Identity and Ethnomathematics Projects in Papua New Guinea

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Indigenous students may find mathematics in schools difficult because there is discontinuity between cultural mathematics and school mathematics. One of the reasons for this is that their teacher's identity as a mathematical thinker may not link to their cultural ways of thinking. In Papua New Guinea, there is a subject to assist student teachers to develop their own and hence their students' consonance between cultural and school knowledge. In the subject, student teachers undertake a project to link culture and mathematics. The question for this research is to explore how student-teacher identity as a mathematical thinker is enhanced when they explore the cultural setting of their mathematics. From 239 reports collected over a 10 year period, 60 were analysed to explore the impact of sociocultural contexts on identity as a mathematical thinker. The document analysis informed the argument that such projects encourage teachers to express both culture and school mathematics and to identify with their cultural mathematical ways of thinking and to value these in school education.

Overview

A quote from one of the reports by a student teacher at the University of Goroka (UOG) in Papua New Guinea (PNG) illustrates his beliefs about mathematics and the role of a teacher in identifying and using ethnomathematics (culture-based mathematics).

> Why do students find it hard to solve mathematics problem? … Why is mathematics too hard to comprehend? Is it because mathematics is written using the second language? Or is it that it is not part of the Papua New Guinea culture? These are serious questions parents, teachers, students and even the elites ask. … To impart what is in the text books to the students is hard for it is not part of their life especially in the society which they come from. (This is) the missing part in the school mathematics curriculum … (By using) traditional mathematics which is in them which they thought was not mathematics … only then will the students be able to understand the current mathematics. (Pepeta, 2001, p. 1)

Pepeta was one of the preservice and inservice student teachers (referred to in this paper as teachers) who reported on their projects in a single elective subject *Mathematics, Language and Culture.* Their projects related cultural activities and artefacts to school mathematics curriculum. The document analysis of their reports covered the ecocultural knowledge and values that are at the forefront of the teachers' identities as mathematical thinkers. The implications of this study for Indigenous teacher education are framed in terms of an ecocultural pedagogy. The teacher's culture, language, physical and geographic spaces are recognised as having a continuous impact on spatial and other mathematical thinking (National Research Council Committee on Geography, 2006) through their social identity, responsiveness, and self-regulation (cognitive and affective aspects) (see Figure 1). As a result identity as a mathematical thinker has a sociocultural dimension that affects teaching. Concepts are developed through interactions with other people, through reflection on ideas that at first seem unrelated as may occur through out-of-school and in-school experiences, and through the resultant self-negotiation mediated through practice (Radford, 2006). In the current study, practice is manifest in a defined project.

In J. Dindyal, L. P. Cheng & S. F. Ng (Eds.), Mathematics education: Expanding horizons (Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia). Singapore: MERGA.

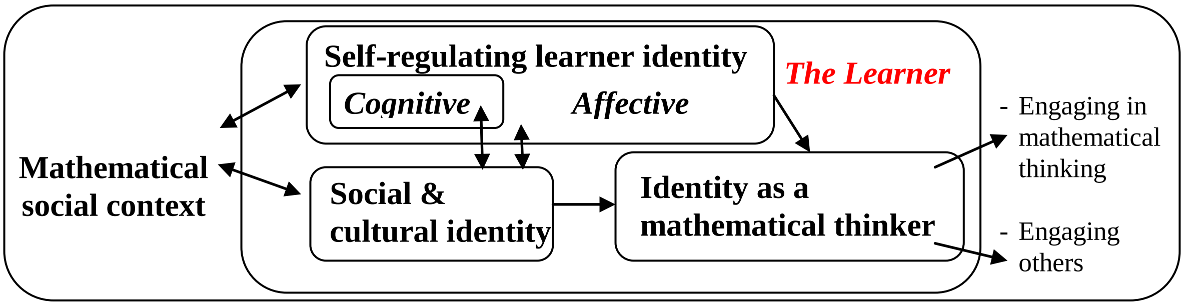

Figure 1. Developing identity as a mathematical thinker (simplified from Owens, 2007/2008).

