QUANTITATIVE CONCEPTS, VERNACULAR, AND EDUCATION IN PAPUA NEW GUINEA

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ASSUMPTIONS

1. Effective learning is dependent on the design of an educational programme which takes into account what the learner already knows and can do, which utilizes his conceptual strengths and is framed in a context which is intelligible and familiar.

2. Most teachers and curriculum designers are not trained in field work, anthropology or linguistics so "common sense" approaches are necessary to the design of teaching programmes related to the cultural milieu of the community.

3. Language is an important indicator of conceptual development and environmental perception. The language of a community has evolved to fit the culture in which it exists: the way in which the symbols of a language represent reality must to some extent reflect its native speakers perceptions of their environment and the way in which they cope with it.

AIM

To investigate whether it is possible to collect language information simply and quickly which could be utilized in a "culture-based" approach to curriculum design. To carry out this investigation in the area of quantitative concepts and their use in the development of maths/science programmes in Papua New Guinea.

PROCEDURES

Working with the headquarters staff of the Summer Institute of Linguistics (S.I.L.) a questionnaire was constructed and sent to all S.I.L. field workers in Papua New Guinea. All of the questions could be answered in an open-ended way if the respondents so desired, so responses were not necessarily invalidated by constraining them within a narrow range. Thirty questionnaire forms were returned; of these 26 had been filled in at great length and obviously a lot of care had been taken in completing them. These 26, each representing a different language group, were utilized in the analysis, some of which is described below. Although the questions were mainly linguistic in nature, the main concern of the questionnaire related to educational problems; accordingly most of the analysis was carried out from that viewpoint.

QUESTICNNAIRE

Macrae (1974) in a discussion of quantitative features which are common to all cultures puts forward the following suggestions:

Measuring, set theory (or classifying), Ordering, Counting systems.

These are topics which are contained in practically every mathematics syllabus, for suspecting that a "culture-based" approach to mathematics (particularly in the early stages) might be feasible. This list was subdivided and extended somewhat to give the following specific areas which the questionnaire was aimed at.

1. Measuring

Length; Weight; Time; Speed; Height; Distance; Area; Volume.

All of the concepts listed above are quantitative, and have specific units which enable them to be measured precisely in Western situations. Much of basic maths and science is concerned with the description and manipulation of these concepts.

2. Classifications

Modern approaches to mathematics rely very heavily upon set theory, which is basically a means of classifying objects and concepts according to various attributes which they possess. The basic structure of formal logic can also follow on from such a scheme. So, it is not difficult to see why the ways in which people commonly classify can be of central importance in determining approaches to mathematical and scientific studies. The vocabulary of classifications ("Not All", "Only", "Some" etc) is important too.

3. Ordering

The ability to order objects in terms of a given quantitative attribute (weight, length, volume, etc.) is easily seen to be important, both for the real understanding of the attributes and for the logic underlying the ordering system. Contexts in which initial ordering exercises are framed are going to be important. The vocabulary of ordering - "bigger than", "shorter than", "the heaviest", etc. is also of importance.

4. Counting systems

The "base-ten" system of counting used in Western culture is arbitrary, having evolved on the basis of man's physical characteristics. Alternative systems are equally valid, and where these exist they are of obvious importance for beginning number work.

Causality/Conditionality

In scientific explanation the notion of a regular cause and effect mechanism is crucial. Even in Western societies, where the idea is well-developed, the perceived nature and "strength" of cause-effect relationships tends to depend upon the context. Choosing the right contexts for work could be important in early teaching programmes.

The questionnaire was organised into fourteen short sections, with all sections having a similar format. In the main, respondents were asked to assess how difficult or easy it was to express the sense of a particular sentence (in English) in the vernacular with which they were working. They were asked to rate the ease of translation on a seven point scale from 1 (= easy: short utterances which clearly carry the same meaning as the English expression) to 7 (= very difficult: practically impossible to express in vernacular). In addition, there was room for comment after each item. On occasions, respondents were asked to describe local systems of numerating, measuring length, determining time etc. Some examples of the above are given below, under the headings described above.

1. Measuring

"The two pieces of wood are the same length"

Easy | 1 2 3 4 5 6 7 | Hard

"It takes the same time to build a house as it does to plant a garden"

Easy | 1 2 3 4 5 6 7 | Hard

Are there any commonly used units of length? If so, please list those which you know of.

"The area of A plus the area of B is equal to the area of C"

Easy | 1 2 3 4 5 6 7 | Hard

"The distance between A and B is the same as the distance between C and D"

Easy | 1 2 3 4 5 6 7 | Hard

etc.

Classifications

Are the following distinguishing classifications commonly made in your local context?

1. Living/Dead Yes/No.
2. Natural/Man-made Yes/No.

"All men are living things, but all living things are not men"

Easy | 1 2 3 4 5 6 7 | Hard

"Some guks are nifs; this is a guk, so it might be a nif or it might not be"

Easy | 1 2 3 4 5 6 7 | Hard

etc.

Ordering

These items occured throughout the other sections: e.g.
"A is longer than B".
"It took a longer time to walk from A to B today than it did yesterday".
"He is the biggest man here".
etc.

Counting Systems

Can you describe the counting system which is used locally?

"Two stones plus three stones equals five stones"
"Four groups of three boys each equals twelve boys"
"Half as much"
etc.

Causality/Conditionality

"Event A happened because event B happened".
"Whenever event A happens, event B follows it".
"If and only if event A happens, then event B follows it".

In addition, a few specific terms were aimed at through sentences such as the following.

"The population of the village is increasing/decreasing"
"Not all of the people can go"
"At least three people were killed"

etc.

The largest amount of information collected from the questionnaires related to the way in which various quantities were measured, and how easy it was to describe and operate upon these concepts. Description, understanding and measurement of these concepts occupies a central position in much of the primary and secondary maths and science which is currently taught it PNG. It follows that the extent to which these concepts are developed and the ways in which Western and local parallels might exist is of importance for teachers and curriculum designers. The remainder of this report is concerned with an analysis of the information relating to quantitative concepts and their measurement, and a discussion of how this information might be utilised in the implementation of a more "culturally-based" educational programme.

FINDINGS

MEASUREMENT

When we talk about measuring something, what we are doing is to describe how many times bigger a given attribute of an object is than the same attribute of some "standard". Some common attributes used in measurement are those which have been described earlier: viz: Length, Weight, Height, Distance, Speed, Area and Volume. The results from the questionnaires indicate that not all of these contexts are equally suitable for the teaching of the basic activity of measurement (which is not at all surprising). This becomes very obvious from a consideration of several aspects of the responses.

