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THE MATHEMATICAL ATTAINMENTS OF POST-PRIMARY SCHOOL ENTRANTS*

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A test based on the curriculum in mathematics for the end of the primary school was administered to 923 pupils in their first term in post-primary school The test was designed to assess the pupils' attainment of 55 objectives of the curriculum The percentage of pupils attaining objectives ranged from a low of 16 to a high of 92 The highest percentages of pupil success were on objectives relating to operations with whole numbers and those relating to the interpretation of charts and graphs, the lowest were on objectives relating to the solution of arithmetical problems In general, girls did less well than boys and pupils entering vocational schools less well than pupils entering secondary schools

Mathematics are central to the primary school curriculum and are studied by practically all students at the junior cycle of the post-primary level and by the majority of students at the senior cycle Nevertheless, we know little about the precise standards Irish pupils reach in the subject. Our present knowledge is based on four sources of evidence the perceptions of teachers, the perceptions of parents, the performance of pupils on public examinations and the performance of pupils on standardized tests of attainment The evidence relating to teachers' perceptions and pupils' performance on standardized tests is limited to the primary level, evidence on public examinations relates only to the post-primary level, while parents' perceptions relate to both primary and post-primary levels

The perception of primary school teachers was ascertained by asking them to indicate if they perceived specified pupils as having difficulty with school subjects, the pupils concerned were eleven years of age. According to the judgments of teachers, 48% of pupils had difficulty with arithmetic (8) Furthermore, problem arithmetic was a more frequent cause of perceived

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difficulty than mechanical arithmetic, 46% were perceived as experiencing difficulty with the former as against 20% with the latter (3) These figures may be contrasted with the numbers who were perceived as having difficulty with other areas 50% in the case of Irish (which is close to the perceived figure for arithmetic) and a much smaller number, 25%, in the case of English

In a study carried out by the Educational Research Centre in 1974, parents' views were elicited in two ways (11) A national sample of Irish adults was interviewed and respondents who had school-going children (at either primary or post-primary level) were asked if they regarded anything which was taught in their child's school as being poorly taught, only 16% said yes When parents in this group were asked to specify the subjects they perceived as being poorly taught, the greatest number (33%) said either arithmetic or mathematics This percentage may be contrasted with the 14% who felt that foreign languages were poorly taught, 12% who thought Irish was poorly taught and 11% who thought reading was poorly taught In a series of questions that parallels the one used with teachers in the study earlier described, parents were asked if they regarded the progress of their children in specific subjects as excellent, good, fair or poor Five per cent of parents of children at the primary level regarded their child's progress in arithmetic as poor and another 24% regarded it as only fair This leaves 71% who regarded their child's progress as good or excellent The figure for children regarded as making fair or poor progress in English reading is somewhat lower (15%) while the figure for children perceived as making only fair or poor progress in Irish reading is higher (33%) When one compares the trends revealed in this study of parents' perceptions with those of the earlier study of teachers' perceptions, two points emerge Firstly, the perceived order of pupil difficulty or unsatisfactory progress is the same for teachers and parents, both groups see the greatest source of pupil difficulty to be with Irish, with arithmetic close behind, least perceived difficulty is associated with English And secondly, parents see fewer pupils as experiencing difficulty – are more satisfied with their scholastic progress – than do teachers, this is true for all subject areas

While parents of pupils at post-primary schools agreed with parents of primary school pupils and primary school teachers in their perceptions of the order of difficulty of school subjects (Irish, mathematics and English), more parents of post-primary pupils perceived their children as making only fair or poor progress at school than was true in the case of parents of primary school children Parents of post-primary pupils, in fact, seem closer

to primary school teachers than to parents of primary school children in their perceptions of pupils' progress Among the parents of post-primary pupils, those with children at vocational schools were more likely to perceive school difficulties and lack of progress for their children than were parents of pupils at secondary schools In the case of mathematics, 38% of secondary parents as against 44% of vocational parents perceived their children's progress as only fair or poor In the case of Irish, the percentages were 42 for secondary parents and 47 for vocational parents and in the case of English, 23 for secondary parents and 30 for vocational parents