An Ecocultural Pedagogy of Mathematics

Mathematics is situated in a context whether it is western culture or the long-standing culture of an Indigenous group. For example, variations of spatial concepts as portrayed by sentences and the overall worldview of the Navajo (USA) indicated three basic concepts (a) the essence of movement and the viewing of objects as a slice in time, (b) the sense of volumeness/flatness, and (c) the notion of dimension (but not as an orthogonal grid) (Pinxten, van Dooren, & Harvey, 1983). Based on these basic concepts, Navajo school mathematics expands into a western school topic, topology. However, the recognition of mathematics within the culture requires teachers to make the connections deliberately. In some cases, this is explained in the curriculum documents such as in Alaska with the Yup'ik (Barnhardt, 2007; Lipka & Adams, 2004) and in Northern Territory Australia with the Yolngu (Thornton & Watson-Verran, 1996). The PNG Education Reform recognises that education is best developed from the home culture and community of the students (Litteral, 2001). It is difficult to be specific in the curriculum since PNG has more than 800 language groups having unique logical systems, languages and purposes for mathematical thinking. Thus it is important to establish a teacher identity that incorporates an ecocultural perspective. An ecocultural pedagogy values holistic, integrated knowledge that has changed and accumulated over time and consists of interrelated constructs that continue to develop with thinking, problem solving and experience (Crotty, 1993; Morrison, 2007). The ways of representing cultural resources and maintaining wellbeing are mediated by teachers to reduce the complexity of everyday experiences, respectfully and "without losing site of the rich and dynamic totality of their lives" (González, Moll, & Amanti, 2005, p. 21). A hybridity of this fund of knowledge develops as two-ways or both-ways education (Stanton, 1994) in which there is negotiation of meaning respecting cultural and school mathematics (Ovington, 1994).

Competing values and identities in cultural and school activities require mediating for consonance of knowledge (Bishop, 2002; Lerman, 2001). The mediating tool may be in the mind such as imposed tessellations of triangular figures on plantations of trees (Owens & Kaleva, 2008a). In the current study, the tool used for mediating was a project (described in detail in methodology) to link cultural ways with the school mathematics curriculum and teaching. When connections are smooth, there is a synergy of knowledge and identities (cultural and mathematical) (de Abreu, 2002; Esmonde & Saxe, 2004; Valsiner, 2000). Establishing meaning depends on the ecocultural backgrounds of teachers (Gruenewald & Smith, 2008), no matter how colonised their backgrounds might be (Chinn, 2007). A teacher may value an aspect of knowledge more than another in general or in a specific situation. During transitions from the culturally mediated tools to school mathematics, there is a bridging of the gap to explain practices (de Abreu, 2002). For example, the phrase *centimeter-meter* in PNG's creole Tok Pisin was a way of saying "a small unit and a big unit composed of the smaller units" (Owens & Kaleva, 2008a). Language also plays a part when teachers use words from their own languages.

Social identity is the identification with the values, knowledge, beliefs and attitudes of a social group but it is influenced by systemic beliefs that regulate the person (Malmivuori, 2006). This was exemplified in a study of PNG architecture students faced with solving a design problem. They had a pride in their cultural heritage that led them to consider they were good architectural designers (Owens, 1999). Their self-regulation, self-confidence and cultural responsiveness (Owens, 2007/2008, see Figure 1) resulted in unique, beautiful, and balanced paper sculptures that reflected cultural artefacts. Identity is an enactive, dynamic, interactive ever-changing state of being. It is a becoming within a social context (Davis, 1999). The interaction between social context and self is two way and does not occur in a linear fashion but flows back and forth over time and in different aspects of being (Macmillan, 2009).