To start with, we may look at the difficulty rating for the sentences associated with the various concepts, and we find that in general the following broad statements can be made.

(i) Statements relating to the concept of length and weight are made relatively readily in most vernaculars, and this is particularly the case for length.

(ii) Statements relating to the concepts of Area and Volume are made only with considerable difficulty in the vernaculars.

(iii) Statements relating to Height, Distance and Speed are made with middling difficulty.

As an example of this, consider the statement:

"The length of (A) plus the length of (B) is equal to the length of (C)".

Nineteen out of the twenty-six respondents rated this on the "easy" end of the scale.

By contrast, the statement:

"The area of (A) plus the area of (B) is equal to the area of (C)" was rated on the "Difficult" end of the scale by seventeen out of the twenty six respondents.

I t also appeared from the open-ended comments which were made that the use of length and weight measurements (again, length in particular) are far more common than for speed or volume say. Some interesting

comments were made with respect to the various techniques of measurement which are employed. A selection of these is given below.

1. Lengths of cane are used as measuring rods when constructing new houses. The canes are used to measure the intervals between the poles of an existent house, then these measurements are transferred direct to the new house.

(Dadibi/Mikaru; S. Chimbu)

2. (In describing a length measurement) "Put your arm three times and get me a length of wood as long as that" or "double-span" (fingertip to fingertip) three times" etc.

(Rossell Is., M.B.D.)

3. Only relative weights exist - heavy, very heavy, heavy little bit, not heavy, etc.

(Patep. Mumeng, Morobe)

4. Weights of various woods are compared with each other, as are bags of fish and coffee and cases of fish. But it is each man's impression; usually referred to as "heavy" or "light".

(Daga; M.B.D.)

5. (With reference to "Distance") The local unit is "a day's travel" or "a stage", which is not very precise.

(Woodlark Is., M.B.D.)

6. There are terms for: truly fast, fast, no so fast, not so slow, slow, truly slow, stopped. There are no local measurable units of speed.

(Rotobas, B'ville)

7. One can only say (in relation to area) "my garden is bigger than yours" - just by looking at it - but not using units of area.

(Langimar, Morobe)

8. "Size" would be used for area. A statement like the above ("The area of my garden is bigger than yours") would be made after visual observation only. There is no method of measuring the garden area.

(Binumarien, Kainantu)

9. Not possible (to say that "The volume of water is equal to (local units)". Unless you said it was the same as the water of N coconuts or N joints of bamboo.

(Nasioi, Bougainville)

10. The people would not think of (the volume of) a solid rock and liquid water using the same words. A rock's volume is in a different class from the water's volume.

(Korafe, Tufi: N.D.)

Taking these statements as being representative of many others which were made in a similar vein, it is possible to discuss some ways in which the teaching of measurement might arise most naturally out of the cultural background. To begin with, it might be necessary to defend the point of view that teaching programmes should arise out of the cultural frame-work. Knowledge, concepts, learning of any real form can only arise out of a framework of experience. It is pointless trying to explain the meaning of "red" to a man who was previously blind and has just regained his sight. One has to present him with a series of red objects so that he comes to gain the concept of redness. A similar approach can be used to teach the colours, blue, yellow, green, etc. Afterwards, one can explain that "colour" is a generic term embracing all of these primary concepts - but to attempt to define colour before he has experienced the range of sensations would be ludicrous. True, a blind man could be taught that "red" is the "sensory impression which results from light of wavelength about 7,000 A^{o} falling upon the retina" - but such a learned definition is completely meaningless to him since it has no experiential context. This is an extreme example, but it has its potential counterparts in many parts of educational programmes.

If we assume then that a background of experience is necessary to enable any meaningful learning to take place, then two basic approaches are possible within a teaching programme. One can teach so that learning arises out of experiences commonly encountered in the culture or one can neglect the cultural context and provide (or at least make the attempt) the necessary range of experiences as an integral part of the programme. There are problems associated with this latter approach. Probably the most serious of these is that the educational programme is perceived as being totally distinct from "real life" - samting bilong skul - whereas most programmes in PNG (and other parts of the world) are now aiming in the direction of a closer affinity between school and community. A second problem is that in many cases it is possible for dysfunctions to occur between school and community learning; totally different approaches may be brought upon the same problem in the two contexts, without school or community acknowledging the existence of the alternative approach. This must surely lead to confusion and misunderstanding. The arguments for building upon the existent experiential framework are persuasive.

We now proceed with the discussion by noting first that measurement was described, basically, as the number of times bigger a certain something is in comparison with a standard something. (For example, we measure length in terms of a standard metre). Comment 1, above, is interesting in that it indicates that there is no need for a standard unit when measurements of house dimensions are made during this particular building process. The house itself is taken as the standard, and a replica constructed simply by transferring a dimension, marked on a piece of bamboo, from the old to the new. This is a perfectly sensible procedure, so long as one is concerned only with replicating lengths. One would need to be careful in bringing up the concept of a standard unit of length, and its usefulness, in such a context where procedures can function perfectly well without it. Comment 2, on the other handindicates a context in which the concept of a

unit measure of length could very easily be introduced. If the name "metre" were tagged onto the arm length measurement, then one would immediately be into an introduction to the Western system of measurement. There are appropriate and inappropriate contexts where the concept of a unit measurement can be introduced.

Comments 3 and 4 are interesting (and representative of a large number of others) in that they demonstrate the way in which descriptive terms, in a specific situation, can take on the meaning of "absolutes", and in effect become terms of measurement. Now, it is true that we do this in a Western context also and indeed primary maths procedures currently in use in PNG (Mathematics Primary Syllabus: Department of Education, Konedobu) are aimed at teaching the meaning of "long" and "short" and "heavy" and "light" through very concrete procedures. There could be something to be said though for using the situations in which such comparisons are commonly made, before moving onto less familiar and obviously engineered situations. In this way, a link between school and the outside world might become more apparent. Also, one should be at pains to bring out the fact that the terms heavy, long, distant, etc. are comparative to some situational norm which always exists; that is, they are made with reference to some kind of vague standard. This could easily lead into a programme of measurement in terms of standard units.

Comments 5 and 6 also feed into the kind of discussion of the last paragraph. They indicate the sort of trouble which is likely to occur in getting across the idea of fixed and constant units. "A day's travel", referred to in comment 5 is probably the most appropriate distance unit in the cultural context. But, it is going to vary according to the specific journey which one is talking about - and it is very important to bear this in mind if one attempts to introduce the Western concept of distance, particularly in relation to length of journey.