The third source of evidence relating to the attainments in mathematics of Irish students is their performance on public examinations In the 1974 Intermediate Certificate examination, 6 5% of boys and 8 6% of girls taking the Higher Course examination failed to attain at least a D grade, of those taking the Lower Course examination, 13 4% of the boys and 20 3% of the girls failed to attain at least a D grade In the Leaving Certificate examination of the same year, 19 9% of boys and 7 3% of girls failed to obtain at least a D grade on the Higher Level course while on the Ordinary Level course, 23 6% of boys and 28 2% of girls failed to obtain at least a D grade In all but one case (Intermediate lower level examinations for boys), the failure rate in mathematics was higher than in Irish or in English – in some cases very considerably so (5)

An analysis of the examination papers would provide some indication of the content and skills being tested in these examinations The only detailed analysis of the Leaving Certificate examination that has been published, however, relates to the 1967 examination (11), that study was concerned with the intellectual abilities tapped by the examination Bloom's (1) hierarchical classification of intellectual skills was used for the categorization of abilities An attempt was made to determine for which of the six major categories of the classification marks were awarded in the examination The study revealed that in the examination in general great weight was placed on the lowest skill in the taxonomic hierarchy which is knowledge (involving the learning and retention of information) The percentage of marks allocated to higher intellectual activities such as analysis and synthesis was small and to evaluation nothing

Mathematics appeared to depend less on simple knowledge than other subjects A considerable proportion of available marks was allocated to items requiring comprehension, while the skills of application also attracted marks Indeed, the mathematics examinations appeared to be the most

successful in tapping a wide range of intellectual abilities Furthermore, of all examinations, mathematics also made the clearest distinction between the pass (ordinary) and honours (higher) courses The two courses were found to differ not only in content, but also in difficulty level and in the level of cognitive functioning required of the student These data refer to the 1967 examination, we do not know to what extent, if any, examinations since then have changed in the skills they examine

The fourth source of information relating to the attainment in mathematics of Irish students is to be found in two studies which used objective tests In one of these, two norm-referenced objective tests of arithmetic, the Schonell Mechanical Arithmetic Test and the Schonell Essential Problem Arithmetic Test were administered to a national sample of fifth standard pupils, aged about eleven years, in Irish schools (10) Both tests had been developed and standardized in Britain The performance of Irish pupils on the tests was below that of the standardization sample, this was more obvious in the case of the problem arithmetic test, on which the mean quotient of the Irish sample was 85 52, as compared with 94 10 on the mechanical arithmetic test For both tests, the British mean was 100 A study of a smaller sample of Dublin eight-year old children, again using the Schonell Mechanical Arithmetic test, reported a mean of 96 61, which is very close to the figure reported above for the larger sample of older Irish pupils (6)

The available evidence does not allow us to state in any detail the standards attained in Irish schools The studies we have cited do not specify in terms of mathematical operations the objectives or criteria against which pupils' progress was being assessed This is as true of public examination procedures as it is of parents' perceptions Norm-referenced objective tests do not help us greatly either They do not tell us what pupils have learned, rather their main function is to provide data on performance which can be compared with the performance of a standardization sample (14) The need for further exploration of the mathematical attainments of Irish school children thus remains The present study is addressed to attempting to throw some light on the precise accomplishments of Irish pupils in the component areas of the mathematics curriculum at the point of transfer from primary to post-primary school In this task, the performance of a sample of first year post-primary pupils on a criterion-referenced mathematics test was examined

A criterion-referenced test is made up of items designed to measure the extent to which pupils have mastered the objectives of a curriculum For

the present study, the Drumcondra Criterion Referenced Mathematics Test, which is based on the objectives of the mathematics curriculum for fifth and sixth classes in the primary school, was administered to a sample of pupils in their first term at post-primary school

