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ABSTRACT

The construction of an exploratory test dealing with concepts relevant to mathematics was required as part of the New Canadian Study. The test devised for this purpose has three sections dealing with the sorting of objects. In Sort One, 10 lines are sorted into groups of two; in Sort Two, numbers from 1 to 10 are sorted; and, in Sort Three, triangles are sorted (due to the complexity of this test, physical aid was provided for the students). These sorting tasks were designed to explore one possible way of examining divergence in a test situation. The test was administered to 5,000 students in Grades 5, 7, and 9. The tasks were not analyzed or presented as standardized tests. It is felt that they illustrate the kinds of tasks which require students to produce rather than choose an answer within a framework that can be machine recorded. Results are presented for (1) scoring, (2) validity of the acceptable sorts, (3) general grade performance for all three sorting tasks; (4) general performance characteristics of the four student groups by grade (i.e., monolingual and bilingual Canadian-born and non-Canadian-born groups), and (5) general performance characteristics of male and female students by grade. (JS)

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AN EXPLORATORY INVESTIGATION OF "DIVERGENT PRODUCTION" USING BASIC CONCEPTS OF MATHEMATICS

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March, 1971.

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AN EXPLORATORY INVESTIGATION OF "DIVERGENT PRODUCTION" USING BASIC CONCEPTS OF MATHEMATICS

INTRODUCTION

In planning the New Canadian Study[1] it was obvious that a variety of measures was desirable. Consultants of the Department of Mathematics[2] constructed a basic computational (arithmetic) test measure for the New Canadian Study. They also suggested the need for a test dealing with concepts relevant to mathematics, a test that required production rather than identification: these might include concepts such as number and area. To include such an approach required the development of a new kind of instrument; it was developed with their assistance and the following report deals with the new measure as well as with the performance of New Canadians.

In a classroom setting teachers frequently ask students to use concepts which they "know," e.g.:

> "Use the word 'rise' in a sentence."
>
> "Show me a group of four similar objects."
>
> "How many different kinds of problems can you make using the numbers two and seven?"

Tests, especially in mathematics, typically ask the student to select or produce a single, correct answer. This obviously places constraints on the student's ability to demonstrate his range and diversity of performance.

The intellectual operation suggested in the classroom technique is one that appears to be rarely measured with the traditional programme-oriented achievement tests. This operation may conveniently be termed

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1 See Appendix A for a listing of the various New Canadian Study reports.

2 Mr. J. Bates, now principal of Blake Street Public School and Mr. D. Irwin, now principal of Roden Public School.

divergent thought production, and under this title it has received theoretical development and formulation most notably by Guilford (1967). The ideas relating to divergent operations can also be found in the work of child development theorists such as J. S. Bruner and Jean Piaget. In education, operations involving divergent thinking are frequently referred to under such labels as creativity, inventiveness and originality.

It should be noted that in Great Britain, at present, a large scale project is nearing completion to provide a new and more socially and educationally relevant intelligence test (Watson, 1970). This test with fourteen parts is being designed to meet the objections of "intelligence test" critics, and employs the most up-to-date theory and research findings. Divergent (or creative) operations play a prominent part in the structure of this new test.

Purposes of Study

The first step was to construct an exploratory test measure using several arbitrarily chosen situations that permitted the application of various concepts relevant to mathematics. Further, the structure or format of this test was to require the operation of divergent production. Such a test, besides providing useful data, would assist teachers who wished to translate a fairly common teaching technique into a test situation. The resulting test is not presented as a finished product since the New Canadian Study provided a setting for a preliminary set of results. The instrument, while not intended as a direct measure of achievement, does reveal the different answers produced by students from different grades and different backgrounds.

CONSTRUCTION OF THE TEST

Classification tasks involve divergent thinking and are also suitable for a group testing situation. Sorting objects is a classification task which can be viewed both quantitatively and qualitatively. For example, almost any group of objects can be sorted into two (or more) piles. Some principle (or criterion, or concept) is selected by the student and is used as the basis for sorting. Size, shape, colour are among the more common properties which people identify in order to classify objects. For this test the objects were all printed on a piece of paper in the same colour. The objects were selected so that many of the properties which the students could select as a basis for sorting such as length, area, odd/even etc., were basic to mathematics.

Three classes were suggested by the mathematics consultants, and these were used to construct three separate sorting tasks: SORT ONE, SORT TWO, and SORT THREE.

1. Line -- Shape -- Curvature
2. Number
3. Area

Each sorting task was constructed with ten objects. Tasks one and two were constructed to require the objects to be sorted into groups of two. The third task (concept), to be more complex, required the objects to be sorted into groups of three. Each task was printed on machine scoreable Digitek sheets, as were the answer boxes in which the students recorded their "sorts."

Test Material

The Instruction Booklet

Before doing the three sorts, each student was given an instruction booklet (shown in Appendix B) which explained the nature of the tasks. This provided uniformity of instruction and made administration simpler. The booklet contains five examples of increasing complexity to illustrate both the tasks and the method of recording answers. To assist the teacher and to maintain consistency, a short administration guide was provided. A copy of this guide is shown in Appendix B.

Sort One (Lines)

The "objects" for the first sort consisted of ten lines. These objects were drawn to provide variations in length, curvature and complexity. The objects were to be sorted into two groups. Students were allowed to make three different sorts of the same group of 10 lines. (See Figure 1.)

Sort Two (Numerals)

The objects for this sort are the numbers 1 to 10. The numbers, done in 9/16" block print, were placed randomly in three rows. Six different sorts were allowed, as shown in Figure 2.

Sort Three (Triangles)

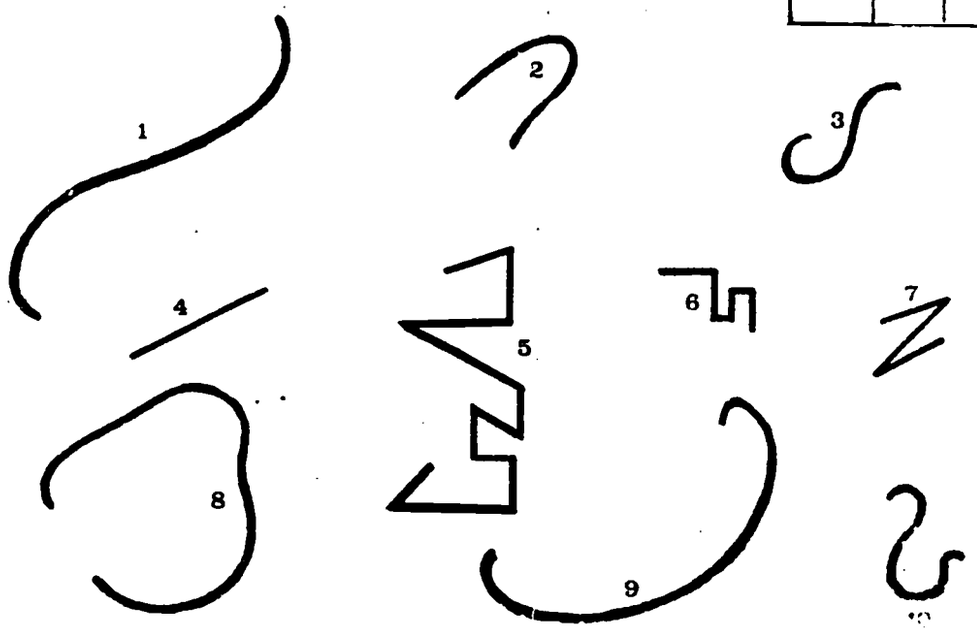
The basic materials for this sort are two identical right-angled triangles. If two identical right-angled triangles are positioned in all ways (in two dimensions) such that one or more equal sides are adjacent there are ten possible configurations. The tenth configuration is achieved by placing one triangle on top of the other, thus forming a single triangle. These ten configurations were the ten items to be sorted.

The sorting was to be made into groups of three with provision for four different sorts (see Figure 3).

Because SORT THREE was more difficult, physical aid was provided for the students. It consisted of the same ten configurations of triangles in larger size each, printed on a perforated sheet (see Appendix C). The students separated the objects and sorted these before recording their answers. This facilitated accurate marking of the answer sheet and also permitted the student physically to check any idea.

