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Educational Mathematical Games as an Aid to Learning with Seventh Grade Mathematics Students at Wahlquist Junior High

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EDUCATIONAL MATHEMATICAL GAMES AS AN AID TO LEARNING WITH SEVENTH GRADE MATHEMATICS STUDENTS AT WAHLQUIST JUNIOR HIGH

by

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INTRODUCTION

One of the trends in mathematics has been the introduction of educational games as learning devices. A student's attitude toward mathematics is recognized to be very high when games are used. Walter Cronkite, on CBS television, summed up the promise of educational gaming when he said, "By participating, by playing a game, an otherwise dull subject becomes fascinating and unforgettable to the student." (Nesbitt, 1971, p. 2) Bradfield states it in this manner:

> Many teachers of mathematics are unbelievably boring in their approach to teaching. Consequently, many potentially strong students never develop any great liking for mathematics. This loss of interest is an educational waste . . . Therefore, a more stimulating atmosphere is needed in most mathematics classrooms. One way of stimulating the atmosphere is to use recreational mathematics material. (Bradfield, 1970, p. 239)

Stark sums up the idea of using games as an aid to learning:

> The "Games Theory" is not a panacea for all educational ills, but possibly another important teaching-learning tool to prepare children for life. It could serve as an inspirational force, providing the human striving for greatness with a playground. (Stark, 1968, p. 44)

Many questions need to be answered for the teacher wanting to use mathematical games in his classroom. It will be the purpose of this paper to summarize the literature concerning the effectiveness of mathematical games in the secondary classroom. In addition, an experiment will be conducted involving the use of mathematical games in the secondary classroom and to survey the changes in attitude of the students, involved in the study, toward mathematics.

Objectives

1. To survey the literature of the last fifteen years concerning the effectiveness of mathematical games in the secondary classroom.

2. To conduct an experiment using seventh grade students involving the use of games as an aid to learning.

3. To survey the attitude of the students involved toward mathematics.

Limitations of the Study

This study will not attempt to review the whole field of gaming. It will concentrate upon the use of gaming in the secondary mathematics classroom. The values and limitations of gaming will be explored.

Definitions

Game: "A game is a contest or play activity among opposing players; these are usually the objectives of winning and the elements of competition." (Chapin, 1968, p. 789)

Attitude: "Attitudes are defined as predispositions to respond toward certain objects, conditions, or events either positively, negatively, or neutrally." (Jones, 1968, p. 604)

Stimulation: "Is a model of a situation (social, mathematical, or physical) with reality simplified; it permits the operation upon a specifically devised problem in a time-sequential method." (Chapin, 1968, p. 789)

Simulation games: "Are models of social situations which involve participants in competition and role playing to bring about a learning outcome or an attitude change." (Colvin, 1972, p. 3)

REVIEW OF RELATED LITERATURE

The review of literature for this study is related only to the nature of the problem and the nature of this investigation. The review is divided into three sections: reasons for using games and values of games; limitations of games; and conclusions. It should be emphasized that the description and research cited here are by no means exhaustive of the available literature.

Reasons for Using Games and Values of Games

"The attitude of a learner towards an activity is important; it crucially affects how well he will learn that activity." (Jeffryes, 1969, p. 112) Many people have been scarred by their early experiences in arithmetic. Writers such as Feldzamen (1968), Rademacher and Teoplitz (1957), and Dutton (1956), are convinced that the attitude of the student toward mathematics determines how well he will achieve. Feldzamen points out that people think of mathematics as "tedious and frustrating." (Feldzamen, 1968, p. 6) Dutton believes the "liking arithmetic has a pronounced effect upon the amount of work attempted, the effort expanded, and the learning that is acquired." (Dutton, 1956, p. 18)

The fact most agreed upon about educational gaming is its power to motivate and involve students. The studies of Boocock and Schild (1968), Coleman (1968), and Cherryholmes (1966) are unanimous in the finding that students show a high degree of interest and react positively to games. Kopp (1969) indicates that two-way communication between the teacher and his class can foster enthusiasm toward mathematics. Writers such as E. Allen (1969), Chapin (1968), and Kysilka and Rogers (1970), support the studies in the viewpoint that games provide motivation and involvement of students.

Emphasis today in mathematics is for the learner to be taught by the discovery method. "In other words, the pupil is supposed to become involved in mathematics learning as an active participant, not as a tell-me-about-it passive listener." (Krulik, 1971, p. iii) Studies undertaken by Boocock and Schild (1968), Abt (1967), and Haggerty (1964) have concluded that students playing educational games have shown subject matter improvement. Friedman (1971) points out three advantages for learning by using games: games present real-life situations; games provide decision making responsibilities; and games may be used to teach functional subject matter. Writers such as Coleman (1968), Stark (1968), and Dohler (1963) share the belief that games can help teach subject matter.

Coleman summarizes the answer to the question of "Why use games?" as:

> Playing a game with a given content has precisely the effect of learning to be motivated toward assimilating that content. The game provides the goal for which the content is relevant, and the very nature of games insures that the player will be motivated towards that goal. (Coleman, 1968, p. 52)

One of the important values of games is the ease with which they can be adapted for use in the classroom. "Children are intrigued by numbers and their relationships to one another. If we as teachers, use this curiosity, it is possible to develop many games which can serve as replacement for traditional drill." (Jordon, 1968, p. 454) Students can create their own games thus adding to the versitility and values of educational gaming.

> The varying degrees of complexity in the games are commensurate with a child's mathematical concepts and interests. In devising the games, the children must try out their ideas and pursue them to a reasonable outcome. (Golden, 1970, p. 113)

Timmons (1967) points out that the value of this kind of activity is the enthusiasm it generates. It allows all to participate no matter their degree of competency. Other authors such as Kopp (1969) and Allen (1969) support this view that children learn by making up their own games.