PROCEDURE

Instrument

The Drumcondra Criterion Referenced Mathematics Test is based on the objectives of the mathematics curriculum of the fifth and sixth standards of primary schools which were derived from the *Primary school curriculum handbook* (4) Not all possible objectives could be included as this would have made the test too long. As the emphasis in mathematics curricula in schools in recent years has been on developing intellectual skills involving the understanding of mathematical concepts, the test is weighted in favour of items based on objectives which involve comprehension Of a total of 55 objectives, 14 involve computation, 36 involve comprehension and 5 involve problem solving When a selection of objectives had been made, the set was submitted to a panel of teachers who judged, after some modification, that the objectives represented a realistic and comprehensive list of the behaviours which would be demonstrated by pupils who had mastered the content of the mathematics curriculum for fifth and sixth standards in Irish primary schools For each objective, at least two, not more than eight, and most usually three test items were written The final test contains 155 items The main categories of objectives covered by the test are (A) operations with whole numbers, (B) whole number structure, (C) fractional number structure, (D) operations with fractions, (E) decimals and percentages, (F) algebra, (G) geometry, (H) charts and graphs, (J) arithmetical problems Several objectives are subsumed under each of these headings (cf Results infra) The tests were administered by the pupils' own teacher, and returned to the Educational Research Centre for scoring The percentage of pupils who had 'mastered' each of a series of objectives was then calculated

Sample

Nine secondary schools and four vocational schools which formed part of a larger national sample of post-primary schools were randomly selected for the administration of the Drumcondra Criterion Referenced Mathematics Test at the first year post-primary level One secondary and one vocational school did

not return completed tests Test scores were obtained for 923 pupils The test was taken in the first term in which the pupils had entered the school in the school year 1974-75

Although the sample is not very large, the pupils can be regarded as representative of the Irish school population in terms of their verbal and numerical ability In addition to the mathematics test, they also had taken the Verbal Reasoning and Numerical Ability sections of the Differential Aptitude Test, Form T (adapted version) Their mean standard scores on the tests were very close to the national means On the Verbal Reasoning subtest, the mean standard score of the sample was 101 (population mean 100) and on the Numerical Ability subtest, their mean score was 99 (population mean 100) Thus, in terms of both verbal and numerical ability as measured by norm-referenced tests, we can regard the sample as similar to the general population of Irish pupils at the first-year level in post-primary schools on whom the tests were standardized

RESULTS

A pupil was regarded as having 'mastered' an objective if he answered correctly two items when there were two or three items for the objective, or six items when there were eight items for an objective For each objective, the percentages of pupils achieving mastery are set out in Table 1 Separate figures are given for boys and for girls, and for secondary and vocational school pupils

DISCUSSION

The figures in Table 1 indicate that a large number of the objectives set for fifth and sixth standard pupils in the primary school curriculum are not attained by many pupils For example, only one objective (pupil can perform simple arithmetical operations involving zero) is mastered by over 90% of pupils A further two are mastered by 80% or more pupils (pupil can complete a simple number sequence and pupil can add and subtract two fractions having the same denominator) At the other extreme, two objectives (pupil can divide a fraction by a whole number and vice versa and pupil can solve simple problems on VAT) are mastered by less than 20% of pupils, five objectives are mastered by fewer than 30% (pupil can identify the distributive property, pupil can identify the least common multiple of two numbers, pupil can multiply a fraction by a whole number, pupil can solve algebraic equations which call for two simple arithmetical

TABLE 1

PERCENTAGES OF PUPILS ATTAINING OBJECTIVES AT BEGINNING OF POST- PRIMARY SCHOOL BY SEX AND TYPE OF SCHOOL

	OBJECTIVES	PERCENTAGE ATTAINING				
		Boys	Girls	Sec	Voc	Total
	N	403	520	748	175	923
A	Operations with Whole Numbers					
1	Pupil can add a column of numbers containing not more than 5 digits	74 69	83 65	83 02	65 71	79 17
2	Pupil can subtract 2 numbers containing not more than 5 digits	70 72	75 19	77 14	56 56	72 95
3	Pupil can multiply 2 numbers containing not more than 5 digits	65 76	73 08	74 06	52 00	69 42
4	Pupil can divide a number containing not more than 5 digits by a number containing not more than 3 digits	59 31	56 54	63 77	32 00	57 92
B	Whole Number Structure					
1	Pupil can position a number on the number line	78 41	61 54	71 79	56 57	69 97
2	Pupil can complete simple number sequences	87 10	88 27	91 04	73 71	87 68
3	Pupil can identify prime numbers and composite numbers	56 58	37 11	46 79	41 58	46 84
4	Pupil can identify the commutative property	59 55	46 92	57 00	32 57	53 23
5	Pupil can identify the distributive property	25 56	18 65	24 47	9 71	22 10
6	Pupil can perform simple arithmetic operations involving zero	90 58	93 46	94 25	83 42	92 02
7	Pupil can factor 2 and 3 digit numbers	78 91	69 20	77 81	57 72	74 05
8	Pupil can identify common factors between 2 numbers	61 29	56 73	63 10	40 00	59 01
9	Pupil can identify the highest common factor between 2 numbers	62 53	55 00	63 50	36 00	58 76
10	Pupil can identify the least common multiple of 2 numbers	31 76	27 69	32 89	14 86	29 72

