

Village Elders' and Secondary School Students' Explanations of Natural Phenomena in Papua New Guinea

Soikava Pauka

Curriculum Reform Implementation Project

National Capital District

Papua New Guinea

[Email: spauka@crip.sagric.com](mailto:spauka@crip.sagric.com)

David F. Treagust

Science and Mathematics Education Centre

Curtin University of Technology, Perth, Western Australia, Australia.

Email: d.treagust@curtin.edu.au

Bruce Waldrip

Faculty of Education

University of Southern Queensland, Toowoomba, Queensland, Australia

Email: waldrip@usq.edu.au

Corresponding author: David F. Treagust

Email: d.treagust@curtin.edu.au

VILLAGE ELDERS' AND SECONDARY SCHOOL STUDENTS' EXPLANATIONS
OF NATURAL PHENOMENA IN PAPUA NEW GUINEA

ABSTRACT

This research investigated the sources of explanations and understanding of natural phenomena in terms of the students' cultural and school science experiences. The first phase involved interviews with eight village elders that probed their explanations and understanding of natural phenomena. The second phase involved the design, development and administration of two questionnaires on natural phenomena to 179 students in a rural boarding high school in Papua New Guinea (PNG). Most village elders gave explanations of many of the phenomena in terms of spirits, spells, magic; religion; and personal experiences. Most school-aged students choose scientific explanations of natural phenomena in terms of what they had learned in school or from personal experiences. However, many choose explanations of the same phenomena about spirits, spells and magic that came from the village, family or home. The study revealed that students' ideas about natural phenomena are strongly governed and controlled by their school science knowledge in the school setting. It is likely that their own traditional knowledge cannot be identified in a school setting but that questionnaires in the students' local language be given to students in their villages (as opposed to school). In addition, so as not to diminish the value of this traditional knowledge, science education programs are needed that are able to consider and harmonise traditional knowledge with school science

Key words: scientific explanations, traditional knowledge; learning science

Papua New Guinea, situated north of Australia, is a culturally diverse developing country with a population of 4.5 million Melanesians. The people speak over 715 different languages and belong to many different cultural tribes (Central Intelligence Agency, 2004). The tribal clans view nature as a whole; continuity from the past to the present and into the future; the clans are linked with the surrounding land, water forests, and heavens (Waiko & Jiregari, 1982). The wisdom and accumulated tools for dealing with and living in the environment are contained in this knowledge base which is learned by repetition, reinforced rituals, sanctions on the ancestors, or rewards from the spirits. For example, Kiki (1963) in his autobiography 'Kiki Ten Thousand Years in a Lifetime' confirms that his mother's people referred to the dead as 'going to the west' because their dead were not buried in the ground but placed high up in tree branches facing the sunset. The people did not believe in the last judgement and had no concept of heaven or hell. But they believed that the dead were ever present and they can be called upon to help in any dangerous situation. Similarly the 'Toaripi' of the Gulf Province referred to their dead ancestors to a dwelling place of the dead called '*alaua-ipi kivokipi*' which connotes a place beyond the western horizon where spirits of the dead were supposed to dwell. Thus the exclamation '*alaua-ipi meaforoe a*' is often said where there is a beautiful sunset, '*what lovely weather in the spirit land*' (Brown, 1968). Thus, Australia is referred to as the spirit land where the dead were supposed to dwell.

Village elders from many tribal groupings are perceived to be the source of wisdom and the recognised authority of tribal knowledge (Waldrip & Taylor, 1999b). In many PNG traditional societies, traditional knowledge is finite and passed down from generation to generation by word of mouth by the older members to the younger generation of the tribe as a survival tactic. Such knowledge includes the skills of hunting, trading expeditions, building canoes, gardening (planting and harvesting), building shelter, healing diseases, forecasting weather, initiation ceremonies, funeral rites, protection against crocodile, fishing expeditions, and various activities associated with cultural heroes. The most respected elder in a community usually conducted the teaching and learning that occurred through practical absorption (observation) and participatory activity embedded in each villager's daily life. Specialists teach the tasks to a selected few who have gone through the primary and secondary streaming processes by way of *pre-initiation* (Kelontii, 1996). Pre-initiation is mainly done through observing the

child's interests at an early age. For example, if a child is found to possess aggressive behaviour, he is singled out and given a warrior's initiation.