Limitations of Games

Games should not become the main part of a curriculum. Rather, they should be used to enhance it. Their use should be restricted to a supplementary role in teaching a unit, rather than being used alone to teach a whole concept. According to Boocock and Schild (1968, p. 83) "It must be recognized that educational games are not a substitute for, but only an enhancing complement of, conventional study methods." Educational gaming is one of the new innovations and teachers should be careful not to overuse them. "Even the best games are ruined by the wrong introduction, inadequate debriefing, or poor teaching." (Nesbitt, 1971, p. 144)

Traditional methods of teaching may present facts, ideas, and concepts faster than most games. Kysilka and Rogers (1970) point out that games are time-consuming, compared to more highly structured, teacher-directed activities such as listening to lectures or studying from the textbook. More classroom time is used in the actual playing of games than regular classroom activities require and games are usually only presenting a specific type of fact. Because of these reasons games should be used with care and insight into the teaching objectives of the lesson.

When games are played in the classroom, the teacher-student relationship is effected. The teacher no longer dominates the learning activity and his role as the authority figure has vanished. The noise level in the classroom is higher with more student movement. Many teachers who are used to a strict, controlled classroom may feel threatened by these conditions.

Many teachers feel that games are not serious or that the students will not take them seriously. Boocock and Schild (1968) point out that possibly a more permanent problem is the attitude that some teachers have toward games. Games have rules, and some simulation games have a great deal of complexity in their rules. Teachers should take care to understand the game themselves before introducing them to the students.

According to Pedoe:

> The Lewis Carroll attitude to mathematics, delightful though it is, has probably had an inhibiting effect on many potential mathematicians. It has made them feel that mathematics is a subject which only clever, witty people can learn and understand. (Pedoe, 1959, p. 5)

Beals sums up some possible problems in using games with the following list of questions:

1. Am I willing to devote the necessary time to the activity?
2. Does the game or simulation chosen really meet the needs of my students, and do my students have the necessary background for it?

3. Does my philosophy and the philosophy of my school permit the use of games and simulations?
4. Does the simulation over-simplify the real situation:
5. Are all required supplies and materials readily available?
6. Is the game a justified part of the curriculum or just a pleasant pastime?
7. How can I evaluate the outcomes of a game or simulation?
8. Does the nature of the simulation place too much emphasis on winning?
9. Does the game or simulation prepare children for participation in the free and open society? (Beals, 1971, p. 96)

Conclusions of Related Literature

What is the future of gaming? Raser (1969) indicates that the method will come into more widespread use, and that existing games will improve, new ones will be devised and game technology further developed.

Thorpe's conclusions are:

> As a result of examining the research described in the preceding pages, as well as other studies not directly reported here, it has become clear to this writer that the claim made by advocates of classroom gaming that students learn more facts and content principles by participating in a game than in more conventional classroom activities, remains unsupported by empirical evidence. Such a hypothesis cannot be accepted without a great deal more research. The evidence collected by researchers thus far seems to support the hypothesis that gaming does arouse more interest than other methods against which games are compared. Students are almost uniformly attracted to game play. (Thorpe, 1971, p. 457)

Six current research projects were reviewed by Cleo H. Cherryholmes (1966) of Michigan University. He tested them in terms of research done in the following studies: Boocock and Schild, Coleman and others. He accomplished this by forming five hypothesis. His second hypothesis stated that students participating in a game would learn more concept facts than those students in a more traditional situation. This hypothesis was rejected because none of the six studies supported the hypothesis. Cherryholmes thus reported that more retention of fact was not evidenced.

D. L. Bradfield (1970) conducted a study involving slow ninth grade mathematics students. He used programmed instruction in two groups of students. One group was supplemented with the use of games. His findings show that students using the games had greater retention of facts. This exception shows some of the inconsistencies of the research done concerning games. This research has thus far proved to be insufficient in terms of testing the effectiveness of games as learning devices.

METHOD AND PROCEDURE

Two seventh grade mathematics classes were used for the purpose of this experiment. The methods and assignments were the same for each class. The following procedure was used:

1. Two groups of seventh grade mathematics students were used:
   a. Control group studied the material without the aid of games.
   b. Experimental group studied the material with the aid of games.
2. The area of study was units on operations with whole numbers and operations with fractions.
3. At the completion of the first unit on whole numbers the groups were reversed for the unit on fractions.
   a. The experimental group became the control group.
   b. The control group became the experimental group.
4. The Steck-Vaughn Mastery Test (Appendix A and B) was used as a pretest and posttest for each unit taught.
5. The mean and standard deviation was used to measure the difference between the two groups of students.
6. Before and after each unit was taught, Wilber H. Dutton's attitude survey (Appendix C) was given to assess changes in attitude of the students toward mathematics.

The two seventh grade classes were used exactly as the registration came from the counselors with no particular emphasis on grouping.

Mathematical games were used as an integral part of the classroom instruction in the experimental group. The games were introduced to demonstrate to the students the practical applications of learning mathematics as well as ways of having fun with mathematical principles. It was hoped that the pupils would be stimulated to learn mathematics if concepts were presented in game form.

Of equal importance to the investigator was the concept of attitude or behavior change as this change was related to the above-described techniques of instruction. Classroom attitudes are dimensions of motivation which in turn are directly related to the learning process.

This experiment was undertaken to test the effect of mathematical games as an aid to learning in the seventh grade classroom. The following hypotheses were subjected to statistical test:

1. Pupil's level of achievement would advance more in the experimental group than in the control group.
2. Pupil's attitude change would change for the better in the experimental group.

Seventy-five students ranging from eleven to twelve years of age were used as subjects in this experiment. No attempt was made to group the students according to ability level. The students were told nothing about the experiment and the desired results. The control group was taught the material without the aid of mathematical games. The same teaching methods were used in the experimental group except that mathematical games were used as an important part of the instruction.

The experiment was divided into two units: Operations with whole numbers and operations with fractions. The Mastery Test by Steck-

Vaughn was employed to evaluate academic changes made by the students involved in the experiment.

Wilber H. Dutton's attitude survey was given before and after each unit. The responses assigned to his questions were: strongly agree, agree, uncertain, disagree, and strongly disagree. These answers were assigned a numberical value of one to five. The students were instructed to circle the answer that they felt was the one answer that most agreed with the way that they felt about the question. The investigator then scored the survey to obtain a numerical value.

