SOME PROBLEMS IDENTIFIED WITH MAYBERRY TEST ITEMS IN ASSESSING STUDENTS' VAN HIELE LEVELS.

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In the early 80s Mayberry (1981) developed a diagnostic instrument to be used to assess the van Hiele levels of pre-service primary teachers. The test which was carried out in an interview situation, was designed to examine seven geometric concepts. There has been no reported attempt to (a) replicate this work in Australia; (b) consider the items in some alternative format; or (c) analyse the validity of the test questions.

To address these issues, a detailed testing and interview program of 60 first year primary-teacher trainees was undertaken at the University of New England. This paper considers one aspect of the findings of this study. It concerns the potential for certain aspects of Mayberry's work to lead to an incorrect assessment of a student's level of understanding in geometry. In particular, four main features were found to account for major problems to the test validity.

The ability to be able to instruct students at their level of understanding is dependent, in part, on the teacher being able to assess students' levels of understanding. In order to make this assessment, there needs to be available a reliable diagnostic instrument. In the early 80s Mayberry (1981) in her work with pre-service primary teachers, developed such an instrument that could be used in an interview situation. While her work has been used as a basis for other research projects (e.g., Denis, 1987), there appears to have been no critical evaluation of the questions used. Before addressing this issue it is appropriate to provide a brief background to the important ideas underpinning her work.

BACKGROUND

The van Hiele Theory

In the 1950s, Pierre van Hiele and Dina van Hiele-Geldof completed companion PhDs which had evolved from the difficulties they had experienced as teachers of Geometry in secondary schools. Whereas Dina van Hiele-Geldof explored the teaching phases necessary in order to assist students to move from one level of understanding to the next, Pierre van Hiele's work developed the theory involving levels of insight. He identified five levels (Levels 1 to 5) and brief descriptions of these are:

Level 1 Perception is visual only. A figure is seen as a total entity and as a specific shape. Properties play no explicit part in the recognition of the shape.
Level 2 The figure is now identified by its geometric properties rather than by its overall shape. However, the properties are seen in isolation.

Level 3 The significance of the properties is seen. Properties are ordered logically and relationships between the properties are recognised.

Level 4 Logical reasoning is developed. Geometric proofs are constructed with meaning. Necessary and sufficient conditions are used with understanding.

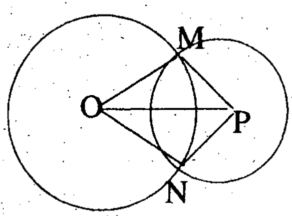
Level 5 The logical necessity of deductive argument is accepted. Insight into the nature of logical laws is acquired.

The van Hieles saw their levels as forming a hierarchy of growth. A student can only achieve understanding at a level if he/she has mastered the previous level(s). Also they saw the levels as discontinuous, that is, students did not move through the levels smoothly. Instead they saw the necessity for a student to reach a "crisis of thinking" before he/she could proceed to a new level. In addition to the descriptions provided above that highlight clear differences between levels, the van Hieles believe that students at different levels speak a "different language" and have a different mental organisation associated with each level.

RESULTS AND DISCUSSION

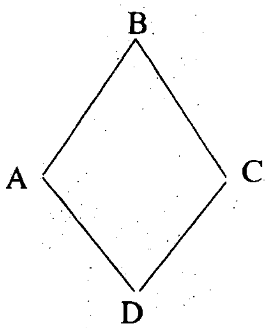
FEATURE 1 (Incorrect assignation of a level to certain items).
Some items did not appear to be measuring the level for which they had been designed. This was identified when large differences were exhibited by students on questions supposedly at the same level. It is possible that some teaching effect or rote learning may have influenced these results but this was not confirmed by interview. An example of this phenomenon can be demonstrated by examining and comparing two of the eleven items which Mayberry designed to test Level 4.

Item 56.



These circles with centres O and P intersect at M and N.
Prove: triangle OMP is congruent to triangle ONP.

Item 55



In this figure AB and CB are the same length.
AD and CD are the same length.
Will angle A and angle C be the same size?
Why or why not?

In Item 56, triangles OMP and ONP are clearly delineated. The solution solely requires identification of three equal pairs of corresponding sides to prove congruency of the triangles. By contrast, Item 55 can be solved by a number of different techniques. One solution to the problem involves the use of congruent triangles. To do this, a decision is needed concerning a suitable construction, i.e., join BD, which will produce the required pair of triangles, (triangles ABD and CBD). The proof of congruency of these triangles then becomes an instrument used within the solution of the problem.