SORT 1

Figure 1



HOW MANY DIFFERENT WAYS CAN YOU SORT THE ABOVE LINES INTO GROUPS OF TWO?

Name

1. [ ] [ ]

2. [ ] [ ]

3. [ ] [ ]

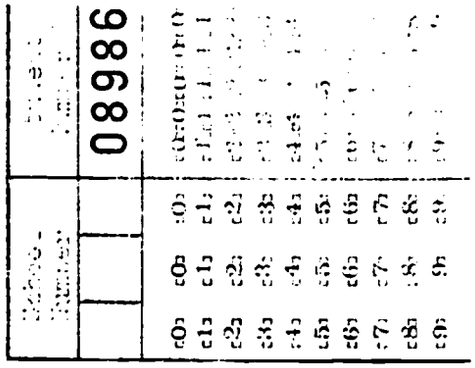
SORT 2

Figure 2

5 2 6

1 9 3 10

8 7 4



HOW MANY DIFFERENT WAYS CAN YOU SORT
THE ABOVE NUMBERS INTO GROUPS OF TWO?

Name

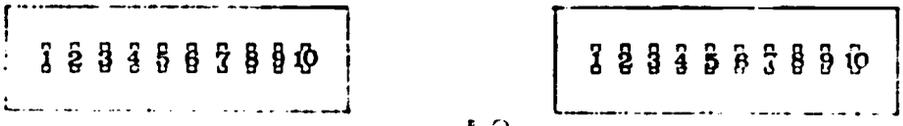
1. 

2. 

3. 

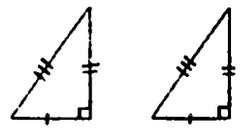
4. 

5. 

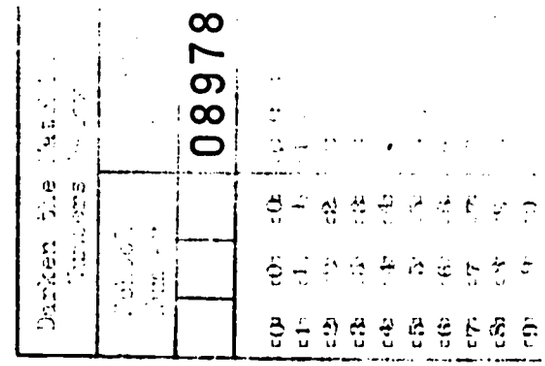
6. 

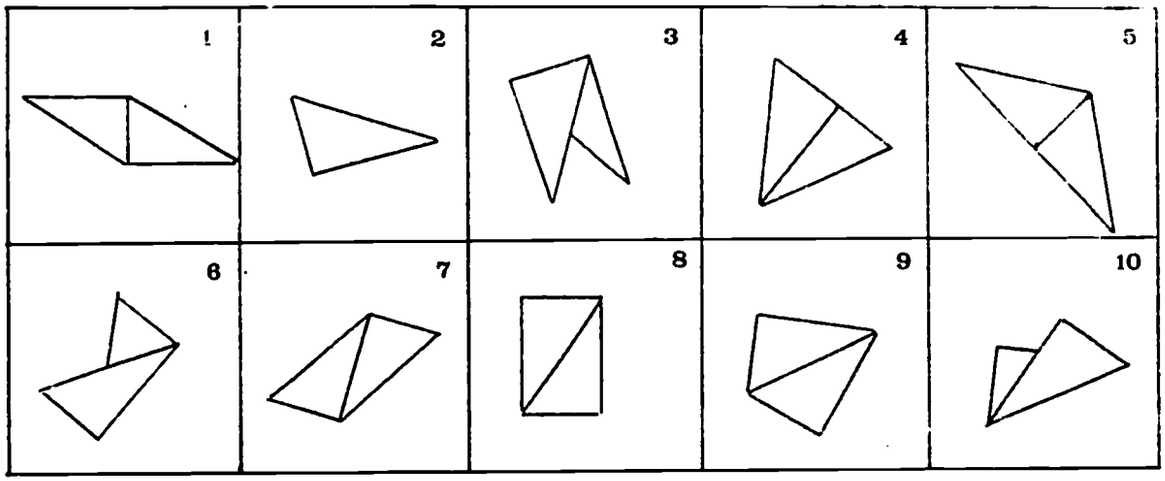
SORT 3

Figure 3



THESE TWO IDENTICAL RIGHT-ANGLED TRIANGLES CAN BE ARRANGED IN 10 DIFFERENT WAYS SO THAT (AT LEAST) TWO EQUAL SIDES ARE TOUCHING.





HOW MANY DIFFERENT WAYS CAN YOU SORT THE ABOVE TRIANGLE PATTERNS INTO GROUPS OF THREE?

Name

1. 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10

2. 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10

3. 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10

4. 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10

RESULTS

The study was developed as part of the larger New Canadian Study, and the sorting tasks were one of the several tests administered to students. Data about the sample of 5,000 students from grades five, seven and nine are discussed in the previously cited New Canadian Study reports (see References). The unusual nature of the material, however, warrants treatment of the results as a separate report.

Scoring

In the analysis of the data, a small number of blank answer sheets were eliminated as it was not known whether a student was unable to make a sort or was absent for that part of the test. This accounts for the slight variation in total numbers among the three sorting tasks.

The remainder, all students who attempted at least one sort, received a score which was the number of sorts attempted. Each student's sorts were assigned to one of the following three categories:

1. Wrong Sorts - These were sorts using less than the ten items or sorts repeating one or several of the items; i.e. a failure to follow instructions.

2. Acceptable Sorts - The criterion for "acceptable" sorts was the presence of a meaningful, rational sorting principle. The acceptable sorts for each of the sorting tasks were determined by the participating mathematics consultants, members of the Research Department, and a selected group of teachers.

3. Novel Sorts - "Novel" sorts were those which did not conform to any of the sorting principles.

For each sorting task (by any grade or group) wrong sorts plus acceptable sorts plus novel sorts equals the total number of sorts attempted. Two features of the task limited the number of sorts attempted: the number of usable response spaces, and the test time limits (five minutes for SORTS ONE and TWO, and ten minutes for SORT THREE).

Validity of the Acceptable Sorts

It must be noted here that for each of the three sorting tasks, the set of specific sorts that were judged acceptable may be incomplete. Readers who study the items in each sort may be able to devise new sort(s) which are as meaningful as those already specified as acceptable. In light of the study's rationale concerning the divergent nature of the tasks, some originality or creativity is to be expected! There is no way to decide whether the "novel" sorts are ingenious inventions i.e. "creative" or nonsense and "unacceptable."

A second issue that is not resolved in the present study concerns the use of unweighted scores. All "acceptable" sorts were treated equally. That is, although one particular sort may have occurred four or five times more frequently than another, both the popular or "easy" and the unpopular or "difficult" each counted as one sort. For some purposes, e.g., where a total score is desired, these "differences" among the acceptable sorts might be weighted. This still does not deal with how, if at all, the "novel" sorts might also be incorporated.

The test results of the three sorting tasks are presented in three sections (A, B, and C). Section A has the following for each grade: (i) the average number of sorts of each type (wrong, acceptable, novel), (ii) the frequency distribution of the different acceptable sorts, and (iii) selected data on the novel sorts. The second section presents

the basic sort and grade characteristics for each of the four student categories used in the New Canadian Study. The student categories are:

Group A -- Canadian born, Monolingual

Group B -- Canadian born, Bilingual

Group C -- non-Canadian born, Monolingual, and

Group D -- non-Canadian born, Bilingual.

Section C presents the data separately for males and females.

SECTION A

Table 1 Table 2 Table 3	SORT ONE
Table 4 Table 5 Table 6	SORT TWO
Table 7 Table 8 Table 9	SORT THREE

SECTION B

Table 10	-	SORT ONE
Table 11	-	SORT TWO
Table 12	-	SORT THREE

SECTION C

Table 13	-	SORT ONE
Table 14	-	SORT TWO
Table 15	-	SORT THREE

SECTION A

GENERAL GRADE PERFORMANCE: SORT ONE

The average number of sorts of each type done by students on SORT ONE is shown in Table 1. Generally the total number of attempts and the number of novel sorts are similar at all grades. The acceptable sorts increase across grades, and the number of wrong (unacceptable) sorts decreases. This relationship is clearly evident in the ratio of wrong to acceptable sorts. On all measures, the performance of grades seven and nine is most similar; the differences appear between grades five and seven.