Results of the Unit on Whole Numbers

Table 1 presents the pretest and posttest means and standard deviations concerning mathematical ability with the operations on whole numbers.

Table 1. Means and standard deviations of pretest and posttest scores of mathematical ability

	Control		Experimental	
	Pretest	Posttest	Pretest	Posttest
Mean	80.7	82.6	82.8	86.1
Standard deviation	14.23	16.68	11.38	11.61

Table 1 shows that the experimental group made the largest gain in class average with the standard deviation staying approximately the same.

Table 2 presents the pretest and posttest means and standard deviations concerning attitude changes of both the control and experimental groups.

Table 2. Means and standard deviations of pretest and posttest scores of attitude change

	Control		Experimental	
	Pretest	Posttest	Pretest	Posttest
Mean	75.3	74.5	77.7	86.4
Standard deviation	8.34	9.97	12.29	12.13

Table 2 shows that the attitude of the experimental group changed the most toward mathematics. The control group's attitude actually decreased as shown by their mean and standard deviation.

Results of the Unit on Fractions

The two groups of students, at this point, were reversed. The experimental group became the control group and the control group became the experimental group.

Table 3 presents the pretest and posttest means and standard deviations concerning mathematical ability with the operations on fractions.

Table 3. Means and standard deviations of pretest and posttest scores of mathematical ability

	Control		Experimental	
	Pretest	Posttest	Pretest	Posttest
Mean	62.8	83.8	26.5	75.3
Standard deviation	22.45	16.07	17.45	21.63

Table 3 shows that the two groups were really very different in ability and that difference makes it difficult to compare the two groups. It can be noted that the experimental group's mean rose dramatically and also that the experimental groups standard deviation also rose dramatically.

Table 4 presents the pretest and posttest means and standard deviations concerning attitude changes of the two groups. Table 4 also shows a very interesting occurrence. The control group's attitude decreased sharply as shown by both the mean and standard deviation scores. In the first unit, this control group was the experimental group. The experimental group's attitude increased as shown by the mean score although the standard deviation changed little. In the first unit, this experimental group was the control group.

Table 4. Means and standard deviations of pretest and posttest scores of attitude change

	Control		Experimental	
	Pretest	Posttest	Pretest	Posttest
Mean	86.4	76.4	74.5	78.8
Standard deviation	12.13	16.75	9.97	9.16

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this paper was to review the literature and to conduct an experiment involving two seventh grade classes using mathematical games as an aid to learning. The review of literature revealed that the effectiveness of educational games is still in question. More precise and controlled studies are needed to answer this question. Educational games have shown themselves to be a useful tool in motivating students.

Educational gaming does have values and merit. There are: one, as a tool to motivate students; two, as a means of involving students; three, higher levels of learning are dealt with; four, students have placed in their situations decision making responsibilities.

The results of the experiment made with seventh grade students generally revealed that students do learn with the aid of games as well as those students without the aid of games. In both teaching units the mean score increased more in the class that had the games used as part of the curriculum than the group that did not use the games. The study also showed that when the games were used student attitude was generally higher than when the games were not used.

In general, this paper has examined a few aspects of educational gaming. Many questions about its usefulness in the classroom are still open to question. D. Johnson (1968, p. 331) stated "These recreational topics should not be used merely to entertain or to use up free time. They should be used to learn mathematical ideas and to build attitudes."

Conclusions

1. The idea of using educational gaming is not a cure for all educational ills.
2. The review of literature revealed no significant learning differences take place when games are used as compared to more conventional types of learning.
3. Games are recognized to be high motivational devices.
4. The experiment with the seventh grade students showed that the students learn with the aid of games and with better attitudes toward mathematics.

Recommendations

1. Teachers should study the games materials thoroughly before using them in the classroom.
2. Games should be used as an aid in the curriculum not as the whole curriculum.
3. Teacher and student designed games are valuable tools.
4. Care should be used in the use of games. They should not be waste time activities.

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APPENDIXES

Appendix A

Steck-Vaughn Mastery Test 1

MASTERY TEST — PART I

Working With Numbers, A Refresher Course

FOR THE FIRST THREE PARTS

Student .... **Grade** ....

Teacher .... **School** ....

Instructions

This test is designed to give you the opportunity to mark your progress at the mid-point of your study of the Refresher Course. The teacher, of course, will be interested in seeing just how well you have done. But you, yourself, will be most interested in seeing whether you have made the right amount of progress and in seeing how well you have retained all the skills studied to this point.

There is no time limit for this test. Use all the time necessary to complete it. If you come to a problem which you cannot work, go on to the others. Then, when you have finished them, come back to any you have skipped. Do your very best and *prove to yourself* that you are making the kind of progress you desire.

The test is divided into four parts: Whole Numbers, Fractions, Decimals, and Word Problems. Each part is divided into the four operations: Addition, Subtraction, Multiplication, and Division. When you have finished the test and it has been scored, enter your scores in the chart below. This will enable you to determine exactly where there are any weaknesses and where you need to acquire more skill.

		PROBLEMS	PERFECT SCORE	MY SCORE
Whole Numbers	Addition	1 - 7	7	
	Subtraction	8 - 13	6	
	Multiplication	14 - 19	6	
	Division	20 - 25	6	
Fractions	Addition	26 - 32	7	
	Subtraction	33 - 38	6	
	Multiplication	39 - 44	6	
	Division	45 - 50	6	
Decimals	Addition	51 - 57	7	
	Subtraction	58 - 63	6	
	Multiplication	64 - 69	6	
	Division	70 - 75	6	
Word Problems		76 - 100	25	
TOTAL SCORE			100	

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Whole Numbers

Add:

1.

```
 9
 7
 5
 4
 6
 2
 8
___
```

2.

```
 12
 55
 74
 37
 49
 86
____
```

3.

```
 464
 647
 528
 786
 953
 275
_____
```

4.

```
 285346
 465987
________
```

5.

```
 380240
  76095
________
```

6.

```
 5237
 4785
 6876
 8569
______
```

7.

```
 4105
 3086
 2470
 5909
______
```

Subtract:

