelve years six and six-tenths months.

Table VI            Grade Equivalents as Shown by the Compass  
 Diagnostic Test: Test IX, Form A, Addition,  
 Subtraction, and Multiplication of Decimals  
 (September 28, 1937)

Grade	No. of Pupils
H 8	39
L 8	9
H 7	15
L 7	16
H 6	23
L 6	16
H 5	11
Below H 5	26
Total	<u>155</u>

The grade equivalents as shown by the norms given for the  
 Compass Diagnostic Test: Test IX, Form A, Addition, Subtraction,  
 and Multiplication of Decimals, ranged from below fifth grade to  
 high eighth grade. The median grade equivalent was low seventh  
 grade.





Table VIII      Age Equivalents as Shown by the Compass

Diagnostic Test: Test X, Form A, Division  
of Decimals (September 29, 1937)

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<u>Years - Months</u>	<u>No. of Pupils</u>
14 - 6	33
14 - 3	4
14 - 0	4
13 - 9	2
13 - 6	2
13 - 3	1
13 - 0	2
12 - 9	3
12 - 6	0
12 - 3	0
12 - 0	2
11 - 9	3
11 - 6	4
Below 11 - 6	<u>95</u>
Total	155

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The age equivalents as shown by the norms given for the Compass Diagnostic Test: Test X, Form A, Division of Decimals, ranged from below eleven years six months to fourteen years six months. The median score was too low to classify - below that of eleven years six months.



**Table IX**      **Grade Equivalents as Shown by the Compass**  
**Diagnostic Test: Test X, Form A, Division**  
**of Decimals (September 29, 1937)**

<u>Grade</u>	<u>No. of Pupils</u>
H 8	42
L 8	4
H 7	2
L 7	3
H 6	0
Below H 6	<u>104</u>
Total	155

The grade equivalents as shown by the norms given for the Compass Diagnostic Test: Test X, Form A, Division of Decimals, ranged from below high sixth grade to high eighth grade level. The median score was too low to classify - below that of high sixth grade level.

The results of the Compass Diagnostic Tests in the fundamental operations in decimals show an urgent need for a special study of the pupils' work for the purpose of locating the exact causes of the difficulty in decimals, and designing a special remedial program to eliminate these deficiencies if possible.

### CHAPTER III

#### THE REMEDIAL PROGRAM

In general, there are three types of diagnostic procedures: the survey, the analytical, and the psychological. The Dodge City program included all three of the procedures. It was a survey program, in that the scores of the pupils were compared with the standards to determine the arithmetic grade and age of each pupil as well as the class in the four fundamental operations in decimals. It was analytical, in that the mistakes were analyzed to determine the types of problems with which the pupils had difficulty, and it was psychological in that there was an attempt to discover the cause of the errors by an analysis of the pupils' written work. Individual examinations were given to a number of pupils by having them work problems aloud when unusual methods were discovered or proper progress was not made in the remedial program.

Arithmetic lends itself readily to analytical treatment as far as the elements involved in computation in arithmetic processes are concerned, for it is made of habits, skills and general abilities.

The basis of this analysis was a study of the written work of one hundred fifty-five eighth grade pupils of the Dodge City Junior High School. After the tests had been given, the incorrect examples were studied to determine the causes of errors. Many peculiar errors,

faulty types of procedure, and special difficulties were found in the work of the pupils. The errors were classified according to type. The total number of different types of errors found was sixty-six. The number of errors were distributed as follows: general difficulties in reading, writing, and converting decimals, 6216; difficulties in addition, 263; difficulties in subtraction, 249; difficulties in multiplication, 1727; and difficulties in division, 6563. The tables contain the classification of a total of 15018 errors.

I. GENERAL DIFFICULTIES IN READING, WRITING, AND CONVERTING DECIMALS	6216
1. Inability to read decimal fractions in words	126
2. Inability to write decimal fractions in words	126
3. Inability to read decimal fractions in figures	243
4. Inability to write decimal fractions in figures	243
5. Inability to convert a decimal fraction to a mixed number or a mixed number to a decimal	126
6. Inability to convert a mixed number to a decimal	126
7. Inability to convert a decimal to a mixed number	126
8. Inability to convert a mixed number to a decimal	126
9. Inability to convert a decimal to a mixed number	126
10. Inability to convert a mixed number to a decimal	126
11. Inability to convert a decimal to a mixed number	126
12. Inability to convert a mixed number to a decimal	126
13. Inability to convert a decimal to a mixed number	126
14. Inability to convert a mixed number to a decimal	126
15. Inability to convert a decimal to a mixed number	126
16. Inability to convert a mixed number to a decimal	126
17. Inability to convert a decimal to a mixed number	126
18. Inability to convert a mixed number to a decimal	126
19. Inability to convert a decimal to a mixed number	126
20. Inability to convert a mixed number to a decimal	126
21. Inability to convert a decimal to a mixed number	126
22. Inability to convert a mixed number to a decimal	126
23. Inability to convert a decimal to a mixed number	126
24. Inability to convert a mixed number to a decimal	126
25. Inability to convert a decimal to a mixed number	126
26. Inability to convert a mixed number to a decimal	126
27. Inability to convert a decimal to a mixed number	126
28. Inability to convert a mixed number to a decimal	126
29. Inability to convert a decimal to a mixed number	126
30. Inability to convert a mixed number to a decimal	126
31. Inability to convert a decimal to a mixed number	126
32. Inability to convert a mixed number to a decimal	126
33. Inability to convert a decimal to a mixed number	126
34. Inability to convert a mixed number to a decimal	126
35. Inability to convert a decimal to a mixed number	126
36. Inability to convert a mixed number to a decimal	126
37. Inability to convert a decimal to a mixed number	126
38. Inability to convert a mixed number to a decimal	126
39. Inability to convert a decimal to a mixed number	126
40. Inability to convert a mixed number to a decimal	126
41. Inability to convert a decimal to a mixed number	126
42. Inability to convert a mixed number to a decimal	126
43. Inability to convert a decimal to a mixed number	126
44. Inability to convert a mixed number to a decimal	126
45. Inability to convert a decimal to a mixed number	126
46. Inability to convert a mixed number to a decimal	126
47. Inability to convert a decimal to a mixed number	126
48. Inability to convert a mixed number to a decimal	126
49. Inability to convert a decimal to a mixed number	126
50. Inability to convert a mixed number to a decimal	126
51. Inability to convert a decimal to a mixed number	126
52. Inability to convert a mixed number to a decimal	126
53. Inability to convert a decimal to a mixed number	126
54. Inability to convert a mixed number to a decimal	126
55. Inability to convert a decimal to a mixed number	126
56. Inability to convert a mixed number to a decimal	126
57. Inability to convert a decimal to a mixed number	126
58. Inability to convert a mixed number to a decimal	126
59. Inability to convert a decimal to a mixed number	126
60. Inability to convert a mixed number to a decimal	126
61. Inability to convert a decimal to a mixed number	126
62. Inability to convert a mixed number to a decimal	126
63. Inability to convert a decimal to a mixed number	126
64. Inability to convert a mixed number to a decimal	126
65. Inability to convert a decimal to a mixed number	126
66. Inability to convert a mixed number to a decimal	126
67. Inability to convert a decimal to a mixed number	126
68. Inability to convert a mixed number to a decimal	126
69. Inability to convert a decimal to a mixed number	126
70. Inability to convert a mixed number to a decimal	126
71. Inability to convert a decimal to a mixed number	126
72. Inability to convert a mixed number to a decimal	126
73. Inability to convert a decimal to a mixed number	126
74. Inability to convert a mixed number to a decimal	126
75. Inability to convert a decimal to a mixed number	126
76. Inability to convert a mixed number to a decimal	126
77. Inability to convert a decimal to a mixed number	126
78. Inability to convert a mixed number to a decimal	126
79. Inability to convert a decimal to a mixed number	126
80. Inability to convert a mixed number to a decimal	126
81. Inability to convert a decimal to a mixed number	126
82. Inability to convert a mixed number to a decimal	126
83. Inability to convert a decimal to a mixed number	126
84. Inability to convert a mixed number to a decimal	126
85. Inability to convert a decimal to a mixed number	126
86. Inability to convert a mixed number to a decimal	126
87. Inability to convert a decimal to a mixed number	126
88. Inability to convert a mixed number to a decimal	126
89. Inability to convert a decimal to a mixed number	126
90. Inability to convert a mixed number to a decimal	126
91. Inability to convert a decimal to a mixed number	126
92. Inability to convert a mixed number to a decimal	126
93. Inability to convert a decimal to a mixed number	126
94. Inability to convert a mixed number to a decimal	126
95. Inability to convert a decimal to a mixed number	126
96. Inability to convert a mixed number to a decimal	126
97. Inability to convert a decimal to a mixed number	126
98. Inability to convert a mixed number to a decimal	126
99. Inability to convert a decimal to a mixed number	126
100. Inability to convert a mixed number to a decimal	126

Table X

## Difficulties in Reading, Writing

## and Converting Decimals

	Frequency
1. Lack of comprehension of the numerical value of decimals	518
2. Lack of comprehension of the place value of numbers	400
3. Difficulties in expressing a decimal number in words	
a. Errors in spelling	33
b. Omission of essential words	61
c. Inability to write decimal fraction in words	182
4. Difficulties in reading and writing decimals	
a. Inability to write decimal fractions in figures	342
b. Omission of decimal point	41
c. Misplacing decimal point	297
d. Inability to express a common fraction or a mixed number as a decimal	830
e. Zero difficulties	
(1) Extra zero in answer	192
(2) Misplacing zero	19
5. Difficulties in writing decimals as common fractions	
a. Inability to reduce fractions to lowest terms	266

Table XI Difficulties in Addition of Decimals

	Frequency
1. Errors in number combination	74
2. Difficulties peculiar to decimal situations	
a. Errors in placing decimal point	39
b. Misplacing the whole number	94
c. Omission of decimal point	31
3. Other difficulties	
a. Not attempted	9
b. Incomplete	6
c. Miscopied	10
<b>Total</b>	<b>263</b>

There were 9 problems in this part of the test. The possible number of errors for the entire class was 1395. (Assuming an error by every pupil on each problem). The percentage of errors and omissions to the nearest tenth of a percent was 18.9%.