Table 2 shows the frequency of occurrence of the different acceptable sorts. At all grades, two sorts are highly favoured. They are the curved versus straight and long versus short lines. Two of the acceptable sorts were used infrequently by the students.

In Table 3, some of the more common novel sorts are shown. With one exception, they occurred infrequently. The exception, whose frequency was sizeable, appeared to involve sorting objects by position number, that is, by using an arbitrarily assigned attribute rather than the attributes of the given objects themselves. Among the three sorting tasks, this was the only occurrence of this principle.

TABLE 1

MEAN SCORES OF STUDENTS ON SORT ONE: BY GRADE

Type of Score	Grade 5 (N = 1882)	Grade 7 (N = 1496)	Grade 9 (N = 1842)
Mean number of sorting attempts	2.62	2.67	2.71
Mean number of novel sort attempts	.19	.25	.23
Mean number of wrong sorts	1.38	.97	.90
Mean number of acceptable* sorts	1.05	1.45	1.58
Ratio of wrong sorts to acceptable sorts	1.31	.67	.57

* See Table 2

TABLE 2

PERCENTAGES OF VARIOUS ACCEPTABLE SORTS ON SORT ONE: BY GRADE

Sorting Patterns* (Six Acceptable Sorts)		Sort Pattern Descriptions	Grade 5 (N = 1980) Per Cent	Grade 7 (N = 2173) Per Cent	Grade 9 (N = 2912) Per Cent
[1 2 3 4 5 6 8 9 10]	[4 5 6 7]	1. Curved - Straight	51.87	52.23	50.48
[1 5 8 9]	[2 3 4 6 7 10]	2. Long - Short	40.81	39.25	39.80
[1 2 3 4 8 9 10]	[5 6 7]	3. Non-Angular - Angular	3.59	4.74	4.64
[1 2 3 5 6 7 8 9 10]	[4]	4. Straight Singular Unit - Non-Stratight Unit	3.03	3.27	4.74
[1 3 10]	[2 4 5 6 7 8 9]	5. Reverse Curve - NO Reverse Curve	.51	.51	.27
[1 2 3 4 5 6 7 10]	[8 9]	6. Ends Likely to converge - Ends unlikely to converge	.20	.00	.07
			100.00	100.00	100.00

* When examining the percentage response of these various sorts, readers can consult Figure 1 for the stimuli (items) that were sorted.

TABLE 3

MOST FREQUENTLY OCCURRING NOVEL SORTS ON SORT ONE: BY GRADE

		Number	Per Cent
Grade 5	[1 3 5 7 9] [2 4 6 8 10]	75	21.25
	[1] [2 3 4 5 6 7 10]	14	3.97
	[5 6] [1 2 3 4 7 8 9 10]	9	2.55
	[4 7] [1 2 3 5 6 8 9 10]	8	2.27
		Remaining less than	2.00 ea.
	Total	353	
Grade 7	[1 3 5 7 9] [2 4 6 8 10]	105	28.61
	[5 6] [1 2 3 4 7 8 9 10]	14	3.81
	[1 3 8 9 10] [2 4 5 6 7]	11	3.00
	[1 8 9] [2 3 4 5 6 7 10]	11	3.00
	[2 8 9] [1 3 4 5 6 7 10]	10	2.72
	[2 3 8 9 10] [1 4 5 6 7]	10	2.72
	[5 7] [1 2 3 4 6 8 9 10]	8	2.18
		Remaining less than	2.00 ea.
	Total	367	
Grade 9	[1 3 5 7 9] [2 4 6 8 10]	85	20.48
	[5 6] [1 2 3 4 7 8 9 10]	21	5.06
	[4 5 6 7] [2 3 8 9 10]	12	2.89
	[1 8 9] [2 3 4 5 6 7 10]	11	2.65
	[6] [1 2 3 4 5 7 8 9 10]	11	2.65
	[5 6 8 10] [1 2 3 4 7 9]	9	2.17
	[2 8 9] [1 3 4 5 6 7 10]	9	2.17
		Remaining less than	2.00 ea.
	Total	415	

GENERAL GRADE PERFORMANCE: SORT TWO

Table 4 shows the average number of sorts of the three types in each grade on SORT TWO. The mean number of attempted sorts shows a small difference across grades. At all grade levels there is an increase in novel sorts over the number for SORT ONE. As for SORT ONE there is (across grades) a decrease in wrong sorts which is reflected in the ratio of wrong to acceptable sorts. As in SORT ONE, the incidence of acceptable sorts exceeds that of novels.

In Table 5, the frequencies of the various acceptable sorts show that one sort is extremely "common." This sort involved the concept of odd versus even numbers. Of the eleven possible acceptable sorts, five were very uncommon across grades with less than one per cent of the students using each of these sorts. It seems likely that uncommon sorts represent difficult sorts. This is not necessarily the case since the test situation allowed students to generate or devise sorts as they wished. However, looking at the principles involved in the common and uncommon sorts, it does not seem too speculative to conclude that the latter are more difficult.

Among the novel sorts, shown in Table 6, none was very common. In all grades, no one novel sort occurred more than ten per cent of the time. Readers may wish to consider the novel sort that occurs with highest relative frequency at all grades and might be described as "doubling from five versus others." To their chagrin, this particular sort had not been developed by the group who had previously specified the set of acceptable sorts.

TABLE 4

MEAN SCORES OF STUDENTS ON SORT TWO: BY GRADE

Type of Score	Grade 5 (N = 1876)	Grade 7 (N = 1500)	Grade 9 (N = 1843)
Mean number of sorting attempts	4.47	4.72	4.87
Mean number of novel sort attempts	.88	1.13	1.18
Mean number of wrong sorts	2.40	1.87	1.71
Mean number of acceptable* sorts	1.19	1.72	1.97
Ratio of wrong sorts to acceptable sorts	2.02	1.09	.87

* See Table 5

TABLE 5

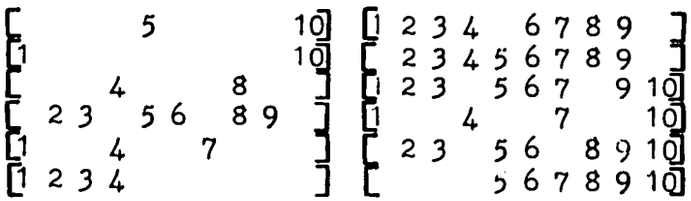
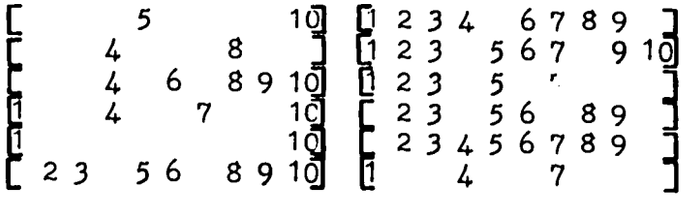
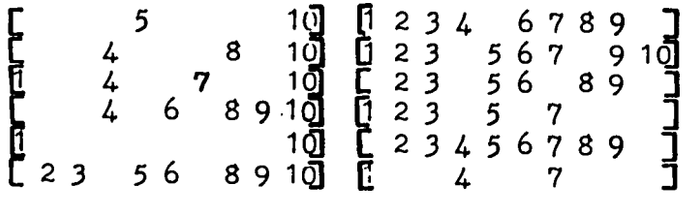
PERCENTAGES OF VARIOUS ACCEPTABLE SORTS ON SORT TWO: BY GRADE

Sorting Patterns* (Eleven Acceptable Sorts)		Sort Pattern Descriptions	Grade 5 (N = 2235) Per Cent	Grade 7 (N = 2579) Per Cent	Grade 9 (N = 3635) Per Cent
[1 3 5 7 9]	[2 4 6 8 10]	1. Odd - Even	54.32	50.14	46.30
[1 2 3 4 5]	[6 7 8 9 10]	2. Small - Large	20.81	16.40	16.07
[1 2 4 8]	[3 5 6 7 9 10]	3. DEBONUACHIE Series - Others (doubling from one)	7.70	12.49	14.55
[1 2 3 4 5 6 7 8 9]	[10]	4. Single Digit - Double Digit	7.65	6.79	7.51
[3 6 9]	[1 2 4 5 7 8 10]	5. Multiples of Three - Others	7.65	10.74	11.00
[2 4 8]	[1 3 5 6 7 9 10]	6. 2^x Powers - Others	1.12	2.06	2.23
[2 3 4 6 8 9 10]	[1 5 7]	7. Multiples of Two, Three - Others	.40	.50	.41
[3 9]	[1 2 4 5 6 7 8 10]	8. 3^x Powers - Others	.13	.43	.52
[1 3 6 10]	[2 4 5 7 8 9]	9. Consecutive Triangular Numbers - Others (Cardinal Additive Progression)	.09	.19	.33
[1 4 9]	[2 3 5 6 7 8 10]	10. Consecutive Square Numbers - Others	.09	.04	.85
[2 3 5 7]	[1 4 6 8 9 10]	11. Prime Numbers - Others	.04	.23	.22
			100.00	100.00	100.00

* When examining the percentage response of these various sorts, readers can consult Figure 2 for the stimuli (items) that were sorted.