The next two comments, 7 and 8, which relate to Area, indicate quite clearly the kind of problem which one would be likely to encounter in getting across the concept. The concept of area, and its measurement, has simply not developed in almost all of the groups covered by the survey - presumably because it has never been needed. True, the possession of land is of central importance: but size alone is not the only criterion which has to be borne in mind. Fertility, location, terrain, etc. all contribute toward the desirability of a piece of land, in addition to its size. (A study of the Australian real estate market will illustrate a similar phenomenon in Western society). If, then, one is to introduce the concept of area, it would have to be done with these constraints borne in mind; a context where area was the prime factor would have to be chosen. A couple of interesting teaching suggestions were made.

"Perhaps it could be taught in terms of how many coconuts could be planted, since these are almost always planted at regular intervals" (Nasioi; Bougainville)

(Area could be taught in the context of) Number of potato rows, and number of vines planted in each" (Kewa; S.H.D.)

Both of these suggestions are interesting in that they indicate that direct analogies between local and Western schemes do in fact exist. In the first suggestion a "coconut space" is a standard (and fairly fixed)

unit of area, while in the second there is a direct relationship with the measurement of area by "length times breadth". These relationships might well be used in teaching strategies.

The last two comments point out the similar difficulty which exists with the volume concept. In general, the concept of volume as "space occupied", regardless of what occupies it, is not needed in village society, and this is clearly indicated by comment 10. So, one would need to be careful in the introduction of the generalised concept, and a more gradual approach, using liquids in the manner indicated by comment 9 might be more valid. Another similar teaching suggestion was received:

"(Volume could be taught) in terms of metal cooking pots of water or in terms of varying lengths of bamboo tubes, with bamboo tubes, both length and diameter could be variables easily maintained and measured"

(Rotobas: Bougainville)

" A cooking-pot full" is a perfectly respectable unit of volume, and the bamboo tube is as close as one is likely to get to a graduated measure found in laboratories. In general, what is being suggested is that there are a great variety of possible starting points from which one can take off, in any teaching programme; and it seems to make sense that the starting point should be one which is already familiar and comprehensible to learners. Eventually, of course, one has to leave familiar situations with which learners are acquainted; but the transition is eased by at least starting off on common ground. This principle of moving from the known to the unknown or from the relevant to the less relevant is well illustrated by the following comment which was received.

"Coffee growing has made a start as a cash crop. The people are being paid according to the weight of their coffee, and this is for most the only encounter with the Western "weight" concept. It is a meaningful context, as they are being paid for labour and the labour is concretely expressed in the weight of the bag of coffee beans. They are intimately acquainted with the fact of the bag's weight, having carried it for miles! Some have the feeling that they may be getting cheated by those who do the coffee buying, since the sellers do not understand the system of weight"

(Dadibi/Mikaru; Kainantu, E.H.D.)

Having set up the principle that teaching programmes (particularly in adult education and early primary) should start off from the culturally kown known, the next sections indicate which situations are likely to be easy and which difficult, through an analysis of respondents' ratings of the ease of utterance of various sentences. The figure in brackets following each sentence is the weighted mean "difficulty" score which was attached to each. A score of 1.0 indicates extreme ease, while 7.0 indicates very great difficulty. (For example, (i) below scores 6.0 and is thus rated as being difficult, while (iii) rates a score of 1.2, and is thus considered to be quite easy).

Length

(i) The length of the piece of ground is (local units). (6.0)

(ii) The length of the pole is nine feet (accepting that people will not understand "nine feet"). (3.7)

(iii) The two pieces of wood are the same length. (1.2)

(iv) The length of (A) plus the length of (B) is equal to the length of (C). (3.1)

(v) A is longer/shorter than B. (1.5)

The sentence which is rated as being most difficult is the first, and this is entirely due to the fact that very few generalised length units exist in PNG societies (although a few rough measures do exist within specific contexts). Among the few general length units reported were the following:

Wagu:	40' - 50')	Daga, M.B.D.
Sewa:	4' - 6')	
Kiksi:	5' -	Faiwol, Kiunga. W.D.

In addition , a number of respondents reported measurements based upon body dimensions; e.g.-

long as your arm (	28")	
long as your leg (	35")	Rossell Is; M.B.D.
long as your finger (	$3\frac{1}{2}$")	

In general the rest of the sentences were not rated as being too difficult, and the main conceptual difference as compared with the Western, seems to be in either the absence of units, or of their being vague and non-unique where they do exist. For example, for Kamono-Kafe in the Eastern Highlands, the four "units" of length are "short" "like-short" "like-long" and "long", and similar adjectival units were reported from other areas. The difficulty which is likely to be encountered in introducing the invariant nature of units is well illustrated by the following comment.

"In teaching (length) the teacher should be aware of the local concepts. The fact should be stressed that the units of length, area, etc are constant and not just relative ; i.e. a foot is an exact length and is always the same length" (Mumeng, Morobe District).

These remarks concerning the unique nature of length units are also applicable to measurements of other attributes of objects, such as weight, volume, etc.

Weight

(i) The weight of the object is (local units) (5.9)

(ii) The weight of the object is 5lbs (accepting that people will not understand 5lbs) (4.3)

(iii) The two stones are the same weight (1.2)

(iv) The weight of the man is equal to the weight of the rock (2.6)

(v) The weight of (A) plus the weight of (B) is equal to the weight of (C) (2.9)

(vi) A is heavier /lighter than B. (1.7)

As with the concept of length, it is the idea of a generalised unit which gives the most trouble, and no weight units per se were reported. A few measures such as "As much as a man can carry" or "As much as a bag of sweet potato" were commented upon, but these are even more vague than the length measures which exist. For example, a list of weight terms confined to "heavy; a little heavy; light" as reported from Kiunga in the Western District is typical.

In addition, these adjectival terms can only apply to a specific context, and as such are being made implicitly in terms of a situational norm. For example, if we say that the bag is heavy, then we must have some kind of typical bag in mind to compare it with. This works perfectly well within familiar situations, but one is lost when it comes to describing weights in an unfamiliar context. In this case a generalised standard is needed. PNG culture in general lacks such a standard (because it has never been needed), and the introduction of such a concept would best be framed in a situation where it was seen to be useful.