8.

```
 17
  9
____
```

9.

```
 99
 53
____
```

10.

```
 1289
  435
______
```

11.

```
 745
 246
_____
```

12.

```
 620
 443
_____
```

13.

```
 84239
 36544
_______
```

Whole Numbers

Multiply:

14.
$$\begin{array}{r} 9 \\ \underline{7} \end{array}$$

15.
$$\begin{array}{r} 14 \\ \underline{9} \end{array}$$

16.
$$\begin{array}{r} 34 \\ \underline{23} \end{array}$$

17.
$$\begin{array}{r} 75 \\ \underline{37} \end{array}$$

18.
$$\begin{array}{r} 762 \\ \underline{56} \end{array}$$

19.
$$\begin{array}{r} 206 \\ \underline{250} \end{array}$$

Divide:

20. $7\overline{)63}$

21. $7\overline{)287}$

22. $12\overline{)384}$

23. $9\overline{)2007}$

24. $16\overline{)4864}$

25. $126\overline{)27090}$

Fractions

Add: (Simplify Answers)

26.
$$\begin{array}{r} \frac{1}{8} \\ \frac{3}{8} \\ \frac{5}{8} \\ \hline \end{array}$$

27.
$$\begin{array}{r} \frac{1}{2} \\ \frac{1}{4} \\ \hline \end{array}$$

28.
$$\begin{array}{r} \frac{2}{3} \\ \frac{1}{4} \\ \hline \end{array}$$

29.
$$\begin{array}{r} 15\frac{3}{4} \\ 12\frac{1}{4} \\ \hline \end{array}$$

30.
$$\begin{array}{r} 19\frac{7}{8} \\ 12 \\ \hline \end{array}$$

31.
$$\begin{array}{r} 27\frac{1}{4} \\ 13\frac{3}{8} \\ \hline \end{array}$$

32.
$$\begin{array}{r} 30\frac{1}{2} \\ 16\frac{1}{3} \\ \hline \end{array}$$

Subtract:

33.
$$\begin{array}{r} \frac{3}{4} \\ \frac{1}{4} \\ \hline \end{array}$$

34.
$$\begin{array}{r} \frac{3}{4} \\ \frac{3}{8} \\ \hline \end{array}$$

35.
$$\begin{array}{r} \frac{1}{3} \\ \frac{1}{4} \\ \hline \end{array}$$

36.
$$\begin{array}{r} 21\frac{3}{4} \\ 9 \\ \hline \end{array}$$

37.
$$\begin{array}{r} 19 \\ 7\frac{2}{3} \\ \hline \end{array}$$

38.
$$\begin{array}{r} 30\frac{1}{2} \\ 14\frac{1}{4} \\ \hline \end{array}$$

Multiply:

39. $5 \times \frac{3}{10} =$

40. $\frac{1}{2} \times \frac{4}{5} =$

41. $\frac{1}{2} \times 25 =$

42. $9 \times 2\frac{1}{3} =$

43. $8\frac{1}{3} \times \frac{3}{5} =$

44. $3\frac{1}{3} \times 2\frac{2}{5} =$

Fractions and Decimals

Fractions

Divide:

45. $\frac{8}{8} \div 3 =$

46. $3 \div \frac{3}{8} =$

47. $\frac{1}{2} \div \frac{1}{6} =$

48. $4\frac{2}{3} \div \frac{7}{8} =$

49. $5\frac{1}{3} \div \frac{1}{2} =$

50. $10\frac{1}{2} \div 1\frac{3}{4} =$

Decimals

Add:

51.

```
 .4
 .5
____
```

52.

```
 .2
 .6
 .3
 .8
____
```

53.

```
 108.75
 235.87
_______
```

54.

```
 214.08
  17.9
_______
```

55.

```
 1.046
  .87
  .9
 4.
______
```

56.

```
 $217.43
    7.15
   29.00
    4.35
________
```

57.

```
 263.0005
  17.6
_________
```

Subtract:

58.

```
 .9
 .4
____
```

59.

```
 128.9
  19.8
______
```

60.

```
 216.5
  19.
______
```

61.

```
 137.
  15.8
______
```

62.

```
 25.004
 16.
_______
```

63.

```
 372.
 135.006
________
```

Decimals

Multiply:

64.
$$\begin{array}{r} .4 \\ \underline{.9} \end{array}$$

65.
$$\begin{array}{r} 1.5 \\ \underline{.9} \end{array}$$

66.
$$\begin{array}{r} .025 \\ \underline{.3} \end{array}$$

67.
$$\begin{array}{r} .15 \\ \underline{.06} \end{array}$$

68.
$$\begin{array}{r} .004 \\ \underline{.03} \end{array}$$

69.
$$\begin{array}{r} 3.5 \\ \underline{2.4} \end{array}$$

Divide:

70. $.5 \overline{)\,.25}$

71. $15 \overline{)\,2.25}$

72. $1.3 \overline{)\,.039}$

73. $1.2 \overline{)\,48.}$

74. $.15 \overline{)\,75.}$

75. $5 \overline{)\,3.}$

Word Problems

Do Your Work Here

76. Sam's father has a truck that weighs 4725 pounds. The truck will carry a load of 7500 pounds. What is the total weight of truck and full load? . . . . ________

77. The population of New York is approximately 7,950,000. Chicago has a population of approximately 5,650,000. What would the combined population be? . . . . ________

78. The Cascade Tunnel in Washington is 41,152 feet long. The Moffat Tunnel in Colorado is 32,798 feet long. How much longer is the Cascade Tunnel? . . . . ________

79. Esther gave the storekeeper a twenty-dollar bill for a purchase of $14.51. How much change should she have received? . . . . ________

80. Mrs. George made a payment of $37.50 on a bill of $73.94. How much did she still owe? . . ________

81. Jack's father sold his farm of 87 acres for $125 an acre. How much did he receive for the farm? . . . . ________

82. The first airplane flight to Paris took 26 hours. The average speed was 130 miles an hour. How many miles long was the trip? . . . . ________

83. Sam can plant 261 cabbage plants in 1 row of his garden. How many rows in his garden must be used to plant 1044 plants? . . . . ________