Table XII

## Difficulties in Subtraction of Decimals

	Frequency
1. Difficulties basic to any subtraction	
a. Carrying difficulties	28
b. Errors in subtraction facts	27
c. Zero difficulties	10
d. Reversed subtrahend and minuend	6
2. Difficulties peculiar to decimal situations	
a. Misplacing decimal number in subtrahend	53
b. Decimal point omitted	19
c. Misplacing decimal point	27
3. Other difficulties	
a. Not attempted	54
b. Failure to follow directions	8
c. Incomplete	9
d. Miscopied	8
<b>Total</b>	<b>249</b>

There were 9 problems in this part of the test. The possible number of errors for the entire class was 1395. (Assuming an error by every pupil on each problem.) The percentage of errors and omissions to the nearest tenth of a percent was 17.8%.

Table XIII Difficulties in Multiplication of Decimals

	Frequency
1. Difficulties basic to any multiplication	
a. Errors in multiplication	139
b. Errors in adding partial products	27
c. Zero difficulties	77
2. Difficulties peculiar to decimal situations	
a. Placement of decimal point	
(1) Misplacing decimal point	738
(2) Omitting decimal point	110
b. Placing of zero	
(1) Failure to prefix zero	38
(2) Failure to annex zero	20
(3) Prefixing unnecessary zero	36
(4) Annexing unnecessary zero	92
3. Other difficulties	
a. Not attempted	417
b. Incomplete	27
c. Miscopied	6
Total	1727

There were 34 problems in this part of the test. The possible number of errors for the entire class was 5270. (Assuming an error by every pupil on each problem). The percentage of errors and omissions to the nearest tenth of a percent was 32.8%.



Table XIV Difficulties in Division of Decimals

	Frequency
1. Difficulties basic to any division	
a. Errors in division	309
b. Difficulties with trial divisor	133
c. Number omitted in quotient	34
d. Errors in multiplication	70
e. Errors in subtraction	61
2. Difficulties peculiar to decimal situations	
a. Placement of decimal point	
(1) Decimal point misplaced	1822
(2) Decimal point omitted	170
(3) Using decimal point when unnecessary	184
b. Placement of zeros	
(1) Failure to prefix zero in quotient	159
(2) Failure to add zero to dividend	252
(3) Failure to add zero to quotient	714
(4) Annexing unnecessary zeros to quotient	154
(5) Prefixing unnecessary zeros to quotient	126
(6) Putting zero in wrong place in quotient	43
3. Other difficulties	
a. Not attempted	1890
b. Incomplete	47
c. Failure to follow directions	387
d. Miscopied	<u>8</u>
Total	6563

There were 73 problems in this part of the test. Assuming an error by every pupil on each problem, the possible number of errors for the entire class was 11316. The percentage of errors and omissions to the nearest tenth of a percent was 58.0%.

On the entire test, there were 207 problems. The possible number of errors for the class was 32085. (Assuming an error by every pupil on each problem). With 15018 errors and omissions, the percentage to the nearest tenth was 46.8%.

Many peculiar errors, faulty types of procedure, and special difficulties were found in the work of the pupils. The following illustrations will show some of the faults most commonly found.

DESCRIPTION OF GENERAL DIFFICULTIES

I. Lack of comprehension of the numerical values of decimals

A. Illustration.--Draw a line under the larger number in each pair below.

.92    "909"    0.318    ".3018"

B. Description.--The pupil drew a line under the longer number and not the number larger in numerical value.

II. Lack of comprehension of the place value of numbers

A. Illustration.--Study the number at the left below and then write on the lines the place value of each of the figures. Notice that the place value of the first figure has already been filled in correctly.

68247.5391	6 ten thousands	5 "thousand"
	8 "millions"	3 "hundred"
	2 "thousands"	9 "hundred"
	4 "hundred"	1 "hundred"
	7 "tenth"	

Description.-- Evidently this pupil had no idea of the place value of numbers. He wrote none of them correctly and gave four different figures in the number the place value of hundreds. The only decimal notation used was tenths which was incorrectly given for the units place.

III. Difficulties in expressing a decimal number in words

A. Instruction.--Write each number below in words.

1. Errors in spelling

(a) Illustration

(1) .9 "nine tents"

(2) .09 "nine hundreds"

(b) Description.--The pupil spelled "tenths" and "hundredths" as he probably pronounced them.

2. Omission of essential words

(a) Illustration

4.247 "Four - two hundred forty seven"

(b) Description.--The pupil placed a dash for the word "and" and omitted the word "thousandths".

#### IV. Difficulties in reading and writing decimals

##### A. Instruction.--Write each of these numbers in decimal form.

###### 1. Inability to write decimals in figures.

###### a. Illustration

(1) Eight hundredths        ".800"

(2) Two hundred ninety-six thousandths        "200.096"

###### b. Description

(1) The pupil wrote eight hundredths as he would eight hundred - then gave the number a decimal point.

(2) The pupil evidently read an "and" in the number for he wrote the number as though it were "two hundred and ninety-six thousandths"

###### 2. Omission of the decimal point.

###### a. Illustration

Thirty and seven-tenths        "307"

b. Description.--The omission of the decimal point was probably due to carelessness.

##### B. Instruction.--Change the fractions and mixed numbers below to decimal form. Carry to three decimal places if necessary.

###### 1. Misplacing of the decimal point.

###### a. Illustration

(1)  $973/100 = ".973"$

(2)  $9\ 4/5 = ".980"$



b. Description

- (1) Evidently the pupil did not know that the denominator 100 is the equivalent to two decimal places.
- (2) The pupil did not count the zero when counting two places for hundredths.

2. Inability to write a fraction or mixed number as a decimal.

a. Illustration

- (1)  $2 \frac{1}{5} = "2.5"$
- (2)  $9 \frac{4}{5} = "49"$

b. Description

- (1) The pupil wrote the denominator of the common fraction in the decimal place.
- (2) The pupil multiplied the whole number by the denominator and added the numerator, then put the result in the decimal place.

3. Extra zero in answer

a. Illustration

$\frac{1}{2} = ".50"$

b. Description.--Unless instructed otherwise, all decimals should be reduced to lowest terms.

4. Misplacing zero in answer

a. Illustration

$85 \frac{27}{1000} = "85.270"$

b. Description.--The pupil has the necessary three places for thousandths, but he failed to place the zero in the proper place.

V. Difficulties in writing decimals as common fraction.

A. Instructions.--Change the decimals below to fraction form.

Reduce fractions to lowest terms wherever possible.

1. Inability to reduce fractions to lowest terms.

a. Illustration

(1) 3.5 = "3 5/10"

(2) 8.25 = "8 25/100"

(3) 2.375 = "2 375/1000"

b. Description.--These errors might have been listed under

"Failure to follow directions".

2. Inability to write decimals as common fractions.

a. Illustration

(1) 8.25 = "8/25"

(2) .6 = "1/6"

(3) 3.5 = "1/2"

b. Description

(1) The whole number was used as the numerator and the decimal was used as the denominator.

(2) Here again the decimal was used as the denominator of the common fractions, then one was annexed for the numerator.

(3) The pupil did not repeat the whole number in writing the mixed decimal as a mixed number.

## VI. Lack of fundamental knowledge

A. Illustration.--Write on each line below a number which will make each statement true.

1. .4 is one-tenth of "24".
2. 8 is ten times as large as "2".
3. 24 is a hundred times as large as "1".
4. 84 multiplied by 1000 equals "48,000".
5. .67 is 1/100 of "4000".

B. Description.--The pupil evidently did not understand the problems and wrote any number in the blanks.

## VII. Other difficulties

A. Carelessness in reading

1. Illustration.--Write each of the numbers in decimal form.  
Twenty-two hundredths = ".32"
2. Description.--A careful pupil would not have written .32 for .22.

B. Not writing out completely

1. Illustration.--Change the fractions and mixed numbers to decimal form.  
 $31 \frac{214}{1000} = 31.2$
2. Description.--This was the last problem attempted, so evidently time was called on the test before the problem was completed.

C. Failure to follow direction

1. Illustration.--Change the fractions and mixed numbers below to decimal form. Carry to three decimal places if necessary.

$$2 \frac{1}{3} = 2.33 \frac{1}{3}$$

2. Description.--The instruction was to carry to three decimal places if necessary. This pupil carried his answer to two places.

DESCRIPTION OF ADDITION DIFFICULTIES

I. Difficulties basic to addition.

A. Error in number combination

1. Illustration.--Add

a. 4.72	b. .7254
8.34	.3219
9.68	.4380
<u>4.28</u>	<u>.0473</u>
"27.01"	"1.4326"

2. Description.--

- a. The correct answer is 27.02.
- b. The correct answer is 1.5326. There may have been a carrying difficulty.

II. Difficulties peculiar to decimal situations.

A. Error in placing decimal point.

1. Illustration.--Add



.7254

.3219

.4380

.0473

"15326"

2. Description.--Evidently the pupil thought there could be no whole number in the answer, since there were no whole numbers in the addends.

B. Misplacing the whole number

1. Illustration.--Copy correctly and add these numbers:

$$34.5 + .09 + 627 + 3.014.$$

34.5

.09

"627"

3.014

"38.231"

2. Description.--The whole number 627 was misplaced.

C. Omission of decimal point

1. Illustration.--Add.

4.27

34.6

93.02

647.1

"77899"

2. Description.--The figures in the answer are correct. The pupil omitted the decimal point.

### III. Other difficulties

#### A. Incomplete

##### 1. Illustration.--Add.

.9

2.0

6.3

18.05

25

2. Description.--Evidently time was called on the test before the problem was completed.

#### B. Miscopied

##### 1. Illustration.--Copy correctly and add these numbers:

$$4.27 + 34.6 + 93.02 + 647.1.$$

"4.72

34.6

93.02

647.1

"779.44"

##### 2. Description

The number 4.27 was copied 4.72.

### DESCRIPTION OF SUBTRACTION DIFFICULTIES

#### I. Difficulties basic to any subtraction

##### A. Carrying Difficulties.

##### 1. Illustration.-Subtract.

$$.00040$$

$$\underline{.00019}$$

"0.00031"

2. Description.--This pupil subtracted 9 from 10 correctly but did not carry one to the one in the subtrahend.

B. Weaknesses in subtraction facts.

1. Illustration.--Subtract.

$$9.346$$

$$\underline{4.132}$$

"5.213"

2. Description.--Evidently the multiplication facts were confused with the subtraction facts in subtracting 2 from 6.

C. Zero difficulties

1. Illustration.--Subtract.

a.  $.00040$

b.  $.00040$

$$\underline{.00019}$$

$$\underline{.00019}$$

"0.00030"

"0.00039"

2. Description.

a. The zero of the minuend was copied in the answer.

b. The nine of the subtrahend was copied in the answer.

