The Value of Indigenous Mathematical Knowledge in Formal Learning

Patricia Paraide Senior Research Fellow, National Research Institute

Introduction

The current Papua New Guinean elementary and lower primary reform curriculum encourages the integration of indigenous knowledge into formal learning. This paper critiques those documents and explores how indigenous mathematical knowledge is used — or not used — as a stepping stone, when teaching formal or Western mathematical concepts. It also focuses on indigenous knowledge — especially the use of indigenous mathematics (counting and measuring only) in one particular language community. The discussion attempts to establish awareness and create a deeper understanding of the values of indigenous mathematical knowledge in other Papua New Guinean cultures, and how they could be integrated with the formal teaching and learning of mathematics.

Indigenous Knowledge

In recent times in many communities, the utilisation of indigenous knowledge and skills has been encouraged in various fields of study, as well as in formal schooling through the school curriculum. Indigenous knowledge is a growing field of inquiry, both nationally and internationally, particularly for those interested in educational innovation (Battiste 2002:2).

During colonial times, indigenous knowledge was usually classified as primitive, and was considered a hindrance to Western progress and development (Nakata 2002:2). Also, indigenous people's cultures were regarded as primitive and inferior. They were ignored and suppressed in formal schooling and the Western environment, which has resulted in the loss of some indigenous knowledge.

Views regarding indigenous knowledge have changed, and such knowledge now appears in academic and scientific publications concerning ecology, soil science, veterinary medicine, forestry, human health, aquatic resource management, botany, zoology, agronomy, agricultural economics, rural sociology, mathematics, management science, agricultural education and extension, fisheries, information science, wildlife management, and water resource management (*ibid.*).

Nakata (*ibid.*) stated that there is an increasing pressure by indigenous people to preserve indigenous knowledge. He suggested that people who clearly understand the cultures should preserve indigenous knowledge and skills in their particular cultures. It would not be the same, if scientists, who are involved in developing technologies and conservation, led the preservation, as they would select and elevate some indigenous knowledge, while discarding and excluding other knowledge, even with indigenous participation (*ibid.*:2).

Although, I agree with Nakata to a certain extent, I believe that, if the integration of indigenous and Western knowledge is to be compatible and encompass the current global changes and developments, both Western and indigenous people should be involved in developing technologies, conservation and school curricula. However, all parties must respect each other, work as equals, and be sensitive to the content of both indigenous and Western knowledge and practices, to ensure balanced preservation. This will make the values and strengths in indigenous and various Western bodies of knowledge visible. Battiste (2002) stated that one way of preserving culture is through the school curriculum. The preservation of culture has been embraced in the reform curriculum development in Papua New Guinea and other parts of the world. However, there is a great deal of Western influence in curriculum development, as reflected in the current reform curriculum.

According to Nakata (2002:3), there is an increasing recognition of the marriage of indigenous and Western knowledge, which has led to some changes in the school curriculum for indigenous students. Nakata (*ibid.*:5) also stated that there is acceptance of the 'value of integrating two systems of knowledge — traditional and scientific — in order to produce new knowledge and practices that will provide solutions for sustainable development and developing countries and communities'.

In current literature, there is a growing emphasis on the incorporation of indigenous knowledge into strategies of application (*ibid.*:6), as well as for the scientific validation of indigenous knowledge. From my perspective, the recognition and acceptance of the value of indigenous knowledge and practices, and their inclusion in the Papua New Guinea school curriculum is a positive step towards the validation of the various bodies of indigenous knowledge. Students may then be able to relate their indigenous knowledge to that of Western and 'other' knowledge learned in formal learning institutions, and be able to expand on and explore that collective body of knowledge further, for the good of our people.

I agree with Nakata (2002) and Battiste (2002) that there should be caution in incorporating indigenous and Western knowledge. While there are similarities that can be easily accommodated for educational purposes, there are also differences that are unique to each culture. These differences cannot be separated or compared with Western cultures, but should be recognised as vital components in their particular cultures. I believe that these components should be accepted as part of particular cultures and taught as a new body of knowledge to those people who are 'outside' those cultures.