TABLE 1 (Contd)

OBJECTIVES	PERCENTAGE ATTAINING				
	Boys	Girls	Sec	Voc	Total
C Fractional Number Structure					
1 Pupil can state a ratio as a fraction	66 75	61 35	66 86	41 71	64 05
2 Pupil can state a fraction (ratio) in a number of equivalent forms	50 87	40 00	48 67	28 00	45 43
3. Pupil can reduce a fraction to its simplest terms	64 02	65 19	71 39	36 00	64 60
4 Pupil can complete ratio statement	70 97	60 58	69 92	44 57	65 77
5 Pupil can sequence fractions in terms of their order of magnitude	49 87	30 77	40 38	33 71	40 32
6 Pupil can convert an improper fraction to a mixed number and vice versa	74 69	69 23	77 94	44 57	71 96
D Operations with Fractions					
1 Pupil can add and subtract two fractions having the same denominators	82 13	83 08	86 77	65 14	82 60
2 Pupil can add and subtract two fractions having different denominators	60 30	52 11	62 43	26 86	56 20
3 Pupil can multiply two fractions having the same denominators	40 69	36 73	41 84	24 00	38 71
4 Pupil can multiply two fractions having different denominators	60 05	64 42	65 51	49 71	62 23
5 Pupil can divide two fractions having the same denominators	51 36	53 65	56 42	36 57	52 50
6 Pupil can divide two fractions having different denominators	40 20	37 40	43 19	19 43	38 80
7 Pupil can add or subtract three fractions with different denominators	60 55	45 97	58 15	27 43	53 26
8 Pupil can subtract a fraction from a whole number and vice versa	62 04	43 46	57 36	26 85	52 75
9 Pupil can multiply a fraction by a whole number	31 76	18 85	28 74	6 29	25 30
10 Pupil can divide a fraction by a whole number and vice versa	19 60	16 15	20 72	4 57	17 85

TABLE 1 (Contd)

	OBJECTIVES	PERCENTAGE ATTAINING				
		Boys	Girls	Sec	Voc	Total
E	Decimals and Percentages					
1	Pupil can sequence decimals in their order of magnitude	63 77	44 62	57 08	35 42	54 19
2	Pupil can convert a fraction to a decimal and vice versa	70 72	63 65	71 12	48 00	67 18
3	Pupil can correctly position the decimal point when performing simple arithmetic problems	37 46	28 85	36 03	13 71	33 15
4	Pupil can convert percentages to decimals and vice versa	63 03	62 12	67 12	42 85	62 51
5	Pupil can convert percentages to fractions and vice versa	47 64	30 00	40 37	26 29	38 82
6	Pupil can calculate the percentage one whole number is of another	56 08	35 00	48 13	27 43	45 54
7	Pupil can convert metric measures from one unit to another	56 58	43 65	53 61	30 86	50 11
F	Algebra					
1	Pupil can solve simple algebraic equations	67 99	49 81	61 89	40 00	58 90
2	Pupil can convert a written problem into an open sentence	67 25	59 42	68 85	37 14	63 33
3	Pupil can solve word problems algebraically	66 50	48 09	60 82	36 00	57 29
4	Pupil can solve algebraic equations which call for 2 simple arithmetical operations	34 24	20 96	30 48	10 86	27 60
5	Pupil can substitute values for the placeholder in simple algebraic expressions	73 45	57 70	69 38	44 00	65 57
6	Pupil can select a correct number sentence from a set of number sentences containing inequalities (> and < only)	64 52	54 42	62 43	43 43	59 47