Speed

(i) A runs faster/slower than B. (2.1)
(ii) A runs at the same speed as B. (2.6)
(iii) The pig can run twice as fast as the boy (6.7)

The third sentence is rated as being extremely difficult to translate accurately into vernacular; the main point which is made is that the exact quantitative relationship is just about impossible (and this holds for measurement of the other attributes too). To say that someone is running faster than someone else is relatively easy, as the difficulty rating for (i) indicates, but to quantify this further is very difficult. Some respondents showed considerable inventiveness in framing the translation in a way which would be intelligible.

"If you ran from here to the house, the pig could run from here to the house and back here in the same time".

(Kewa, S.H.D.)

"The pig running and reaching the water could return. And the boy could (just) reach the water.

(Nasioi, Bougainville)

This kind of discussion involving different distances travelled in a fixed time could be used as the basis for getting over the idea of comparative speeds. Certainly, there are considerable difficulties associated with this concept (in its Western sense) and this is well illustrated by the respondent who writes:

"Speed can only be expressed in general terms: ie, fast, very fast, slow, very slow. Lacking a unit of time and a unit of distance, there is no real way to express speed; hence no local unit of speed".

(Dadibi/Midaru; S. himbu)

It is interesting to note that in a large percentage of the vernaculars sampled, there was no comparative construction. This means that the idea of "faster than" (or "longer than", "heavier than", etc) may not have quite the same meaning as it does in English. Consider the following two examples, which are representative of comments made about sentence (i).

No comparison construction. "A runs fast. B runs slow".

There is no comparative degree in Binumarien, so the statement is not a concise one. However, it may be expressed as:

"A is a great runner - he is above B".

Now, the literal translations given above do not have exactly the same meaning, in English, as the original. First language speakers of English would agree that "A runs faster than B" has a different connotation from "A runs fast, B runs slow". It is interesting to note that attention has already been drawn to the "absolute" interpretations which Papua New Guinean students tend to place upon purely comparative statements. (Jones, 1972). In a discussion of the way in which PNG students responded to an item involving the word increase, the following statement was made.

"All it (ie. the sentence containing the word "increase") indicates is that population is now greater than it was some time previously, a fact which was understood perfectly by the first language sample - all responded correctly to the item. The second language sample, on the other hand, impose the extra implication that (a) the previous population was small and/or (b) the present population is large, and answer accordingly."

This imposition of the extra implications referred to above could possibly arise out of the fact that some of the respondents had first languages which contained no comparative construction. Hence there could be this tendency for purely relative constructions to be viewed in more absolute terms.

Height

Are there different words for "height" and "length"?	))	Yes - 9 No -17
Is "height" expressed differently from "distance"?	))	Yes - 11 No - 15

(i) The height of the tree (as apposed to length) is (local units). (6.1)
(ii) The two men are the same height. (1.8)
(iii) A is higher than B. (1.8)

It appears from the answers to the first two questions that in many cultures in PNG height is not distinguished from length. Going a little deeper into the replies though, one finds that distinctions are usually drawn (and indeed it would be rather surprising if they were not). However, one would need to be rather careful, in many situations, in

drawing distinctions between or comparing length and height measurements. The comments below speak for themselves.

A thing "goes up" for height, but is not really in contrast to the term for long; ie. either can be used for tall, but not both for long.

(Bena Bena, Goroka, E.H.D.)

Height and distance are not abstracts in the language. Neither is heard.

(Usarufa)

If an object is in contact with the ground, like a tree it is the same (as "length"). If separated by a space, like a plane, it is a different word.

(Woodlark Is; M.B.D.)

Length measured horizontally is measured as short, medium, long, etc; while height vertically is expressed as "its leg is short, medium, long etc."

(Patep, Mumeng, Morobe)

It is easy to say that two men are the same, but it is difficult to specifically indicate the idea of height.

(Aiua Kainantu, E.H.D.)

Often the two terms (for height and length) are mixed, so that length can also mean height - but not vice-versa.

(Daga, M.B.D.)

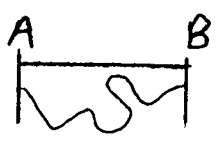
To get across that you were comparing height you would have to say - "these two men are the same. They are tall/short".

One comes up against exactly the same kinds of problem concerning units of height as one does with units of length. Usually they do not exist. A couple of respondents reported that referents, such as a length of bamboo, are used to transfer a height dimension from one location to another; this is in contrast to transferring the dimension in terms of a standard unit (such as a foot or a metre).

Distance

Is it possible to distinguish between distance "as the crow flies" and the distance from one point to another as one must travel between them?

Yes - 9
No - 17



(i) With reference to the diagram above how easy is it to say concisely:

"The distance between A and B remains the same, no matter which of the two paths one takes". (5.6)

(ii) The distance between A and B is (local units). (5.8)

(iii) The distance between A and B is the same as the distance between C and D. (3.2)

(iv) The distance between A and B is less than/greater than the distance between C and D. (3.0)

(v) A is farther away/nearer than B. (2.2)

Referring to (ii) we see that, as for the other attributes, it is difficult to specify a distance accurately, since no local units exist. The following two comments illustrate this quite well.

We can only say "as far as such and such a village from here"

(Rossel Is; M.B.D.)

The local unit is "a day's travel" or "a stage", which is not very precise.

(Woodlark Is; M.B.D.)

The high difficulty score given to the first sentence indicates that the distinction between "straight line distance" and "travelled distance" is hazy. This is not really surprising, since the concept of distance as "distance travelled" is far more useful in PNG cultures - and in most cases too in Western society. One respondent makes this point well:

The idea of distance is relevant only to the paths that must be travelled, so the distance between A and B depends upon the path.

(Patep, Mumeng, Morobe)

And this idea of the evaluation of concepts in line with perceived usefulness in the environment is illustrated beautifully by the following comment which refers to "distance as the crow flies".

Yes. (it would be easy to get the concept over) if you could convince them first that it is meaningful to talk about distances "as the crow flies". What good does a measurement do them? In our culture (ie. Western) no-one ever travels directly through the earth, so no distances are ever recorded as chords of the earth's circle, even though that would be the "real" distance.

(Nasioi, Bougainville)

This highlights very nicely the difficulty which is likely to be experienced in teaching concepts for which no use can be seen, and which do not arise out of experience. As the man remarked above, teaching distance between New York and Port Moresby as distance in a straight line through the earth would be rather ludicrous and somewhat confusing. However, the fact remains that "crow-flight" distance is a useful concept in many Western situations - but this concept is probably best left until it arises naturally out of a contest where it does have meaning. Air travel is an obvious example; and indeed this has had an effect in some places.

Our people do understand Plane Travel straight from Tufi to Wanigela

as opposed to the circuitous canoe trip. The word dambu can be used to indicate straight.