TABLE 6

MOST FREQUENTLY OCCURRING NOVEL SORTS ON SORT TWO: BY GRADE

		Number	Per Cent
Grade 5		111	6.71
		98	5.92
		99	5.98
		93	5.62
		74	4.47
		67	4.05
		Remaining less than	3.00 ea.
	Total	1655	
Grade 7		148	8.76
		132	7.81
		107	6.33
		103	6.09
		86	5.09
		83	4.91
		Remaining less than	3.00 ea.
	Total	1690	
Grade 9		203	9.30
		194	8.89
		123	5.64
		122	5.59
		118	5.41
		100	4.58
		Remaining less than	3.00 ea.
	Total	2182	

GENERAL GRADE PERFORMANCE: SORT THREE

SORT THREE shows some distinct differences from SORTS ONE and TWO. We do not mean to imply that performances on the three sorts are directly comparable. Each sort task must be treated separately since the sorts were such different tasks. But some characteristics of the students' performance may be compared to uncover basic differences among the three tasks.

Table 7 shows the basic performance data of the three grade levels on SORT THREE.

As is true for SORTS ONE and TWO, the mean number of sorting attempts on SORT THREE is similar for the three grades. The novel sorts show a low incidence, increasing slightly across grades, and the number of wrong (unacceptable) sorts decreases across grades.

The mean number of acceptable sorts, while increasing across grades, is extremely low. For example, in grade five the mean is .24. This means that, on the average, only one out of every four grade five students generated an acceptable sort. At grade nine the average is higher although still low: two out of three students produced one acceptable sort.

The ratio of wrong to acceptable sorts shows an extreme decrease on this sort. The decrease is especially evident from grade five to grade seven where the occurrence of wrongs to acceptable decreased from ten times as many to only four times as many.

A particularly interesting characteristic at all grades is that the incidence of novel sorts exceeds the incidence of acceptable. For

both SORT ONE and TWO, the reverse was true: that is, the acceptables exceeded the novels. This probably reflects the difficulty of the task. In addition to the conceptual difficulty of dealing with highly related triangles on the sort, students were required to devise sorts of three sets instead of two.

Table 8 shows the proportions of different acceptable sorts that were obtained. Only two of the ten acceptable sorts were produced with great frequency. These were: (1) sorting by number of sides, and (2) sorting by area size.

Several acceptable sorts did not occur at all at one or more grade levels. Again, the principles involved in these sorts seem more difficult.

From Table 9, it is evident that there was no overwhelming preference for any of the novel sorts (which occurred more frequently than acceptables). The most common novel sort which occurred at all grades illustrates some of the approaches used by the students which differ from the rationale used by the adults in developing the classes of acceptable sorts.

TABLE 7

MEAN SCORES OF STUDENTS ON SORT THREE: BY GRADE

Type of Score	Grade 5 (N = 1847)	Grade 7 (N = 1489)	Grade 9 (N = 1816)
Mean number of sorting attempts	3.15	3.15	3.22
Mean number of novel sort attempts	.44	.66	.73
Mean number of wrong sorts	2.47	1.98	1.84
Mean number of acceptable* sorts	.24	.51	.66
Ratio of wrong sorts to acceptable sorts	10.29	3.88	2.79

* See Table 8

TABLE 8

PERCENTAGE OF VARIOUS ACCEPTABLE SORTS ON SORT THREE: BY GRADE

Sorting Patterns* (Ten Acceptable Sorts)	Sort Pattern Descriptions	Grade 5 (N = 437) Per Cent	Grade 7 (N = 758) Per Cent	Grade 9 (N = 1192) Per Cent
[1 7 8 9][2 4 5][3 6 10]	1. 4 Sides, 3 Sides, 5 Sides	42.56	36.97	35.99
[1 4 5 7 8 9][2][3 6 10]	2. Three Sizes in Area	40.96	47.61	48.66
[1 3 6 7 8 9 10][4 5][2]	3. Triangles: Single, Doubles, Mixed	13.27	11.97	10.91
[1 3 4 5 6 7 9 10][2][8]	4. Number of Right Angles Showing	1.60	1.20	2.35
[1 2 7 8][4 5 9][3 6 10]	5. SYMMETRY II	1.14	1.46	.76
[1 3 4 5 7 8 9 10][2][6]	6. Number of ACUTE Angles (4, 2, and 5)	.46	.40	.42
[1 3 6 7 8 10][2][4 5 9]	7. SYMMETRY I	0.00	.40	.67
[1 4 5 7 9 10][2 3 6][8]	8. Number of Right Angles (2, 1, and 4) assumed	0.00	0.00	.08
[1 4 5 7][2 3 6 9 10][8]	9. Right Angle by PERIMETER	0.00	0.00	.08
[1 7][5 9][2 3 4 6 8 10]	10. Obtuse Angles (2, 1, and 0)	0.00	0.00	.08
		100.00	100.00	100.00

* When examining the percentage response of these various sorts, readers can consult Figure 3 for the stimuli (items) that were sorted.

TABLE 9

MOST FREQUENTLY OCCURRING NOVEL SORTS ON SORT THREE: BY GRADE

		Number	Per Cent
Grade 5	[1 7 8][2 4 5 9][3 6 10]	35	4.26
		Remaining less than	2.00 ea.
	Total	815	
Grade 7	[1 7 8][2 4 5 9][3 6 10]	53	5.36
	[1 7 8][2 4 5][3 6 9 10]	29	2.93
	[1 2 4 5 9][7 8][3 6 10]	20	2.02
		Remaining less than	2.00 ea.
	Total	989	
Grade 9	[1 7 8][2 4 5 9][3 6 10]	80	6.04
	[1 7 8][2 4 5][3 6 9 10]	72	5.43
	[1 2 4 5 9][3 6 10][7 8]	36	2.72
	[1 3 6 9 10][2 4 5][7 8]	32	2.41
		Remaining less than	2.00 ea.
	Total	1325	

SECTION B

GENERAL PERFORMANCE CHARACTERISTICS OF THE FOUR STUDENT GROUPS BY GRADE

To illustrate the various ways in which different student groups might be compared, Tables 10, 11 and 12 show the general performance characteristics of the students separated by grade and by two of the four categories used in the New Canadian Study reports:

Group A -- Canadian born, Monolingual,

Group B -- Canadian born, Bilingual,

Group C -- non-Canadian born, Monolingual, and

Group D -- non-Canadian born, Bilingual.

Since this report describes an exploratory study, any differences noted between student groups must be viewed as suggestive, not definitive.

Table 10 shows the performance on SORT ONE by group and grade. Noticeable differences are few. One difference that emerges is the superior performance of Group B (Canadian born, Bilingual) on all measures: a high number of sorting attempts, a high number of acceptable sorts, but Group B is very similar to Group A.

Within each grade, the number of attempted sorts is similar for each group.

The ratio of wrong to acceptable sorts shows some variation across grades. In grade five, Group D shows the highest level while in grades seven and nine, the higher levels are shown by Group C.