84. Last summer we took an auto trip of 3,427 miles. After we had driven 1,578 miles, how many miles were left? . . . . ________

85. For the first four months of the year, rain fell as follows: $2\frac{1}{2}$ in., $3\frac{1}{4}$ in., $1\frac{1}{8}$ in., and $1\frac{1}{2}$ in. What was the total rainfall for these four months? . . . . ________

86. Ruth used $1\frac{3}{4}$ cups of sugar in making a cake and $\frac{3}{4}$ cup in making the icing. How much sugar did she use in all? . . . . ________

87. Last year Milwaukee had a total fall of snow amounting to 92 inches. The normal fall is $52\frac{1}{4}$ inches. How much above normal was the snowfall last year? . . . . ________

Word Problems

Do Your Work Here

88. The storekeeper sold $9\frac{1}{4}$ yards from a piece of material containing 53 yards. How much was left in the original piece? . . . . ________

89. Hay sells for $18 per ton. How much will Ted's father have to pay for five and one-half tons? . . . . ________

90. Last week we drove to Detroit. At an average speed of 42 miles per hour, the trip took $4\frac{1}{2}$ hours. How far was it? . . . . ________

91. Mr. Thomas shoveled $12\frac{1}{2}$ yards of sand in $2\frac{1}{2}$ hours. At that rate how many yards did he shovel in one hour? . . . . ________

92. How much material was required for each of two dresses of the same size if it took $5\frac{1}{2}$ yards for both? . . . . ________

93. Rain fell last month as follows: 2.4 in., .19 in., 3.7 in., and .9 in. What was the total rainfall? . . . . ________

94. From Chicago to Memphis is 527.4 miles. From Memphis to New Orleans is 393.8 miles farther. How many miles is it from Chicago to New Orleans? . . . . ________

95. The heaviest rainfall in one day on record for New York City is 9.4 inches. The next heaviest is 6.32 inches. How much greater is the record fall? . . . . ________

96. The longest nonstop run by train was made from Montreal to Vancouver, a distance of 2937.67 miles. The next longest nonstop run was made from Chicago to Denver, a distance of 1014.9 miles. The first was how much longer than the second? ________

97. Since water weighs 8.355 lb. to the gallon, how much do 9.4 gallons weigh? . . . . ________

98. Milk weighs 8.605 lb. to the gallon. How much do 12.2 gallons weigh? . . . . ________

99. Mr. Lee drove his car 297.6 miles while using 16 gallons of gas. How many miles does he get to the gallon? . . . . ________

100. One of the new type streamlined trains travels 217.5 miles in 3 hours. What average speed per hour does it make? . . . . ________

Appendix B

Steck-Vaughn Mastery Test 2

MASTERY TEST — PART II

Working With Numbers, A Refresher Course

FOR THE ENTIRE BOOK

Student .... **Grade** ....

Teacher .... **School** ....

Instructions

This test is designed to give you the opportunity to measure the amount of progress you have made in the study of the Refresher Course. It is to be used after you have finished studying the course, so that you can tell exactly how much you have achieved. The teacher, of course, will want to know how well you have studied. But you yourself will be most interested in proving to *yourself* how much you have learned, and in finding out whether you have acquired all the skills you will need.

There is no time limit for this test. Use all the time necessary to complete it. If you come to a problem which you cannot work, go on to the others. Then, when you have finished them, go back to any you have skipped. Do your very best and *prove to yourself* just how well you have studied.

The test is divided into six parts: Whole Numbers; Fractions; Decimals; Per Cent; Measurements and Formulas; and Ratio, Proportion, and Simple Equations. When you have finished the test and it has been scored, enter your score in the chart below. This will enable you to determine exactly where there are any weaknesses and where you need to acquire more skill.

		PROBLEMS	PERFECT SCORE	MY SCORE
Whole Numbers	Addition	1 - 4	4	
	Subtraction	5 - 8	4	
	Multiplication	9 - 12	4	
	Division	13 - 16	4	
Fractions	Addition	17 - 20	4	
	Subtraction	21 -24	4	
	Multiplication	25 - 28	4	
	Division	29 - 32	4	
Decimals	Addition	33 - 36	4	
	Subtraction	37 - 40	4	
	Multiplication	41 - 44	4	
	Division	45 - 48	4	
Per Cent		49 - 68	20	
Measurements and Formulas		69 - 84	16	
Ratio, Proportion, and Simple Equations		85 - 100	16	
TOTAL SCORE			100	

STECK-VAUGHN COMPANY • AUSTIN, TEXAS

Whole Numbers

Add:

1.
```
 17
 29
 78
 85
 34
----
```

2.
```
 2176
 3429
-----
```

3.
```
 2943
   34
  176
 2053
-----
```

4.
```
 27965
 30609
 22079
 30705
 50078
------
```

Subtract:

5.
```
 546
 227
----
```

6.
```
 1943
  849
-----
```

7.
```
 2050
 1564
-----
```

8.
```
 907086
 548299
-------
```

Multiply:

9.
```
 247
  24
----
```

10.
```
 306
  24
----
```

11.
```
 305
 240
----
```

12.
```
 2516
  123
-----
```

Whole Numbers and Fractions

Whole Numbers

Divide:

13. $15\overline{)225}$

14. $24\overline{)504}$

15. $18\overline{)3654}$

16. $32\overline{)19616}$

Fractions (Reduce Answers)

Add:

17. $\frac{5}{8}$ + $\frac{1}{8}$ + $\frac{3}{8}$ + $\frac{7}{8}$

18. $\frac{1}{2}$ + $\frac{1}{4}$ + $\frac{1}{8}$ + $\frac{3}{4}$

19. $2\frac{1}{8}$ + $4\frac{3}{8}$ + $7\frac{5}{8}$ + $6\frac{7}{8}$

20. $2\frac{1}{2}$ + $3\frac{1}{4}$ + $15\frac{1}{8}$ + $12\frac{5}{16}$ + $3\frac{3}{4}$

Subtract:

21. $\frac{5}{8}$ − $\frac{3}{8}$

22. $\frac{3}{4}$ − $\frac{2}{3}$

23. $12\frac{9}{16}$ − $4\frac{3}{8}$

24. $9\frac{1}{2}$ − $2\frac{2}{3}$

Multiply:

25. $\frac{1}{3} \times 12 =$

26. $14 \times \frac{3}{7} =$

27. $\frac{3}{4} \times 4\frac{2}{3} =$

28. $5\frac{1}{4} \times 2\frac{2}{3} =$

Divide:

29. $18 \div \frac{1}{3} =$

30. $\frac{2}{3} \div 4 =$

31. $\frac{3}{5} \div 4\frac{1}{2} =$

32. $10\frac{1}{2} \div 5\frac{1}{4} =$

Decimals

Add:

33.

```
  .8
  .7
  .3
  .2
```

34.

```
  .9
  .15
  .008
  .54
  .3
```

35.

```
  .15
  .05
  .025
  .2008
  .4
```

36.

```
  252.495
   28.17
    9.6
   15.24
  106.80
```

Subtract:

37.

```
  6.276
  1.042
```

38.

```
  94.78
  15.
```

39.

```
  8.14
  6.1
```

40.

```
  1.9
   .674
```

Multiply:

41.

```
  .7
  .5
```

42.

```
  .84
    5
```

43.

```
  .862
     2
```

44.

```
  .0004
     .3
```

Divide:

45. 3) 6.6

46. 16) 9.6

47. .8) .648

48. 1.8) 9

Per Cent

Change to Per Cent:

49. $\frac{1}{2} =$

50. $.75 =$

51. $.375 =$

Change to Decimals:

52. $\frac{1}{4} =$

53. $60\% =$

54. $87\frac{1}{2}\% =$

Change to Fractions:

55. $.75 =$

56. $40\% =$

57. $62\frac{1}{2}\% =$

Solve:

58. 14% of $300 =$

59. 75% of $440 =$

60. Taxes are often discounted if paid at an early date. Father received a 3% discount on his tax bill of $120. How much tax did he have to pay?

Answer: ....

61. The fastest-growing larger city in the U.S. is San Antonio. It had a population of 256,000 in 1940. The 1950 census showed the population to be 180% of the 1940 count. How large was it in 1950?

Answer: ....

62. A merchant was allowed ½% discount for prompt payment of a bill amounting to $400. What was the amount of his discount?

Answer: ....

63. Last year, a salesman sold merchandise amounting to $160,500. His commission of 6% amounted to how much?

Answer: ....

64. Last month our gas and light bill was $8.00. This month shows a decrease of 12½%. How much is this month's bill?

Answer: ....

Do Your Work Here

Per Cent; Measurements and Formulas

Per Cent:

65. The distance from New York to San Francisco is 5400 miles by way of the Panama Canal. This is 60% of the distance by way of the Straits of Magellan. How far is it by way of the Straits of Magellan?

Answer: ....

66. Mr. Evans, the grocer, borrowed \$1250 at 6% for 6 months. How much interest would he owe on the loan?

Answer: ....

67. Dan's bank pays 2½% interest. How much interest will he have on his savings account of \$360 at the end of a year?

Answer: ....

68. To help build some houses, Mr. Raymond borrowed \$12,000 from the bank and agreed to pay it back in two and one-half years, with interest at 5%. How much interest will he pay?

Answer: ....

Measurements and Formulas:

69.

$P = 2l + 2w$
$l = 400'$
$w = 300'$

$P =$ ....

70.

$A = lw$
$l = 60'$
$w = 50'$

$A =$ ....

71.

$V = lwh$
$l = 30$
$w = 20$
$h = 10$

$V =$ ....

72.

$C = \pi d$
$\pi = \frac{22}{7}$
$d = 14'$

$C =$ ....

73.

$A = \pi r^2$
$\pi = \frac{22}{7}$
$r = 7$

$A =$ ....

74.

$V = \pi r^2 h$
$\pi = \frac{22}{7}$
$r = 7$
$h = 10$

$V =$ ....

75.

$I = prt$
$p = \$500$
$r = 4\%$
$t = 24$ mo.

$I =$ ....

Do Your Work Here

Measurements and Formulas; Ratio, Proportion, and Simple Equations

Measurements and Formulas:

76. From the formula $A = lw$, write the formula for finding w.

77. What is the perimeter of the rectangle whose length is 60 ft. and whose width is one-half the length?

Answer: ____________

78. How many feet of wire will be required to enclose a triangular-shaped park whose sides are 150′, 140′, and 200′?

Answer: ____________

79. A gymnasium floor measures 90 ft. by 150 ft. How many square feet are there in this floor area?

Answer: ____________

80. How much did Mother pay at $4 per square yard for a rug which measured 9′ by 12′?

Answer: ____________

81. A cord of wood is a pile 8′ long, 4′ wide, and 4′ high. How many cubic ft. are in a cord?

Answer: ____________

82. How many cubic yards of dirt will be required to fill a hole 27′ by 30′ by 10′?

Answer: ____________

83. A coal car has inside dimensions of 40 ft. by 6 ft. and is filled level to a 5-ft. depth. Allowing 40 cu. ft. to the ton, how many tons of coal are there in this car?

Answer: ____________

84. A water standpipe is 60 feet high and has a diameter of 14 feet. What is the volume of the standpipe (in cubic feet)?

Answer: ____________

Ratio, Proportion, and Simple Equations:

85.
$$(120 \div 3) - (7 \times 5)$$

$= $ ____________

86.
$$5x + 3 = 18$$

$x = $ ____________

87.
$$5x - 1 = 4x + 3$$

$x = $ ____________

88.
$$5(x + 4) = 4(x + 6)$$

$x = $ ____________

Do Your Work Here

Ratio, Proportion, and Simple Equations (Continued)

89. Together Pat and Jerry have \$5.25. Pat has \$.25 more than Jerry. How much does each have?

Answer: ....

90. The sum of Father's age and my age is 65 years. Father is 25 years older than I am. How old is each?

Answer: ....

91. The perimeter of a rectangular field is 60 rods. The length is twice the width. Find the length and width.

Answer: ....