In PNG, ethnomathematics is barely articulated in the secondary curriculum or textbooks. For this reason, teacher education incorporating the links between language, culture and mathematics will be a predominant way of achieving the stated goal of education to value and maintain cultural knowledge (Papua New Guinea Government, 2003). A similar issue occurs with the Australian Curriculum where culture is mentioned but not elaborated (Australian Curriculum Assessment and Reporting Authority, 2010). The question is how does an ethnomathematics project develop a teacher's identity as an ethnomathematical thinker and prepare a teacher who plans teaching according to an ecocultural pedagogy?

Methodology

UOG has a large collection of 239 reports produced by (preservice and inservice) teachers in *Mathematics, Language and Culture.* The teachers had received a book of readings and lectures on language and ethnomathematics. They were required to describe aspects of their cultures and relate these to the school curriculum by providing lesson plans and examples that illustrated this connection. All reports (held at UOG) were read but 60 reports that gave good details of culture and school mathematics were analysed to see how the teachers identified and related their cultural and school knowledge.

Figure 1 provided a framework for the analysis. Social identity includes the identity as a PNG mathematics teacher within this university and class. The teachers come from many different language groups and all PNG regions (from high forested mountain ranges, coastal plains, river catchments and islands). Many of their parents have minimal school education and speak their own language fluently as do the students. Cultural identity was evident by the students' emotive words when referring to their culture, family, and fellow students, references to themselves as part of the cultural community of practice, the details of their descriptions, and use of their language words.

Identity as a mathematical thinker was evident by their sense of ownership of the cultural and school mathematics as expressed by affective terms, knowledge depth, ability to problem solve through the project such as finding appropriate connections between cultural and school mathematics, and the quality of the written reports. Each of these identifiers has a basis in the self-regulating learner's cognitive and/or affective learning.

The document analysis was part of a larger research project with ethics approval from my Australian University and the host PNG University whose relevant Department had requested the document analysis and supplied all the documents. The wider project and 15 years of living in Papua New Guinea and an additional 25 years continuing research with Papua New Guinean colleagues has informed my analysis.

Results and Discussion

Cultural identity was strong. Every teacher despite distance from ancestral land or non-use of traditional language proudly gave their language and details of artefacts or cultural activities that involved mathematics. Cultural identity was expressed through the stories in their examples; the affective language that showed pride in the relationships and achievements of their culture, relatives or ancestors.

Dingi (2007) from Gumine District, Simbu Province, showed pride in his cultural heritage and illustrated how the ecocultural context supports not only his cultural identity but his identity with cultural mathematics and hence his identity as a mathematical thinker. He pointed out the dissonance with school mathematics as well as the unconscious tacit knowledge of his people (Frade & Falcão, 2008; Malmivuori, 2006). Dingi explained:

> The conditions that people are in determine the type of houses they build. …The housing traditions … reflect the social patterns, climate and resources, which exist in a particular area … an outward sign of community self-reliance and cultural pride. …The people have been very practical with their knowledge … but the system of education does not help our students to acknowledge and relate those knowledges to the Western brought school knowledge. However, Ethno mathematics tries to change this perspective. This project looks at investigating the Mathematics that are found in the everyday activities… The people have precise knowledge and understanding of the behavior and characteristics of the materials they use to build their houses … in consideration with the climatic factors and its durability,… Given the limited range of available building materials, the people exhibit skillful response to the spanning of space ---- the collection of gravitational forces and their transmission to the ground ---- and the need for stability against lateral loads. The basis of the structures of the buildings come as a result of trial-and-error, intuition and from astute observation of structures found in nature (e.g. trees) … All buildings in my area are constructed by their inhabitants with assistance from close kin who would expect the favor returned. … Though my ancestors and some of my elderly people did not go to school, they are indeed great mathematicians. In their everyday life, they use mathematics that is taught in the classrooms. In almost all the activities that they do, they unconsciously use mathematics.