Although I agree with Nakata that it is logical that the development and integration of cultural knowledge into any school curriculum should be under the leadership of person(s) who themselves have sound indigenous knowledge, I would like to stress that whoever is involved in such projects must be sensitive to the knowledge and practices of all cultures involved, particularly in the mathematics and sciences. This will ensure a balanced representation of both systems of knowledge.

Ethnomathematics

Ethnomathematics is a new field of study which 'lies as an intersection of anthropology, education, and mathematics' (Rauff 2003:2). Ethnomathematicians view all signs of counting, measuring, designing, patterning, modelling, sorting, or reasoning as evidence of mathematical ideas. Rauff (*ibid.*) adds that these ideas, whether implicit or explicit, past or present, and irrespective of the cultural setting, are grist for ethnomathematicians. Ascher (2002:2) stated that ethnomathematics is a powerful tool for understanding other cultures, and that:

> Local mathematics can be detected, for instance, in the work of artisans and craftsmen, as well as in the lives of farmers, fishermen, healers, storytellers and street merchants. It manifests itself in beadwork, games, hairstyles, maps, painted designs, songs, and woven goods (*ibid.*:2).

Ascher (*ibid.*) discusses the Iqwaye people of Papua New Guinea, who use fingers, toes, and spaces between toes as tools for counting to numbers much higher than ten, twenty, or twenty-eight. These form the basis of a sophisticated numbering system that can count to numbers of infinitely large sizes. However, Ascher (*ibid.*) did not discuss any other mathematical knowledge used by the Iqwaye people, or the fact that there are also other Papua New Guineans who have sophisticated numbering systems. For example, a group of people from East New Britain, the Tolais, who speak Tinatatuna, also count numbers of indefinite large sizes, using measurements and other mathematical concepts.

Counting and Measuring in Tinatatuna

The Tinatatuna language has the word mar (or mari) which shows that the people can count one to *a mar (*or *mari)* which means hundred, and to *arivu* (or *arip)*, which means thousand. So one hundred is *tikana mar/mari*, two hundred is *aura mar/mari*, one thousand is *tikana arip/arivu*, and two thousand is *aura arip/arivu*. Many items in Tolai people's lives are counted individually this way.

Coconuts are tied in twos (*a evevutu*), then grouped in fours (*a varivarivi*), then in sixes (*a kurakurene*), then the sixes are grouped in twelves (a *tangutanguvani*), and then the coconuts are counted in sets of twelves. The coconuts are counted in sets of twelves for recording purposes. Taro used to be counted in sets of six for commercial purposes, but not any more. Bananas and wild fowl eggs are counted in fours for recording for commercial purposes, but different words are used for counting them.

Tabu (shell money) is still used as currency in Tolai society. Counting *Pala tabu* (individual tabu shells) begins with five (*a ilima na pala tabu*), then the shells are counted in twos and valued as tens (*a tip na ilima*), twelves (*a tip na lapikai*) and twenties (*a tip na arivu*). These numbers have different values. *A ilima na pala tabu* (five shells) is the lowest value and could buy three ripe bananas in the past. Also, *a tip na ilima* (ten shells) and *a tip na lapikai (twelve shells)* could buy a bundle of peanuts or greens (but different quantity) in the past.

Now everything that is sold begins at *a tip na rivu* (twenty shells). After twenty, *pala tabu,* the *tabu* are valued by length, and are strung together on thin strips of cane. The spacing between the shells adds value to the *tabu*. The *pala tabu* have to be a tip of the middle finger (2 centimetres) apart and must be evenly spaced for it to be valued as a *boina na tabu* (valuable tabu). The *tabu* is then measured using the arms of an adult. The different lengths of tabu have different values — the longer the *tabu* the more valuable. *Tabu* is measured from the tip of an adult's middle finger to the elbow or shoulder, or chest or two adult arm lengths (middle finger tips), and used for buying various items, depending on the price.

Such practices clearly indicate that the Tolais use addition, subtraction, multiplication, division, fractions, and measurement concepts, and do understand them in practical terms. I am convinced that these are mathematical traditions that developed entirely outside the Western models, because the Tinatatuna language has words for all this knowledge and these concepts. Lean (1994) discussed the counting system in Tinatatuna, and also reported that Codrington (1885), Ray (1891) and Parkinson (1907) recorded this counting system in their writings. This mathematical knowledge, if integrated into the school mathematics curriculum, will strengthen the students' understanding of the basic counting and measurement concepts learned in formal learning situations, especially at the lower levels of education, as both systems of knowledge will be reinforced in the formal and informal learning environments.