(Korafe, Tufi; N.D.)

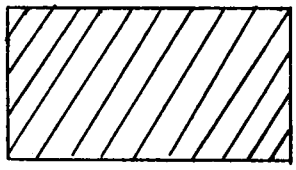
In some societies, the concept is obviously very well developed, as the following comment shows.

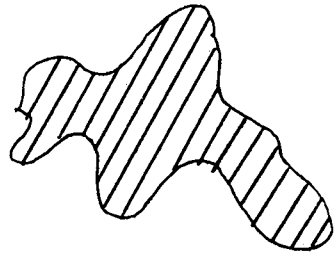
"If we went straight, the distance to go from A to B, or to go from C to D; their distance would be the same". ie. this distinguishes distance from length of the roads between places".

All one can say in general is that any effective educational programme which introduced western concepts of distance measurement would have to be aware of local concepts, and the programme would need to be planned accordingly.

Area

(i) The area of the garden is (local units). (6.6)
(ii) The areas of those two gardens are the same. (3.6)
(iii) The area of my garden is bigger than the area of yours. (3.3)
(iv) The area of A plus the area of B is equal to the area of C. (4.9)
(v)





"The areas of the figures are the same, although the shapes are different". (5.2)

The overall impression which one gets from the difficulty ratings is that the concept of area (in the Western sense) is handled only with difficulty. There is certainly nothing which approaches a unit of area, although - as was pointed out earlier - the "space needed for one coconut" or something similar could serve as a unit of area. As the respondent put it:

The best context (for teaching Area) would be garden size or cocoa plantings' size; related to number of trees per unit area.

(Rotobas; Bougainville)

A few comments will give some idea of the state of development of the concept in most of the groups covered.

One can only say "the two gardens are the same". This is ambiguous, as it might refer to fertility as well as size.

(Aiua; Kainantu. E.H.D.)

It's the concept that is difficult. One can say all these things in some way, but it is doubted in fact.

It could be said (ie. that the two gardens are equal in area) but it would always be debated.

(Bena Bena, Goroka; E.H.D.)

This last comment is interesting in that it does indicate a context in which a measure of area would arise naturally, and would be seen to be useful. An effective teaching strategy might arise out of this. Another respondent made this point well when he wrote:

Although at present there is no shortage of land, the situation will change if Chimbus are allowed to re-settle among the people. Then the matter of area will become more meaningful, and could even now be a good frame of reference.

(Dadibi/Mikaru; S. Chimbu)

It seems as if it is the area of land through which the concept could be most easily and validly introduced (this suggestion was almost unanimous), but there were some other suggestions too, such as from Rossel Is., where it was suggested that the area of different sails would be a meaningful context.

Volume

(i) Are there terms which express the volume of:

(a)	A block of wood.	Yes - 2, No - 24
(b)	An amount of water.	Yes - 8, No - 18
(c)	A rock.	Yes - 0, No - 26
(d)	The amount of space in a house or other hollow object.	Yes - 2, No - 24

(ii) The volume of this stone is equal to (local units). (7.0)
(iii) The volume of the water is equal to (local units). (6.8)
(iv) The volume of liquid in the two vessels is the same (4.3)
(v) The volume of the rock is equal to the volume of the water. (6.8)

(i) shows that with the exception of some terms for volume of water, the volume concept is almost totally absent from the sample of vernaculars. In addition, (ii), (iii) and (v) are all rated as being so difficult as to be almost impossible. This is not too surprising, since volume (as opposed to length or weight say) is a concept which can easily be done without in PNG societies. This is particularly the case for the abstraction of volume from two very different substances like rock and water. As one respondent wrote with reference to (v).

This kind of comparison does not exist, there being no reason for it.

(Binumarien, Kainantu; E.H.D.)

The idea of volume in relation to liquids is more immediately useful than it is in relation to solids (as far as most PNG people are concerned

anyway); so this is probably the best place to start. If one wants to develop the idea of volume as a general attribute of all materials, then the following comment - with reference to (v) above - should certainly be borne in mind.

If the container holding the water was obviously similar in volume to the rock, it would help. If the rocks were spherical and the water were in a thin bamboo, for example, the idea would probably be lost.

(Dadibi/Mikaru; S. Chimbu)

TIME

Time conceptualization is rather different from the other concepts (length, volume, etc) which have been so far dealt with, in that it represents a much less tangible entity. Even so, the quantitative aspects of time are of importance in many educational programmes and differences between Western and local systems could lead to problems for learners.

(i) All respondents reported that words or phrases existed in the vernaculars for the following time periods.

A. Two years.
B. Three months.
C. Two weeks.
D. Three days.

Years are reported as being measured in terms of (a) planting seasons (b) festivals (c) natural phenomena. For example:

(a) Year is equal to a "taro cycle" (Salt-Yui, Chimbu).
(b) Year = sing sing festival (Kewa; S.H.D.).
(c) Year is the same work, as the low-tide season, as the low-tide season comes each year. (Rossel Is.; M.B.D.)

Months are almost without exception equated with the phases of the moon; frequently "moon" and "month" is represented by the same word.

Weeks are in many cases represented by the imported pidgin word "wik"; in other cases it is referred to in terms of a specific day of the week: e.g.,

Two weeks = two Saturdays (Dadibi/Mikaru; S. Chimbu).

Days are usually referred to in terms of light/dark. e.g.

day = "sun-time" (Salt-Yui; Chimbu).

In answer to the question:

"Is there any countable unit of time smaller than the day?"

most respondents replied in the affirmative. However, from the examples which were given it became clear that what was being referred to were specific points in time, rather than a unit of time. In many cases, the day is divided up into a series of "time zones" which shade one into the

other. The complexity (or otherwise) of some of these is indicated by the example below.

Kamano/Kafe; E.H.D.