The project as a mediating tool engaged Dingi and he was able to identify with both cultural mathematics and scientific thinking (Kahan, 2004) and make connections, thus developing his mathematical identity. Dingi also presented sound examples connected to the syllabus about shapes and measurements related to village houses. “Working on this project gives me greatest insight to see into many ordinary activities that I do and people at home do (that) involve a lot of mathematics that I learn in the classroom.” As a tool, the project fulfilled Lebow’s (1993) suggestions for quality teaching: (a) it provided a context for learning that encouraged both autonomy and relatedness, (b) the reasons for learning were embedded in the learning itself, and (c) it supported self-regulated learning by providing skills and attitudes that enabled the learner to take increasing responsibility for the restructuring process. Dingi’s emotive language and close connection to family activities were linked to increasing self-esteem, even of school dropouts.

> I think we use many activities from our local environment in our teaching … this would at least help the students to realize that in whatever they do they are putting their intelligence into practice… and this would help maintain their self-esteem. At the end, we can expect fewer problems in our society.

In terms of the diagram in Figure 1, his identity as a mathematical thinker is being applied back into society, a feature found in the USA studies mentioned above when culture and place were taken into account in mathematics education. Bire (2007) also noted the benefits to society

> my Mate Mr. (MN) … has explicitly demonstrated the construction of Bandicoot Trap in a sequential order by using the appropriate materials available from the bush. … This project is trying to restore and rejuvenate the traditional bandicoot trap which is … (a part) of our unique culture. …The hunters are very skilful … In actual fact, the elderly old people who constructed the trap do not know about western mathematical ideology (sic) but they make use of it. Nevertheless, I as a mathematics student (teacher) from that particular culture can … figure out the different branches of mathematics that blend in to complement the success of the trap.
>
> **To conclude**, it (is) now apparent that many of our cultural activities involve mathematical concepts. Inasmuch, the reformed education emphasizes the importance of upholding our cultural heritage and identity; which is important to teach mathematical concepts using cultural activities. … It is evident that the mathematical ideas which are very abstract are well understood when a teacher/instructor uses analogies from the cultural context in teaching. … students will learn mathematics and on other hand, they also learn their own cultures and perhaps master the abstract concepts better in their own cultures. Hence, they will … fit well in their various societies … there will be a reduction (in) crimes.

Bire noted the hunters' skill and ability to plan carefully; he lamented the use of purchased traps. He expressed his belief in the role that culture plays in learning mathematics. About 95% of teachers identified themselves as mathematics teachers having similar beliefs about mathematics, a recognised cultural identity, a role in restoring culture, and a desire to make mathematics more meaningful to their own students. These common values of promoting culture were supported by National policy (Papua New Guinea Government, 2003). Within the sociocultural context of the Reform curriculum, there is the sociocultural community of practice of the University class itself (Wenger, 1998). The sociocultural contexts impinged on their cognitive and affective learning (Figure 1).

Most teachers (95%) adequately represented school mathematics. About 20% of the teachers provided the steps and ways of thinking required for creating an artefact whether a garden or an object like a wig. For example, Piru (2005), Huli, Southern Highlands, marvelled at the mathematics of his ancient cultural group, and at the explanation that was linked to school mathematics with drawings and superimposed orthogonal axes: to symmetries, parabolas, and calculus. He mixed school mathematics adequately with the customary explanation of wig making in terms of curves, comparisons and measures, order of events, and exactness. He is cognitively and affectively engaged. Onggi (2005) used the making and painting of a door board for a large community building (e.g. a *haus tambaran* for men or a family long house) by the Telefol, Sandaun Province. He had ratios of paint mixtures and geometry topics (e.g. symmetry) linked to both cultural design and school mathematics. The two-way synergy of school and cultural mathematics was evident.