D. Reversed the subtrahend.

1. Illustration.--Copy correctly and subtract these numbers:

$$36.724 - 36.0724.$$

$$36.0724$$

$$\underline{36.724}$$

"3484"

2. Description.--The longer number and not the larger number was placed in the minuend.

## II. Difficulties peculiar to decimal situations.

### A. Misplacing decimal number in subtrahend

1. Illustration.--Copy correctly and subtract  $921.008 - 911.25$

$$921.008$$

$$\underline{911.25}$$

"8292.83"

2. Description.--Regardless of the decimal point, the numbers were placed for subtraction as whole numbers.

### B. Decimal point omitted

1. Illustration.--Subtract.

$$72.445$$

$$\underline{51.002}$$

"21 441"

2. Description.--The pupil subtracted correctly but carelessly omitted the decimal point in the answer.

### C. Misplacing decimal point

1. Illustration.--Subtract.

$$9219.30$$

$$\underline{213.14}$$

"90.0616"

2. Description.-Evidently the pupil followed the rule for placing the decimal point for multiplication rather than subtraction.

III. Other difficulties.

A. Failure to follow direction.

1. Illustration.-Copy correctly and subtract these numbers.

72.443

51.002

"123.445"

2. Description.-The problem was added instead of subtracted.

B. Incomplete.

1. Illustration.-Subtract.

921.008

911.25

"8"

2. Description.-Time was called before the pupil had time to complete the problem.

C. Miscopied.

1. Illustration.-Find the difference between six and three hundredths and four and two tenths.

"6.300"

"4.210"

"2.090"

2. Description.-The pupil copied .300 for .03 and 210 for .2.



## DESCRIPTION OF MULTIPLICATION DIFFICULTIES

## I. Difficulties basic to any multiplication.

## A. Errors in multiplication facts.

## 1. Illustration.- Multiply.

654

.89

5886

"5024"

"56126"

2. Description.- This pupil multiplied by nine correctly but made errors in multiplying by eight.

## B. Errors in addition of partial products

## 1. Illustration.- Multiply

.9182

.2104

36728

9182

18364

".19418928"

2. Description.- The error in addition was made in adding the column of two numbers, 9 and 3. With the one carried, the sum of this column is 13 rather than 14.

## C. Zero difficulties.

## 1. Illustration.- Multiply.

$\begin{array}{r} a. \quad 760.1 \\ \underline{30.5} \\ "3805" \\ \underline{"2283"} \\ "2321.05" \end{array}$	$\begin{array}{r} b. \quad .9182 \\ \underline{.2104} \\ 36728 \\ 9182 \\ \underline{18364} \\ ".01994948" \end{array}$
--	---

c.  $.046 \times 0 = ".046"$

## 2. Description.-

- a. The zero was handled correctly in the multiplier but not in the multiplicand.
- b. The zero was not handled correctly in the multiplier.
- c. The zero was given the value of one in the multiplication.

## II. Difficulties peculiar to decimal situations.

### A. Misplacing decimal point.

#### 1. Illustration.- Multiply.

450.3

.2653

13509

22515

27018

9006

"11946.459"

2. Description.- To locate the decimal point in the product, five places were counted from left rather than from the right.

B. Omitting decimal point

1. Illustration.- Multiply.

.273

.194

1092

2457

273

52962

2. Description.- The decimal point was omitted in the product.

C. Failure to prefix a zero.

1. Illustration.- Multiply.

.983

.041

983

3932

"40303"

2. Description.- Six decimal places were needed in the product.

This pupil failed to prefix a zero for the sixth place.

D. Failure to annex a zero.

1. Illustration.- Multiply.

$3.2 \times 100 = "32"$

2. Description.- The decimal was moved only one place to the right rather than two places in multiplying by 100.

**E. Prefixing unnecessary zeros.**

1. Illustration.- Multiply.

$$.04 \times 100 = ".0004"$$

2. Description.- The decimal was moved two places to the left rather than two places to the right in multiplying by 100.

**F. Annexing unnecessary zeros.**

1. Illustration.- Multiply.

$$7510.3 \times 100 = 7510300.$$

2. Description.- Two zeros were added to the multiplicand in multiplying by 100 rather than moving the decimal two places to the right.

**III. Other difficulties.**

**A. Incomplete**

1. Illustration.- Multiply.

$$450.3$$

$$\underline{.2653}$$

$$13509$$

$$15$$

2. Description.- Evidently time was called on the test before completion of the problem.

**B. Miscopied.**

1. Illustration.- The figures below are correct as printed. But there are mistakes in placing the decimal point. Cross out the given answers and write the correct answers below.

3.256  
4.11  
 3256  
 3256  
13024  
 1.338216  
 "13.32816"

2. Description.- The decimal was located correctly but the 8 and 2 were reversed in copying the answer.

#### DESCRIPTION OF DIVISION DIFFICULTIES

#### I. Difficulties basic to any division.

##### A. Errors in division.

##### 1. Illustration.- Divide

$$\begin{array}{r}
 \text{"9"} \\
 341 \overline{) 7307.63} \\
 \underline{\text{"3069"}} \\
 \text{"2366"}
 \end{array}$$

2. Description.- After errors in division and subtraction the pupil became discouraged and quit. He attempted the next eight problems and made errors in six of them.

##### B. Difficulty with trial divisor.

##### 1. Illustration.- Divide.



$$\text{a. } .17 \overline{) 5399.20} \quad \begin{array}{l} \text{"316160"} \\ \hline \end{array}$$

51

29

17

129

"102"

"27"

"17"

102

102

$$\text{b. } 75.4 \overline{) 219736.0} \quad \begin{array}{l} \text{"31356"} \\ \hline \end{array}$$

"2202"

"995"

734

2613

2202

4116

3670

4460

4404

56

## 2. Description.-

a. The correct answer is 31760.

b. The correct answer is 2993.678<sup>-</sup> or credit is given if carried to one decimal place or more.

## C. Number omitted in quotient.

### 1. Illustration.- Divide.

$$.06 \overline{) 4.590} \quad \begin{array}{l} \text{"7.5"} \\ \hline \end{array}$$

42

39

36

30

30

2. Description.- The work is correct. The pupil omitted 6 from the correct quotient 76.5.

D. Error in multiplication.

1. Illustration.- Divide.

$$6.7 \overline{) 217.08} \quad \begin{array}{l} \text{"32.4"} \\ \text{"267"} \end{array}$$

201

160

134

268

"267"

1

2. Description.- An error was made in multiplying 7 by 4.

E. Error in subtraction

1. Illustration.- Divide.

$$8.9 \overline{) .0212} \quad \begin{array}{l} \text{"178"} \\ \text{"189"} \end{array}$$

178

97

89

"189"

178

11

2. Description.- An error was made in subtracting 89 from 97.

II. Difficulties peculiar to decimal situations.

A. Decimal point misplaced.

## 1. Illustration.- Divide.

$$6.7 \overline{) 217.08} \quad \begin{array}{l} \text{"324"} \\ \hline \end{array}$$

2. Description.- The decimal point in the dividend was moved to the left rather than to the right to locate the decimal point in the quotient.

## B. Decimal point omitted.

## 1. Illustration.- Divide.

$$205 \overline{) 2328.80} \quad \begin{array}{l} \text{"1136"} \\ \hline \end{array}$$

2. Description.- The decimal point in the quotient was omitted.

The correct answer is 11.36

## C. Using decimal point when unnecessary.

## 1. Illustration.- Divide.

$$1.74 \overline{) 384.54} \quad \begin{array}{l} \text{"2.21"} \\ \hline \end{array}$$

2. Description.- The correct answer is 221.

## D. Failure to prefix zero in quotient.

## 1. Illustration

$$8.8 \overline{) .18779} \quad \begin{array}{l} \text{"211"} \\ \hline \end{array}$$

2. Description.- The figures are correct in the quotient, but the pupil failed to place a zero between the decimal point and two. The correct answer is .0211.

## E. Failure to add zero to the dividend.

## 1. Illustration.- Divide.

$$.316 \overline{) 104912} \quad \begin{array}{l} \text{"332"} \\ \hline \end{array}$$

2. Description.- The pupil did not move the decimal point three places to the right in the dividend. The correct answer is 332000.

F. Failure to add zero to quotient.

1. Illustration.- Divide.

$$\begin{array}{r}
 \text{"4.3"} \\
 1.74 \overline{) 70.122} \\
 \underline{69 \ 6} \\
 522 \\
 \underline{522}
 \end{array}$$

Description.- The correct answer is 40.3.

G. Annexing unnecessary zeros in the quotient.

1. Illustration.- Divide.

$$\begin{array}{r}
 \text{"21400"} \\
 45.2 \overline{) 93728}
 \end{array}$$

2. Description. - The decimal point was moved two places to the right in the dividend instead of one place to locate the decimal point in the quotient. The correct answer is 2140.

H. Prefixing unnecessary zeros.

1. Illustration.- Divide.

$$\begin{array}{r}
 \text{"0221"} \\
 1.74 \overline{) 384.54}
 \end{array}$$

2. Description.- The correct answer is 221. The decimal point in the dividend was moved to the left rather than to the right in locating the decimal point for the quotient.

### I. Putting zero in wrong place in quotient.

1. Illustration.- The figures in the quotients below are correct, but they are not pointed off correctly. Cross out all wrong quotients and write the correct ones above the incorrect ones.

$$\begin{array}{r} \text{"0214"} \\ 214 \\ 45.2 \overline{) 96728} \end{array}$$

2. Description.- The zero and decimal were both misplaced. The correct answer is 2140.

### III. Other difficulties.

#### A. Failure to follow directions.

1. Illustration.- Divide.

$$38 \div 100 = \text{"3800"}$$

2. Description.- The pupil multiplied by one hundred instead of dividing by one hundred. The correct answer is .38.

#### B. Miscopied.

1. Illustration.- Divide.

$$476 \div 10 = \text{"46.7"}$$

2. Description.- The 6 and 7 were reversed in the quotient. The correct answer is 47.6.



The diagnostic tests showed not only the level of ability of the pupils in the various operations in decimals but pointed out weaknesses so that the school work was organized in such a way as to give some time to those who were below the standard and omit deadening drill for those who were above. Various factors affect a pupil's performance on the tests, such as speed of writing, the amount of effort put forth, the understanding of the directions, the degree of interest, and the pupil's state of health. The degree of accuracy was considered also, for a pupil's rate of work and his accuracy could not be considered separately. The pupil's method of work was another important element considered, for a pupil may have made a satisfactory score on the tests but at the same time be working considerably below his possible maximum level of achievement because of faulty habits of work. Through observation such faults as counting, lack of neatness in writing out the work, carelessness in copying numbers, or reading directions, dawdling and inattention were discovered. Efficient methods of work were substituted for these faults as nearly as possible.

