Pupils' Competence In Primary 4 And Primary 6 Mathematics Assessments

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Abstract

The research paper reports on the evaluation of pupils' competence in the Primary 4 and Primary 6 Assessments. Items from each assessment were also analysed to determine if there are any co-relations between their competence and the types of questions for assessments. The test results from the reports had implications to the teaching of primary mathematics in Singapore.

Objectives and Samples

The first objective of the tests is to determine whether the Primary 4 and Primary 6 pupils have understood and mastered some mathematical concepts which they have learned in their first part of the year. The second objective is to identify the strengths and weaknesses of pupils in the topics/areas tested. The third objective is to find out the level of difficulty for each item.

The test items were constructed on the basis of some contents in the school textbooks for each level. For Primary 4, the topics are the four operations on numbers, fractions and addition and subtraction of fractions. For Primary 6, they are the four operations on numbers and fractions. In addition to the questions derived from these topics of the modules, 3 out of 35 questions are unconventional problems which require pupils' ability to operate at a higher level of mental thinking. These are problems which are not usually taught in schools but they require pupils to apply their acquired knowledge to solve the problems. The questions were constructed according to 6 levels of difficulty. The 6 levels are:

(A)	computation skill A involving the order of the four operations,
(B)	computation skill B involving the concept of equation,
(C)	word problem A involving mathematical language,
(D)	word problem B requiring 1-2 steps for problem solving,
(E)	word problem C requiring multi-steps for problem solving and
(F)	unconventional problem.

The samples are from the average pupils of various schools. 199 pupils from Primary 4 and 444 pupils from Primary 6 sat for the tests. All pupils have completed all the contents stated in the previous paragraph before the tests were administered to them.

Pilot Study

The purpose of the pilot study was to check the suitability of the hierarchical levels and accuracy of the items constructed. Tests were administered to about 40 high-ability pupils at each of the Primary 4 and Primary 6 Level pupils. This was to ensure that the items constructed would be solvable by the pupils at the specific levels.

The items which were found to be too difficult were modified accordingly before they are used for the main study. Typographical errors were also corrected.

The Results of the General Performance of the Samples

Primary 4 Sample

The general performance of pupils is reported in 3 sections. The first section is on pupils' achievement with respect to the different levels of skills A to F. The second is on the pupils' performance in the various sections of the paper. The last is the overall performance of the pupils.

(i)   **Pupils' Achievement with Respect to the Different Levels of Skills**

Table 1. Pupils' Achievement with Respect to the Levels of Skills (A-F)

Skills	No. of Passes	% Passese
A	189	94.9
B	94	47.2
C	92	46.2
D	79	39.7
E	8	4.0
F	3	1.5

A - Computation skill A (the order of 4 operations)
B - Computation skill B (involving the concept of equation)
C - Word problem A (involving mathematical language)
D - Word problem B (1-2 step problems)
E - Word problem C (multi-step problems)
F - Unconventional problem (Refer to definition on page 2)

When the test items were designed, the 6 levels A to F of the items are hypothesised to be in ascending order of difficulty. This order of difficulty is supported by the result of the analysis as shown in Table 1. Among the 6 skills, about 90% of the pupils passed Skill A while more than 50% failed in each of the Skills B to F. However, for Skills B and C, the percentages of failures are only marginal, i.e. 47.2% and 46.2% respectively. In general, the pupils are weak in Skill D. Only 39.7% of the pupils passed this skill. The table shows that the pupils are very weak in Skills E and F. Only 4.0% and 1.5% passed the two skills, E and F, respectively.

The histogram below summarises the data from Table 1 according to the skills and performance of pupils.

Figure 1: Histogram Showing % of Pupils Passed in Each Skill
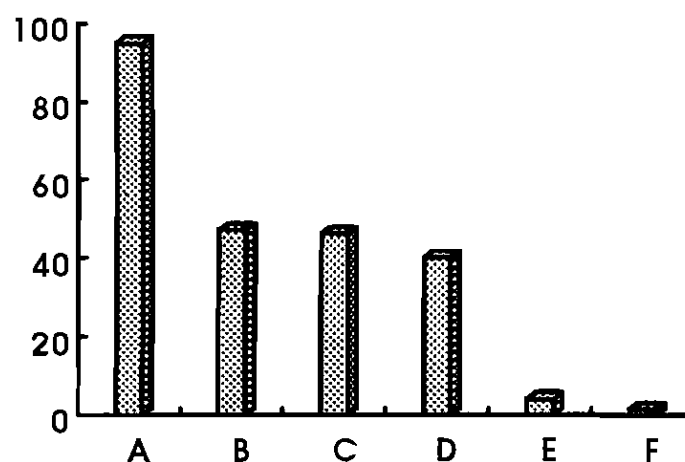
(ii) **Analysis of Pupils' Performance on the Basis of Achievement in each Section of the Paper**