However, teachers frequently situated school mathematics examples in their cultural background but they did not always make a link between the mathematical thinking of the community and school mathematical thinking. Teachers used the cultural artefact as a contextual problem for engaging school students and providing a context for school mathematics (Owens, 2012) rather than providing ethnomathematical thinking required in creating the artefact. This is similar to western school students considering the mathematics found in environmental objects during mathematics trails or scavenger hunts in a park or a zoo (Owens, Pattison, & Lewis, 2003; Smart & Marshall, 2007).

Language is an important component of cultural identity. Bire used Nega language words to describe each kind of material required and gave distances in both Nega and metric language. He called the steps of bandicoot trapping *Klge'vu* an action word. Piru (2005) used *K (ki)* = ½ cm for the unit in his wig-making. Onggi (2005) used questions on proportion structured like school mathematics related to mixing paint using his language for colours, grease, and typical containers for measurement. About 30% of teachers used language words for the names of objects used in the activities and/or the counting systems but 10% gave action words or measurement words involved in a mathematical process.

The teachers considered the intuitive, experiential mathematics gained from observation or activity in the village as "building blocks" (Bafimu, 2007) or fundamental analogies for school mathematics. For example, Pepeta (2001), quoted in the opening paragraph of this article, from Wapenamanda, Enga Province, described a connection between the children's game *bras flaua* (matching cards in the same family) and the collection of like terms in algebra. Teachers generally considered school mathematics as more exact than village mathematics which only had to meet the needs of the village but several reports show this perspective is contested. For example, ropes, sticks and steps were used to measure and ensure the house was sturdy while small units like finger widths ensured a wig or mud-head mask fitted the wearer properly.

Piru's wig study illustrated how the synergy between culture and school mathematics plus the enthusiasm and ownership generated by these connections resulted in well planned school mathematics and pedagogical content knowledge. Overall the plans were of a high standard. However, a small number (5%) of reports showed a discrepancy between the derived construction of school mathematics from the cultural artefact and the generally accepted school mathematics (cf, Owens & Kaleva, 2008b). The sociocultural context did not always ensure development of school knowledge despite having school textbooks available. For example, after studying the symmetry of different weaving and bag designs, one teacher (whom I have selected not to name) discussed the angle sum of interior angles of polygons: "Since there are six equilateral triangles to the hexagon, the sum of the total interior angles would be 180^0 x 6 triangles = 1080^0" but this includes angles at the centre of the hexagon which are not regarded as interior angles in school mathematics. This teacher used words such as "subtended" and "interior" without appreciating their meaning. Despite the use of a diagram, the teacher was unable to recognise the error. This suggests that language difficulties resulted in a struggle to review her work well, that is to self-regulate, a critical aspect of identity (Owens, 2007/2008). Nevertheless, these few teachers still reported clearly their mathematical journeys.

Conclusion

The social contexts for the teachers were an ecocultural background and a school system that adapted western mathematics. The ethnomathematics project engaged the teachers and provided them with an opportunity to inquire about their cultural mathematics. They showed a sense of ownership of the knowledge that they constructed from their personal, cultural backgrounds. They had a strong sense of identity with their culture, and their projects encouraged them to reflect upon their cultural heritage and recognise that it was valuable and relevant to school mathematics education. Construction of knowledge arose from resolving the dissonance between curriculum knowledge and the ethnomathematics knowledge embedded in cultural practices. As Presmeg (2002) noted any dissonance is associated with a negative shattering of valuing themselves as agents who can affect their own lives and society's development. This point was recognised by teachers who were concerned about the dropouts from school.

The teachers adapted an ecocultural pedagogy in planning mathematical problems for school students. There were differences in links to school mathematics between the making process in terms of the systems used for construction versus the use of the end-product. Teachers valued the abilities or mathematical processes of their ancestors and Elders but their understanding was enhanced by school mathematics. The teachers recognised the importance that an ecocultural pedagogy had in terms of learning and developing their students' sense of worth, and hence to be a sociopolitical force in society. The adequacy of expressions of school mathematics reflected the mediation that occurred during the teachers' projects. However, the sociocultural background of valuing school textbook questions still impacted on the variation in connections between ecocultural and school practices as shown in the planned examples. Nevertheless the project strengthened both social and cultural identity and identity as a mathematical thinker who was able to provide an ecocultural pedagogy for mathematics.