A knowledge of the types of errors made in the tests was necessary to provide adequate remedial drill. The weaknesses in knowledge of the number facts in whole numbers resulted in inaccurate work in the application of these facts to decimal situations. The first remedial work was done in whole numbers.

Individual sets of number cards were used to study the one hundred addition combinations. On one side of the card the addition combination was printed thus,  $\frac{9}{7}$  and on the reverse side,  $\frac{9}{7}$ . Each pupil played a

game, "Dummy", with the cards. The pupil thought the answer, then looked on the reverse side to see if the "thought of" answer was correct. If correct, the card belonged to him, and if an error was made, the card belonged to "Dummy". The object of the game was to beat "Dummy", and to beat "Dummy" the pupil must think every answer correctly. At the close of the game "Dummy's" cards were studied, and the game was repeated. After a pupil was able to beat "Dummy", he recited the cards to one of the better students. Speed was not stressed during the game.

However, the fact that 4285 problems were not attempted, and 112 were incomplete showed a need for speed. Accuracy with rapidity is the aim of number drills. Individual differences in the needs of pupils and in their rates of learning were taken into consideration in the speed and accuracy drills. In most classes of pupils the differences in number ability is three to one. If the quickest pupils in a class can perform the given drill in one minute, the slowest will take three minutes. Drill practice will not materially change this ratio. By practice the slow-motored pupil may become a one and a half minute one, and the quicker pupil may become a one-half minute one. Drill tests should give proper credit to the slower as well as to the faster pupil as they grow more proficient.

To measure rapidity a trial test was given. A time chart was placed on the blackboard. The shortest time was written first, and quarter minute intervals were listed until the slowest pupil had

completed the test. The test was repeated, the time intervals were erased as they elapsed. The pupils wrote at the top of their papers the shortest time interval remaining on the board, put their pencils down and sat quietly until the test was finished. By this method the bright pupils received credit to the limit of their ability unhampered by the slower pupils, and the slower pupils worked up to their capacity, and were not discouraged in a vain attempt to go beyond their proficiency.

In order to teach arithmetic successfully there must be many drills. The next drills applied the combinations to the higher decades, for in column addition nearly all the sums required are secured by applying the simple combinations to the higher decade. The following drill was

used:

16		1
14		2
18		3
17		4
12	and	5
10		6
13		7
11		8
15		9
19		

After the pupil added each single number in the right column to each of the numbers in the column at the left, the tens figure of the left column was changed to other numbers. This gave much drill in addition in higher decades.

To strengthen the attention span in column addition of those who had difficulty in holding a sum in mind as the attention was returned to adding, practice was given in adding a "thought of" number with a seen number. The pupils kept in mind a number, such as 65, and added



it to numbers from the board. Occasionally the "thought-of" number was changed.

In the subtraction review, number cards similar to those described in addition were used. The same plan was used in the review of the one hundred subtraction facts as was used in the review of the one hundred addition facts.

For a rapid oral drill in the one hundred subtraction facts the following table was used.

0	2	4	1	5	7	6	0	3	9	8
1	5	9	2	6	1	3	8	4	10	7
2	6	7	3	10	9	4	2	11	5	8
3	9	3	12	7	3	11	4	5	10	6
4	13	7	11	9	12	5	10	4	6	8
5	6	10	8	12	5	11	14	9	13	7
6	8	11	9	14	12	15	6	13	7	10
7	12	15	14	7	11	9	16	8	13	10
8	16	9	13	17	10	15	11	14	12	8
9	13	10	16	9	14	17	15	11	18	12

The numbers in the left column are the subtrahends.

In the oral drill a pupil was required to give the differences, subtracting 0 from each number in the first horizontal row, 1 from each number in the second horizontal row, 2 from each number in the third horizontal row, etc. In the written drill the differences to the row designated were written by the entire class.

Drill was then given in working examples in which the number in the minuend was less than the number in the subtrahend, and the carrying process was involved, such as:

- 75  
27 Carrying in the unit's place.
- 43  
9 subtraction by endings - a blank space.
- 623  
382 carrying in the ten's place.
- 362  
198 Carrying in unit's and ten's place.  
 (carrying to a 9 in the subtrahend.)
- 50  
44 Zero difficulty in subtraction.  
 (4 from 10, and 5 from 5.)
- 600  
107 Carrying to a zero in subtrahend.

In the multiplication review, number cards similar to those described in addition were used. The same plan for the review of the one hundred multiplication facts was used as in addition and subtraction. To give accuracy in the multiplication of examples similar to 649 which involves  $9 \times 9$ ,  $9 \times 4 + 7$ , and  $9 \times 6 + 3$ , the following

X 9  
 drill was used:

	6		1
	3		2
	7		3
	9		4
	2		5
9 X	1	and	6
	5		7
	0		8
	8		
	4		

The pupil began with  $9 \times 6$  and 1,  $9 \times 3$  and 1,  $9 \times 7$  and 1, etc., until he finished the column. He then began with  $9 \times 6$  and 2,  $9 \times 3$  and 2,  $9 \times 7$  and 2, etc. The digit in the multiplier was changed frequently. The number to be added was never greater than one less than the multiplier.



Special attention was given to examples involving zeros in either the multiplier or multiplicand. Zeros in the multiplicand involved the following types of drill:

- 80  
3 zero at the end.
- 402  
3 zero in middle - no carrying.
- 408  
3 zero in middle - carrying.
- 200  
3 double zero at the end.
- 4007  
3 double zero in the middle.
- 4070  
3 alternate zeros.

Zeros in the multiplier involved the following type of drill.

- 368  
40 zero at end of two place multiplier.
- 368  
540 zero at end of three place multiplier.
- 368  
504 zero in middle of multiplier.
- 380  
540 zero at end of both the multiplier and multiplicand.
- 308  
540 zero at end of multiplier and in middle of multiplier.
- 308  
504 zero in middle of both multiplier and multiplicand.
- 5891  
5400 two zeros at end of multiplier.
- 5891  
5004 two zeros in multiplier.

In the division review, much drill was given on the division facts, especially those having remainders. The following drill was used in overcoming inaccurate work:

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1	4	16	20	36	42	53	66	72	83	91
2	1	14	23	38	46	50	68	76	87	95
3	9	10	26	32	48	56	62	78	89	97
4	2	18	28	35	43	58	65	73	84	92
5	7	19	25	31	49	55	61	79	80	98
6	2	13	22	33	40	52	63	70	81	99
7	8	17	27	39	45	57	69	75	86	94
8	5	11	29	37	47	59	67	77	88	96
9	6	15	21	30	41	51	60	71	82	90
	0	12	24	34	44	54	64	74	85	93

---

The numbers in the left column are the divisors. The numbers in the first vertical column were divided by one, the numbers in the second vertical column by two, and the third by three, etc. The numbers are so arranged that all the division facts about one are in the first column, all the division facts about two are in the first two columns, about three are in the first three columns, etc. After much drill was given on the division facts drill was given in short division similar to the following:

2  $\overline{) 36}$  Even division - two place quotient.

2  $\overline{) 368}$  Even division - three place quotient.

2  $\overline{) 408}$  Even division - zero in middle of quotient.

2  $\overline{) 480}$  Even division - zero at end of quotient.

2  $\overline{) 168}$  Initial trial dividend two figures.

2  $\overline{) 418}$  Zero difficulty - carrying.

2  $\overline{) 439}$  Carrying - remainder at end of example.

2  $\overline{) 419}$  Carrying - zero - remainder.

The types of long division in which much drill was given were:

36  $\overline{) 1116}$   $\begin{array}{r} 31 \\ \hline \end{array}$  There are both carrying in the multiplication and borrowing in the subtraction. The trial divisor is the true divisor.

28  $\overline{) 1936}$   $\begin{array}{r} 62 \\ \hline \end{array}$  The trial divisor is not the true divisor.

75  $\overline{) 15225}$   $\begin{array}{r} 203 \\ \hline \end{array}$  Zero is involved in quotient.

55  $\overline{) 165220}$   $\begin{array}{r} 3004 \\ \hline \end{array}$  Two zeros in quotient.

84  $\overline{) 30240}$   $\begin{array}{r} 360 \\ \hline \end{array}$  Zero at end of quotient.

23  $\overline{) 70150}$   $\begin{array}{r} 3050 \\ \hline \end{array}$  Alternate zeros in quotient.

36  $\overline{) 172800}$   $\begin{array}{r} 4800 \\ \hline \end{array}$  Two zeros at end of quotient.

Drill was also given in division problems involving remainders.

In the reading and writing of whole numbers, the place value of each number to the billion group was studied. Attention was called to the fact that ten units in an order make one in the next higher order. A figure in any order expresses  $1/10$  of what it would express in the next higher order.

Drills of the following type were used to stress the place value of numbers.

Give the value of 9 in each of the following numbers:

987654321  
876543219  
654321987  
765432198  
432198765  
198765432  
321987654  
543219876

The place value of each of the other figures in the numbers were then given.

After the difficulties in reading and writing of whole numbers were overcome, the place value of decimals was reviewed. Attention was called to the fact that although the decimal point separates the whole number and the fractional part, the names of the places go both ways from the unit's figure and not from the point. Thus, from the unit's place, the first figure on the left is tens, and the first figure on the right is tenths; the second place on the left is hundreds, and the second place on the right is hundredths.

When the underlying principle of expressing decimals was understood, that a decimal is a fraction whose denominator is a power of ten, in which the denominator is not written but is expressed by the position of the numerator, the reading and writing of decimals became a simple matter. In reading and writing of decimals the following rule was observed, "To read a decimal read the numerator of the decimal as though it were an integer and then express its denominator which is the same as the name of the right hand order. To write a decimal write the numerator of the decimal as though it were an integer and then place the decimal point as many places to the left as is necessary to express the denominator."



The similarity in reading and writing of whole numbers and decimals was emphasized by the reading and writing of many numbers, such as:

.8345 eight thousand three hundred forty-five ten thousandths.

8345 eight thousand three hundred forty-five.

The importance of correct spelling and pronunciation was shown by such examples as:

.08 eight hundredths

800 eight hundred

A drill similar to that used in studying the place value of whole numbers was used in studying the place value of the figures in a decimal. Numbers like the following were placed on the board:

6000.000

0000.600

0006.000

0600.000

0000.006

0000.060

0060.000

After the values of the numbers were given they were arranged in the order of their value.