TABLE 1 (Contd)

	OBJECTIVES	PERCENTAGE ATTAINING				
		Boys	Girls	Sec	Voc	Total
G	Geometry					
1	Pupil can identify common geometric forms (parallel lines, perpendicular, cube)	72 96	64 23	72 46	49 14	68 59
2	Pupil can identify common geometric terms (angle, axis of symmetry, etc)	52 85	28 65	41 31	30 29	40 75
3	Pupil recognizes facts about angles (measure of rotation, right angle = 90^{o}, circle = 360^{o}, sum of angles in triangle = 180^{o}, etc)	70 72	42 11	55 08	52 57	56 41
4	Pupil can label the parts of a circle	81 39	67 08	77 54	58 28	74 23
5	Pupil can calculate the perimeter of simple geometric shapes	74 94	56 73	67 25	53 71	65 83
6	Pupil can calculate the area of simple geometric shapes (triangle, square, rectangle)	44 17	20 19	33 43	48 86	32 18
H	Charts and Graphs					
1	Pupil can interpret charts and graphs	74 19	62 30	72 46	46 29	68 24
J	Arithmetical Problems					
1	Pupil can calculate the speed of a body given distance and time	57 32	35 96	49 47	27 43	32 68
2	Pupil can calculate averages	55 09	32 12	46 52	23 43	43 60
3	Pupil can solve simple problems on VAT	14 64	17 69	17 51	11 43	16 16
4	Pupil can solve simple problems on interest rates	46 90	25 19	38 37	18 86	36 04
5	Pupil can solve simple problems on profit - loss	39 45	13 65	28 21	10 86	26 55

operations, pupil can solve simple problems on profit-loss) and a further eight objectives are mastered by less than 40% (pupil can sequence fractions in terms of their order of magnitude, pupil can multiply two fractions having the same denominators, pupil can divide two fractions having different denominators, pupil can correctly position the decimal point when performing simple arithmetic problems, pupil can convert percentages to fractions and vice versa, pupil can identify common geometric terms, pupil can calculate the area of simple geometric shapes and pupil can solve simple problems on interest rates)

The objectives with a low level of mastery are fairly well distributed over each section or group of objectives, all sections with the exception of sections on Operations with Whole Numbers and on Charts and Graphs contain such items Within most sections then, there are objectives with a low degree of mastery By looking at individual objectives, it is difficult to discern any clear pattern in the type of objective that causes difficulty, except that fractions appear in several of them

The calculation of mean percentages achieving mastery for each section does throw some light on the relationship between content and mastery The highest over-all mastery level is achieved on Section A, Operations with Whole Numbers (70 13%), this is not surprising since these items were based on the curriculum which should have been covered by the end of standard four and were included in the test partly to give pupils confidence on beginning the test Perhaps the surprise is that the over-all mastery figure should be as low as 70% at this point in the pupils' school career

The section with the next highest mastery rate is Section H, Charts and Graphs (67 49%), followed by Section B, Whole Number Structure (58 91%) and Section C, Fractional Number Structure (58 16%) These latter two sections include content relating to basic concepts and, since logically the concepts involved would seem to be prerequisites for the algorithms involved in later sections (like operations with fractions), it is not unexpected that the level of mastery achieved in these areas should be higher than in later sections involving applications of the concepts Section G, Geometry (55 18%) and Section F, Algebra (54 48%) come next, pupils achieve a similar level of mastery in both areas The areas in which the lowest levels of mastery are achieved are Section E, Decimals and Percentages (49 43%), Section D, Operations with Fractions (46 67%), and last of all, Section J, Arithmetical Problems (32 68%) In this finding regarding arithmetical problems, the opinions of teachers and the findings of an earlier study using norm-referenced standardized tests receive support

A difference between boys and girls in favour of the former, though not an entirely consistent one, has been reported in several studies of numerical ability and mathematical attainment carried out in other countries (9) In this country, the difference is probably reflected in the small number of girls taking Higher Level mathematics for the Leaving Certificate examination The findings of the present investigation also reveal differences between boys and girls in the mastery of mathematical objectives Of the 55 objectives included in the test, boys do better than girls on 45 of them