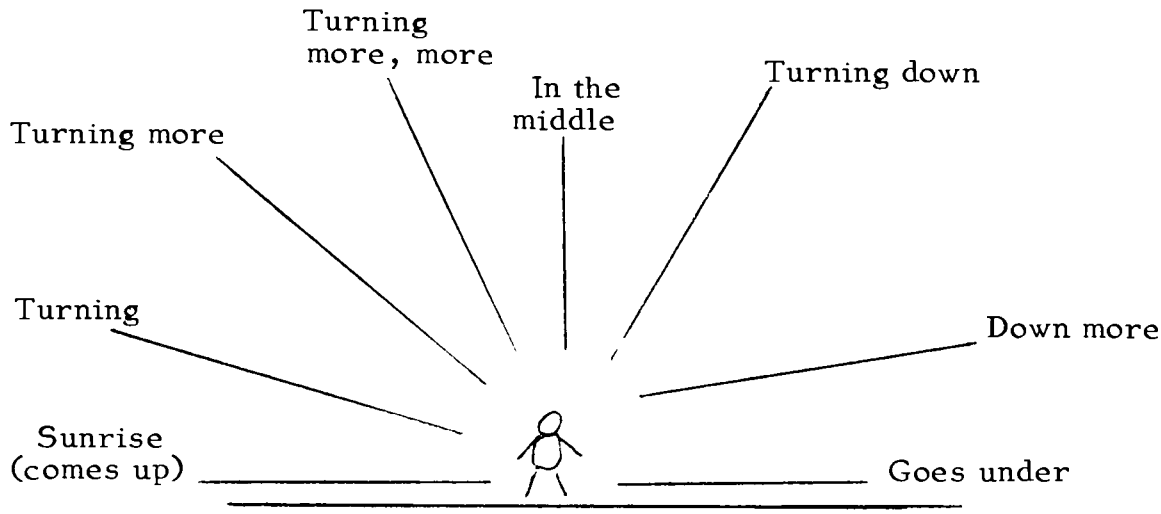
day light/sun up just morning sun rises		Till about 10.00 a.m. - morning
midday	10.00 - 2.00 p.m.	
sun turns	3.00 p.m.	
sun dies	5.00 - 6.00 p.m.	
dark	7.00 p.m.	
night	from bed-time onwards	
trying to light	3.00 - 4.00 a.m.	
about to light	5.00 a.m.	early morning
light	6.00 a.m.	

Woodlark Is.; M.B.D.

There are only terms for Morning, Afternoon and Night.

Kewa; S.H.D.

Time is judged by the position of the sun in the sky; now equated (in some sense) to points on a clock.



Given below are respondents' difficulty ratings for various sentences involving time concepts.

(i) It took a long time to build the house (2.1)
(ii) It took a short time to walk there (2.4)
(iii) At what time did you get there? (1.7)
(iv) I got there at (point in time) (2.5)

(v) I went there two months ago (2.0)
(vi) I will go there in two days' time (1.5)
(vii) In the past, I lived in that house (1.0)
(viii) In future, I will do as you say (1.1)
(ix) It takes the same time to build a house as it does to plant a garden (3.5)
(x) Yesterday I walked from A to B, today I walked from C to D, and on both occasions I took the same time (4.5)
(xi) I dropped the object and shouted at the same time (1.2)
(xii) Event A in location 1 and event B in location 2 occurred simultaneously (2.0)
(xiii) It took a longer time to walk from A to B today than it did yesterday (3.2)
(xiv) Doing activity A and then doing activity B takes the same time as doing activity C (4.2)

Overall, the sentences which deal with points in time, the past and future are rated as being quite easy to express. It is only when we get the concepts involving length of time, in a fairly specific quantitative sense, that difficulties arise. The following two comments are fairly typical:

(With Ref. to (x)). "The road is the same; cannot say that the time is the same".

(Kamano/Kafe, E.H.D.)

(With Ref. to (xiv)). This can be said, but it's awkward. If it is in units smaller than days, it's hard to express that it is the times which are being compared rather than the kinds of activities.

(Patep, Mumeng; Morobe)

The concept of simultaneity is easily handled by all of the vernaculars, and this is the case even when the events referred to occur in separate locations; several respondents indicated the existence of verb tenses which denote simultaneity. However, this is certainly not true in every case, e.g:

(With ref. to (xii)). "Only possible if both events could be described as near each other geographically".

(Bena Bena, Goroka, E.H.D.)

(With ref. to (xii)). "Event A happened and event B happened." The conjunction used indicates that they were either closely-related activities or were happening at the same time.

(Patep, Mumeng; Morobe)

From a number of responses it appears that "time" and "distance/space are often treated as the same basic concept. This does not lead to difficulties so long as communicators have a common understanding of a "normal rate of travel"; but, it can obviously lead to misunderstandings when a new context, with speed unknown, is encountered. This phenomenon is exemplified by the following responses.

(Ref. to (ii)). They would say "the road is short".

(Daga, M.B.D.)

It is possible to say these things ("it took a long time - - - -" etc) but only in relation to the normal time it takes to walk such a distance. A stranger to the culture would not understand.

(Binumarien, Kainantu; E.H.D.)

You would tend to talk in distance terms rather than time.

(Korafe, Tufi; N.D.)

(Ref. to (x)). Literal translation as follows:

"Yesterday from A to B I -reached. And today from C to D I-reached. Same reach-part to-feel/experience". (The two trips felt same in distance - both "time" and "space" are measured by "distance").

(Nasioi; Bougainville)

An appreciation of this perceived equivalence of distance and time (and the effect which this is likely to have upon the "speed" derivative) would be essential for any educational programme which sought to make use of these concepts. The almost total absence of a general unit of time (shorter than a day) - as opposed to distinct points in time, which are numerous - would also have to be taken into account. Insofar as units of time of the order of days, weeks or years are concerned, there does not appear to be any conceptual difficulty. Problems are more likely to occur when relatively short periods of elapsed time are considered. The area of "historical" time was not tapped in this survey; any conceptual difficulties associated with this domain are likely to be of a different kind, since it is outside peoples' direct experience.

DISCUSSION

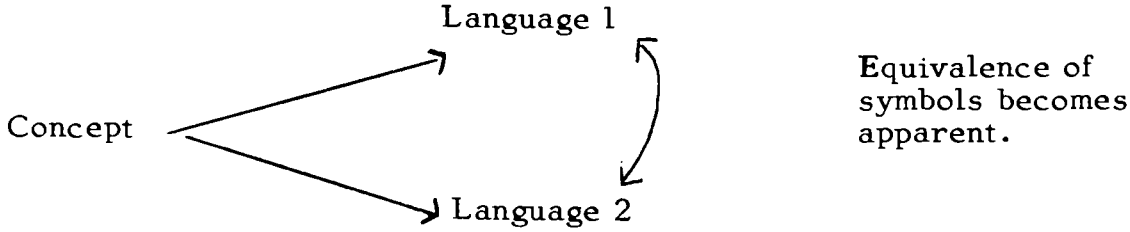
There have been a number of investigations within Papua New Guinea dealing with conceptual difficulties encountered by students throughout the educational system (e.g. Kelly 1971a, 1971lb, Prince 1969, Jones and Wilson 1972, Jones 1973). The purpose of this discussion is not that of spending a considerable time in synthesising previous work in the light of this report. There is no need, since the basic results of this earlier work can be summed up in a nutshell:

Students experience difficulty in dealing with Western science concepts, and are several years "behind" their Western counterparts.