Drill was given in selecting the larger number in pairs of numbers such as:

47891	4789.9
0.814	.8014
6.59	6.6
.83	.808
15.00	1.599
3.05	3.50
437	1.437

Drill was given in writing decimals from words and vice versa. The decimal order beyond the sixth place was not emphasized. Most of the emphasis was placed upon the first three orders.

Attention was directed to another method of reading decimals, thus 73.264 may be read seven-three-point-two-six-four.

Drills were given in changing common fractions to decimal fractions, and vice versa. The reduction of the common fraction to lowest terms was stressed. Flash cards similar to those used in addition, subtraction, and multiplication were used to memorize the decimal equivalent of the following important fractions:  $\frac{1}{2}$ ,  $\frac{1}{3}$ ,  $\frac{2}{3}$ ,  $\frac{1}{4}$ ,  $\frac{3}{4}$ ,  $\frac{1}{5}$ ,  $\frac{2}{5}$ ,  $\frac{3}{5}$ ,  $\frac{4}{5}$ ,  $\frac{1}{6}$ ,  $\frac{5}{6}$ ,  $\frac{1}{8}$ ,  $\frac{3}{8}$ ,  $\frac{5}{8}$ ,  $\frac{7}{8}$ ,  $\frac{1}{10}$ ,  $\frac{3}{10}$ ,  $\frac{7}{10}$ , and  $\frac{9}{10}$ . On one side of the card the fraction was given, and on the reverse side the decimal equivalent was given. The game of "Dummy" as described in addition was played. Each pupil was responsible for studying those equivalents that he did not know. The two forms of the fractions were thought of as two languages, the common fraction language and the decimal fraction language, and an arithmetic pupil must know both languages. Much drill

was given in completing charts similar to:

<u>common fraction</u>	<u>decimal fraction</u>
2 1/5	_____
_____	3.33 1/3
5 7/8	_____
4 5/6	_____
_____	8.3

In the review of the addition and subtraction of decimals, not only the need for keeping decimal points directly under each other in its operation was stressed, but also the need for neat figures and straight columns. In irregular columns the pupils were permitted to fill the blank places with zeros, thus making each decimal have the same denominator. The importance of placing the decimal point in the answer was also emphasized.

To give a better understanding of the rule for placing the decimal point in the product in the review of multiplication of decimals, a number of problems were worked twice using two methods, thus:

(1)

$$6.7 \times .84$$

$$\begin{array}{r} 6.7 \\ .84 \\ \hline 268 \\ 536 \\ \hline 5.528 \end{array}$$

(2)

$$6.7 \times .84$$

$$6 \frac{7}{10} \times \frac{84}{100}$$

$$67/10 \times 84/100 = 5528/1000 = 5 \frac{528}{1000} \text{ or } 5.528$$

To acquire facility in the application of the rule in placing the decimal point in products, drill was given in placing the decimal point in the given product of many examples. Many examples were similar to the following:  $.03 \times .014 = 42$ , in which zeros had to be prefixed to the product.

The following rule was applied in multiplying by 10, 100, and 1000: "to multiply by 10, 100, or 1000, move the decimal point as many places to the right as there are zeros in the multiplier."

In multiplying by .1, .01, or .001, application was made of the following rule: "to multiply by .1, .01, or .001, move the decimal point as many places to the left as there are decimal places in the multiplier."

In the review of the division of decimals, the problems were taken in the following order: (1) problems with decimal point in the dividend only: (2) decimal point in dividend and divisor: (3) decimal point in divisor only. Special attention was given to zero difficulties. To acquire facility in placing the decimal point in the quotient many drills were taken similar to the following: The figures in the quotient are correct. Place the decimal point correctly

(1)		(2)	
$\begin{array}{r} 5489 \\ 36 \overline{) 197604} \end{array}$		$\begin{array}{r} 5489 \\ .36 \overline{) 1976.04} \end{array}$	$\begin{array}{r} 5489 \\ 3.6 \overline{) 1976.04} \end{array}$
$\begin{array}{r} 5489 \\ 36 \overline{) 1976.04} \end{array}$		$\begin{array}{r} 5489 \\ 3.6 \overline{) 19760.4} \end{array}$	$\begin{array}{r} 5489 \\ 3.6 \overline{) 197.604} \end{array}$
$\begin{array}{r} 5489 \\ 36 \overline{) 19760.4} \end{array}$		$\begin{array}{r} 5489 \\ .036 \overline{) 19760.4} \end{array}$	(3)
$\begin{array}{r} 5489 \\ 36 \overline{) 19.7604} \end{array}$		$\begin{array}{r} 5489 \\ .36 \overline{) 197.604} \end{array}$	$\begin{array}{r} 5489 \\ 3.6 \overline{) 197604} \end{array}$
$\begin{array}{r} 5489 \\ 36 \overline{) 1.97604} \end{array}$		$\begin{array}{r} 5489 \\ .036 \overline{) 1976.04} \end{array}$	$\begin{array}{r} 5489 \\ .36 \overline{) 197604} \end{array}$
$\begin{array}{r} 5489 \\ 36 \overline{) .197604} \end{array}$		$\begin{array}{r} 5489 \\ .36 \overline{) 19760.4} \end{array}$	$\begin{array}{r} 5489 \\ .036 \overline{) 197604} \end{array}$

The following rules were applied to many problems: (1) To divide by 10, 100, or 1000 move the decimal point as many places to the left as there are zeros in the divisor. (2) To divide by .1, .01, or .001, move the decimal point as many places to the right as there are decimal places in the divisor. A better understanding of these rules was given by working a number of problems by the long method.

To add variety and interest to the drill work involved in the addition, subtraction, multiplication, and division facts, the metron-o-scope was used a number of times. It furnished a mechanical adaptation of the flash card. The number facts were exposed at regular intervals. With the metron-o-scope, it was possible to regulate the speed, and to repeat any fact represented by the drill.

At no time during this experiment were children required to remain after school hours for extra help. Remaining after school was



considered a privilege of which a few took advantage whenever they thought extra help was necessary. However, once a week school was dismissed one hour early for those pupils who were doing satisfactory work and six to eight pupils were required to remain for special help. Much individual diagnosis was done during this period and many difficulties were removed. Pupils were required to work problems aloud. Many round-about methods were discovered in addition, and more time was given to the addition drills already described. (See addition). Several pupils were confused in subtraction. Borrowing and additive methods of subtraction were used within the same problem. These pupils were required to select one method and to use it entirely. In the multiplication and division by 10, 100, and 1000, one pupil was able to state the rules but his difficulty was in knowing right from left. Practice was given in pointing to the left and right, raising the left and right hands, and selecting the left and right pages of his book. During the helping period the addition, subtraction, multiplication, and division facts were made more mechanical for a number of pupils. Others were given more drill work to remove the zero difficulties involved in the fundamentals. With such a few in the class much remedial was accomplished by those pupils who need more individual instruction than can be given in a larger group.

Practice and then more practice in each of the fundamental operations in decimals with every possible relation and combination of numbers was continued daily for about three months. Then about



fifteen minutes of intensive drill was given daily for another three months in order to retain the skills developed and to secure the desired results of greater accuracy with increased speed.

#### THE RESULTS

On March 28 and 29, 1932, the Oregon Diagnostic Tests  
 Arithmetic Test II, Form A, Addition, Subtraction, and the  
 Test of Accuracy and Test II, Form A, Division of the Oregon Diagnostic  
 Tests in Arithmetic were administered to a group of 100 pupils  
 in the second year of the Oregon Diagnostic Tests in Arithmetic.  
 Originally it was planned to give the tests to  
 the pupils, but that was not available from the publishers. In  
 order to give a more accurate picture of the achievement of the pupils  
 in the second year of the Oregon Diagnostic Tests in Arithmetic  
 March 28, 1932.

After the Oregon Diagnostic Tests II and II, the scores of each  
 individual of each pupil were found and the percentages were found.  
 There were no norms provided for the Oregon Diagnostic Tests in  
 the scores were not and a comparison was made in the percentages  
 scores at each part of the test with those of the Oregon Diagnostic  
 Tests II and II.

CHAPTER IV

THE RESULTS

On March 23 and 24, 1938, the Compass Diagnostic Test in Arithmetic: Test IX, Form A, Addition, Subtraction, and Multiplication of decimals; and Test X, Form A, Division of Decimals were given again to determine the improvement made as a result of the remedial program in decimals. Originally it was planned to give Forms B of the tests, but they were not available from the publishers. So in order to give a more accurate result of the achievement of the pupils in the remedial program, the Brueckner Diagnostic Test was given March 25, 1938.

For the Compass Diagnostic Tests: IX and X, the age and grade equivalents of each pupil were found and the improvements were noted. There were no norms provided for the Brueckner Diagnostic Test, so the errors were noted and a comparison made in the percentage of errors in each part of the test with those of the Compass Diagnostic Tests: IX and X.

Table XV  
Compass Diagnostic Test: Test IX, Form A  
Addition, Subtraction, and Multiplication  
of Decimals (March 23, 1938)

Score	No. of Pupils	Score	No. of Pupils
192	45	165	1
191	24	164	0
190	7	163	0
189	6	162	0
188	3	161	1
187	11	160	2
186	3	159	1
185	7	158	0
184	3	157	1
183	4	156	0
182	3	155	1
181	3	154	0
180	6	153	0
179	1	152	0
178	4	151	0
177	2	150	0
176	1	149	1
175	1	148	0
174	5	147	0
173	0	146	0
172	0	145	1
171	0	144	0
170	3	143	1
169	0	142	0
168	1	141	1
167	0	Total	<u>155</u>
166	1		

The scores ranged from 141 to 192 with a possible score of 192.

The median score was 189.75.

Table XVI      Age Equivalents as Found by the Compass  
 Diagnostic Test:    Test IX, Form A, Addition,  
 Subtraction, and Multiplication of Decimals  
 (March 23, 1938)

Years - Months	No. of Pupils
14 - 6	149
14 - 3	1
14 - 0	1
13 - 9	0
13 - 6	1
13 - 3	2
13 - 0	<u>1</u>
Total	155

The age equivalents as shown by the norms given for the Compass Diagnostic Test: Text IX, Form A, Addition, Subtraction, and Multiplication of Decimals, ranged from thirteen years to fourteen years six months. With the exception of six pupils, the class had an age equivalent of fourteen years six months.