Performance levels of the groups on SORT TWO are shown in Table 11. Some differences between the groups is evident on this task in each grade.

In all grades, the non-Canadian born groups (C and D) show mean numbers of acceptable sorts that are lower than the Canadian born groups. Groups C and D also show a higher ratio of wrong to acceptable sorts and fewer novel sorts.

As seen in Table 12, the performance levels of the groups on SORT THREE do not reveal a consistent pattern in all three grades. With each grade the number of attempts remains similar, the number of novel sorts increases and the number of wrong sorts decreases.

TABLE 10

MEAN SCORES OF THE FOUR STUDENT GROUPS ON SORT ONE: BY GRADE

Type of Sort	Type of Group			
	A	B	C	D
Grade 5 (1877)	(N = 1028	(N = 398)	(N = 77)	(N = 374)
Mean number of sorting attempts	2.59	2.69	2.68	2.61
Mean number of novel sorts	.19	.19	.21	.16
Mean number of wrong sorts	1.29	1.39	1.39	1.59
Mean number of acceptable sorts	1.10	1.11	1.08	.86
Ratio of wrong sorts to acceptable sorts	1.17	1.25	1.29	1.85
Grade 7 (1496)	(N = 893)	(N = 266)	(N = 42)	(N = 295)
Mean number of sorting attempts	2.66	2.68	2.79	2.66
Mean number of novel sorts	.23	.26	.29	.28
Mean number of wrong sorts	.98	.86	1.45	.98
Mean number of acceptable sorts	1.46	1.56	1.05	1.40
Ratio of wrong sorts to acceptable sorts	.67	.55	1.38	.70
Grade 9 (1845)	(N = 1022)	(N = 270)	(N = 108)	(N = 445)
Mean number of sorting attempts	2.71	2.74	2.60	2.69
Mean number of novel sorts	.23	.27	.15	.20
Mean number of wrong sorts	.86	.76	1.06	1.05
Mean number of acceptable sorts	1.62	1.72	1.40	1.44
Ratio of wrong sorts to acceptable sorts	.53	.44	.76	.73

TABLE 11

MEAN SCORES OF THE FOUR STUDENT GROUPS ON SORT TWO: BY GRADE

Type of Sort	Type of Group			
	A	B	C	D
Grade 5 (1869)	(N = 1026)	(N = 397)	(N = 76)	(N = 370)
Mean number of sorting attempts	4.50	4.55	4.00	4.42
Mean number of novel sorts	.96	.92	.66	.69
Mean number of wrong sorts	2.24	2.42	2.24	2.85
Mean number of acceptable sorts	1.31	1.22	1.11	.88
Ratio of wrong sorts to acceptable sorts	1.71	1.98	2.02	3.24
Grade 7 (1500)	(N = 895)	(N = 268)	(N = 42)	(N = 295)
Mean number of sorting attempts	4.63	4.86	5.29	4.77
Mean number of novel sorts	1.13	1.24	1.00	1.05
Mean number of wrong sorts	1.81	1.77	2.67	2.05
Mean number of acceptable sorts	1.70	1.85	1.62	1.66
Ratio of wrong sorts to acceptable sorts	1.06	.96	1.65	1.23
Grade 9 (1843)	(N = 1023)	(N = 270)	(N = 105)	(N = 445)
Mean number of sorting attempts	4.93	5.00	4.60	4.71
Mean number of novel sorts	1.24	1.40	1.04	.97
Mean number of wrong sorts	1.67	1.37	1.87	1.98
Mean number of acceptable sorts	2.02	2.24	1.70	1.76
Ratio of wrong sorts to acceptable sorts	.83	.61	1.10	1.13

TABLE 12

MEAN SCORES OF THE FOUR STUDENT GROUPS ON SORT THREE: BY GRADE

Type of Sort	Type of Group			
	A	B	C	D
Grade 5 (1840)	(N = 1006	(N = 394)	(N = 74)	(N = 366)
Mean number of sorting attempts	3.16	3.18	2.82	3.18
Mean number of novel sorts	.49	.42	.43	.34
Mean number of wrong sorts	2.40	2.56	2.03	2.68
Mean number of acceptable sorts	.27	.20	.37	.15
Ratio of wrong sorts to acceptable sorts	8.89	12.80	5.49	17.87
Grade 7 (1489)	(N = 886)	(N = 267)	(N = 41)	(N = 295)
Mean number of sorting attempts	3.11	3.18	3.46	3.17
Mean number of novel sorts	.70	.64	.68	.58
Mean number of wrong sorts	1.92	1.98	2.24	2.12
Mean number of acceptable sorts	.50	.57	.54	.47
Ratio of wrong sorts to acceptable sorts	3.84	3.47	4.15	4.51
Grade 9 (1816)	(N = 1007)	(N = 269)	(N = 108)	(N = 432)
Mean number of sorting attempts	3.18	3.34	3.16	3.27
Mean number of novel sorts	.71	.92	.64	.69
Mean number of wrong sorts	1.80	1.55	2.07	2.04
Mean number of acceptable sorts	.67	.86	.44	.54
Ratio of wrong sorts to acceptable sorts	2.69	1.80	4.70	3.78

SECTION C

GENERAL PERFORMANCE CHARACTERISTICS OF MALE AND FEMALE STUDENTS BY GRADE

The traditional variable employed in research studies and intensive experiments is that of sex. The use of this variable is so widespread, especially in exploratory studies, that it seemed highly appropriate to have available the general grade and sort information on male and female students. If a large sample study such as this had shown any distinctive differences between male and female students, future development of these sort tasks would attempt to account for such differences.

Tables 13, 14 and 15 show the general performance levels of the sex groups on the three sort tasks.

No differences are evident between male and female students. In fact, a brief examination of the tables shows that the two groups are extremely similar; in several cases, their performance is even identical.

TABLE 13

MEAN SCORES OF MALE AND FEMALE STUDENTS ON SORT ONE: BY GRADE

Type of Sort	Male	Female
Grade 5	(N = 996)	(N = 886)
Mean number of sorting attempts	2.62	2.61
Mean number of novel sorts	.20	.17
Mean number of wrong sorts	1.35	1.40
Mean number of acceptable sorts	1.07	1.03
Ratio of wrong sorts to acceptable sorts	1.26	1.36
Grade 7	(N = 721)	(N = 775)
Mean number of sorting attempts	2.66	2.68
Mean number of novel sorts	.25	.24
Mean number of wrong sorts	1.01	.93
Mean number of acceptable sorts	1.40	1.50
Ratio of wrong sorts to acceptable sorts	.72	.62
Grade 9	(N = 1016)	(N = 828)
Mean number of sorting attempts	2.70	2.71
Mean number of novel sorts	.25	.20
Mean number of wrong sorts	.84	.97
Mean number of acceptable sorts	1.61	1.54
Ratio of wrong sorts to acceptable sorts	.52	.63

TABLE 14

MEAN SCORES OF MALE AND FEMALE STUDENTS ON SORT TWO: BY GRADE

Type of Sort	Male	Female
Grade 5	(N = 992)	(N = 884)
Mean number of sorting attempts	4.54	4.40
Mean number of novel sorts	.91	.85
Mean number of wrong sorts	2.43	2.36
Mean number of acceptable sorts	1.20	1.19
Ratio of wrong sorts to acceptable sorts	2.03	1.98
Grade 7	(N = 723)	(N = 777)
Mean number of sorting attempts	4.74	4.70
Mean number of novel sorts	1.14	1.12
Mean number of wrong sorts	1.89	1.86
Mean number of acceptable sorts	1.72	1.72
Ratio of wrong sorts to acceptable sorts	1.10	1.08
Grade 9	(N = 1013)	(N = 829)
Mean number of sorting attempts	4.93	4.79
Mean number of novel sorts	1.25	1.11
Mean number of wrong sorts	1.74	1.67
Mean number of acceptable sorts	1.94	2.01
Ratio of wrong sorts to acceptable sorts	.90	.83

TABLE 15

MEAN SCORES OF MALE AND FEMALE STUDENTS ON SORT THREE: BY GRADE

Type of Sort	Male	Female
Grade 5	(N = 973)	(N = 874)
Mean number of sorting attempts	3.15	3.16
Mean number of novel sorts	.44	.44
Mean number of wrong sorts	2.47	2.48
Mean number of acceptable sorts	.24	.24
Ratio of wrong sorts to acceptable sorts	10.29	10.33
Grade 7	(N = 718)	(N = 771)
Mean number of sorting attempts	3.09	3.20
Mean number of novel sorts	.64	.69
Mean number of wrong sorts	1.95	2.00
Mean number of acceptable sorts	.50	.51
Ratio of wrong sorts to acceptable sorts	3.90	3.92
Grade 9	(N = 997)	(N = 818)
Mean number of sorting attempts	3.21	3.24
Mean number of novel sorts	.76	.69
Mean number of wrong sorts	1.82	1.85
Mean number of acceptable sorts	.62	.70
Ratio of wrong sorts to acceptable sorts	2.94	2.64

SUMMARY AND CONCLUSION

A variety of measures was developed for use in the New Canadian Study so that a wide range of abilities could be investigated. The three sorting tasks were designed to explore one possible way of examining "divergence" in a test situation. The tasks were not analyzed or presented as standardized tests. They do illustrate some kinds of tasks which ask students to produce rather than choose an answer within a framework that can be machine recorded. The problem of assessing the "value" or "difficulty" of various replies is not directly tackled.

