The Implemented Mathematics Curriculum

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Abstract

This paper describes some of the author's research involving students at the Institute of Distance and Continuing Education (IDCE), University of Papua New Guinea. The analyses focus on a few of the findings on the learners' perceptions of the implemented mathematics curriculum. The dimension for investigation is on the cultural and social variables that shape learners' perceptions during the process of enculturation and acculturation. Clearly, learners' perceptions have been influenced, to a large extent, by significant others, such as the media and other social variables. In an attempt to provide some remedies for the issues discussed in the paper, two approaches for a mathematics curriculum are recommended for implementation.

Introduction

It is fundamental that students who have experienced the influences of cultural variables on their learning of mathematics, whether positively or negatively, are required for this research (Kari, 1998). Moreover, the analyses of the data will determine whether the results of previous research studies in Papua New Guinea (PNG) and other countries support the findings in this research. To ensure that the findings are credible, the sample of the population has to be valid. Thus, the subjects come from a wide spectrum of the distance-learner population, for example, the employed and the unemployed, the urban and the rural, males and females, those enrolled in the different mathematics courses in the pre-matriculation and matriculation programs, and different regions of the country.

The research instrument consisted of a questionnaire and an interview structure and they focused on students' perceptions of the Institute of Distance and Continuing Education (IDCE) mathematics curriculum and the mathematical ideas in their home cultures. The dimensions investigated were: the nature of mathematics, mathematical ability and effort, language, social interactions, usefulness of mathematics, examination-oriented teaching and learning and mathematical ideas in home cultures. There were thirty statements in the questionnaire and about five statements on each dimension. The subjects were required to circle a symbol that represented their views about that statement. In the interview, the principal focus was on the interviewees' reasons for their perceptions of implemented curriculum. Furthermore, the interviewees were probed to describe whether their learning of mathematics in their home cultures had a bearing on how they learnt formal mathematics.

The issues of mathematical enculturation and mathematical acculturation were significant within the main thrust of discussion in this analysis. Because students are social beings, it follows that their learning of techniques and strategies of concepts, including mathematical concepts, would be significantly influenced by their cultures. This implies that strategies adopted for formal mathematics lessons may not necessarily coincide with the strategies adopted in students' home cultures.

It is envisaged that we develop an appreciation of the significance of social variables that have exerted so much influence on students' mathematical thinking. Moreover, we take into account these significant variables and accommodate the many different ways people learn the same thing. It is not a case of teaching different mathematics to different people, but teaching the same mathematics in different ways to the same people.

Perceptions of the implemented mathematics curriculum

Discussion focused on the dimensions of the instruments, namely the subjects' perceptions of their mathematical ability and effort, language, usefulness of mathematics, social and work interactions and mathematical ideas in home cultures. The reasons for the views were extracted from their interviews. The findings of research conducted in other countries were also used to verify the issues discussed in this paper.

(a) Mathematical ability and effort

The males were more inclined to claim that their mathematics was improving than their female counterparts. Moreover, as the course becomes more advanced the females were less inclined to think that their mathematics was improving than their male counterparts (see Table 1). These results seem to confirm the notion that the dominant males are more liable to articulate positive attitudes towards any activity that promotes their dominance in their society, (see for example Kaeley 1995, Sukthankar, 1995). This does not necessarily mean that they have those qualities they profess to possess.

Table 1. ANOVA: S13: My mathematics is continually improving

CSS/3: General Manova		Summary of all Effects; design 1 - Gender 2 - Course				
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1	5.820	152	.8165	7.127	.008
2	2	2.406	152	.8165	2.947	.055
12	2	4.996	152	.8165	6.119	.002
CSS/3: General Manova				MEANS		
Gender		Course		Variable 13		
M		…		4.19		
F		…		3.48		

M	BM	4.22
M	M1	4.33
M	M2	4.34
F	BM	4.50
F	M1	4.37
F	M2	3.57

(b) Language

The subjects believe that English in mathematics tutorials is different from the English used in everyday living, and also that expressing mathematical ideas in English is difficult. Moreover, they maintain that their mother tongues have words to describe mathematical ideas. These results seem to suggest that the concept of mathematical register of English is troublesome for the subjects and also that there is evidence of mathematical ideas in their cultural activities that are described in their mother tongues.