Ethnomathematics has gained increasing recognition during the past few decades. As an authority in ethnomathematics, Ascher (2002) described this field as a 'research program in the historical and epistemological foundations of mathematics with pedagogical implications'. In part, that involves mapping the vast diversity among groups of people in the field of mathematics, the ways that numbers are understood and conceived, the methods of reasoning, and the systems that people adopt to model and find patterns in their own social and natural environments.

Understanding cultural mathematical concepts can assist learners and teachers to comprehend abstract mathematical concepts. Ascher (2002) supports this view:

> When one views cultural practices from a mathematical perspective, understanding is deepened, vague descriptions are clarified, and the sophisticated conceptual underpinnings of those practices are revealed (*ibid.*:3).

The Pedagogy of Mathematics

The history of formal mathematical education has been dominated by decontextualised knowledge and skills (Ascher 2002). Western mathematical concepts have been taught to indigenous students, with no links to the mathematics that they already had. However, attempts have now been made to cater for this inadequacy in some reform curricula. Ascher (*ibid.*) noted that mathematical concepts which were taught in isolation, in a foreign language and understood and taught from a Western perspective have dominated past, and much current, formal mathematical teaching.

From a post-colonial and feminist post-structural theoretical perspective (Davies 1994:3; Pennycook 1998:20), I believe that indigenous mathematical knowledge and the meaningful way it was taught has been made invisible in the Papua New Guinea's school mathematics curriculum for a long time, as it was ignored, not understood, and not valued by past education authorities.

Ethnomathematical teaching strategies consider the parallels between traditional indigenous perspectives and Western mathematical knowledge and concepts, and also the teaching of mathematics as part of particular cultures. Local mathematics cannot be separated from its social setting because it functions as a part of the total cultural picture (Ascher 2002:4).

Ascher (*ibid.*) stated that ethnomathematical projects encourage the marriage between indigenous and Western mathematical knowledge in formal learning situations. For example:

> Numerous similar projects teaching Western mathematics in traditional settings are underway from Papua New Guinea to the inner cities of the United States. All recognise that understanding of local mathematical knowledge can both validate a child's native culture and provide a bridge to modern Western mathematics (i*bid.*:5).

Ascher (*ibid.*) stated that the emphasis on the total cultural perspective has led mathematics educators working in non-Western settings to recognise the importance of ethnomathematics in their own work. Lara-Alecio (ed.) (2002:2) stated that, with the recognition of indigenous mathematics, mathematics educators can bond or link culture into the formal curriculum and develop students' competence and confidence using ethnomathematics. Moll and Diaz (in Lara-Alecio (ed) 2002:2) also stated that ethnomathematics calls for a reconstruction of the mathematics curriculum to achieve cultural compatibility.

The National Department of Education, through the curriculum reform, currently emphasises the teaching of cultural mathematics in elementary and lower primary levels of education (Department of Education 2000, 2003). I believe that these documents are supposed to guide teachers in assisting students to appreciate the mathematical knowledge that they already have, and link them with those in formal learning situations. However, the elementary and lower primary mathematics curricula have provided inadequate practical examples to assist teachers to achieve this, if appreciation of the students' everyday environments is indeed the aim of these documents.

Currently, minimal literature has been cited relating to the transition of indigenous and home mathematical knowledge to formal mathematical teaching and learning in Papua

New Guinea. Bishop (2002:43) has discussed some of the difficulties that migrant students have in formal learning situations:

- the different levels of mathematical understanding;
- cultural and economic background;
- methods of mathematics application that various students already have when they enrol in formal learning environment; and
- some of the difficulties that students have in relating to concepts in formal mathematical learning situations.

For example, students who are involved in informal trading at home have difficulties linking addition, substraction, multiplication, and division knowledge to their formal mathematics lessons. Similarly, Tolai students who use a complex counting system at home have similar difficulties with the transition, as migrant students. They still have difficulties with addition, subtraction, multiplication, and division operations. Some even do poorly in these areas in formal mathematics, and yet they use these concepts competently in all of their trading activities and counting after school.