Besides suggesting some new approaches which might be useful for a teacher, some comparisons were possible. Among the sorts it was apparent that they presented varied challenges to the students. SORT ONE had the smallest number of novel sorts and SORT TWO had the most novel sorts. SORT THREE had slightly more wrong sorts than SORT TWO and far fewer acceptable sorts on the average than either of the others. The pattern of performance in grade five as compared with grades seven and nine was consistently different for all three sorts. On each task grade five students produced about the same average number of attempts but they tended to have fewer acceptable sorts, fewer novel sorts and more wrong sorts. The performance for grades seven and nine was similar on all sorts.

Clear patterns distinguishing the "New Canadian Groups" were less apparent. When the variations from grade to grade are ignored, both English speaking and non-English speaking immigrant students have a tendency, on the average, to have fewer novel sorts and fewer acceptable sorts. This is least apparent in SORT ONE.

No clear differences were observed between the performances of male and female students.

The use of the "novel" category led to a great deal of ambiguity. While a rationale for some of the sorts could be invented after the fact, the performances themselves do not indicate the principle which the students believed they were using in generating the different responses. Teachers might find the material in this report useful both as a way of developing an indication of students' skills in divergent production (originality or creativity) and also as a basis for discussion in class and a teaching procedure. An examination of the various "novel" productions reported in this study emphasizes the importance of asking the student to indicate the reasons or principles underlying a particular sort. The results also indicate that although there may be sound principles for a variety of sorts, only some of these are likely to be used by the majority of the students.

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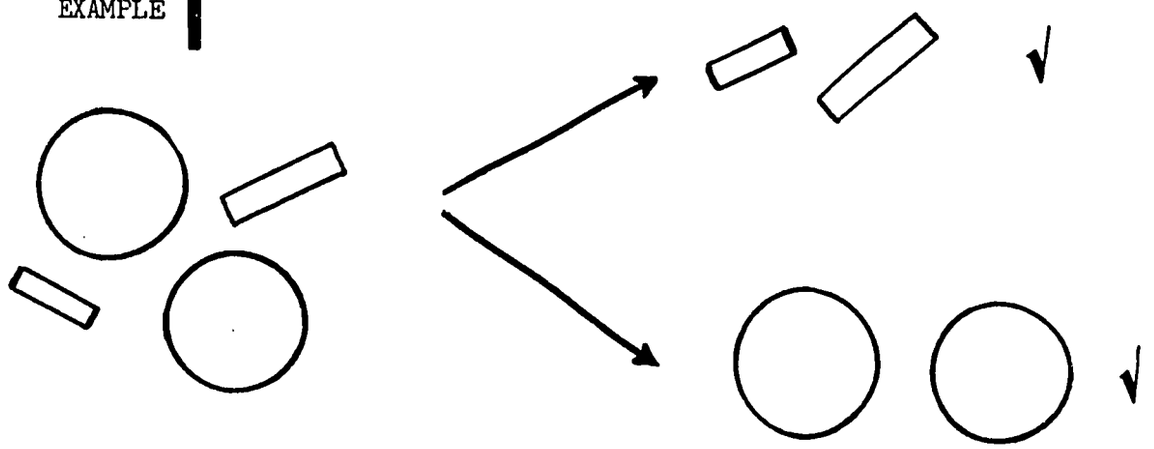
* Research Department reports are listed numerically.

APPENDIX A

EXAMPLE BOOKLET FOR SORTING

SORTING INTO GROUPS OF TWO

EXAMPLE 1



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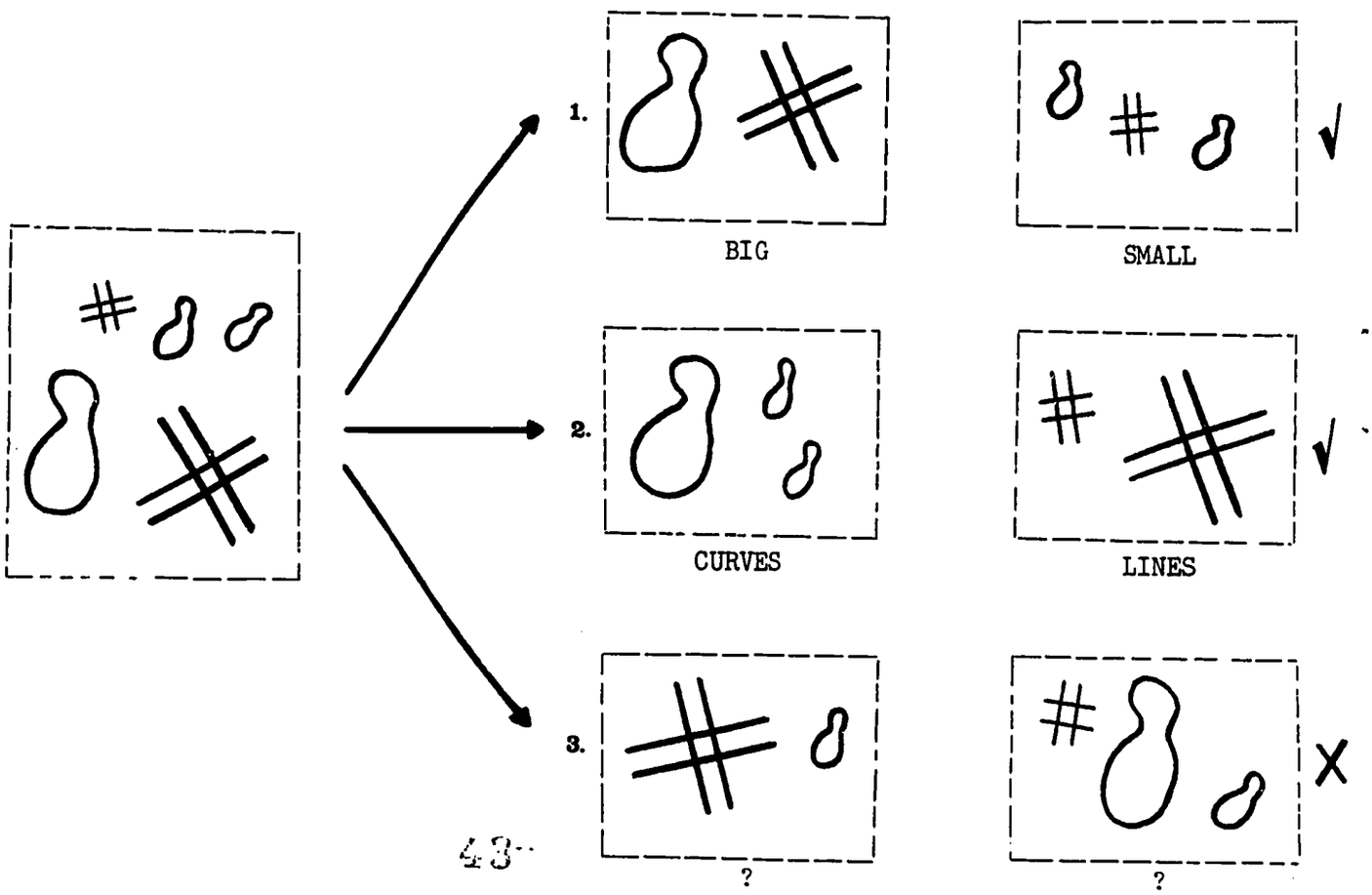
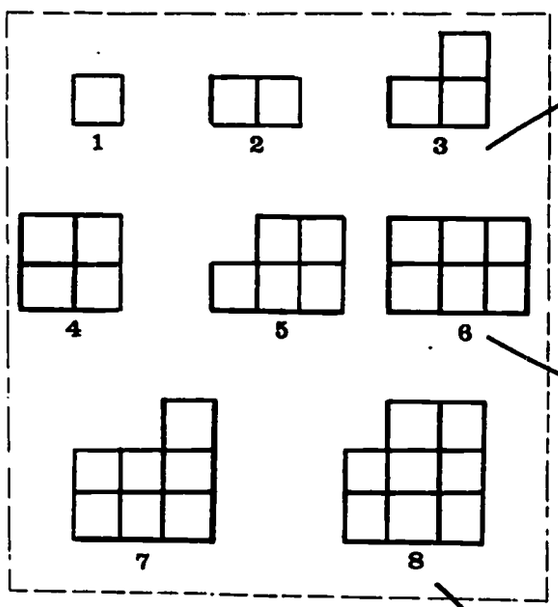