Table XVII

## Grade Equivalents as Shown by the Compass

Diagnostic Test: Test IX, Form A, Addition,  
Subtraction, and Multiplication of Decimals

(March 23, 1938)

Grade	No. of Pupils
H 8	151
L 8	1
H 7	<u>3</u>
Total	155

The grade equivalents as shown by the norms given for the Compass Diagnostic Test: Test IX, Form A, Addition, Subtraction, and Multiplication of Decimals, ranged from high seventh grade to high eighth grade. With the exception of four pupils the class had a grade equivalent of high eighth grade.



Table XVIII Compass Diagnostic Test: Test X, Form A

Division of Decimal (March 24, 1938)

Score	No. of Pupils	Score	No. of Pupils
138	14	87	0
137	3	86	2
136	1	85	1
135	2	84	2
134	1	83	0
133	11	82	0
132	2	81	0
131	5	80	0
130	1	79	0
129	1	78	0
128	8	77	2
127	7	76	0
126	1	75	1
125	1	74	0
124	3	73	1
123	4	72	2
122	7	71	0
121	8	70	1
120	4	69	0
119	4	68	0
118	2	67	1
117	2	66	1
116	1	65	1
115	6	64	0
114	6	63	0
113	2	62	0
112	1	61	0
111	3	60	0
110	1	59	0
109	1	58	0
		57	0

Table XIX

Age Equivalents as Shown by the Compass  
 Diagnostic Test: Test X, Form A, Division  
 of Decimals (March 24, 1938)

Years - Months	No. of Pupils
14 - 6	145
14 - 3	1
14 - 0	2
13 - 9	1
13 - 6	1
13 - 3	2
13 - 0	0
12 - 9	0
12 - 6	0
12 - 3	0
12 - 0	0
11 - 9	0
11 - 6	0
Below 11 - 6	3
Total	<u>155</u>

The age equivalents as shown by the norms given for the Compass Diagnostic Test: Test X, Form A, Division of Decimals, ranged from below eleven years six months to fourteen years six months. With the exception of ten pupils, the class had an age equivalent of fourteen years six months.

**Table XX**      **Grade Equivalents as Shown by the Compass**  
**Diagnostic Test: Test X, Form A, Division**  
**of Decimals (March 24, 1938)**

<b>Grade</b>	<b>No. of Pupils</b>
H 8	149
L 8	1
H 7	2
L 7	0
H 6	0
<b>Below H 6</b>	<b><u>3</u></b>
<b>Total</b>	<b>155</b>

The grade equivalents as shown by the norms given for the Compass Diagnostic Test: Test X, Form A, Division of Decimals, ranged from below high sixth grade level to high eighth grade level. With the exception of six pupils, the class had an high eighth grade level.

Table XXI Improvements Made on the Compass Diagnostic Test IX, Form A, Addition, Subtraction, and Multiplication of Decimals by Pupils Making Perfect Scores on Test Given March 23, 1938.

Improvement	No. of Pupils	Improvement	No. of Pupils
91	1	48	3
90	0	47	1
89	0	46	0
88	0	45	0
87	0	44	0
86	0	43	1
85	0	42	0
84	0	41	0
83	0	40	1
82	0	39	0
81	0	38	2
80	0	37	0
79	0	36	2
78	1	35	1
77	0	34	1
76	0	33	1
75	0	32	0
74	0	31	0
73	0	30	1
72	0	29	3
71	2	28	0
70	0	27	0
69	0	26	0
68	0	25	1
67	1	24	2
66	0	23	2
65	1	22	0
64	1	21	0
63	0	20	1
62	0	19	1
61	1	18	0
60	0	17	0
59	0	16	1
58	2	15	1
57	0	14	1
56	1	13	1
55	2	12	0
54	0	11	1
53	1	10	0
52	0	9	1
51	0	Total	45
50	1		
49	0		

Table XXII Improvements Made on the Compass Diagnostic  
Test IX, Form A, Addition, Subtraction, and  
Multiplication of Decimals by Pupils Making  
Errors on Test Given March 23, 1938.

Improvement	No. of Pupils	Improvement	No of Pupils
134	1	74	0
133	0	73	2
132	0	72	0
131	1	71	3
130	0	70	3
129	0	69	2
128	0	68	1
127	1	67	3
126	0	66	3
125	0	65	0
124	0	64	1
123	1	63	1
122	0	62	0
121	0	61	1
120	0	60	2
119	0	59	2
118	1	58	0
117	0	57	0
116	0	56	4
115	0	55	0
114	0	54	0
113	0	53	0
112	0	52	0
111	0	51	0
110	0	50	0
109	0	49	0
108	0	48	0
107	0	47	0
106	0	46	0
105	0	45	0
104	0	44	0
103	0	43	0
102	0	42	0
101	0	41	0
100	0	40	0
99	0	39	0
98	0	38	0
97	0	37	0
96	0	36	0
95	0	35	0
94	0	34	0
93	0	33	0
92	0	32	0
91	0	31	0
90	0	30	0
89	0	29	0
88	0	28	0
87	0	27	0
86	0	26	0
85	0	25	0
84	0	24	0
83	0	23	0
82	0	22	0
81	0	21	0
80	0	20	0
79	0	19	0
78	0	18	0
77	0	17	0
76	0	16	0
75	0	15	0
74	0	14	0
73	0	13	0
72	0	12	0
71	0	11	0
70	0	10	0
69	0	9	0
68	0	8	0
67	0	7	0
66	0	6	0
65	0	5	0
64	0	4	0
63	0	3	0
62	0	2	0
61	0	1	0
60	0	0	0



## Table XXIII Improvements Made on the Compass Diagnostic

Test X, Form A, Division of Decimals by

Pupils Making Perfect Scores on Test Given

March 24, 1938.

Improvement	No. of Pupils	Improvement	No. of Pupils
86	1	52	0
85	0	51	0
84	0	50	0
83	0	49	0
82	1	48	0
81	0	47	0
80	1	46	0
79	0	45	2
78	0	44	0
77	0	43	0
76	0	42	1
75	1	41	0
74	0	40	1
73	0	39	0
72	0	38	0
71	0	37	0
70	0	36	0
69	0	35	1
68	0	34	0
67	1	33	0
66	0	32	1
65	0	31	0
64	0	30	0
63	0	29	0
62	0	28	0
61	0	27	2
60	0	26	0
59	0	25	0
58	0	24	0
57	0	23	0
56	0	22	1
55	0	Total	<u>14</u>
54	0		
53	0		

Table XXIV Improvements Made on the Compass Diagnostic

Test: X, Form A, Division of Decimals by

Pupils Making Errors on Test Given March 24,

1938.

Improvement	No. of Pupils	Improvement	No. of Pupils
112	2	59	0
111	0	58	0
110	1	57	1
109	2	56	5
108	1	55	2
107	0	54	1
106	1	53	3
105	0	52	1
104	2	51	3
103	0	50	3
102	0	49	0
101	0	48	2
100	0	47	4
99	0	46	1
98	3	45	0
97	0	44	1
96	2	43	2
95	2	42	1
94	1	41	1
93	2	40	4
92	3	39	2
91	4	38	2
90	1	37	0
89	0	36	2
88	3	35	0
87	2	34	3
86	2	33	1
85	1	32	0
84	1	31	0
83	1	30	0
82	0	29	1
81	1	28	0
80	4	27	2
79	1	26	0
78	2	25	1

Table XXV

## Brueckner Diagnostic Test In Decimals

(March 25, 1938)

Score	No. of Pupils
117	24
116	17
115	17
114	22
113	14
112	16
111	15
110	5
109	3
108	3
107	4
106	1
105	2
104	1
103	1
102	0
101	0
100	4
99	1
98	0
97	0
96	3
95	0
94	1
93	0
92	0
91	0
90	1
Total	<u>155</u>

The scores ranged from 90 to 117 with a possible score of 117.

The median score was 114.11.

Table XXVI Difficulties in Reading, Writing and Converting  
 Decimals As Shown By the Compass Diagnostic  
 Test: IX, Form A, Addition, Subtraction, and  
 Multiplication of Decimals (March 23, 1938).

	Frequency
1. Lack of comprehension of the numerical value of decimals.	91
2. Lack of Comprehension of the place value of numbers.	23
3. Difficulties in expressing a decimal number in words.	
a. Errors in spelling	3
b. Omission of essential words	6
c. Inability to write decimal fractions in words	5
4. Difficulties in reading and writing decimals	
a. Inability to write decimal fractions in figures	6
b. Omission of decimal point	9
c. Misplacing decimal point	63
d. Inability to express a common fraction or a mixed number as a decimal	57

Table XXVII Difficulties in Addition of Decimals As Shown  
 By the Compass Diagnostic Test: IX, Form A,  
 Addition, Subtraction, and Multiplication of  
 Decimals (March 23, 1938).

	Frequency
1. Errors in number combination	22
2. Difficulties peculiar to decimal situations	
a. Errors in placing decimal point	10
b. Misplacing the whole number	3
c. Omission of decimal point	8
3. Other difficulties	
a. Not attempted	0
b. Incomplete	3
c. Miscopied	<u>8</u>
Total	54

There were 9 problems in this part of the test. The possible number of errors was 1395. (Assuming an error by every pupil on each problem). The percentage of errors to the nearest tenth of a per cent was 3.9%.



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Table XXVIII Difficulties in Subtraction of Decimals As  
 Shown by the Compass Diagnostic Test: IX, Form A,  
 Addition, Subtraction, and Multiplication of  
 Decimals (March 23, 1938).

	Frequency
1. Difficulties basic to any subtraction	
a. Carrying difficulties	7
b. Errors in subtraction facts	10
c. Zero difficulties	0
d. Reversed subtrahend and minuend	2
2. Difficulties peculiar to decimal situations	
a. Misplacing decimal number in subtrahend	1
b. Decimal point omitted	5
c. Misplacing decimal point	3
3. Other difficulties	
a. Not attempted	0
b. Failure to follow directions	0
c. Incomplete	2
d. Miscopied	<u>1</u>
Total	31

There were 9 problems in this part of the test. Assuming an error by every pupil on each problem, the possible number of errors for the entire class was 1395. The percentage of errors to the nearest tenth of a per cent was 2.2%.

