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HELPING ABORIGINAL STUDENTS TO UNDERSTAND MATHEMATICS AND SCIENCE CONCEPTS

*R.M. Hastie
#D.F. Treagust

Teachers of Aboriginal children in Australia often have the problem of adapting or modifying curriculum materials which have been developed to meet the needs of the average white Australian/ European child. For science and mathematics teachers especially, we believe that appropriate adaptation is essential to ensure that Aboriginal children are better able to comprehend the concepts involved. Many of these concepts at the primary school level involve some aspect of conserving quantities. For example, take a simple experiment where a child is asked to find out whether or not aluminium foil sinks in water. Its flotation, of course, is dependent on shape. The child may roll the aluminium foil into a ball, or flatten it out, and place it in the water. What happens can be observed and discussed and reported. But what if the child thinks this aluminium foil has some unexplainable properties? Maybe it not only changes shape but also its weight! Certainly, on the surface this may appear to be a typical case of nonconservation of weight, but perhaps this is a direct consequence of working with unusual materials and is not a true indicator of mental development!

This paper reports on the principal aspects of a study which involved the adaptation of standard laboratory materials to those found readily in the local environment. We believe that these materials more reliably and validly examine the conservation behaviour of Aboriginal children aged from eight to eleven years. We believe the findings have sound implications for adaptation or development of curriculum materials in science and mathematics. In other words, any science and mathematics taught must contain aspects of familiarity of material and of language if the subject matter taught is not to be seen as trickery, or Aboriginal students are not considered to be poor learners.

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* *Ross M. Hastie, Education Officer, Goldfields Regional Education Office, Kalgoorlie, W.A. 6430*
# *David F. Treagust, Science and Mathematics Education Centre, Western Australian Inst. of Technology, Bentley, WA, 6102*

PIAGETIAN DEVELOPMENT APPLIED TO THE CLASSROOM

The use of Piaget's levels of conceptual development have become accepted and widely used in the development of curriculum materials for use in schools over the past two decades. As an example, the introductory notes of the Education Department of Western Australia's *Primary Mathematics Syllabus* (1978) sets out the stages of development according to Piaget, along with the appropriate chronological age at which each stage should occur. Similarly, the curriculum materials developed for the *Australian Science Education Project* (ASEP) were based on the ideas of Piaget (Ramsey & Dale, 1971). Indeed, many curriculum developers and teachers have gained deeper insights into children's learning from their understanding of Piaget's ideas.

Consequently, the developmental steps of conservation in concrete operational thinking are seen as important integral prerequisites in the transition to logical thinking and formal operational thought. The ability to conserve aspects of number, length, volume, area and weight is viewed as being essential for children to fully comprehend many of their school studies, particularly in the areas of mathematics and science. In keeping with this interest in Piaget's ideas, considerable research has been undertaken in past years to ascertain the levels of conservation development among Aboriginal peoples in Australia. Much of this research has been reported in the literature by de Lemos (1969), Seagrim and Lendon (1980), and Adey (1982).

SHOULD PIAGETIAN TASKS BE MODIFIED?

In most cases of cross-cultural Piagetian psychology involving non-Westernised people, researchers have made slight adaptations to the classical Piagetian tasks in an effort to lessen the effects of cultural influences on task results. Indeed, whether or not such tasks should be adapted or modified for culture-fairness is a matter of debate (see, for example, Ashton, 1975; Berry, 1978; Dasen, 1972; de Lemos, 1969; Goodnow, 1962; Hastie, 1984; Seagrim and Lendon, 1980).

In considering whether or not standard Piagetian protocols should be modified when tasks are presented to Aboriginal subjects, a review of the relevant literature reveals seven major areas of distinct differences between Western and Aboriginal subjects which can negatively affect performance of Aboriginal subjects on standard conservation tasks, rendering results both unreliable and invalid.

These seven areas are:

1) The specific nature of Aboriginal learning (S.Harris, 1977).