SORTING INTO GROUPS OF TWO

EXAMPLE 3



SORT ONE

ODD

EVEN

SORT TWO

DOUBLING FROM ONE

NOT DOUBLING FROM ONE

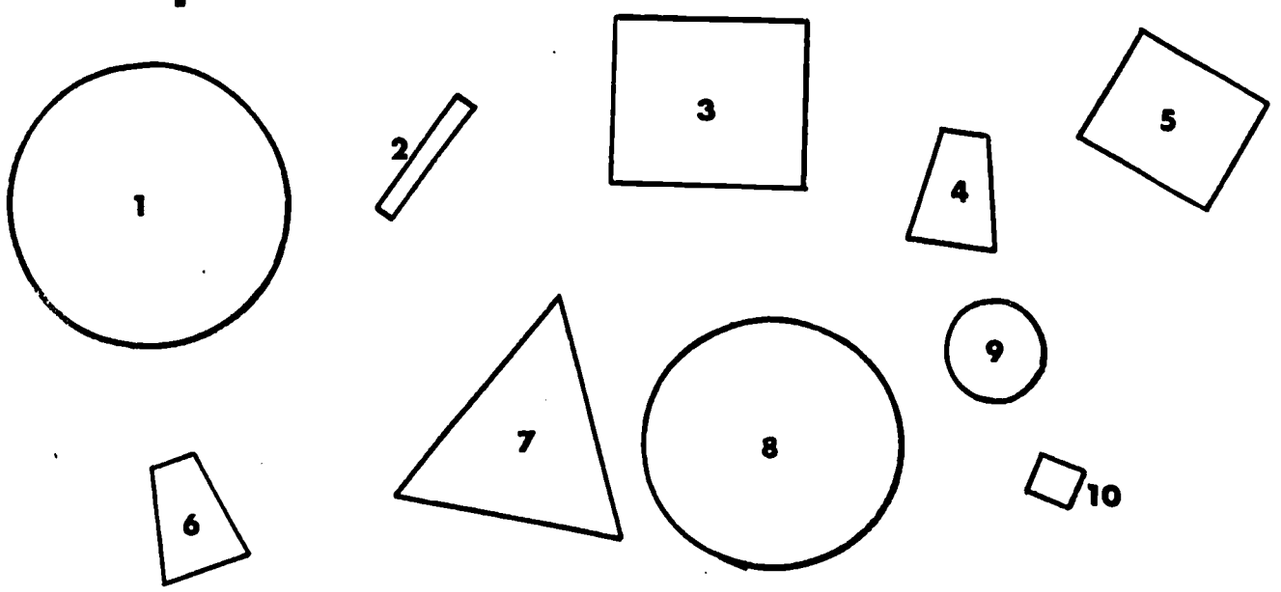
SORT THREE

ENDS

MIDDLES

SORTING INTO GROUPS OF TWO

EXAMPLE 4



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1.  BIG  SMALL √

---

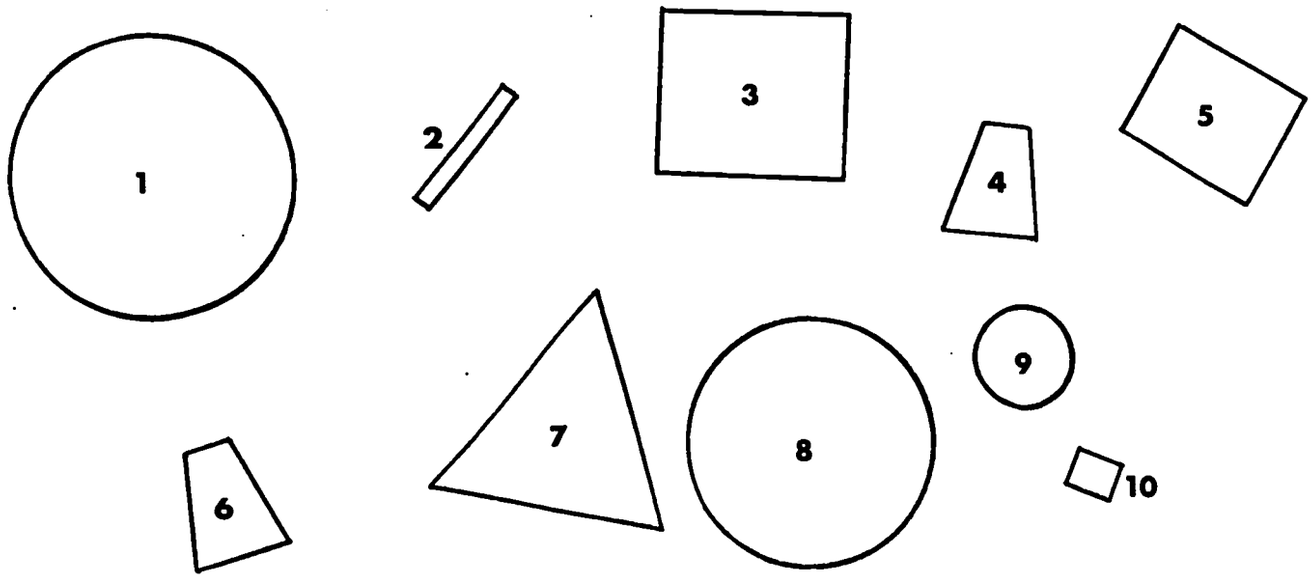
2.  ROUND  SHARP √

---

3.  ROUND, square, TRIANGLE  FOUR SIDED X

SORTING INTO GROUPS OF THREE

EXAMPLE 5



1. ROUND | TRIANGULAR | SQUARE & FOUR SIDED ✓

2. BIG | NOTHING OR EMPTY | SMALL ✗

APPENDIX B

TEACHER GUIDE FOR ADMINISTERING THE
MATHEMATICAL SORTING TASK

It is suggested that this task follow the Computation Test. The time delay between the two administrations is not important.

The three sorting tasks are to be attempted by students on three separate digitek sheets (each with "grids" for School and Student Number) and are not to be considered a "test" in the same sense as the Arithmetic/Computation Test.

An example booklet (showing simple sorting procedures) is provided for each student to study before he receives the three sorting tasks.

SORT 1 -- involves kinds of lines and is fairly easy.

SORT 2 -- involves the numbers one to ten.

SORT 3 -- involves a set of 10 "triangle" patterns. With this task are provided perforated sheets with the 10 patterns. The student will separate these 10 patterns and sort them on his desk for "experiment" or "study" before filling in his answer.

PENCILS MUST BE USED AS THE OPTICAL SCANNER DOES NOT RECORD INK.

When the test is over, collect and destroy the "triangle" patterns which the students used.

PROCEDURE FOR INTRODUCING SORTING TASKS

SUGGESTED VERBAL INSTRUCTIONS TO STUDENTS

(This guide may be revised at the discretion of the administrator. The lower grades may require most of this suggested material; Grade IX's may require less instruction.)