Table 2. Distribution of Lower-group Pupils in Each Section of the Paper

	Categories of Pupils	No. of Pupils in Each Category	Percentage of Pupils in Each Category
(I)	FA	35	17.6
(II)	FB	108	54.3
(III)	FC	191	98
(IV)	PA, PB	52	26.1
(V)	FA, FB	34	17.1
(VI)	PA, FB	73	36.7
(VII)	FA, PB	1	0.5

FA - Failed Section A   PA - Passed Section A
FB - Failed Section B   PB - Passed Section B
FC - Failed Section C   PC - Passed Section C

The questions in Section A are multiple-choice questions. Section B are simple open-ended questions and Section C are multi-step word problems. The result of (iii) in Table 2 shows a significant percentage (98%) failing in Section C.

The results of (i), (ii) and (iii) in Table 2 show that a significant percentage (98%) of pupils failed in Section C as compared to 17.6% who failed in Section A. About half (54.3%) of the pupils failed in Section B. It appears that pupils have greatest difficulty in multi-step word problems.

In (iv), of those who passed Section A and Section B, 26.1% failed overall in the test due to failure in Section C. This further suggests the weakness of pupils in multi-step word problems.

(iii)   Overall Pupils' Achievement in the Primary 4 Test

Table 3. Overall Pupils' Achievement in the Test When Unconventional Problems are Included or Omitted

	% Passed	% Failed	Total %
Unconventional Problems Included	22.1	77.9	100
Unconventional Problems Omitted	45.2	54.6	100

As defined in the first Section, *'unconventional problems are those questions which are not directly taught to the pupils but demand a higher level of thinking'.* Less than 10% of the questions are unconventional problems. Table 3 shows that a big increase in pupils' performance is noted when this type of problem is omitted (22.1% to 45.2%), i.e. double the percentage passed.

Primary 6 Sample

Similar to the Primary 4 sample, the general performance of pupils is reported in 3 sections. The first section is on pupils' achievement with respect to the different skill levels A to F. The second is on the pupils' performance in the various sections of the paper. The last is the overall performance of the pupils.

(i)   **Pupils' Achievement with Respect to the Different Levels of Skills**

Table 4. Pupils' Achievement with Respect to the Levels of Skills (A-F)

Skills	No. of Passes	% Passese
A	281	63.7
B	303	68.5
C	258	58.1
D	169	37.6
E	80	18
F	10	2.2

A - Computation skill A (the order of 4 operations and fractions)
B - Computation skill B (involving the concept of equation)
C - Word problem A (involving mathematical language)
D - Word problem B (1-2 step problems)
E - Word problem C (multi-step problems)
F - Unconventional problem

The six levels of skills A to F are arranged in ascending order, i.e., Level B questions are assumed to be more difficult than Level A questions. The order of difficulty approximately conforms to the result as shown in Table 4 except for the Level B skill which is relatively easier than the Level A skill in the sample. Among the 6 skills, the pupils passed Skills A, B and C. They were weak in Skills D and E and did poorly in Skill F, the unconventional problems. Only 2.2% of the pupils were successful in answering Skill F problems.

The histogram below summarises the data obtained in Table 4 according to the levels in skills and percentage of pupils passed in each skill.