The difference is also clear when one compares the mean levels of mastery in sets of objectives (cf Table 2) For the first two categories, there is a slight difference in favour of girls, these categories refer to more basic operations For all the other categories, boys do better than girls, considerably so on Decimals and Percentages and on Charts and Graphs, while the gap is even wider for Algebra, Geometry and Arithmetical Problems A recent American study also reported that girls tend to do better on 'pure computation' exercises, the superiority of boys on items requiring the application of specific mathematical processes was found, though it was not as clear-cut as in the present study (13)

TABLE 2

PERCENTAGES OF PUPILS BY SEX ATTAINING SETS OF OBJECTIVES

SET OF OBJECTIVES	PERCENTAGE ATTAINING	
	Boys	Girls
A Operations with Whole Numbers	67 63	72 17
B Whole Number Structure	55 38	55 46
C Fractional Number Structure	62 86	54 52
D Operations with Fractions	50 87	45 18
E Decimals and Percentages	56 46	43 98
F Algebra	62 33	39 40
G Geometry	66 17	46 50
H Charts and Graphs	74 19	62 30
J Arithmetical Problems	42 68	24 90

An examination of the order of difficulty in the various operations for boys and girls considered separately does not reveal any great difference in pattern of attainment The areas in which the greatest mastery is achieved for both groups are operations with Whole Numbers and Charts and Graphs, the area in which least mastery is attained is Arithmetical Problems In between, there is some variation in order, for example, Algebra occupies a higher rank for boys than for girls, while Whole Number Structure occupies a higher place for girls than for boys

TABLE 3

RANK ORDER OF MASTERY OF SETS OF OBJECTIVES BY SEX

	RANK ORDER OF MASTERY	
	Boys	Girls
Charts and Graphs	1	2
Operations with Whole Numbers	2	1
Geometry	3	5
Fractional Number Structure	4	4
Algebra	5	8
Decimals and Percentages	6	7
Whole Number Structure	7	3
Operations with Fractions	8	6
Arithmetical Problems	9	9

It is possible to examine differences between pupils entering secondary schools and those entering vocational schools, but as the numbers in the vocational school sample are small, these will not be considered in detail On every objective of the 55, secondary school pupils do better than vocational pupils Further, the differences in the numbers achieving mastery on many objectives are considerable This finding, though based on a small sample, is consistent with an earlier report that secondary school pupils, on entry, differ from vocational ones in verbal reasoning ability and in the satisfactoriness of their scholastic progress in the primary school as perceived by teachers (7)

In conclusion, the most obvious finding of the present investigation is that many children enter post-primary schools without having mastered the objectives of the mathematical syllabus of the primary school curriculum

Furthermore, it has been possible to identify the percentages of pupils that attain many specific objectives of the curriculum It is clear that some objectives are attained by a relatively small proportion of pupils This is particularly true of objectives in the area of arithmetical problems, the situation with regard to operations with fractions and decimals and percentages is not very different In general, our findings show that girls do less well than boys and that pupils entering vocational schools are lower in attainment than pupils entering secondary schools

These findings certainly raise a number of questions regarding the primary school curriculum and its objectives in the area of mathematics In the first place, one may ask if teachers have inferred the same objectives for their teaching as we inferred for this investigation Since the objectives are not explicitly stated in the *Primary school curriculum* (4), there is room for variation in their specification If many teachers do not specify the objectives which we did, then these objectives might not be reflected in their teaching or in their students' learning If, however, most teachers are in agreement on the objectives of the curriculum as specified in this paper, then the question of the reasonableness of expecting the majority of pupils to attain all the objectives must be raised Should one, as has often been recommended in the educational literature, be setting different objectives and goals for different pupils because of the large range in individual differences that may exist between them? Is it unrealistic to expect all, or at least the vast majority of pupils, to achieve mastery of the objectives of the curriculum we are considering? Or, given the right conditions and adequate time, as Bloom, Hastings and Madaus (2) have suggested, is such mastery a realistic goal for most students? If so, what are the right conditions and how much time is needed?

The findings of the present study can only raise such questions, not answer them The need for a search for such answers should be obvious Meanwhile, teachers at both primary and post-primary levels will have to seek their own solutions in dealing with the phenomena which our findings represent

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