Traditional knowledge comes from a wide diversity of experience in nature, from teaching and apprenticeship, working with the land, by absorbing the feel of the wild animals and plants, and by listening to legends and stories (Emery & Patton, 1997). Therefore traditional knowledge is organised and based on integration, not on analysis into parts. In addition, basic assumptions about classification of plants and animals or cultural actions and rituals are often very different to those of technology-based societies. The characteristics of traditional learning are through observation, imitation, and verbal instruction; by personal trial and error through demonstrations; mostly with real life activities; and being context specific and person oriented (Harris, 1992). In many villages, learning of indigenous languages, folklore, personal-social relationships, traditional vacations and dances and the nature of family structures, still depend heavily on these procedures and experiences from the past. During puberty, secret or true knowledge concerning the tribe and life originating from the gods were passed on through sometimes, painful initiation ceremonies.

The Melanesian worldview incorporates humans and animals, the seen and the unseen, the living and the dead, in a way that is vastly different from the European outlook (Flannery, 1998). What Europeans call 'supernatural' factors are for Papua New Guineans simply the non-visible parts of a single continuum of life. Indeed, they are eminently 'natural' (p. 200). Because of its divine origin, McLaughlin (1996) highlights several features in describing Melanesian concepts of knowledge. Firstly, unlike Western knowledge, which is meant to be challenged, Melanesian knowledge was finite and not tested. It dictated a set of moral principles that guided behaviour and maintained the spiritual strength of the community. The young learners were schooled in the accurate reproduction of received knowledge and customs. At no point were they encouraged to question or innovate as these would alienate them from adult society (McLaughlin, 1995). Similarly, Emery and Patton (1997) assert that in many indigenous cultures, the elders speak the truth and the hunters' words are unquestioned. Indigenous people understand that there are different qualities of knowledge from people who have different levels of experience and wisdom, so they accept the knowledge the way it is presented. They do not attempt to challenge the wisdom of an elder.

Finally, most of these Melanesian students have not seen, let alone experienced, the examples of concepts that teachers use to explain science, such as traffic lights, solar water heaters, air conditioners, vacuum flasks, jet aircraft. This lack of exposure can alienate the students from the information presented and their teacher (Koosimile, 2004). That is, students are implicitly taught to devalue traditional knowledge and are not exposed to indigenous knowledge with which they are familiar as examples of scientific concepts. Naijke (2004) found that teachers' and students' understanding of science concepts were influenced by their worldviews. Also, the background of the student was reflected in whether they held naïve, transitional or canonical views of the nature of science. These students with different worldviews can face a dilemma when exposed to Western science as how can they accommodate or process both worldviews (Aikenhead, 2001). Unfortunately, there is a tendency for students to view Western science as desirable and superior to local knowledge (Siegel, 2002; Waldrup & Taylor, 1999a) and that their knowledge of it is related to their later success.

THEORETICAL FRAMEWORK AND SIGNIFICANCE OF THE STUDY

Teaching and learning science in PNG has always being a dilemma because the students come from different tribal groupings where cultural ideas and beliefs are a reality in their minds. Baker and Taylor (1995) reviewed an integrated research on how culture affected the learning of science in non-western countries. They claimed that attempt to nationalise western science curricular was ineffective because of the disconnectedness between the students' worldviews and school views. Their study identified a relationship between language use and concept development. It stated that 'personal construction of meaning in science is related to the linguistic background of the learner and compatibility of the learner's language with that of science education (p. 697)'.

Science, in particular, makes a strong demand on students' use of language (Gee, 2004). This use requires students to utilise oral, printed, symbolic and traditional worldviews to assist them to understand Western science concepts. In fact, learning is restricted if the students cannot situate their learning in terms of embedded experience which includes traditional stories and knowledge. Traditional story telling utilises gestures. Science teaching in Papua New Guinea by national teachers utilises a high degree of gestures.

Students use these gestures in developing their understanding of science (Roth, 2004). Since traditional story telling utilises gestures, one needs to examine whether students retain traditional understandings of concepts that can conflict with Western science concepts. Furthermore, this study states that the learner's cultural background has an effect in knowing and learning science as this creates a gap between western and non-western interpretations of reality in science education.