It is important that teachers are aware of this fact, otherwise they would be making assumptions concerning their pupils which were totally unfounded. However, a recognition of the problems is not the same thing as a solution (though it is an obvious first step), and indeed it may be the case that a solution is not going to be easily located within the present structure of education in PNG. In order to amplify this last statement some consideration has to be given to the way in which culturally foreign material is digested - and a useful point at which to begin is that of the learning of a

second language.

Any language is a symbolic way of representing reality, and spoken or written forms of the language all have their referents in real-life experience. Consider, for example, the very simple concept of "girl". The word serves simply to represent a class of things which we know from life, and Madchen or Merched (in German or Welsh) serves equally well as a symbol. In effect then, learning a second language consists of learning new symbols for concepts which already exist for the learner. We can represent this process in the way shown below.



This can only work, of course, if the concept for which a new symbol is being learned exists in equivalent forms in the two cultures. If it does not, then the process becomes more complicated, and confusion is likely to occur. Bulmer (1971) makes this point well when he writes:

"Probably they (non native-speakers of English) assume initially that an English term has more or less equivalent referents to some term in their own language - the elementary pitfall of all learners of a second language. If it doesn't, confusion and loss of confidence in the use of the term then follow".

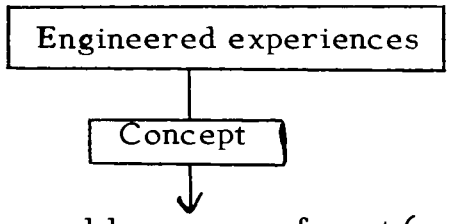
Dart (1971) puts forward an interesting suggestion for the teaching of "foreign" science concepts, by drawing an analogy between this and second language teaching. He writes:

"It seems to me that early science (should be offered) as a "second culture", valid in its own right, and taught in much the same spirit as a second language is taught. When an Urdu speaking boy or girl begins to learn English, there is no suggestion that Urdu is wrong, nor that English will totally replace his native Urudu. --- Science taught in this spirit as a "second culture" can be learned without the stress or conflict set up by attempts to unlearn an alternative set of relationships".

One feels bound to agree with the sentiment that a traditional body of concepts should not be devalued by the introduction of a Western system. Particularly since the concepts which are in existence have evolved in response to the needs of the community, its environment and its culture. But, whether one could effectively teach people to have the two systems existing side by side is rather more doubtful, and the language analogy rapidly breaks down. A more fruitful approach would be that of starting from "first culture" concepts, and moving to "second culture" alternatives through situations where the former are inadequate. In this way no devaluation would occur and the two systems could be viewed as an integrated whole with different interpretations applying in appropriate contexts.

Consider a fairly typical programme which might take place in a school

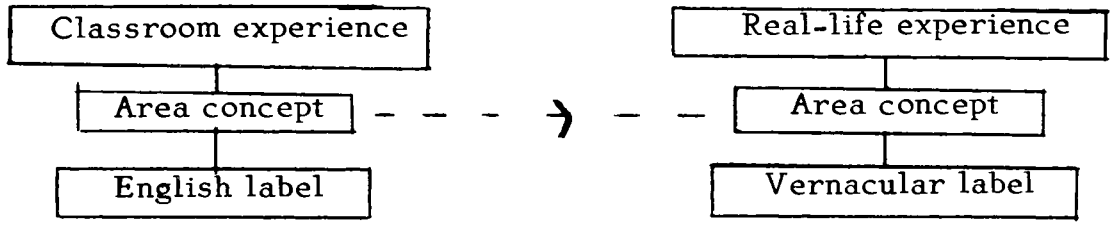
in Papua New Guinea, aimed at teaching some concept. (it could be "Area", "cubic centimetre", "bigger than", or anything similar). In the worst kind of teaching situations, the presentation is entirely chalk and talk - or just talk - and learners then have no hope of grasping what is being broached. A better approach would first of all involve the students in some activity, and out of these experiences an attempt at deriving the concept would be made. We can represent this approach schematically, as below.



This approach is perfectly respectable, but it has a number of drawbacks, some of which are listed below.

(a) learners' out-of-school experiences are almost entirely untapped.
(b) it is doubtful whether a sufficient experiential framework can be provided in the, usually, very short time available in the formal school situation.
(c) the learning which has taken place is meaningful only within the context of the school.

If one attempts to overcome drawback (c) by referring to the situation existing outside the school, then confusion is likely to result, simply for the reason that one is drawing parallels when it is very likely that equivalent referents do not exist (c.f. Bulmer's point above). Take a concrete example concerning the concept of "area". Kelly (private communication) has reported that in the Enga district the size of a piece of land is characteristically determined by measuring the length of two sides (in terms of some rough standard). The nearest approximation to "area" in the local culture consists of these two measurements. At the same time, students learn that area in the Western sense in defined in quite different terms, and they will normally have acquired the western concept (to some undefined extent) by activities involving sheets of paper or card. Now, to draw parallels between the "school" concept of area and the "cultural" concept is only to invite confusion, since no real parallel exists. To move from the classroom situation to the real-life context would be a long and painstaking job. It is possible to represent the problem as below.



Since the two area concepts are not the same, then the comparison can only lead to confusion, and certainly there will be no reduction in the compartmentalization of classroom and real-life experience. It follows too that the English word "area" cannot serve as a generalized label, but

will be confined to the specific classroom context. This is totally in line with the "learning without understanding" phenomenon and the inability to transfer knowledge and skills across contexts, which so many teachers complain of.

Suppose that instead of providing classroom experiences for students and extracting concepts from these, we started off by talking about the local concepts in English. Essentially, this would be an English learning exercise, since what one would be doing is to attach different labels to concepts which already exist for learners. In this way, a vocabulary of terms would be built up.