Figure 2:   Histogram Showing % of Pupils Passed in Each Skill
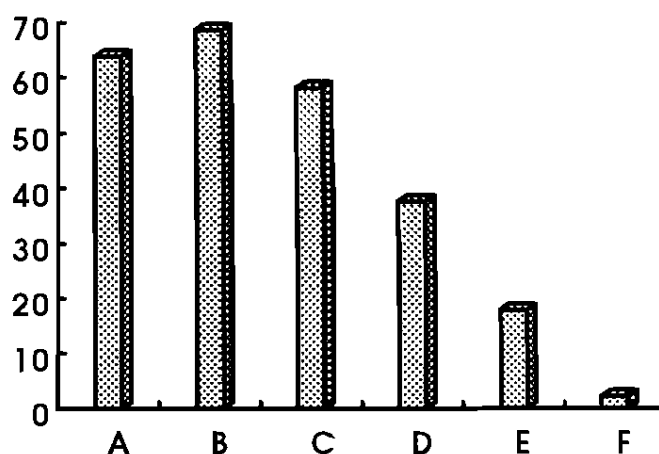
(ii)   Analysis of the Pupils' Performance on the Basis of Achievement in each Section of the Paper

Table 5. Distribution of Lower-group Pupils in Each Section of the Paper

	Categories of Pupils	No. of Pupils in Each Category	Percentage of Pupils in Each Category
(I)	FA	71	15.9
(II)	FB	191	43.0
(III)	FC	377	84.9
(IV)	PA, PB	61	13.7
(V)	FA, FB	68	15.3
(VI)	PA, FB	150	33.8
(VII)	FA, PB	70	15.8

FA – Failed Section A   PA – Passed Section A
FB – Failed Section B   PB – Passed Section B
FC – Failed Section C   PC – Passed Section C

Table 5 shows that quite a great percentage (84.9%) or pupils failed Section C. Section C comprises multi-step problems and unconventional problems.

As compared to Section C, there were about 16% and 43% of pupils who could not handle Section A and Section B respectively. It appears that quite a big proportion of pupils was not able to handle Section C problems.

The result is further supported by the figure from (iv) of Table 5 that about 14% of pupils who passed Sections A and B failed Section C.

(iii)   Overall Pupils' Achievement in the Primary 6 Test

Table 6. Overall Pupils' Achievement in the Test When Unconventional Problems are Included or Omitted

	% Passed	% Failed	Total %
Unconventional Problems Included	36.9	63.1	100
Unconventional Problems Omitted	54.7	45.3	100

Three questions included in the test were unconventional problems. Table 6 shows that the percentage of pupils who could have passed the test dropped by about 24% (54.7% to 30.9%) when this type of problems was introduced in the test. Overall, when the unconventional problems were not included in the test, slightly more than 50% of the pupils managed to pass the test.

Item Analysis

Primary 4 Sample

This section deals with analysis of questions. The questions are analysed according to:

(i)   levels of difficulty from A to F;

(ii)   difficulty levels of Sections of the test which comprises multiple choice, open-ended, and open-ended/multi-step questions and

(iii)   proportion of correct responses of each question at each level.

Table 7. Analysis of Items According to Levels of Difficulty and Proportion Correct for Each Item

Levels	Question No.	Proportion Correct
A	1	0.98
	2	0.96
	3	0.84
	4	0.85
	16	0.89
	17	0.73
	18	0.79
B	5	0.88
	6	0.78
	12	0.28
	19	0.54
	20	0.65
	21	0.34
	25	0.31
	26	0.83
C	7	0.56
	8	0.70
	10	0.59
	11	0.61
	24	0.53

	27	0.15
D	9	0.84
	13	0.80
	14	0.33
	22	0.18
	23	0.57
	29	0.17
E	31	0.12
	32	0.45
	33	0.14
F	15	0.12
	30	0.23
	34	0.03
	35	0.03

From Table 7, Level A questions show a range of correct-response proportions from 73% to 98%. This high proportion of correct answers confirms that Level A questions are the easiest among the 6 levels of skills. This level of skill comprises computation problems involving the four operations on numbers and fractions.

Level B questions, which are comparatively more difficult than Level A questions, comprise computation problems involving the concept of equation. For this skill, the proportion of correct responses ranges from 31% to 88%. Three of these questions 12, 21 and 25 are relatively more difficult. Less than 34% of pupils passed each of these 3 questions. The difficulty of these questions could be due to the fact that they require pupils to operate more than one step to solve the open-ended questions. However, the other questions at this level require only one-step operation.

The range of C-R proportions in Level C is small, from 53% to 70%, except for question 27 which has a very low C-R proportion of 15%. A possible

explanation could be that the problem requires multiplication involving the difficult fact 8 and division involving the 7 fact.

For Level D questions, the range of C-R proportions is very large, from 17% to 84%. For Questions 9 and 13, more than 80% of pupils answered them correctly. These 2 questions involved simple four-operation problems. However, for Questions 14, 22 and 29, more than 60% of pupils had difficulty in answering this type of questions which involves 2-step ratio and proportion concepts.

