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Designing questions for diagnosing children's difficulties in Mathematics

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Conducting remedial classes to help children solve mathematical problems is not uncommon in most schools. However, a systematic or scientific approach of carrying out the remedial activity is seldom seen in many schools. For example, teachers in many schools may use the same classroom methods of teaching in their remedial lessons. They usually do not carry out any diagnostic tests to determine the actual weaknesses of pupils before embarking on any appropriate methods in their teaching. This article describes two techniques of diagnosis which are based on children's error patterns and task-analysis concept. These techniques may provide some insights to teachers who engage in remedial activities.

Multiple-choice-question (MCQ) Technique

Multiple choice questions have often been designed by specialists in testing to test pupils' achievement in mathematics. They are also used to determine specific weaknesses of pupils. The procedure is to identify and select appropriate responses to MCQ. The selected responses of the MCQ are based on children's error patterns identified from their erroneous solutions. Thus, in order to use this approach for designing MCQ, educationists must have adequate data obtained from the results of the analysis of children's errors in solving some specific mathematics questions. An example is shown below to illustrate the procedure of this approach to construct a MCQ.

An error analysis of pupils' solutions was carried out on a subtraction problem,

$$\begin{array}{r} 675 \\ -\ 298 \\ \hline \\ \hline \end{array}$$

Three systematic errors were identified and the erroneous answers given by pupils were (a) 423, (b) 287 and (c) 973.

(a) $\begin{array}{r} 675 \\ -\ 298 \\ \hline 423 \\ \hline \end{array}$ (b) $\begin{array}{r} 675 \\ -\ 298 \\ \hline 287 \\ \hline \end{array}$ (c) $\begin{array}{r} 675 \\ -\ 298 \\ \hline 973 \\ \hline \end{array}$

Pupils who responded with the answer 423 in (a) did not use the renaming procedure. Probably they did not have the concept of renaming. They merely subtracted a smaller number from a bigger number at the hundreds, tens and ones places (i.e. 6-2=4, 9-7=2 and 8-5=3).

Apparently, pupils who responded with the answer 287 in (b) always "borrowed" from the extreme-left number, 6, when renaming is required. Two "borrowings" were operated at the hundreds place. The value 6 is renamed to 4 and 4 minus 2 gives the value 2 at the hundreds place. At the tens place, 17 minus 9 gives 8 whereas at the ones place, 15 minus 8 gives 7. The answer 287 is obtained.

Many pupils made careless errors in computation. In (c) above, pupils treated the subtraction sum as an addition problem.

Using the three erroneous responses above and the correct answer 277, a MCQ is designed as follows:

The difference between 675 and 298 is

(1) 423 (2) 277

(3) 287 (4) 973.

Apparently, this approach provides an avenue to test designers to construct MCQ for achievement tests. This approach helps the test designers to select alternative choices of item responses which are meant for determining the actual weaknesses of pupils.

"Eliminating-task" Technique

The task analysis concept provides an avenue to help teachers identify pupils' skills which they are lacking. According to the concept, for each mathematical (terminal) task, we may relate a series of subtasks which are contributing tasks to the terminal task. The set of subtasks can also be arranged in hierarchical linear or branched order of difficulties. On the basis of the task analysis, two or more questions may be constructed to check whether some specific tasks have been mastered by the pupils. For example, to add two 2-digit numbers which require regrouping, the subtasks to this terminal task are

(a) addition of two 2-digit numbers without regrouping,

(b) addition of two 1-digit numbers with regrouping, and

(c) addition of two 1-digit numbers without regrouping.

Then with the above objectives in mind, a set of questions are constructed as follows:

(a)	4	(b)	24	(c)	6	(d)	26
	+ 5		+ 35		+ 9		+ 39
	_____		_____		_____		_____

Comparing items (a) and (b), notice that the concept of place value of tens is required in order to work on item (b). The concept of place value of tens is an additional task in item (b) as compared with item (a). Item (c) requires pupils to use regrouping in addition. Thus, regrouping is the additional task included in item (c) as compared with items (a) and (b). Similarly item (d) has an additional task, adding 2-digit numbers with regrouping, as compared with item (c).

Pupils' weaknesses in regrouping in addition computation can be determined by checking and comparing their responses to the set of items above.

Discussion

The previous paragraphs show that questions may be carefully designed for use in diagnosing pupils' difficulties in mathematics. They are not just constructed out of the blue but on the basis of sound educational theory such as the task analysis and the results from error pattern research. For the MCQ technique, teachers are required to be familiar with the error pattern concept in diagnosis and sufficient data should be accumulated over the years so that they may be retrieved whenever the need arises. One short coming of the technique is that during the test a pupil may just pick one of the responses of a question as his answer does not match with any one of the four responses. Under such circumstances, the result of analysis does not reflect on the actual problem of the pupil. However, this short coming may not arise in the case of "eliminating-task" approach. The later approach is task oriented in which a lack of certain skill will be reflected in his responses. This paper discussed two approaches of constructing diagnostic questions which are essentially the underpinning tools for conducting remedial lessons to help children with mathematical difficulties. The erroneous response of pupil to each question could indicate the actual weakness of the pupil. On identification of the specific weakness of the pupil to this question helps teacher to prescribe the correct method of conducting remedial lesson. This diagnosis-remediation paradigm is more effective in helping children with mathematical difficulties than just going through the same topic/problem with the pupil again.

References

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