The males are more likely to claim that *their mother tongues have words for mathematical ideas* than their female counter parts (see Table 2). This result seems to suggest that the dominant males are more inclined to articulate positive attitudes towards any activity that promotes their dominance in their society (Sukthankar, 1995). This does not necessarily mean that they have those qualities they claim to possess.

The males and females in urban areas are less likely to argue that *the English in mathematics tutorials is different from the English in everyday living* than their male and female counter parts in rural areas (see Table 3). This result seems to suggest that males and females in urban centres, who have more opportunities to communicate in English, have become more familiar with English than their counterparts in rural areas. Furthermore, the data also show that, on average, males are more likely to argue that *the English in mathematics tutorials is not different from the English in everyday living* (see Table 3). This result seems to endorse the commonly-held view that in Papua New Guinea cultures males are more dominant than females, and males are most likely to suppress any situation or event that would lead to the undermining of their authority (see for example Cox, 1987).

Table 2. S20: My mother tongue has words for mathematical ideas

CSS/3: General Manova		Summary of all Effects; design 1 - Gender				
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1	8.279	198	1.188	6.964	.008
CSS/3: general Manova		MEANS				
Gender		Variable 20				
M				4.12		

F	3.53

The subjects believe that English, the language of instruction, used in tutorials is different from the English they use outside tutorials. Moreover, they believe that it is difficult to express mathematical ideas in English. Why should this be the case? First, tutors would refer to the problems in the unit textbooks that are written to fulfil independent learning and mathematical requirements. Therefore, the language used has to be different in order to meet these requisites. Secondly, in the process of explaining concepts, skills and strategies, tutors are obliged, in order not to obscure meanings, to use words or phrases that are unique to mathematics. These two modes of teaching merely present the situation to expose the subjects' deeper problem closely connected with the understanding of English and mathematics.

Why should the subjects find English in Mathematics different and in many ways difficult? Misunderstanding of concepts is largely attributed to the concept of mathematical register of natural English (Dawe, 1983). There are English words and phrases that are assigned the set of meanings appropriate for mathematical knowledge (Halliday, 1974). Thus, the mathematical register of English shares with English its central nucleus of prepositions, nouns, pronouns, verbs and various other distinctions. At the same time, however, the meanings of many are unique to mathematics. This occurs in two fundamental ways. First, there are special terminologies (for example pi, theorem, etc.) borrowed from other languages. Secondly, through existing words and phrases in English, but these are given special mathematical meaning. Such words and phrases include ‘set’, ‘group’, ‘is’, ‘let’ and many more.

Mathematics leans very heavily on those mechanisms of natural language that carry the force of logical relationships such as causality, dependence and restriction (Strevens, 1974). Strevens calls them ‘grammatico-logical-operators’ and he lists such examples as 'because', 'if', 'unless', 'therefore' and many others. These terms are vital to the understanding of complex thought and verbalization in any field of discourse. Strevens draws attention to the fact that it takes some time for English pupils to learn the complexities of grammatico-logical operators when he writes:

> It takes several years from the beginning of schooling for a child in Britain... to master the full range of logico-grammatical-semantic complexities of his mother tongue, English, as it is used in mathematics’ [Strevens, 1974; p.61]

When it takes time for English speakers to master the mathematical register of natural English, it is reasonable to assume that it would take much more time for the subjects in this study to do the same because English is not their first language, and not necessarily their second

Table 3. S14: The English in mathematics tutorials is different from the English in everyday living (negative statement)

CSS/3: General Manova		Summary of all effects; design 1 - Gender 2 - Location				
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1	6.356	196	1.603	3.964	.04
2	1	3.061	196	1.603	1.909	.16
12	1	10.560	196	1.603	6.588	.01