Generally pupils found Level E questions (31, 32, 33) difficult. On the average, only 25% of pupils could solve this type of multi-step problems. Specifically, Question 31 involves the understanding of mathematical language 'more than' and 'less than' while Question 33 requires pupils to use ratio and proportion concept. This may be a simple concept, which explains why only a small number of pupils who could answer this category of problems.

Questions classified under Level F are unconventional questions. The result shows that an average of approximately 10% of pupils could answer this type of questions. A very small number of pupils (3%) could answer Questions 34 and 35. Question 34 involves pupils' ability to associate and relate 2 unknown whole numbers and a given number using the operation such as addition and subtraction. This requires pupils to operate at a higher level of thinking in problem solving.

Primary 6 Sample

Similar to the Primary 4 level, this section also reports on the anlaysis of questions in 3 different sections. They are analysed according to:

(i)   level of difficulty from A to F,

(ii)   difficulty levels of Sections of the test which comprises multiple-choice, open-ended and open-ended/multi-step questions, and

(iii)   proportion of correct responses of each question at each level.

Table 8. Analysis of Items According to Levels of Difficulty and Proportion Correct for Each Item

Levels	Question No.	Proportion Correct
A	1	0.91
	2	0.88
	3	0.80
	4	0.50
	7	0.82
	16	0.69
	18	0.53
	19	0.55
	20	0.64
	28	0.43
B	8	0.81
	9	0.74
	10	0.61
	13	0.48
	17	0.50
C	5	0.80
	6	0.81
	11	0.44
	12	0.62
	15	0.63
	23	0.44
D	14	0.85
	21	0.37

	22	0.37
	24	0.27
	25	0.28
	26	0.57
	27	0.45
	29	0.62
E	31	0.45
	32	0.10
	33	0.10
F	30	0.20
	34	0.02
	35	0.12

For Level A skills, the C-R proportion of each question ranges from 50% to 91%. Generally, they comprise computation problems which are easy items and achievable by most pupils. They are concerned with computation problems on the operations of whole numbers and fractions.

For Level B skills, the extreme interval of C-R proportions becomes narrower ranging from 48% to 81%. This indicates that this level of skill consists of questions which are relatively more difficult than Level A skill. The questions are computation problems which involve the concept of equation. Questions 13 and 17 are relatively harder than Questions 8, 9 and 10. One explanation is that Questions 13 and 17 include multiplication and division of mixed numbers.

At Level C, all the four questions, 5, 6, 11 and 23, involve the understanding of mathematical language such as 'sum', 'product', 'the result of' and 'sevenths'. Questions 5 and 6 are found to be relatively easier than Questions 11 and 23. One explanation is that Questions 5 and 6 involve simple interpretation of mathematical terms such as 'sum' and 'product'. However, Questions 11 and 13 require pupils not only to understand the mathematical terms but also to formulate an equation from them.

Level D questions are one-to-two-step word problems. On the average, the C-R proportions for this set of questions is approximately 50%. Question 14 is relatively very much easier than the other questions (proportion correct = 85%); whereas Questions 24 and 25 are more difficult than the other questions. Analysis shows that Question 14 is a 1-step simple ratio and proportion problem. Questions 24 and 25 require pupils to draw upon two mathematical concepts to solve the problems. For example, Question 25 requires pupils to associate and link division and area concepts to solve the problem. It requires more than one-step to work out the answer.

Generally this sample of pupils is weak in multi-step problems which are classified as Level E skill. Only 10% of the pupils are able to solve Questions 32 or 33. Similar to the Primary 4 pupils, the pupils at the Primary 6 level are also weak in solving unconventional problems. Only 2% and 12% of pupils could solve Question 34 and Question 35 respectively.

Summary and Implications

Primary 4 Sample

The paragraphs below summarise the results of the following 3 main areas of analysis and their implications for mathematics teachers:

(i)   general performance of pupils,

(ii)   pupils' performance with respect to the 6 levels, A to F, and

(iii)   the difficulty level of each question with reference to the 6 levels.

(i)   General Performance of Pupils

The result shows that 45.2% of pupils passed the test. The test was constructed on the basis of the Primary 4 Module 1 topics. When some unconventional problems were included in the test, only 22.1% of pupils could manage to achieve the pass level at 50%. A decrease in percentage passes was observed when unconventional problems were included in the test.