92. Joe has \$3.00, and John has \$2.00. What is the ratio of Joe's money to that of John?

Answer: ....

93. The perimeter of a triangle is 81 feet. The three sides are in the ratio of 2 to 3 to 4. Find the length of each side.

Answer: ....

94. Frank, George, and Tom together have \$45. The ratio of their monies is 4 to 5 to 6. How much does each one have?

Answer: ....

95.

$$30 : x = 2 : 3$$

$x =$ ....

96.

$$\frac{x}{6} = \frac{5}{3}$$

$x =$ ....

97. A kodak picture 3″ by 4″ was enlarged so that the 3″ side would be 6″. How large would the other side be?

Answer: ....

98. The area of a square varies as the length of a side. Square A has a side twice as great as that of square B. The area of square A is how many times the area of square B?

Answer: ....

99. The volume of a cube varies as the cube of one side. Cube A has a side of 2″, and cube B has a side of 4″. The volume of cube B is how many times the volume of cube A?

Answer: ....

100. A telephone pole casts a shadow of 30 feet at the same time a fence post casts a shadow of 3 feet. The fence post is 6 feet tall. How tall is the telephone pole?

Answer: ....

Appendix C

Dutton Attitude Survey

ATTITUDE SURVEY

1. I would like to spend more time in school working arithmetic.

   Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

2. I don't feel sure of myself in arithmetic.

   Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

3. I enjoy doing problems when I know how to work them well.

   Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

4. I like arithmetic, but I like other subjects just as well.

   Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

5. Arithmetic thrills me, and I like it better than any other subject.

   Strongly agree, Agree, Uncertain, disagree, Strongly disagree

6. I don't think arithmetic is fun, but I always want to do well in it.

   Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

7. I am afraid of doing word problems.

   Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

8. Arithmetic is as important as any other subject.

   Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

9. I have never liked arithmetic.

   Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

10. Sometimes I enjoy the challenge presented by an arithmetic problem.

    Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

11. I cant't see much value in arithmetic.

    Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

12. Arithmetic is something you have to do even though it is not enjoyable.

    Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

13. I think about arithmetic problems outside of school and like to work them out.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

14. I detest arithmetic and avoid using it at all times.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

15. I enjoy seeing how rapidly and accurately I can work arithmetic problems.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

16. I avoid arithmetic because I am not very good with figures.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

17. I think arithmetic is the most enjoyable subject I have taken.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

18. I like arithmetic because it is practical.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

19. Arithmetic is very interesting.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

20. I have always been afraid of arithmetic.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

21. I am not enthusiastic about arithmetic, but I have no real dislike for it either.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

22. I never get tired of working with numbers.

Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

Appendix D

Two Games Used for Teaching Whole Number Concepts

Two Games Used for Teaching Whole Number Concepts

"Jet-0-1"

Method. The game of 52 cards consists of 4 "suits" of 13 cards each. The suits may be designated by operational symbols +, -, x, +, (operational symbols may be printed in different colors). The ordered pair of numbers as well as operational symbol involved can be placed in the upper left and lower right corners of the card similar to regular card decks.

Numbers of Players. 2 through 6.

Rules.

1. After cards have been shuffled, the dealer will deal out the entire deck.

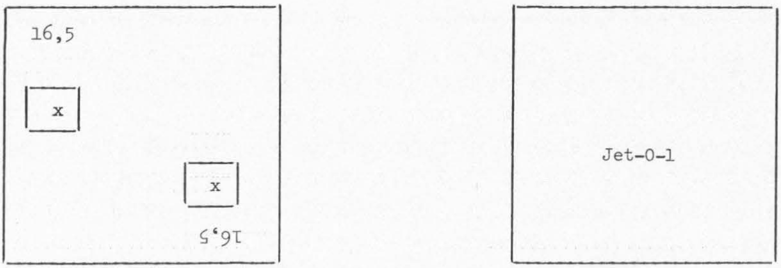
2. Player to the left of the dealer will place a card from one of the suits in the middle of the table. The other players must follow suit. The player placing the card with the highest evaluation takes the trick.

3. A player not able to follow suit must place a card on the trick but will not be able to take the trick.

4. In case of a tie, the player playing first takes the trick.

Scoring. Players can score a point for each trick taken. Variations may be devised such as bidding and trump suits, partner players, etc.

Examples of Cards.



"Situation"

Method. The deck of cards consists of 16 SITUATION cards (4 of each suit with each suit containing 1 each of the 4 operations) and 40 PLAYING cards (10 of each suit.) The symbols (suits/operations) and ordered pairs should be placed on the cards as indicated below. A nylon tip marker works well for putting the suit and operation designs on the card. The ordered pairs can be typed or hand-written as desired.

Number of Players. 3,4, or 5. However, if three players, then 1 card of each suit is to be taken from the 40 PLAYING cards.

Rules.

1. Shuffle the 40 PLAYING cards and 16 SITUATION cards separately.

2. Place the SITUATION cards face down in the center of the table.

3. Deal the PLAYING cards, one at a time, to the players.

4. Each player sorts the cards into like-suits.

5. To begin play, the dealer turns up the top SITUATION card to determine the suit and operation to be performed on the ordered pair.

6. Starting at the dealer's left, each player plays a card of that suit, calling out the value of the card as he plays.

7. For the operations of subtraction and division, the second number of the ordered pair is defined as the subtrahend and divisor, respectively.

8. The player who plays the largest value and card wins the trick.

9. Each player must play a card on every trick even if he cannot follow suit. If he cannot follow suit, he cannot win the trick.

10. If no player can follow suit, then that trick is dead (nobody's trick) and the trick goes into a "kitty."

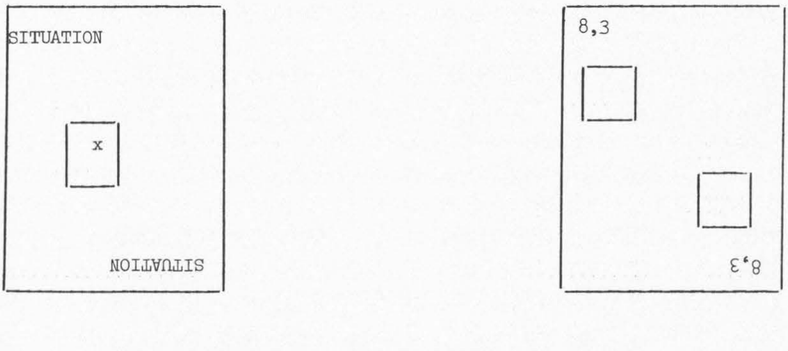
11. At the end of the hand, any unclaimed tricks in the kitty go to the player with the <u>lowest</u> score during the course of the game and not just for that hand.