CSS/3: General Manova		MEANS
Gender	Location	Variable 14
M	…	3.73
F	…	3.11
M	UR	3.54
M	RU	3.48
F	UR	3.72
F	RU	2.50

Language has a prominent role in enculturation and acculturation (Stephan and Stephan 1990), and there are more than 700 languages in PNG (Lean 1994). In the view of the author, the subjects' problem with the mathematical register of natural English is further compounded by the *'multiple translations'* of the same concept development. This means that subjects would necessarily interpret a mathematical problem, first into the mother tongue, then to English and then back again to the mother tongue, and may continue translating in this order several times, before arriving at a sensible translation. In this complex process, the essence of the mathematical problem is most likely to be distorted or lost. This makes English, as the medium of written and verbal forms of communication, a significant factor in fostering comprehension of concepts and skills. The same theme was contended by Vygotsky (1962) when he made the assertion that *'...behind words there is the independent grammar of thoughts.'* (p.128)

Furthermore, the subjects' belief that they need to be taught in a language they understand if they are to succeed in mathematics appears to show that the subjects' success in mathematical enculturation motivates them to imply that they desire to learn in their mother tongues. Clearly, this assertion reinforces what Orton (1993) was advocating when he concluded his remarks with *'There would seem to be a great need to develop mathematics curricula which enable and encourage students to think in their mother tongue.'* (p.143)

(c) Usefulness of mathematics

The subjects are divided when it comes to decide whether methods of solving school mathematics are useful in their home cultures (see Table 4). This particular result appears to confirm the previous expressed views that mathematics is abstract and theoretical and also that mathematical ideas exist in their home cultures. Thus, it is expected that some subjects see the relationship between the usefulness of mathematics across contexts, and are most likely to agree that methods of solving school mathematics are useful in their home cultures. On the other hand, some focus on the abstract and theoretical aspect of school mathematics, and who may not see the link to home culture mathematics. These subjects are likely to conclude that methods of solving school mathematics are not useful in home cultures.

Table 4. Usefulness of mathematics

Item No.	Statements	SA %	A %	NS %	D %	SD %
S10	I have learned some useful mathematics	57.0	41.5	0.0	1.0	0.5
S15	Methods of solving school mathematics problems are not useful in my home culture	19.5	29.5	10.0	17.5	23.5

The subjects strongly consider that they have learned some useful mathematics (see Table 4). What is the most likely reason for this result? Let us consider what other studies say about students' perception of the usefulness of mathematics, in order to understand the subjects' observation. In their extensive review of studies that have examined psychosocial variables and achievement in mathematics, Meyer and Koehler (1990) concluded that the subjects' perception of the usefulness of mathematics, both immediately and in the future, is a variable shown to be strongly associated with mathematics participation and achievement. Although the literature referred to by Meyer and Koehler have no data from PNG, the current findings suggest that their assertion can be still valid for this study. The mathematics courses are necessary for matriculation, and those they are the prerequisites for other courses, especially the science courses. The subjects purposely study them in order to achieve matriculation status.

Data in this study show that the subjects are convinced that only some mathematics is useful. Their arguments that *'mathematics is abstract and theoretical'* and that *'mathematics is practical and useful'* is an affirmation of the above assertion. In their responses to the interview question *'How useful is the mathematics you are studying?'*, all the interviewees emphasized their belief that only *some* mathematics is useful. The word '*some*' was used by all the interviewees. Below is a response, which is typical of all responses:

> *'...it seems useful [pause] I say some because some maths is also abstract... some is useful for my science courses. I mean it is useless to my people in the village [pause] yes some...well back in the village they use their own maths'* [Maths 2 student: NCD]

(d) Social and work interactions

The belief that social and work interaction is important in influencing their learning of mathematics is strongly held by subjects (see Table 5). For example, they believe that their friends help them to learn mathematics, and that their discussions in mathematics tutorials are not a waste of time. Moreover, they believe that they learn mathematics outside school (see Table 5). These results appear to suggest that the subjects value interaction as a means through which they solicit assistance as well as providing help to others. The belief that discussions in tutorials are not a waste of time is, clearly, a commendation of the real objective of discussions that is to foster learning, as Barnes (see Orton, 1993) remarked:

> Verbalization is important because ideally it makes thought - processes open to conscious inspection and modification. It seems likely that verbalizing...aids the retrieval of schemes, their manipulation and combination, and the evaluation of their appropriateness. [p.140]

Table 5. Social and work interactions

Item No.	Statements	SA %	A %	NS %	D %	SD %
S12	My friends help me to learn mathematics	19.5	50.5	9.0	14.0	7.0
S18	Discussions in mathematics tutorials are a waste of time	2.0	0.5	3.0	21.0	73.5
S23	I do not learn mathematics outside school	4.0	5.0	2.5	44.0	44.5

If we assume that social and work interactions are inseparable aspects of their everyday life, and that knowledge was and is successfully communicated and transferred to everyone within their societies through social interactions, then it is clear that the subjects' belief about the value of social interactions is a consequence of their desire to learn. A previous investigation (Wall, 1965: see Orton, 1993) testifies to the significance of social interactions, concerning formal learning:

> groups are more productive of hypotheses and therefore are likely to be more productive than single persons, though in fact they take more time. The solutions reached tend to have a higher quality....' [p.140]

In another observation with subjects solving mathematical problems, Gagne and Smith (1962) made a similar assertion when they argued that students who were encouraged to talk while solving problems produced better quality results than those for whom talk was not apparent.

The females believe more strongly than males that discussions in mathematics classrooms are valuable (see Table 6). Also, females believe more strongly that they have learned some mathematics from discussions with friends, than their male counterparts. What could account for these different results? Since, individuals are unique and they live in complex and multivariate environments, there are many complex reasons. However, previous studies on gender and mathematics have revealed certain trends that are quite consistent, and these are the plausible explanations of the results in this study.

First, the assertion that males excel in spatial ability while females excel in verbal ability is generally accepted (Hutt, 1972). The consequence of this assertion is that females are more inclined to verbalise their thinking and strategies than males. Although, Hutt's research was conducted in another country, the biological structure of human brains is the same everywhere regardless of nationality or race. In the view of the author, it is logical to assume that Hutt's assertion is still valid for the subjects in this study.

Second, males display confidence about their mathematical ability, which is sometimes unjustified while females, perhaps with better test results, display unjustified anxiety (Russell, 1983). Therefore, it is reasonable to assume that the males would discuss their problems with friends less often than females, and this assumption is appropriate for this study. In addition, admittance of weakness is not a virtue in Melanesian patrilineal societies where males are more dominant than females, and events considered detrimental to males' status quo are unnecessarily suppressed, (see for example Cox, 1987, Sukthanker, 1995).

Third, females and males receive differential treatment during tutorials (Good and Brophy, 1978; Koehler, 1990; Fennema, 1990; Becker, 1980). In PNG males and females are brought up differently, and are also treated differently. Thus, it is logical to assume that they would be treated differently, intentionally or unintentionally, in formal learning situations. Much evidence on unintentional preferential classroom treatment is documented in literature (Good, Biddle and Brophy, 1975; Moore and Smith, 1980). The preferential classroom treatment between males and females in the IDCE program is also intentional, and for very good reasons. Most of the female subjects are married women and almost all the tutors are males. It is extremely dangerous for a tutor or a male subject to be too friendly with females for obvious reasons. When dealing with females, tutors deliberately avoid such things as; looking at them in the eyes for lengthy periods, discussing problems for too long with particular individuals, and so forth. When interaction is defined in this manner during tutorials, it follows then that females would isolate themselves from the bigger group, and discuss their problems with themselves because they feel more comfortable with one another.

Finally, research of the classroom organization, in terms of small - group learning has shown remarkable pattern of behaviour between females and males. In reviewing two previous studies (Webb, 1984; Webb and Kendersky, 1985), Koehler (1990) noted the subjects in those studies were divided into gender-majority and gender-balanced groups. They were observed during a mathematical activity. Eventually, the authors (p. 143) concluded that:

(1) females were more responsive to their peers and gave more help frequently
(2) males were helpful to other males more often than to females
(3) males and females tend to ask males for help more often than females.