Succeeding stages of the teaching process would then consist of moving students from the cultural concepts to the Western concepts in contexts which are seen to be meaningful. Take the area concept as an example: practically all respondents reported that it is in relation to the size of pieces of land that this concept would have most meaning. So, it makes sense that the teaching of area should begin in relation to blocks of land (rather than with sheets of paper). If a system similar to that of the Enga, quoted above, is in operation then this system could be used initially to determine the areas (local-style) of various pieces of land. To break away from this system of area-measurement one would have to demonstrate that it did not work effectively in certain situations - because if it works effectively all the time, then why on earth should one want to change it anyway! This would be very easy to arrange in the above situation. It would be possible to take two gardens - one triangular and one rectangular for example - which had the same areas in local terms, and yet one of which yielded far more produce than the other. Ways of resolving this dilemma could be discussed, and it might turn out that the food production of the garden (c.f. the number of potato mounds suggested as a unit, in the section on measurement of area p. 32) is decided upon as an alternative measurement of size or area. From this it is only a short step to defining a unit of area as something like the amount of ground needed to generate x produce, which could be eventually defined in terms of length: and now we are talking about something which is very close to the Western concept of the measurement of area. To get from this point to a generalised concept of area, applicable to land, sheets of paper, pieces of cloth, etc, is still not easy and would have to be taken slowly. But, in terms of the very sound principle that one can only meaningfully move from the known to the unknown, students would seem to stand a much better chance of grasping the general concept when proceeding in this direction, rather than starting off in the artificial environment of the classroom.

One suspects strongly that the present structure of education, where students are extracted from their framework of real-life experience in order to learn, exists because it is superficially efficient. It is relatively easy to train a body of teachers to act in a specific way in an idealised and largely artificial environment; i.e. the classroom. Prescribed practices can then be carried out, and an appearance of meaningful activity easily maintained. However, severe doubt exists as to whether these procedures constitute, in general, an effective learning environment. In addition to the studies quoted earlier in this section, some unpublished work by Williamson (1974) is interesting for the way in which it shows how even a very well-designed and trialled programme can lead to minimal learning on the part of the students. Williamson investigated the extent to which standard 6 primary school pupils who had taken the TPPS phase 3

primary science course (almost certainly one of the best-designed programmes ever introduced in PNG) had understood the concept of volume and its measurement. He used an individual testing technique, where on pupil at a time was asked to carry out specific operations which would demonstrate an understanding of what had been covered in the course. The vast majority of the pupils performed dismally; in general, there was no understanding of the concepts which the programme had been aiming at, and there was a lot of confusion concerning activities which had been specifically covered in the programme. (It's worth mentioning that this investigation was carried out in an urban, demonstration school, where the execution of the programme was likely to have been far superior to that at an average primary school).

Some possible reasons for this failure of the programme are as follows:

(i) The amount of experience which it is possible to provide for pupils within the classroom is insufficient to enable them to derive the concepts which are being aimed at. At most, pupils spend about 45 minutes per week in handling materials and carrying out activities related to the science programme. This is a tiny drop in comparison with their real-life experiences.

(ii) The majority of the activities which are carried out are not meaningful in terms of life outside the classroom (a failing of most educational practices). Most of science and mathematics which is taught in schools in PNG only impinges on the fringes of life as most Papua New Guineans lead it. It is only possible to learn effectively when what is being learned is seen to be of use and to fit into a broader framework of experience (c.f. the comment made with regard to "distance as the crow flies"). Moving from the known to the unknown would consist of placing learners in a context where the known was no longer capable of dealing with the situation (as in the "area" example quoted above).

(iii) Many of the concepts - particularly the basic science concepts with which this report has been concerned - which are taught in schools are at odds with the concepts which exist and are useful outside school. (A host of examples of this originated out of the questionnaire replies). It would not be surprising if this led to confusion in the minds of the learners.

If one is to adopt an educational strategy which seeks to capitalise more upon the actual experiences of the learners, out side the classroom situation, then a radical shift of emphasis in teacher training is needed. Rather than the initiating of teachers into the mechanics of a well-defined syllabus, the training programme would have to concentrate upon turning teachers into "action researchers". The end-points or objectives of programmes would have to be specified, the starting points would not be (though some general principles could be formulated). And while some general strategies for shifting learners from known starting points to unknown end-points could be similarly outlined, the detail would have to be the province of the individual teacher. A few broad steps by which such a programme might progress are outlined below.

(i) In terms of the end-points of the programme, the nearest possible cultural equivalent for the learners would be identified. The initial phase would consist of elucidating the traditional version of the western concepts which are being introduced, and during this phase a vocabulary would be built up. All of this early work would, of necessity, take place in a context which was meaningful.

(ii) A situation where the traditional concepts broke down or were inadequate would have to be set up - again in a context which is as natural and meaningful as possible. Through this "conflict", it would be possible to modify the cultural concept and move it in a direction which is closer to the end point.

(iii) It may be necessary to produce more of these "conflict" situations before the learners arrive at the desired end-point. When they do get there, it will be in terms of situations which are meaningful and seen to be useful for real-life contexts.

(iv) At this point it may be desirable to shift into the more idealised atmosphere of the classroom and attempt to generalise the concept, applying it to more artificial set-ups and demonstrating its universal applicability. This is a difficult step - but it is usually the one which is attempted first in current educational programmes.

All of this of course will change the image of a teacher completely, and whether it would be possible to get the majority of teachers who are already in service to act as researchers is a debatable point. (See e.g. Jones and Kelly (1973) for some discussion concerned with this subject). However, it should be possible to train new teachers to act in such a way, and given sufficient moral and material back-up these new people could rapidly bring about a change in the system, particularly since material which was uncovered and approaches used would act as a resource for others in the same situation once it had been recorded. All over the world a move against the aloof and often irrelevant and meaningless nature of educational practice is gathering momentum; the main cry is that one cannot divorce education from the experiences of life outside school. (See Holt (1973) for a fluent and persuasive argument). Essentially, it is this move which is being echoed here; and other opinion in favour of such a move in PNG has been voiced too.

Philp and Kelly (1974) have argued in favour of building upon traditional concepts, in the teaching of maths and science (particularly with regard to classifications) and have suggested a "cultural games" approach. Prince (1969) too is suggesting something close to this approach when he remarks:

"The teacher himself can play an active part in forwarding the necessary research. Insights provided daily in the classroom can be recorded, written up and either published or passed on to others to record in their research material". (Bulmer (1971(is a most pressing advocate when he writes):

"It may sound utopian, but I for one would like to see every school in this country transformed into a junior research institute".

It's true that it does sound utopian; but on the other hand one begins to wonder how much longer the present educational structure, which gives its

students so little in the way of meaningful learning, can survive. The movement toward a more "community-based" system for PNG has produced a deluge of words over the last few years, and little in the way of results. If teachers were trained to become action-researchers, and if programmes were built on learners' meaningful experiences (which would then be inevitable), then a more community-oriented system would follow naturally. And it is a reasonable assumption that students would understand a lot more of maths and science than they do at the moment.

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