References

Australian Curriculum Assessment and Reporting Authority. (2010). Australian Curriculum Mathematics

Bafimu, K. (2007). *The making of yam gardens*. Unpublished report. University of Goroka. Goroka, PNG.

Barnhardt, R. (2007). Creating a place for Indigneous knowledge in education: The Alaska Native Knowledge Network. In D. Gruenewald & G. Smith (Eds.), *Place-based education in the global age: Local diversity* (pp. 113-133). New York, NY: Lawrence Erlbaum.

Bire, J. (2007). *Traditional bandicoot trap*. Unpublished report. University of Goroka. Goroka, PNG.

Bishop, A. (2002). Mathematical acculturation, cultural conflicts and transitions. In G. De Abreu, A. Bishop & N. Presmeg (Eds.), *Transitions between contexts of mathematical practices* (pp. 190-210). Dordrecht, The Netherlands: Kluwer.

Chinn, P. (2007). Decolonizing methodologies and Indigenous knowledge: The role of culture, place and personal experience in professional development. *Journal of Research in Science Teaching, 44*(9), 1247-1268.

Crotty, T. (1993). *Constructivist theory unites distance education and teacher education*. River Falls, WI: University of Wisconsin-River Falls.

Davis, B. (1999). Thinking otherwise and hearing differently: Enactivism and school mathematics In W. F. Pinar (Ed.), *Contemporary curriculum discourses: Twenty years of JCT* (pp. 325-345). New York Lang.

de Abreu, G. (2002). Towards a cultural psychology perspective on transitions between contexts of mathematical practices. In G. de Abreu, A. Bishop & N. Presmeg (Eds.), *Transitions between contexts of mathematical practices* (pp. 170-189). Dordrecht, The Netherlands: Kluwer.

Dingi, D. (2007). *Construction of houses*. Unpublished report. University of Goroka. Goroka, PNG.

Esmonde, I., & Saxe, G. (2004). *'Cultural mathematics' in the Oksapmin curriculum: continuities and discontinuities* Paper presented at the Proceedings of the 6th international conference on Learning Sciences, Santa Monica, California

Frade, C., & Falcão, J. T. d. R. (2008). Exploring connections between tacit knowing and situated learning: Perspectives in the context of mathematics education In A. Watson & P. Winbourne (Eds.), *New directions in situated cognition* (pp. 205-232). New York, NY: Springer.

González, N., Moll, L., & Amanti, C. (Eds.). (2005). *Funds of knowledge: Theorizing practice in households, communities, and classrooms*. Mahwah, NJ: Lawrence Erlbaum.

Gruenewald, D., & Smith, G. (2008). *Place-based education in a global age: Local diversity*. New York, NY: Lawrence Erlbaum.

Kahan, S. (2004). Engagement, identity and innovation: Etienne Wenger on communities of practice. *Journal of Association Leadership* *http://www.asaecenter.org/PublicationsResources/JALArticleDetail.cfm?ItemNumber=16217.*

Lebow, D. (1993). Constructivist values for instructional systems design: Five principles toward a new mindset. *Educational Technology Research and Development*, *41*, 4-16.

Lerman, S. (2001). Cultural, discursive psychology: A sociocultural approach to studying the teaching and learning of mathematics. *Educational Studies in Mathematics*, *46*, 87-113.

Lipka, J., & Adams, B. (2004). Culturally based math education as a way to improve Alaska native students' math performance. Working Paper 20. Appalachian Collaborative Center for Learning (ED484849).

Litteral, R. (2001). Language development in Papua New Guinea. *Radical Pedagogy*, *3*(1).

Macmillan, A. (2009). *Numeracy in early childhood*. Sydney, NSW: Oxford University Press.