In the view of the author, the first conclusion is an appropriate explanation for the result shown in this study, but with a slightly different orientation. The females would be more responsive to the needs of their female colleagues than their male counterparts. The reasons for this behaviour have been discussed (see the third reason).

Table 6. S12: My friends help me to learn mathematics

CSS/3: General Manova		Summary of all Effects; design 1 - Gender 2 - School				
Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1	6.425	196	1.309	4.906	.02
2	1	4.240	196	1.309	3.237	.07
12	2	3.680	196	1.309	2.810	.09
CSS/3: General Manova MEANS						
Gender		School		Variable 12		
M		…		3.56		
F		…		4.11		

(e) Mathematical ideas in my home culture

The view that *'mathematical ideas exist in my home cultures'* is definitely endorsed by the subjects (see Table 7). What mathematical ideas are they referring to? To ascertain a meaningful explanation for this question, we need to consider the interviewees' responses to one of the interview questions *'what mathematical ideas do you experience in your home culture?'* All the interviewees argued that 'addition', 'subtraction', 'number', 'counting', 'sharing' and 'measuring' are frequently used. Some of the interviewees also mentioned 'designing' and 'patterns'. Although, this is not a complete list of mathematical ideas common to all pre-technological societies (see Bishop, 1992; p.182-184), nonetheless most of the Bishop's activities are either implicitly or explicitly stated. Evidence in other literature regarding mathematical ideas in pre-technological societies (Ascher, 1991; D'Ambrosio, 1985; Saxe, 1991; Lancy, 1983; Gerdes, 1996; Pinxten 1994) proved that primitive cultures utilize mathematical ideas.

The subjects argued that these mathematical ideas are not seriously considered by the implemented curriculum. How could we account for this result? As we have observed earlier, both curricula, the intended and implemented, are designed to accommodate the requirements of modern technology and economy. This school of thought was and still is very strong, and espoused at the political level as the Prime Minister of the country, Sir Julius Chan said, *'There is no Melanesian Way to pilot a plane'* [see Lancy, 1983, p.210] To further illustrate this point, the interviewees were asked the question *'Why did you circle ( ) in S22?'* Without exception, and in one-way or another, the interviewees argued that some mathematical ideas are not common to both the IDCE curriculum and the home cultures. Below is a response, which is typical of other responses:

> *'...it [mathematical ideas in home culture] is different from what we are learning...some of what we are learning is not found in our culture.' [Maths 1 student: ESP]*

Table 7. Mathematical ideas in my home culture

Item No.	Statements	SA %	A %	NS %	D %	SD %
S17	I used mathematical ideas before enrolling in school	28.0	51.0	5.5	7.5	8.0
S22	Methods of solving school Mathematics problems exist in my home culture	12.0	36.0	12.5	22.5	17.0

The interviewees' responses to another question; *'Are these people (photograph of village people building a house) doing mathematics?'* The interviewees argued that the people are engaged in activities, which involve 'adding', 'measuring', 'designing', 'counting' and 'estimating'. These basic mathematical ideas are common to both the home culture activities and the IDCE mathematics courses, especially the less advanced ones. It is reasonable to assume that the subjects recognize the similarities between home culture and formal mathematics learning situations. The response given here is typical:

> *'yes, they are doing mathematics. Doing measurement, designing patterns, calculating number of materials and so on.' [Basic Maths student: ESP]*

The subjects believe that their first experience with mathematical ideas has a significant influence over their formal mathematics learning situations. This relationship, in the view of the author, reinforces their other belief that some mathematics is common to both the village life and the IDCE mathematics courses, especially the less advanced ones. However, even the similarities between the two learning situations are not considered in the IDCE mathematics curriculum.