Ascher (2002), Bishop (2002), and Paraide (2002) also identified language that is used as the language of instruction in formal mathematical learning, as one of the contributing factors to a weak understanding of mathematical concepts. Students may not have an adequate vocabulary in the language of instruction to fully understand the knowledge which is communicated by the mathematics teachers and other students in class. Bishop's study (2002:45) also identified previous teachers' methods of teaching mathematics, the level of mathematics taught, and the work demand placed on students in precious mathematics learning experiences, as having an impact on how students participate in, build on, and explore their existing mathematical knowledge.

Elementary and Lower Primary Mathematics Curricula

The elementary and lower primary mathematics curriculum documents state that **space**, **measurement**, **number**, **pattern,** and **chance** are taught at those levels. These concepts are present in the Tolai culture, and most probably in other Papua New Guinean cultures as well.

> One must stress caution concerning the conversion of indigenous mathematical concepts that may be similar to Western mathematical concepts, as Nakata (2002), Battiste (2002), and Ascher (2002) did in their discussions regarding indigenous knowledge. For example, the Tolai counting system of coconuts can be converted to Western multiplication — x 2, x 4, x 6, and x 12 operations. However, it cannot be related to any of the Western base number systems, because when counting coconuts in Tinatatuna, coconuts are always tied in twos, then grouped in fours, then grouped in sixes, then the sixes are again grouped in twelves, and then the coconuts are counted in

sets of twelves for recording purposes. Coconuts are counted in sets of twos, sets of fours, sets of sixes, and sets of twelves, simultaneously.

This complex counting cannot be easily translated into the Western concept of base counting systems, or taught using Western teaching methods. It is not as neat as counting in base six and twelve. I agree with Ascher (2002) that indigenous mathematics cannot be separated from the people's cultures and the way particular mathematical concepts are used.

The new reform elementary and current lower primary mathematics syllabuses and the teachers' guide documents do not detail how cultural or indigenous mathematical skills and knowledge can be linked to the strands listed in the documents. There are no examples from any language groups detailing how indigenous mathematical concepts and knowledge can be integrated into the mathematical strand in the syllabus. Kaleva (1998) stated that teachers who do not know their own or their students' indigenous mathematics have difficulties in linking cultural mathematics to formal mathematics.

Findings on teacher training (Guy *et al.* 2002), indicate that the trainers' level of understanding of indigenous or cultural mathematical concepts and knowledge also affects integration with, and linking to formal mathematical teaching and learning environments. The competency of trainers to transfer that knowledge to the elementary teachers will have an impact on how well indigenous and Western mathematics can be integrated at the elementary level, and how well the transition from one body of knowledge to another can be conducted.

The teaching approaches section in the lower primary syllabus does not explain how teachers can link indigenous mathematics with strands in the syllabus. Research evidence (Guy *et al.* 2002) suggests that providing examples of teaching concepts and practical demonstrations showing how to apply a particular teaching strategy in classroom situations is a preferred pedagogic strategy. Papua New Guinean teachers learn better through this type of presentation, because they can visualise the concepts and understand better, rather than through **'dry'** print information alone.

The curriculum documents provide sufficient examples to show the links or integration with other subject areas, which is equally important. However, the integration between formal and indigenous mathematics is minimal (Paraide 2004:47). The integration of indigenous mathematics into formal mathematics should be the main focus in the Papua New Guinean mathematics syllabuses, given that cultural bonding in all subjects is encouraged at various levels of education.

Conclusion

The discussion here is intended to make visible the indigenous mathematical knowledge which is present in the various Papua New Guinean cultures. It is anticipated that Papua

New Guinea's curriculum developers and teachers will become more aware of how they can explore and build on the mathematical knowledge which the students already have, and integrate that into the mathematical knowledge which they are presented with in formal learning situations. The elementary and lower primary curriculum documents promote the integration of formal and indigenous (home) knowledge. However, these documents provide insufficient examples and background information of indigenous mathematical knowledge for teachers to use as resources, so that they can build on it when they are teaching in their various locations in Papua New Guinea. The elementary and lower primary mathematics curriculum materials need to strengthen the information on the integration of indigenous and Western mathematical knowledge to enable teachers to better understand how these two knowledge systems can best be integrated and made compatible for formal learning purposes.

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