Malmivuori, M.-L. (2006). Affect and self-regulation. *Educational Studies in Mathematics, 63*, 146-164. doi: 10.1007/s10649-006-9022-8

Morrison, D. (2007). E-Learning in higher education: The need for a new pedgagogy. In M. Bullen & D. Janes (Eds.), *Making the transition to e-learning* (pp. 104-120). Hershey, PA: Information Science.

National Research Council Committee on Geography. (2006). *Learning to think spatially: GIS as a support system in the K-12 curriculum*. Washington DC: National Academies Press.

Onggi, C. (2005). *Deriving academic mathematics from Telefol traditional door board designs*. Unpublished report. University of Goroka. Goroka, PNG.

Ovington, G. (1994). "Both Ways Education" dominant culture access and minority culture maintenance: An analysis of competing theories. *Journal of Multilingual and Multicultural Development, 15*(1), 29-46.

Owens, K. (1999). The role of culture and mathematics in a creative design activity in Papua New Guinea. In E. Ogena & E. Golla (Eds.), *8th South-East Asia Conference on Mathematics Education: Technical papers,* (pp. 289-302). Manila, The Philipinnes: Southeast Asian Mathematical Society.

Owens, K. (2007/2008). Identity as a mathematical thinker. *Mathematics Teacher Education and Development, 9*, 36-50.

Owens, K. (2012). Papua New Guinea Indigenous knowledges about mathematical concepts. *Journal of Mathematics and Culture (on-line), 6*(1), 15-50.

Owens, K., & Kaleva, W. (2008a). Case studies of mathematical thinking about area in Papua New Guinea. In O. Figueras, J. Cortina, S. Alatorre, T. Rojano & A. Sepúlveda (Eds.), *Annual conference of the International Group for the Psychology of Mathematics Education (PME) and North America chapter of PME, PME32 - PMENAXXX* (Vol. 4, pp. 73-80). Morelia, Mexico: Organising Committee of PME32-PMENAXX.

Owens, K., & Kaleva, W. (2008b). *Indigenous Papua New Guinea knowledges related to volume and mass.* Paper presented at the International Congress on Mathematics Education, Discussion Group 11 on The Role of Ethnomathematics in Mathematics Education, Monterray, Mexico.

Owens, K., Pattison, J., & Lewis, E. (2003). Organising maths trails. *Reflections, 28*(1), 27-30.

Papua New Guinea Government. (2003). *National curriculum statement*. Port Moresby, PNG: Ministry of Education.

Pepeta, P. (2001). *Developing mathematics in the traditional/cultural activity*. Unpublished report. University of Goroka. PNG.

Pinxten, R., van Dooren, I., & Harvey, F. (1983). *The anthropology of space: Explorations into the natural philosophy and semantics of the Navajo*. Philadelphia, Pa: University of Pennsylvania Press.

Piru, P. (2005). *Mathematics derived from Huli wig construction*. Unpublished report. University of Goroka. Goroka, PNG.

Presmeg, N. (2002). Shifts in meaning during transitions. In G. De Abreu, A. Bishop & N. Presmeg (Eds.), *Transitions between contexts of mathematical practices*. Dordrecht, The Netherlands: Kluwer.

Radford, L. (2006). The anthropology of meaning. *Educational Studies in Mathematics, 61*, 39-65. doi: 10.1007/s10649-006-7136-7

Smart, J., & Marshall, J. (2007). A geometric scavenger hunt. *Science & Children, 45*(2), 36-40.

Stanton, R. (1994). Mathematics "Both Ways": A mathematics curriculum for Aboriginal teacher education students. *For the Learning of Mathematics, 14*(3), 15-23.

Thornton, M. B., & Watson-Verran, H. (1996). *Living maths*. Abbotsford, Victoria: Yirrkala Community School and Boulder Valley Films.

Valsiner, J. (2000). *Culture and human development*. London: Sage.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. New York, NY: Cambridge University Press.