Table XXIX Difficulties in Multiplication of Decimals  
 As Shown by the Compass Diagnostic Test: IX,  
 Form A, Addition, Subtraction, and Multiplication  
 of Decimals (March 23, 1938)

	Frequency
1. Difficulties basic to any multiplication	
a. Errors in multiplication	40
b. Errors in adding partial products	13
c. Zero difficulties	4
2. Difficulties peculiar to decimal situations	
a. Placement of decimal point	
(1) Misplacing decimal point	20
(2) Omitting decimal point	14
b. Placing of zero	
(1) Failure to prefix zero	14
(2) Failure to annex zero	6
(3) Prefixing unnecessary zero	10
(4) Annexing unnecessary zero	16
3. Other difficulties	
a. Not attempted	4
b. Incomplete	1
c. Miscopied	3
<b>Total</b>	<b>145</b>

There were 34 problems in this part of the test. Assuming an error on every problem by each pupil, the possible number of errors was 5270. The percentage of errors and omissions to the nearest tenth of a percent was 2.7%.

Table XXX Difficulties in Division of Decimals as Shown  
 by the Compass Diagnostic Test: X, Form A,  
 Division of Decimals (March 24, 1938).

	Frequency
1. Difficulties basic to any division	
a. Errors in division	292
b. Difficulties with trial divisor	57
c. Number omitted in quotient	16
d. Errors in multiplication	51
e. Errors in subtraction	25
2. Difficulties peculiar to decimal situations	
a. Placement of decimal point	
(1) Decimal point misplaced	86
(2) Decimal point omitted	101
(3) Using decimal point when unnecessary	45
b. Placement of zeros	
(1) Failure to prefix zero in quotient	68
(2) Failure to add zero to dividend	48
(3) Failure to add zero to quotient	51
(4) Annexing unnecessary zeros to quotient	44
(5) Prefixing unnecessary zeros to quotient	20
(6) Putting zero in wrong place in quotient	12
3. Other difficulties	
a. Not Attempted	120
b. Incomplete	20
c. Failure to follow directions	100
d. Miscopied	<u>5</u>
Total	1161

There were 73 problems in this part of the test. Assuming an error on every problem by each pupil, the possible number of errors for the entire class was 11315. The percentage of errors and omissions to the nearest tenth of a per cent was 19.3%.

On the entire test, there were 207 problems. The possible number of errors for the class was 32085. (Assuming an error on every problem by each pupil). With 1899 errors and omissions, the percentage to the nearest tenth was 5.9%.

1. Inability to understand words	
2. Inability to write definite sentences	
3. Inability to write definite sentences as given	
4. Inability to write definite sentences as given	
5. Inability to write definite sentences as given	
6. Inability to write definite sentences as given	
7. Inability to write definite sentences as given	
8. Inability to write definite sentences as given	
9. Inability to write definite sentences as given	
10. Inability to write definite sentences as given	
11. Inability to write definite sentences as given	
12. Inability to write definite sentences as given	
13. Inability to write definite sentences as given	
14. Inability to write definite sentences as given	
15. Inability to write definite sentences as given	
16. Inability to write definite sentences as given	
17. Inability to write definite sentences as given	
18. Inability to write definite sentences as given	
19. Inability to write definite sentences as given	
20. Inability to write definite sentences as given	
21. Inability to write definite sentences as given	
22. Inability to write definite sentences as given	
23. Inability to write definite sentences as given	
24. Inability to write definite sentences as given	
25. Inability to write definite sentences as given	
26. Inability to write definite sentences as given	
27. Inability to write definite sentences as given	
28. Inability to write definite sentences as given	
29. Inability to write definite sentences as given	
30. Inability to write definite sentences as given	
31. Inability to write definite sentences as given	
32. Inability to write definite sentences as given	
33. Inability to write definite sentences as given	
34. Inability to write definite sentences as given	
35. Inability to write definite sentences as given	
36. Inability to write definite sentences as given	
37. Inability to write definite sentences as given	
38. Inability to write definite sentences as given	
39. Inability to write definite sentences as given	
40. Inability to write definite sentences as given	
41. Inability to write definite sentences as given	
42. Inability to write definite sentences as given	
43. Inability to write definite sentences as given	
44. Inability to write definite sentences as given	
45. Inability to write definite sentences as given	
46. Inability to write definite sentences as given	
47. Inability to write definite sentences as given	
48. Inability to write definite sentences as given	
49. Inability to write definite sentences as given	
50. Inability to write definite sentences as given	
51. Inability to write definite sentences as given	
52. Inability to write definite sentences as given	
53. Inability to write definite sentences as given	
54. Inability to write definite sentences as given	
55. Inability to write definite sentences as given	
56. Inability to write definite sentences as given	
57. Inability to write definite sentences as given	
58. Inability to write definite sentences as given	
59. Inability to write definite sentences as given	
60. Inability to write definite sentences as given	
61. Inability to write definite sentences as given	
62. Inability to write definite sentences as given	
63. Inability to write definite sentences as given	
64. Inability to write definite sentences as given	
65. Inability to write definite sentences as given	
66. Inability to write definite sentences as given	
67. Inability to write definite sentences as given	
68. Inability to write definite sentences as given	
69. Inability to write definite sentences as given	
70. Inability to write definite sentences as given	
71. Inability to write definite sentences as given	
72. Inability to write definite sentences as given	
73. Inability to write definite sentences as given	
Total	

Table XXXI      Difficulties in Reading, Writing and Converting  
 Decimals As Shown by the Brueckner Diagnostic  
 Test in Decimals    (March 25, 1938)

	Frequency
1. Lack of comprehension of the numerical values of decimals	22
2. Lack of comprehension of the place value of numbers	0
3. Difficulties in expressing a decimal number in words	
a. Errors in spelling	0
b. Omission of essential words	0
c. Inability to write decimal fractions in words	4
4. Difficulties in reading and writing decimals	
a. Inability to write decimal fractions in figures	15
b. Omission of decimal point	0
c. Misplacing decimal point	2
d. Inability to express a common fraction or a mixed number as a decimal	22
5. Difficulties in writing decimals as common fractions	
a. Inability to reduce fractions to lowest terms	2
b. Inability to write decimals as common fractions	6
6. Lack of fundamental knowledge	0
7. Other difficulties	
a. Not attempted	16
b. Carelessness in reading	9
c. Not writing out completely	0
d. Failure to follow directions	0
Total	98



There were 26 problems on this part of the test. The possible number of errors by the entire class was 4030. (Assuming an error on every problem by each pupil). The percentage of errors to the nearest tenth of a per cent was 2.4%.

Table XXXII Difficulties in Addition of Decimals As Shown  
by the Brueckner Diagnostic Test in Decimals  
(March 25, 1938).

	Frequency
1. Errors in number combinations	25
2. Difficulties peculiar to decimal situations	
a. Errors in placing decimal point	2
b. Difficulties in adding common fractions and decimals	14
c. Misplacing the whole number	0
d. Omission of decimal point	5
3. Other difficulties	
a. Not attempted	0
b. Incomplete	1
c. Miscopied	<u>2</u>
Total	49

There were 12 problems on this part of the test. Assuming an error on every problem by each pupil, there would be 1860 errors. The percentage of errors to the nearest tenth of a per cent was 2.6%.

Table XXXIII Difficulties in Subtraction of Decimals As  
Shown by the Brueckner Diagnostic Test in  
Decimals (March 25, 1938).

	Frequency
1. Difficulties basic to any subtraction	
a. Carrying difficulties	12
b. Errors in subtraction facts	16
c. Zero difficulties	5
d. Reversed subtrahend and minuend	4
2. Difficulties peculiar to decimal situation	
a. Misplacing decimal number in subtrahend	0
b. Decimal point omitted	3
c. Misplacing decimal point	2
3. Other difficulties	
a. Not attempted	0
b. Failure to follow directions	0
c. Incomplete	2
d. Miscopied	<u>2</u>
Total	46

There were 17 problems on this part of the test with 2635 possible scores by the entire class. (Assuming an error on every problem by each pupil). The percentage of errors to the nearest tenth of a per cent was 1.7%.

Table XXXIV Difficulties in Multiplication of Decimals As  
 Shown by the Brueckner Diagnostic Test in  
 Decimals (March 25, 1938)

	Frequency
1. Difficulties basic to any multiplication	
a. Errors in multiplication	77
b. Errors in adding partial products	7
c. Zero difficulties	0
2. Difficulties peculiar to the decimal point	
a. Placement of the decimal point	
(1) Misplacing decimal point	36
(2) Omitting decimal point	26
b. Placing of zero	
(1) Failure to prefix zero	8
(2) Failure to annex zero	6
(3) Prefixing unnecessary zero	4
(4) Annexing unnecessary zero	4
3. Other difficulties	
a. Not attempted	21
b. Incomplete	1
c. Miscopied	0
Total	190

There were 32 problems on this part of the test with 4960 possible errors by the entire class. (Assuming an error on every problem by each pupil). The percentage of errors to the nearest per cent was 3.8%.

Table XXXV Difficulties in the Division of Decimals As  
 Shown by the Brueckner Diagnostic Test in  
 Decimals (March 25, 1938).

	Frequency
<b>1. Difficulties basic to any division</b>	
a. Errors in division	157
b. Difficulty with trial divisor	30
c. Errors in multiplication	27
d. Errors in subtraction	10
<b>2. Difficulties peculiar to decimal situations</b>	
a. Placement of decimal point	
(1) Decimal point misplaced	42
(2) Decimal point omitted	19
(3) Using decimal point when unnecessary	10
b. Placement of zeros	
(1) Failure to prefix zero in quotient	17
(2) Failure to add zero to dividend	8
(3) Failure to add zero to quotient	9
(4) Annexing unnecessary zeros to quotient	5
(5) Prefixing unnecessary zeros to quotient	5
(6) Putting zero in wrong place in quotient	0
<b>3. Other difficulties</b>	
a. Not attempted	13
b. Incomplete	4
c. Miscopied	<u>1</u>
<b>Total</b>	<b>357</b>

There were 30 problems on this part of the test with 4650 possible errors by the entire class (assuming an error on every problem by each pupil). The percentage of errors to the nearest tenth of a per cent was 7.7%.

There were 117 problems on the entire test and assuming an error on each problem by every pupil there would be 18135 possible errors. There were 740 errors made by the entire class. The percentage of errors to the nearest tenth of a per cent was 4.1%.

Table XXXVI      A Comparison of the Number of Problems on  
Each Part of the Two Decimal Tests.

	Compass Diagnostic Test	Brueckner Diagnostic Test
General	82	26
Addition	9	12
Subtraction	9	17
Multiplication	34	32
Division	<u>73</u>	<u>30</u>
Total	207	117

There were 207 problems in the Compass Diagnostic Test and 117 problems in the Brueckner Diagnostic Test.