In the Australian study, of the nine students correctly answering Item 56, only three were also correct for Item 55. No student was incorrect for Item 56 yet correct for Item 55. Of these nine students, only three showed competence at Level 4.

The spontaneous recognition of the need to construct triangles before undertaking congruency requires a deeper overview of the power of congruency. This problem begs the question: Is the ability to give a proof of congruency working at Level 4, or only at Level 3? Van Hiele summarises from his dissertation that a student will have reached Level 3 thinking "if, on the strength of general congruence theorems, he (she) is able to deduce the equality of angles or linear segments of specific figures" (1957, in Fuys, Geddes, and Tischler, eds., 1982, p. 239). The very real difference between using the idea when it is apparent and recognising the need to use the idea is highlighted by the comparison of performances for these two Mayberry items.

FEATURE 2 (Unequal treatment of concepts across levels).
The seven geometric concepts used in Mayberry's work do not appear to be treated in an equal manner. Investigation of the results across all the concepts reveals that either the students in both USA and Australia had achieved a much greater understanding of the concept circles, or else the items designed for that concept were not true to level descriptions. In Mayberry's research, of the 33 occasions when a question of a Level 4 standard was asked, 9 (27 per

The difficulties became obvious when students in the Australian sample were able to score much higher on circle questions than on other concepts. This could not be rationalised in terms of greater experience or familiarity with circles.

FEATURE 3 (Uneven distribution of questions across levels).
The test items are not evenly distributed throughout the cells of the matrix/grid. This results in an imbalance between levels within a concept, and has the potential to lead to response-pattern errors. This can best be illustrated through the comparison of criteria requirements for Levels 2 and 3. In her design, Mayberry has allocated between three and seven items per concept to test for Level 3, however, she has allocated only one or two items to test for Level 2. Five concepts, right triangles, isosceles triangles, parallel lines, similarity and congruency, are tested by a single item at Level 2. For example, the most obvious case concerns the concept isosceles triangles. Whereas seven separate items (Items 28 - 32, 42 and 49) test at Level 3, only a single item (Item 18) determines whether or not a student displays mastery at Level 2. Thus the criteria for Level 2 in isosceles triangles is a perfect score, one out of one:

Item 18.
What can you tell me about the sides of an isosceles triangle? _______
What can you tell me about the angles of an isosceles triangle? ______________________________

Should a student have misunderstood the thrust of this single item, answering, for example, "there are three", or "the angles sum to 180 degrees", or have incorrectly answered " they are all less than 90 degrees" (an answer commonly resulting from frequent exposure to acute-angled diagrams), he/she is deemed not to have shown mastery at that level. Often such students can still correctly display mastery of Level 3. Twelve out of a total of twenty-four response pattern errors in Mayberry's results (50 per cent) occur at Level 2.

FEATURE 4 (Unbalanced distribution of question focus within levels).
In the Mayberry scoring, it would appear that a subject can be adversely affected through the lack of exposure to a particular aspect of a form of reasoning. In the testing of the concept 'squares' at Level 3, the notion that a square is also a rectangle accounts for three of the nine possible scores, (see items 9a, 25b, and 42d). Criteria for this level is a score of six out of nine, hence, lack of exposure to the above notion means that a student must score correctly for all other questions in order to register success at Level 3. Should a student not have been exposed to, for example, class inclusion, a Level 3 concept, the Mayberry scoring could assess that student as having mastery only of Level 2. Pegg (1992, p.24) in his investigation of recent research into properties of levels, summarises:

> It is not sufficient to say that a student is not at Level 3 is he/she does not believe a square is a rectangle. Class inclusion is not simply a part of a natural mathematical development. It is linked very closely to a teaching/learning process. It depends upon what has been established as properties. ....The main feature of Level 3 should not, in my view, be the acceptance of class inclusion but the willingness, ability and the perceived need to discuss the issue.

CONCLUSION

This analysis not only gives us a clearer perspective about the Mayberry test and the results, but also provides further insight into the van Hiele Theory itself. In particular it provides further empirical evidence about what it means to work at a particular level.

REFERENCES

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