12. In case of a tie in the value of the cards played, the winner of the trick is the first player to play the card with that value.

13. The winner of the trick turns up a new SITUATION card and the game continues with the winner of the last trick playing first.

<u>Scoring</u>. Each player receives 1 point for each trick taken during the hand. Several hands may be played before the winner of the game is determined. This is decided by the goal stated before play is begun.

<u>Examples of Cards</u>.



Appendix E

Two Games Used for Teaching Fraction Number Concepts

Two Games Used for Teaching Fraction Number Concepts

"Two-A-Part"

Method. Two cards with each of the following: 1/2, 1/3, 2/3, 1/4. 2/4, 3/4, 1/6, 2/6, 3/6, 4/6, 5/6, 1/8, 2/8, 3/8, 4/8, 5/8, 6/8, 7/8, 4/3, 5/4, 3/3, 7/6, 10/8. One Card with each of the following: 2/2, 4/4, 3/3, 6/6, 8/8, 5/2.

Number of Players. 2 through 6.

Rules.

1. Dealer will deal out seven cards to each player. Use the balance for a draw pile. Turn the top card over for the discard pile.

2. Player to the left of the dealer begins the game by taking a card from the draw pile or fom the discard pile.

3. Player should draw a card, then lay down his card combinations of 2 or more cards that will form a value of two. After the player has laid down his card combinations (or books) he must discard one of his remaining cards.

4. The game is continued until one of the players runs out of cards.

5. In case no one is able to go out after playing though all cards on the draw pile and the discard pile, the players may score their books and deduct points for cards held.

Scoring. Player may use any operation or combination of the basic operations to get a book equivalent to 2.

1. Player may score 2 points for each book of 2 or 3 cards. A book of 4 or more cards may score 4 points.

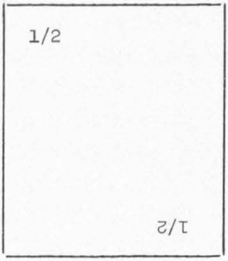
2. Player going out first gets an additional 3 points.

3. Players may be allowed to lay down books after a player has gone out, and may score 1/2 the regular scoring.

4. Each player will lose 1 point for each card left in his hand after the playing stops.

5. No player will have a score less than zero.

Examples of Cards.



"Zero In"

Method. The deck should contain 52 cards of the form below:

1. 25 cards; 5 each of the fractions 1/3, 2/3, 3/3, 2/4, and 4/4.

2. 18 cards; 6 each of the fractions 1/4, 1/2, and 2/2.

3. 7 cards of the fraction 3/4.

4. 1 card each of the fractions 4/3 and 3/2.

Number of Players. 2 through 6

Rules.

1. Select a dealer by any means which seems appropriate.

2. The dealer shuffles the deck and deals 7 cards to each player.

3. The remaining cards are placed face down in the center of the table to form the stock pile and top card is turned face up beside the pile to form the discard pile.

4. Each player then checks his hand to see if he has any cards which may be combined, using any of the four basic operations, into books having a value of zero. He may use any combination of operations and grouping in arranging his cards in books with a value of zero.

5. Multiplication by zero is not permitted.

6. Play starts with the person to the left of the dealer and moves clockwise.

7. Any player may draw from the discard pile or draw the top card from the stock pile.

8. After each draw a player must discard, face up on the discard pile, a card from his hand.

9. Play continues until someone ZEROS-IN by discarding one card on the discard pile and plays the remaining seven cards in a book or books, each having a value of zero. The other players may then lay down any books which are contained in their hands.

10. After all of the players have laid down their book(s), any player may challenge any of his opponents regarding the construction of their book(s). When challenged, a challenged player must explain the operations and grouping he used in making his book(s). If the challenged player's book is incorrect, he must give the challenging player <u>all</u> of his books. If the challenged player's book is correct, the challenger must give all of his books to the player he incorrectly challenged.

11. If a book is incorrect but goes unchallenged, it is regarded as a correct book and scored accordingly.

12. If a player incorrectly ZEROS-IN and is subsequently challenged, he loses his book(s), even though they are incorrect, to the challenging player (see #3 of Scoring). He then must retire from the play of that hand and play continues until another player ZEROS-IN.

13. The first player to accumulate 20 points is the winner.

Scoring.

1. A player receive 5 points for a ZERO-IN plus 1 point for each of the books he plays. (See 12 above)

2. All players receive 1 point for each book they correctly play.

3. All players receive 1 point for each book they receive from an opponent via a correct challenge even though that book is incorrect.

4. The player with the largest book receives a bonus of 2 points. (No points are awarded under this rule if there is a tie.)

Examples of Cards.

VITA

Lewis Riley Taylor

Candidate for the Degree of

Master of Education

Report: Educational Mathematical Games as an Aid to Learning with Seventh Grade Mathematics Students at Wahlquist Junior High

Major Field: Secondary Education

Biographical Information:

Personal Data: Born at Malad, Idaho, October 1, 1944, son of Horace R. and Karma Gibbs Taylor; married Jolinda Hart, July 15, 1966; two children--Kelly and Lance.

Education: Attended elementary school in Orgen, Utah; graduated from Ben Lomond High School in 1962; graduated from Weber State College in 1966 with a Social Science Composite major and a minor in Mathematics; attended a National Science Foundation Mathematics Institute in 1970 at Utah State University; completed requirements for the Master of Education degree, specializing in secondary education and mathematics, at Utah State University in 1972.

Professional Experience: 1966 to 1972 teacher and coach at Wahlquist Junior High School.