2) The absence of verbalization in Aboriginal communication and learning (S.Harris, 1977; J.Harris, 1979).

3) The difference in cognitive context and style between cultures (de Lemos, 1969; J.Harris, 1979).

4) The nature of the language used in everyday life (Graham, 1982; P.Harris, 1981).

5) The interference caused by using two or more languages, one of which is English (Berndt, 1979; Bruner, Oliver and Greenfield, 1967).

6) Cultural and questioning factors (S.Harris, 1977; J.Harris, 1979; Hastie, 1984).

7) Sense of purpose of the tasks as viewed by the testee (S.Harris, 1977; Hastie, 1984).

DECISION: TASKS SHOULD BE MODIFIED!

With these seven areas in mind the first author developed a set of modified conservation tasks and presented these to Aboriginal children aged from eight to eleven years living in the Goldfields of Western Australia (Hastie, 1984). The children attended a Special Aboriginal School, located on the Mount Margaret Aboriginal Reserve approximately 40 kilometres from Laverton, the nearest town. The standard Piagetian tasks for conservation of number, length, area and weight (Matthews, Phillips and Good, 1971) and quantity (Piaget and Inhelder, 1974) were modified with regard to familiarity of materials and questioning techniques. The modifications were based upon observations from administration on a previous occasion of the standard tasks for number, area and weight to a similar group of Aboriginal children. During the presentation of these standard protocols with Aboriginal children it became quite apparent that the tasks were not measuring a true reflection of the children's abilities, or giving a valid insight into these children's mental processes. Consequently, the impetus for the tasks to be modified was to provide a more reliable and valid appraisal of the children's conservation ability.

Previous research has shown that Aboriginal children tend to develop conservation abilities at a later date than their Western counterparts. Many or all of the seven factors cited above may influence the apparent late development; perhaps the difficulty in language comprehension between child and interviewer is of paramount importance, especially where children speak an Aboriginal dialect as their first language and English as their second.

HOW THE TASKS WERE MODIFIED

Consequently, tasks for examining the conservation of number, length, area, volume and weight were rewritten. Rather than attempt to rewrite the questions completely in Ngaanyatjarra, the main Aboriginal dialect of the children being tested, an attempt was made to restructure the questions in English so that greater understanding would take place, and in the hope that the procedure would appear less alien and hostile to the children.

Two local Aboriginal women, fluent in Ngaanyatjarra and relatively fluent in English, were made aware of the aims and methods of the tasks and subsequently agreed to assist in the equivalent translation of the questions in the conservation tasks. The translations were performed in the following way:

- The Standard Question (SQ) is the English generally presented in the standard conservation tasks.

- The Direct Translation (DT) is a translation of the standard question into Ngannyatjarra adhering as closely as possible to the former. This translation of the English question is as a person would attempt to state it in Ngaanyatjarra.

- The Possible Dialectic English Translation (PDET) is a 'retranslation' back into English as it would probably be used within the community.

In some cases, the changes through translation are very slight, and in other cases the global terms used seem relatively imprecise. For example, 'big' for 'bigger'. The inherent concept, however, is assumed to be identical (P.Harris, 1981).

As mentioned, each of the conservation tasks were first modified to include familiarising as opposed to standard but unfamiliar materials. For the *Conservation of Weight* task, plasticene was replaced with 'damper', an uncooked flour and water mixture which when cooked is a staple food throughout the region. All children "grow up" with damper, and are extremely familiar with it and its

properties. Thus, they can relate to it and know of no "magical" properties that it may have in the hands of an experimenter. It is very easy to use, and is easily pounded and rolled into the shapes required in the task.

The translation for the questions in this modified task, measuring for conservation of weight, is given below:

Establishing Equivalence:

SQ: Make these two pieces of damper into pieces that weigh the same.

DT: *nyuma waarrku palyarnu purlkanya*
(damper same make big)

PDET: Make these the same (visual hefting while making statement) or, Make this one big like this one.