Proposed mathematics curriculum

The students' problem with the IDCE mathematics curriculum is probably best catered for by a change in the implemented curriculum itself, with the emphasis of utilizing the home-culture mathematical ideas to supplement and complement IDCE mathematics, and vice versa. This proposition suggests that the mathematics curriculum should be valued and implemented from two perspectives. It is recommended that the first approach is termed the ‘ethnomathematical approach’, and it should emphasize the dominance of home-culture learning situations, with the formal mathematical learning situations to reinforce and link the concepts as tool and object of learning. Moreover, some examples of linguistic conventions for mathematical knowledge and skills are taken from the author's home culture, with the purpose of justifying the viability of the proposition. The second approach is labelled the ‘integrated approach’, which involves formal mathematics learning situation as the focus of attention, with the home-culture learning context being used to demonstrate the link between both contexts.

(a) Ethnomathematical approach

The ethnomathematical approach is constructed to facilitate a meaningful transition during which the development from the rich context of the learners to abstractions in formal mathematics becomes the object of teaching. Moreover, much evidence from research studies in PNG and other studies (see for example Abreu, 1989; Bishop, 1988) makes this proposal not only necessary, but also desirable. Some of these results are:

(1) mathematical ideas exist in home-cultures
(2) mathematics learning is also influenced by socio-cultural factors
(3) home-culture mathematical ideas and IDCE mathematics are rationally related.

In this approach, mathematical ideas in cultural activities are purposely taught, and to facilitate understanding and appreciation of the development of mathematical knowledge, appropriate formal mathematics learning situations are used as reinforcement. As documented earlier, Bishop's (1988) six activities show that formal mathematical knowledge and skills can be developed through them. Thus, the author recommends that tutors should apply these activities to show the appropriateness of the ethnomathematical approach for learners in Papua New Guinea.

In describing the various concepts, references are made to two home-culture contexts, namely ‘village people building a house’ and ‘navigation’, but it is not the intention of this analysis to exhaust the mathematical ideas in home cultures in PNG, rather to provide sufficient evidence to justify the introduction of the ethnomathematical approach.

When building a house, the activities that include counting, locating, measuring, designing and explaining are either affected in a mutually exclusive way or by interacting together. Counting is a necessary mathematical activity found in all societies (see Bishop, 1988). Furthermore, the developments of the number systems, number relationships, frequencies and algebraic representation could be developed from cultural activities (for example see Pinxten, 1994). Natural numbers are used to count materials needed for the house, and they are represented by linguistic conventions (Lean, 1986; Saxe, 1982; Lancy, 1983). To further demonstrate the existence and usefulness of natural numbers, the author gives an example from his mother tongue; and natural numbers extend as far as nine thousand nine hundred and ninety-nine (9,999).

Table 8. Natural Numbers in Ba'abon Language (Manus)

Ba'abon Language	Number	Ba'abon Language	Number
Ari	1	Rinek	100
Lauh	2	Lunek	200
Taloh	3	Tonek	300
Hahuu	4	Hanek	400
Limeh	5	Lemenek	500
Onoh	6	Ndro-hanek	600
Ndrotaloh	7	Ndro-tonek	700
Ndrolauh	8	Rawa	1000
Ndroari	9	Luwa	2000
Ronoh	10	Lamawa	5000
Lunoh	20	Ndro-hawa	6000
Tonoh	30	Ndro-tuluwi	7000
Hanoh	40	Ndro-luwa	8000
Lomonoh	50	Ndro-rawa	9000

Rational number concepts are also applied. The perception of part of a whole is extensively used in the workmanship required for the house; and again this concept is represented by linguistic convention. For instance in the authors' mother tongue, Ba'abon (see Lean, 1986), the following words are used to represent various fraction numbers.

Table 9. Linguistic convention for part/whole Ba'abon language (Manus Province)

Ba'abon Language	Meaning
Ranah	One piece of an object
Lunah	Two pieces from the same object
Tunih	Three pieces from the same object
Hanah	Four pieces from the same object
Lamanah	Five pieces from the same object
Ndro-hanah	Six pieces from the same object
Ndro-tunih	Seven pieces from the same object
Ndro-lunah	Eight pieces from the same object
Ndro-ranah	Nine pieces from the same object

The idea of grouping is considered a normal activity, and again expressed by linguistic conventions. People or objects are grouped according to some criteria, approved by the people in a given situation.