Many researchers (Baker & Taylor, 1995; Boeha, 1987; Cobern, 1993; 1996; Cobern & Aikenhead, 1998; Jegede; 1995; 1997; Maddock, 1981; Ogbu, 1992; Ogawa, 1986; Okebukola & Jegede, 1990; Waldrip & Taylor, 1999a) have stated that the culture of a learner plays a central role in learning science. The use of prior knowledge and situated cognition is a basis for arguing how learning occurs and is dependent on the environment as a source of information. In the case of PNG students who attend science classes with Melanesian worldviews, the interaction between the Western mechanistic worldview and the Melanesian traditional knowledge may complicate their cognitive processes. Traditional beliefs, ideas or stories to explain natural phenomena do exist in every community. As evidenced by the voluminous research globally, students bring to science classes their ideas and beliefs about the natural world (Driver, et al., 1994) that often are not in conformity with the scientific notions. As other examples of research studies in PNG (Boeha, 1987; George, 1991; Kelontii, 1996; Maddock, 1981; Vlaardingerbroek, 1990) have shown prevalent traditional beliefs or ideas exist to explain natural phenomena. These studies have shown that scientific explanations of the physical world are learned in school science chiefly for passing examinations. However, these studies have not examined the concurrent existence of traditional knowledge and students' understanding of the natural world while attending science classes.

PURPOSE OF THE STUDY

The primary purpose of the research was to investigate the sources of students' explanations and understanding of natural phenomena in terms of the students' cultural and school science experiences. Village elders were interviewed to ascertain their explanations which were interpreted in terms of spirits, spells and magic; personal experience, religion and modern science. These explanations as well as scientific

explanations were used to develop two questionnaires to be administered to secondary school students to ascertain their choice of explanations of the same natural phenomena.

BACKGROUND TO THE STUDY

This study has its origins from an earlier study on '*Children's understanding of natural phenomena*' (Pauka, 1988) and relates back to the first author's early years of teaching secondary school science (1978-1983) and his involvement in writing distance learning materials (1983-1986 and 1989-1994) in which the importance of traditional knowledge that most students bring to science classes had not been researched in detail except in Kelontii's (1996) study. This interest allowed him to go back to his village of '*Lelefiru*' where he interviewed eight village elders on their understanding of natural phenomena between October and November of 1997.

The first author had continued to maintain strong ties between his village and his growing-up in Port Moresby in the late 1950s and early 1960s after his parents moved there. His parents were among the first '*Toaripi*' people to move into Port Moresby, first as an indentured labourer (his dad) and then as a family group (his mother) after World War 2 (Ryan, 1989). He remembers that his mother said that she and his elder sister sailed on a '*lagatoi*' (double hulled canoe with crab-claw sails) during one of the last of the famous *Hiri* Trade expeditions back to *Motuan* villages around Port Moresby. During the early *Hiri* expeditions in 1940s, the *Motuans* traded their clays pots for the sago and betelnuts of the *Elema* people in the Gulf Province (Kiki, 1963). It was also through the many stories that his parents told of a big village called '*Lelefiru*' near the sea and how the villagers used to paddle up and down a once fast flowing '*Meporo*' river to cut and make sago and plant new gardens. The name '*Lelefiru*' if separated into '*lele*' meaning 'a bird called an egret' and '*firu*' meaning 'an island', therefore fully it means 'island of the egrets'. Most interesting of all was that this long beach near the village has been eroded gradually away by the sea; village elders like his mother, blame the event on the use of magic spells ('*seseva*'). It is beliefs such as this that interested him into identifying the common ideas and beliefs that village elders hold on natural phenomena.

As these villager elders live within reach of their own natural environments, perhaps maybe they would have an in-depth understanding in explaining certain ideas (Waldrip & Taylor, 1999b). As a result, this led to several interviews which probed the elder's understanding of occurring natural phenomena. The task was mainly to discover the traditional beliefs, worldviews and explanations held by these village elders on natural phenomena. The interviews were conducted on the front veranda of the first author's brother-in-law's house. It was a comfortable and relaxing atmosphere with conditions very warm at that time between October and November of 1997 because it was during one of the worst droughts in PNG.

METHODOLOGY

Village Elders

Initial contacts with all the eight village elders were made through the first author's brother in-law, a respected retired Reverend of the United Church who has invaluable knowledge of the structures of the different clans in the village. Morauta (1984) affirms this stronghold of Christianity which relates back to the early arrival of Reverend James Chalmers in 1881, from the London Missionary Society (LMS) who was the first European to visit the two big villages of 'Uritai' and 'Mirihaea' where a mission station was set up in 1884. Several of these elders may have been either educated by the early missionaries to Grade 6 and held different positions within the government or private sectors and have retired and come back to live in the village. Several of them have also been actively involved in church activities in the village and in Port Moresby. Pou, the oldest is in his late 70s and is the only surviving member of his clan with knowledge of folklore. Mora in his early 70s is a known fisherman and when I met him, he was mending his fishing nets. Mesea in his late 50s is a businessman and owns a truck which brings garden produce and transports people to and fro from Malalaua and Kerema. Mai in his late 60s is a retired government employee and has come back to live in the village through fishing and making gardens and is involved in church activities. He has been involved with the Native Corporative Society business in the village. Ivan, Tati and Sari in their early 60s have all lived and worked in Port Moresby but have retired and moved back to live in the village. They all live through gardening and fishing and taking part in church activities. Sevese in his late 60s has been involved with

the Native Corporative Society business in the village and also lives by gardening and fishing.