The Task Itself:

SQ: Are these two pieces of damper the same weight or is one piece heavier/lighter than the other?

DT: *ngaanys munda waarku ka wandana purlkanyu?*
(this affirmative same or which big/heavier?)

PDT: Are they still the same? (visual hefting) ...

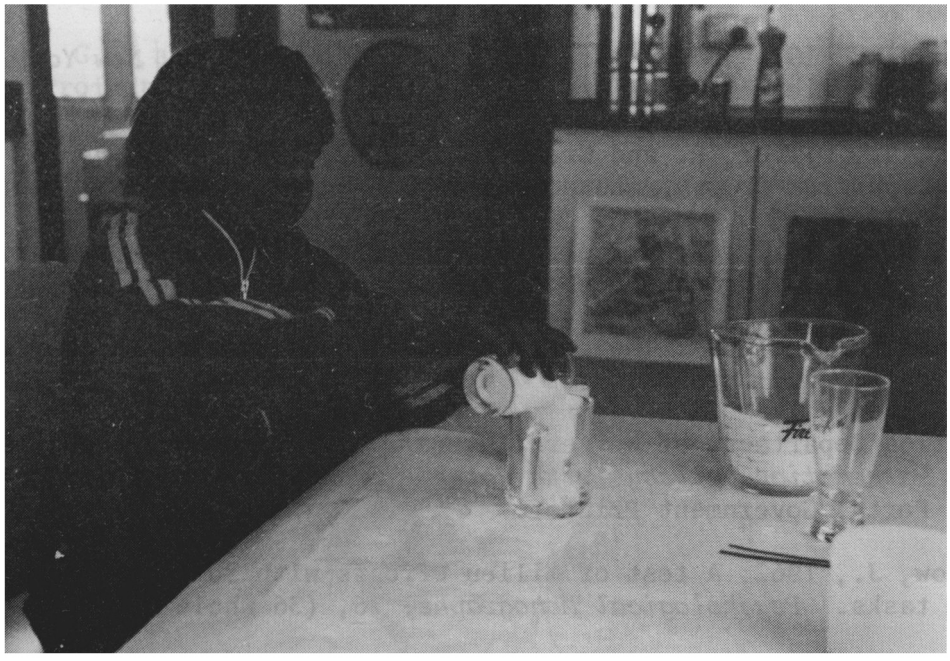
negative reply ... Which one is heavy?

Conservation of Weight task

It is the authors' contention that the modified tasks developed are examining the same processes and require the same criteria to be satisfied as standard protocols. Consequently, the content validity of the modified protocols has not been reduced. Many researchers, including Piaget, (in Dasen, 1972) agree that the flexibility of Piagetian tasks allows for modifications in the interviewing procedures. Test-retest reliability of the modified tasks was found to be very high.

HOW THE CHILDREN RESPONDED

Children being asked questions in the modified tasks were found to be far more relaxed and showed greater understanding of the requirements of the tasks than did children presented earlier with the unmodified tasks. Responses to the questions in the modified tasks, which are described in detail by Hastie (1984), show a much greater proportion of children conserving than on the unmodified protocols. (Copies of the modified protocols are available by writing to the first author.) The implication is that the children show superior conservation ability on the modified conservation tasks since these tasks adequately address both context and language familiarity of the Aboriginal children.



Conservation of Volume task

IMPLICATIONS FOR TEACHING MATHEMATICS AND SCIENCE CONCEPTS

The authors contend that it is essential that the aspects described here are considered when evaluating cognitive performance of Aboriginal children and that such concerns should be addressed in adapting or developing curriculum materials produced originally for Australian students of European background. Certainly, activities in mathematics and science teaching which relate to Aboriginal children being able to conserve number, length, area, volume and area need to be appropriately modified for familiarity of materials and language. The outcomes of the findings reported by Hastie (1984) would appear to support this contention.

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