(ii)   Pupils' Performance with Respect to the 6 Levels, A to F

The test questions were classified in terms of 6 levels of difficulty. The result shows that computation problems are the least difficult problems to pupils. The majority of them have difficulties in the multi-step problems (Level E skills) and the unconventional problems (Level F skills). This is further confirmed by the results from the analysis of questions in each of the three Sections of the paper. A very high percentage of pupils did poorly in Section C (95% of pupils could not pass this Section of the paper). Section C contained three multi-step word problems and two unconventional problems. The analysis also shows that approximately 25% of pupils who failed overall could pass Section A and Section B of the paper. This further confirmed pupils' weaknesses in the multi-step and unconventional problems.

(iii)   Difficulties of Individual Questions

In the item analysis, pupils' weaknesses in solving certain types of problems were also detected. For the Skill B type of questions which involves the concept of equation, pupils perform poorly on items which require two or more steps in the solutions. For example, Question 25 (207 + ? = 262 x 7) is a two-step problem involving the concept of equation. The analysis also shows that this group of pupils seems to be weak in solving 2-step ratio and proportion problems. Further analysis of individual item also supports the findings from the previous paragraphs that pupils are generally weak in the multi-step and deviant problems.

(iv)   Implications for the Teachers

One implication which can be drawn from the analysis is that teachers should concentrate on and improve children's ability to solve multi-step problems and unconventional problems. One possible solution is to acquire some effective strategies in teaching such as task analysis, metacognition and continuous revisions. Since pupils are generally weak in the application of unitary method (a ratio and proportion concept) in solving 2-step problems involving the concept of equation, specific strategies should be taught to pupils. Problems involving mathematical terms also pose difficulties to pupils. Teachers should ensure that pupils have understood these mathematical terms. The 'model' approach is helpful to remediate pupils weak in this area.

As far as this test is concerned, teachers should pay more attention to pupils who are weak in the following topics:

* open-ended problems involving the concept of equation,
* 2-step problems involving the concept of ratio and proportions or unitary method and
* multi-step problems

Primary 6 Sample

Using the same approach as Primary 4, the following paragraphs summarise the results in a sequence as follows:

(i)   general performance of pupils,

(ii)   pupils' performance with respect to the 6 levels A to F, and

(iii)   the difficulty level of each question.

(i)   General Performance of Pupils

The overall result shows that 54.7% of pupils passed the test. The questions constructed were based solely on the contents of the Primary 6 Module 1. However, when unconventional problems were included in the test, the pupils scored below average on the test. The percentage passes dropped to 36.9%.

(ii)   Pupils' Performance with respect to the 6 Levels, A to F

When the questions of the test were analysed in terms of different skills from A to F, the result shows that approximately 65% of them could manage to pass Skills A, B and C. They did poorly on Skills D and E and badly on Skill F. It could be inferred that this group of pupils is generally weak in multi-step problems and unconventional problems. This result is further supported from additional analysis that 14% of pupils failed the test although they could pass both the Sections A and B of the test. Section C involves only multi-step and deviant problems.

(iii)   Difficulties of Individual Questions

From the results of item analysis, pupils were found to do well on Skills A to C. They are concerned with computation skills in the four operations on numbers and fractions, skills involving equation concept and questions which require understanding of mathematical terms. However, some difficult questions were also determined. Some Skill B questions are different because they require not only the understanding of equation concepts but also multiplication and division of mixed numbers. For Skill C, difficult questions identified require interpretation of mathematical terms and formulation of equation together with understanding of the mathematical terms.

Level D skill is concerned with solving 1-2 step problems. Difficult questions identified in this category usually require pupils to associate and link a few concepts in the process of solving problems.

The result also indicates that pupils are generally weak in solving multi-step problems and unconventional problems.

(iv)   Implications for the Teachers

One implication which can be drawn from the result is that teachers should pay more attention to pupils who failed marginally in the test. Their failures were mainly due to their inability to solve multi-step problems. About 14% are the pupils is in this category.

Teachers should acquire more effective specific and general strategies to help this group of pupils. Such strategies, which were also mentioned in the Primary 4 recommendations, are metacognition, continuous revisions and the use of the 'model' approach.

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