Table 10. Linguistic conventions for grouping Ba'abon language (Manus Province)

Ba'abon Language	Meaning
Rabuuk	One group of people or objects
Lubuuk	Two groups of people or objects
Tulubuuk	Three groups of people or objects
Habuuk	Four groups of people or objects
Lamabuuk	Five groups of people or objects
Ndro-habuuk	Six groups of people or objects
Ndro-tulubuuk	Seven groups of people or objects
Ndro-lubuuk	Eight groups of people or objects
Ndro-rabuuk	nine groups of people or objects

The type of house built would require how much of each type of material needs to be collected, and how much effort is required, in terms of number of people, to collect those materials. Linguistic conventions exist in home-cultures, which are used to represent the quantities of materials collected

Clearly, the volume of linguistic conventions for mathematical ideas in pre-technological societies is incredibly extensive. Results of research studies nationally and internationally show the need to link home-culture learning situations with those of formal mathematics learning situations; and vice versa. The ethnomathematical approach has been described and we now turn our attention to the other approach that is designed to utilize mathematical knowledge and skills in both contexts.

(b) Integrated approach

The integrated approach is a means to promote an integrated curriculum, which utilizes knowledge from both systems in order to maximize and consolidate learning. This approach is supported by Pinxten, Dooren and Soberon (1987) who asserted that

> 'in order to guarantee a good and proper understanding of abstraction and abstract thought when dealing with another culture [than the Western one], it is advisable and desirable to develop native abstractions in a native context and by means of native language' (p.30)

Inevitably, this approach requires that the mathematical ideas and methods of both systems should be integrated. Research studies conducted in Papua New Guinea and in other international communities expound how and why the proposed integrated curriculum facilitates meaningful transition.

The author has demonstrated, in the previous section, some examples of mathematical ideas in home-cultures that are teachable in the formal context. These ideas and the learning situations in which they occur should be applied in the formal curriculum teaching. Let us demonstrate with an example. When the tutor introduces the concept of ‘line’ and ‘straight line’ in a geometry lesson, the concept of line in home-culture contexts should also be taught and compared with what is being taught, in order for learners to ‘visualize’ the integration and translatability of one system in the other. This integration of mathematical ideas from the two learning situations, if implemented with proper preparation, is most likely to facilitate meaningful translation of mathematical knowledge in both contexts. This assertion is supported by Pinxten, Dooren and Soberon (1987) who studied spatial knowledge amongst Navajo Indians, whose educational experiences are very similar to those of Papua New Guineans.

Moreover, in the integrated curriculum, the author maintains that both mathematical ideas in home-cultures and the mathematics curriculum are taught as important and useful. They complement and supplement each other, and the learners are encouraged to recognize the value of their home-culture mathematics in the mathematics curriculum.

In recommending the two approaches, it is envisaged that in order to facilitate a smooth transition from mathematical enculturation to mathematical acculturation, the ethnomathematical approach should precede the integrated approach. Moreover, most teaching in the lower grades should focus on ethnomathematical issues, and as the students progress to higher grades they should be encouraged to link home-culture and formal mathematics situations. In addition, their ability to recognize the translatability of mathematical concepts should be valued by tutors, and recognized by tutors as an appropriate process for learning.

The two general approaches are proposed because they are most likely to address the three problems revealed by the author’s research among distance learners (Kari, 1998). More specifically, they present mathematics as important and useful in formal and informal learning contexts. Furthermore, the proposed approaches are designed to assist learners to be aware of the conflicting societal influences, which may affect how they learn mathematics. Finally, the interdependent learning and the translatability of mathematical concepts and skills are probably more feasible than ever before. The ethnomathematical approach is appropriate because it embraces learning from the learners' rich cultural contexts, from which the solid foundation for higher specification and sophistication is found.

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