DISTRIBUTE EXAMPLE BOOKLETS FOR SORTING

"TODAY YOU ARE GOING TO SORT THINGS (OR OBJECTS). THIS TASK WILL BE A LITTLE DIFFERENT FROM THE OTHERS YOU HAVE BEEN DOING."

(Remind them that this is not a test.)

"DO YOU KNOW WHAT SORTING MEANS?"

If necessary use simple concrete examples such as:

letters -- numbers fishes -- birds houses -- stores	specific kinds of objects
small -- large smooth -- rough circular -- rectangular	characteristics of objects

"OPEN THE EXAMPLE BOOKLET TO PAGE ONE. EXAMPLE ONE HAS FOUR THINGS (OR OBJECTS)."

"THEY ARE SORTED INTO TWO GROUPS. CAN YOU DESCRIBE HOW THE GROUPS ARE DIFFERENT?"

(Coach if necessary -- e.g. circles or round things in one group, rectangles or bars in the other group.)

"LOOK AT EXAMPLE TWO -- HERE THERE ARE FIVE OBJECTS. HOW ARE THEY SORTED IN THE FIRST SORT?" (Have students note big and small as the characteristic.) "HOW ARE THEY SORTED IN THE SECOND SORT?" (Have students note curved objects and straight lines as the characteristic.)

"SORT THREE IS POOR -- DO YOU KNOW WHY?"

(If necessary, explain that a basic principle (characteristic) has not been used to sort all the objects in two groups.)

"TURN TO PAGE TWO. YOU HAVE EIGHT OBJECTS AND THREE DIFFERENT SORTS: TWO ARE GOOD, ONE IS POOR. THIS TIME, THE TWO GROUPS IN EACH SORT ARE MARKED ON GRIDS, THE WAY YOU WILL DO IT ON YOUR ANSWER SHEET. THE FIRST SORT PUTS THE ODD NUMBERED OBJECTS INTO ONE GROUP AND THE EVEN NUMBERED INTO ANOTHER."

"THE SECOND SORT HAS ONE GROUP WHICH DOUBLES IN SIZE AS THEY PROGRESS -- 1, 2, 4, 8, AND THE OTHER GROUP HAS THE REST WHICH DO NOT FIT -- 3, 5, 6, 7."

(If there are questions, you might explain that, for example, 3 doubles to 6, but 1 or 2 cannot be doubled to 3. Therefore, 3 cannot go in the doubling series.)

NOTE: In the sorting tasks, a specific object or item cannot be placed in both groups at the same time.

"THE THIRD SORT IS POOR. CAN YOU SEE WHY?"

(If necessary, explain that there is no clear idea of relation between first and last as opposed to middles, e.g. you could also say that 1, 2, 7, and 8 are at the ends. The example is called poor but not necessarily WRONG.)

"TURN TO PAGE THREE. NOW YOU HAVE 10 OBJECTS WITH 3 DIFFERENT SORTS MARKED IN THE ANSWER GRIDS."

"SORT ONE IS BIG -- SMALL."

"SORT TWO IS ROUND -- NOT ROUND. BOTH OF THESE ARE GOOD SORTS."

"SORT THREE IS A POOR SORT -- WHY?"

(If necessary, explain that Round, Square, and Triangular objects do not make a "good" group when four-sided objects are in the other. To make this better, the Squares should be sorted with the four-sided objects.) (3, 5, and 10 would be marked in the second box and not in the first box.)

"NOW TURN TO PAGE FOUR -- HERE IS A HARDER SORT. THE SAME 10 OBJECTS ARE SORTED INTO THREE GROUPS."

"SORT ONE HAS ROUND OBJECTS (1, 8, 9) IN ONE GROUP,

THE TRIANGLE (7) IN A SECOND GROUP, AND THE

FOUR-SIDED OBJECTS (INCLUDING SQUARES, AND

RECTANGLES) (2, 3, 4, 5, 6, 10) IN A THIRD GROUP."

"DO YOU UNDERSTAND?"

(If necessary, explain the sort on the basis of number of sides.)

"SORT TWO IS WRONG. WHY?"

(Because one group is empty. NOTE: This is the first time that a sort has been called WRONG!)

ADMINISTRATION PROCEDURE FOR THE THREE SORTS

ADMINISTRATION

Distribute Sort 1

Have Students Print Name

Mark Student Number on grids.

Mark School Number on grids.

} as on previous Answer Sheets

"NOW TRY TO DO AT LEAST ONE SORT, WITH THESE TEN LINES."

- allow FIVE minutes
- if questions -- do not give clues -- encourage students to guess at least one sort. Students may turn in Answer Sheet without any sorts -- this is permissible.

"STOP NOW."

Collect Answer Sheets.

Distribute Sort 2

Have Students Print Name

Mark Student Number on grids.

Mark School Number on grids.

} as on previous Answer Sheets

"NOW TRY TO DO AT LEAST ONE SORT WITH THESE NUMBERS."

- allow FIVE minutes
- again, if there are questions -- do not give clues -- tell students to guess. A student may turn in his answer without any sorts attempted.

"STOP NOW."

Collect Answer Sheets.

Distribute the Perforated Sheets with the 10 "Triangle" Patterns

-- ONE Sheet to each Student

"TEAR APART THE 10 SQUARE PIECES OF PAPER AND LOOK AT THE TRIANGLE PATTERN."

"YOU CAN USE THESE TO HELP DO THE SORTING BEFORE YOU MARK YOUR ANSWER SHEET."

Distribute Sort 3

Have Students Print Name

Mark Student Number on grids

Mark School Number on grids

} as on previous Answer Sheets

"USE THE SAMPLES ON YOUR DESK -- SORT THEM INTO THREE GROUPS EACH TIME DECIDE ON A SORT THEN DARKEN THE NUMBERS ON YOUR ANSWER SHEET."

- allow TEN minutes

"STOP NOW."

Collect Answer Sheets.

Place in the envelopes (addressed to the Research Department)

- the 3 Sort Answer Sheets
- the unused, perforated sheets
- the Example Booklets for Sorting

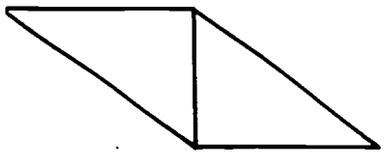
Return these envelopes to the school office to be picked up by the Transportation Department.

Collect and destroy the 10 little paper squares which each student used.

APPENDIX C

OBJECT SET FOR SET THREE:
THE TEN ITEMS THAT ARE SEPARATED AND USED BY STUDENTS

1



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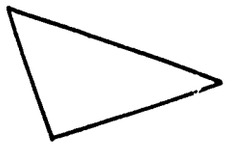

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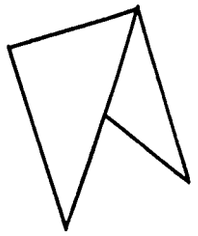

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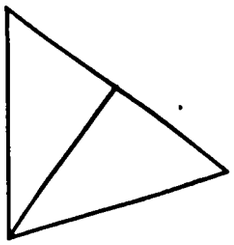

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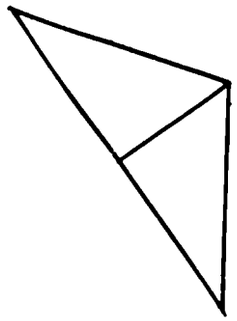

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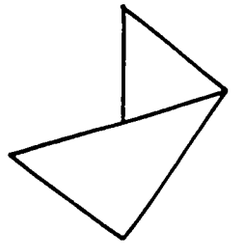

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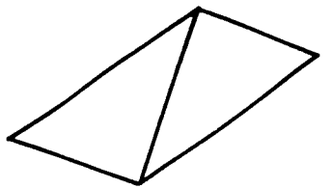

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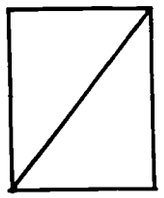

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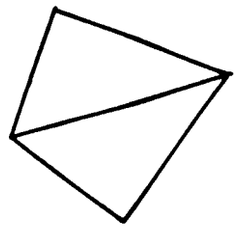

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