Table XXXVII  
A Comparison of the Number of Errors  
on the Three Tests in Decimals

	Compass Diagnostic Test (Sept.)	Compass Diagnostic Test (March)	Brueckner Diagnostic Test (March)
General	6216	508	98
Addition	263	54	49
Subtraction	249	31	46
Multiplication	1727	145	190
Division	<u>6563</u>	<u>1161</u>	<u>357</u>
Total	15018	1899	740

Although there were fewer problems in multiplication in the Brueckner Test than in the Compass Test, the Brueckner Test contained one more type of multiplication - the multiplication of a common fraction by a decimal and vice versa. This accounts for the greater number of errors in multiplication in the Brueckner Test than in the Compass Test.

Table XXXVIII A Comparison of the Percentage of Errors  
on the Three Tests in Decimals

	Compass Diagnostic Test (Sept.)	Compass Diagnostic Test (March)	Brueckner Diagnostic Test
General	48.9%	4.0%	2.4%
Addition	18.9	3.9	2.6
Subtraction	17.8	2.2	1.7
Multiplication	32.8	2.7	3.8
Division	58.0	10.3	7.7
The Test as a Whole	46.8	5.9	4.1

In the Compass Diagnostic Test in Decimals, the percentage of errors was reduced from 46.8% in the first test to 5.9% in the second test, while the percentage of errors in the Brueckner Diagnostic Test was 4.1%.

Table XXXIX A Comparison of the Medians of the Three Tests

	Score	Age Equivalent	Grade Equivalent
Compass Diagnostic Test IX (Sept.)	130.25	12 yr. 6.6 mo.	Low Seventh
Compass Diagnostic Test IX (March)	189.75	14 yr. 6 mo.	High Eighth
Compass Diagnostic Test X (Sept.)	47.75	Below 11 yr. 6 mo.	Below High Sixth
Compass Diagnostic Test X (March)	121.31	14 yr. 6 mo.	High Eighth
Brueckner (March)	114.11	-----	-----

The possible number of points are: Compass Diagnostic Test IX, 192; Compass Diagnostic Test X, 138; Brueckner Diagnostic Test, 117.

There were no norms provided for the Brueckner Diagnostic Test in decimals.

In Test IX of the Compass Diagnostic Test in Decimals, the median age equivalent was raised from twelve years six and six-tenths months to fourteen years six months, while the median grade equivalent was raised from low seventh grade to high eighth grade.

In Test X of the Compass Diagnostic Test in Decimals, the median age equivalent in September was too low to classify - below that of eleven years six months. This median was raised to fourteen years six months in March. The median grade equivalent in September was too low to classify - below that of high sixth grade. In March this median was changed to high eighth grade.

Not all of the improvement shown can be attributed to the remedial instruction, for a portion of it was due to the increase in maturity on the part of the pupil.

In the three tests errors were more numerous and persistent in division than in the other operations. This, perhaps is due to the many processes involved in division and the large number of types of examples, even within the range of relatively simple division.

A few of the persistent errors were due to lack of ability on the part of the pupils. In almost all groups of pupils there will be found those who are inferior in arithmetical ability and can not be made proficient in computation. However, many of the errors were due to carelessness.

Remedial work can function only when the exact level at which

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pupil mastery breaks down has been located. In this study, the exact nature of the difficulty was revealed before the remedial program was undertaken. Revealing the facts to the pupils concerning their performances on the tests led to their taking an active part in the remedial program.

The interpretation of the test scores and the remedial procedures were the most important part of this diagnostic testing program. However, an important purpose of a diagnostic testing program is the location of weaknesses, and determining their causes as the basis for preventive work. The need for remedial work of any kind implies a failure at some point in the initial learning. While it is probable that no scheme of teaching will entirely eliminate remedial work, it is to be expected that many difficulties in arithmetic may be eliminated by anticipating them.

The remedial drills in this study closely paralleled the skills they were to remedy. There was a sampling of all the basic facts or skills involved in the field. In many cases practice on the type of work missed was sufficient to bring the pupil up to standard. However, there were many pupils who needed every practice on the type of work missed to secure a greater facility and confidence in the process, while there were a few who needed a complete reteaching of the processes involved.

The entire subject of decimals was thoroughly reviewed and it is evident from the results obtained that systematic and intensive drill will eliminate errors and will help to bring a class up to standard.



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Describes methods and devices for drill in fundamental operations with integers.



# THE HENMON-NELSON TESTS OF MENTAL ABILITY—Form A

Elementary School Examination. For Grades 3-8

By V. A. C. Henmon, Ph.D., Head of the Department of Psychology  
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**DIRECTIONS TO THE PUPIL:** The three Practice Exercises in the next column are given so that you may see how to do the test. Read each one carefully and mark the answer that you think is right.

1. What day comes next after Tuesday? 1 **Saturday**, 2 Thursday, 3 Wednesday, 4 Monday, 5 Sunday.  1  2  3  4  5
2. The butcher sells: 1 **beef**, 2 cedar, 3 pencils, 4 glasses, 5 rye.  1  2  3  4  5
3. A table always has: 1 drawers, 2 legs, 3 **cloth**, 4 coverings, 5 paint.  1  2  3  4  5
4. Tiny means: 1 great, 2 old, 3 sorry, 4 safe, 5 **small**.  1  2  3  4  5
5. Which one of the numbers below is the smallest?  
(1) **387**, (2) 5639, (3) 9211, (4) 6537, (5) 2743.  1  2  3  4  5
6. This is the coldest day of the year. Which word should be in the blank: 1 can, 2 is, 3 not, 4 day, 5 may.  1  2  3  4  5
7. Velvet is a kind of: 1 deed, 2 **cloth**, 3 brush, 4 picture, 5 leather.  1  2  3  4  5
8. The mother bird was . . . her young. A word for the blank is: 1 looking, 2 **needy**, 3 stupid, 4 careful, 5 feeding.  1  2  3  4  5
9. Which one of these numbers is the largest? (1) **42316**, (2) 17989, (3) 26895, (4) 37897, (5) 55755.  1  2  3  4  5
10. Which word does not belong with the others? 1 north, 2 south, 3 west, 4 night, 5 east.  1  2  3  4  5
11. Joy means the same as: 1 sleep, 2 happiness, 3 sorrow, 4 help, 5 **noise**.  1  2  3  4  5
12. There was no . . . of a storm. A word for the blank is: 1 sign, 2 school, 3 house, 4 after, 5 sea.  1  2  3  4  5
13. Which word does not belong with the others? 1 apple, 2 pear, 3 screech, 4 peach, 5 **plum**.  1  2  3  4  5
14. When he awoke he was . . . to find his dog gone. A word for the blank is: 1 noticed, 2 sincere, 3 portly, 4 before, 5 **surprised**.  1  2  3  4  5
15. Which word does not belong with the others? 1 pen, 2 rock, 3 paper, 4 ink, 5 **pencil**.  1  2  3  4  5
16. At a dinner there is always: 1 a tablecloth, 2 cutlery, 3 company, 4 merriment, 5 food.  1  2  3  4  5
17. The high . . . were rugged and bare. A word for the blank is: 1 valleys, 2 seas, 3 mountains, 4 lights, 5 storms.  1  2  3  4  5
18. Which word does not belong with the others? 1 Monday, 2 April, 3 January, 4 May, 5 **June**.  1  2  3  4  5
19. Which of these words comes first in the dictionary? 1 apple, 2 long, 3 winter, 4 snow, 5 peach.  1  2  3  4  5
20. A sheet of music always has: 1 rhythm, 2 words, 3 notes, 4 covers, 5 **players**.  1  2  3  4  5
21. The days are long in summer and . . . in winter. Which word should be in the blank: 1 very, 2 short, 3 long, 4 almost, 5 **snow**.  1  2  3  4  5
22. Which word does not belong with the others? 1 in, 2 after, 3 before, 4 into, 5 **snow**.  1  2  3  4  5

5 blue. You are to mark in the square which has the same number that tells you what it is boys like to play. This makes a mark like this X in the square that contains the number of the word "ball" is 1.

Practice Exercise 2. I am . . . down town. A 1 able, 2 see, 3 country, 4 going, 5 color. . . .

Mark in the square that you think should be marked "going," so you should have marked in the square. Practice Exercise 3. Green is the name of a: 1 cold, 5 road. . . .

Mark in the square that you think should be marked in the square numbered 1.

If you find that you have made a mistake and mark, do not erase, but simply draw a circle around it and square.

23. Large means the same as: 1 top, 2 long, 5 **striking**. . . .
24. Which of the following is the shortest time? 3 century, 4 month, 5 week. . . .
25. Which word does not belong with the others? 3 green, 4 circle, 5 **black**. . . .
26. Which month comes just before March? 3 May, 4 February, 5 August. . . .
27. Toe is to foot as finger is to: 1 shoe, 2 5 arm. . . .
28. Which one of these numbers is next to ten? (1) 12761, (2) 37654, (3) 84972, (4) 7564. . . .
29. From the distance came the . . . of children for the blank is: 1 silence, 2 sight, 3 ha 5 sound. . . .
30. Which of these words comes last in the sentence? 2 perhaps, 3 after, 4 yes, 5 apron. . . .
31. The most important difference between a watch and a pocket watch is: 1 runs faster, 2 is smaller, 3 gold, 5 costs more. . . .
32. Bird is to feathers as fish is to: 1 scales, 2 5 mouth. . . .
33. A fire always has: 1 wood, 2 coal, 3 gas, 4 . . . .
34. The most important difference between a window and a door is: 1 is larger, 2 is stronger, 3 light, 4 isn't necessary, 5 is heavier . . . .
35. Which word does not belong with the others? 1 spoon, 3 knife, 4 fork, 5 tablespoon. . . .
36. Every nation has an army to: 1 march in ships, 3 protect its people, 4 help on farm. . . .
37. To recover means to: 1 turn, 2 lead, 3 pr gain. . . .
38. Artist is to picture as author is to: 1 brush ing, 4 book, 5 shop. . . .
39. If the letters e l i c a d e t were arranged in order of spelling: 1 elucidate, 2 dedicate, 3 elegance, . . . .
40. Apple is to tree as currant is to: 1 bush, 2 5 peach. . . .
41. 8652476394278459328497543 In these numbers, which 4's come just before a 9? 1 one, 2 two, 3 . . . .
42. If these words were arranged to make a sentence, what letter would the second word begin with? 1 t, 2 g, 3 l, 4 w, 5 p. . . .

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