Each of the village elders were interviewed in '*Toaripi*', the common language spoken in this village with which the first author is familiar. In order to ensure that the elders perceived the interview process as meaningful, they were told that whatever they said was judged not to be right or wrong and would be kept confidential as it was based on their own understanding. The initial questions focused on the context of their involvement within their village, that is, the ocean or the land environment. Each elder was asked about the sand on the beach, what happened to the sand when it was eroded and where it was deposited. From where the interview was conducted on the veranda of the house, the beach was in full view with the sea and the wind blowing through the swaying coconut palm trees. Each elder interviewed fully understood what the interview was about and at some stages thought that some of the questions asked were interesting such as what is a rainbow, what is lightning and thunder, and what causes the wind to blow.

Secondary School Students

The students involved in the study came from villages situated either on the coast or inland between Cape Possession to the Avei mouth of the Purari River in the Gulf of Papua. Most of these students have spent their community schooling in their villages as most of these villages have their own community schools. After 6 years of community school they sit an entrance examination which qualifies them for a place into Malalaua Provincial High School which caters for students around this area. This school is situated near Malalaua Station, east of the provincial capital, about 45 kilometres. The school is easily accessible both by road and air. The students who mainly attend the school come from about 17 different '*Toaripi*' speaking villages and speak about four other languages apart from learning in *English* which is the medium of instruction in schools. They are taught English, Mathematics, Science, Social Science, Commerce, Agriculture, Home Economics, Practical Skills and Guidance. The school is made of three Grade 7, two each of Grades 8, 9 and 10 classes. Most of the students are boarders who reside in two double stories dormitories each for boys and girls. A typical school day begins at 7.40 am and finishes at 1.50 pm, a duration of 8, 40-minutes lessons.

Students do work parades on Mondays, Wednesdays and Friday afternoons from 3.00 to 4.00 pm to keep the school clean and play sports on Tuesday and Thursday afternoons. There have been problems experienced at this school such as that of closing early during a term due to food shortage and also a high rate of absenteeism which results in fewer students in a class (normal class size = 40 students).

Method, Design and Procedures

The first phase of this research was an ethnographic-interpretative study (Erickson, 1986) of interviews with eight village elders that probed their explanations of natural phenomena. The second phase involved the design, development and administration of two questionnaires on explanations of natural phenomena to 179 students.

Initially, elders in villages of the Gulf Province in PNG were interviewed about their explanations of natural phenomena and the stories that were passed down from one generation to the next. The interviews followed a structure format with a set of questions based on natural phenomena that included *erosion* and *deposition*, *drought*, *sun* (*sunrise* and *sunset*), *burning*, *moon*, *rain*, *thunder*, *lightning*, *rainbow*, *clouds*, and *plant growth* to identify the village elders' responses. These extensive interviews, which were tape-recorded and analyzed, identified four categories of explanations using traditional knowledge (Pauka, 1999). These explanations were categorized based on 1) spirits, spells and magic, 2) personal experience, 3) religion and 4) modern science.

Using these explanations, the first questionnaire, which consisted of 11-items was developed based on the natural phenomena of *clouds*, *erosion/deposition*, *drought*, *plant growth*, *sun*, *moon*, *rain*, *thunder/lightning*, *rainbow*, *wind*, and *burning*. Students responded by stating where they have heard the explanations being used from four situations, 1) home/family/village, 2) school, 3) church, or 4) they have never heard it used.

The second questionnaire contained open-ended questions on *erosion*, *deposition*, *plant growth*, *rain*, *thunder*, *lightning*, *rainbow*, *moon*, *sun*, *wind*, *clouds* and *drought*. Students were asked to write down their responses to these questions on natural phenomena. The questionnaires were written in *English* and administered in a science

classroom where the language of instruction was *English*; however each student spoke as many as four local languages in their village communities.

The questionnaires were administered to a sample of 179 students from Grades 7 (n = 25), 8 (n = 54), 9 (n = 64) and 10 (n = 36), ages of students range from 13 to 20 year olds in October 1998 at a rural high school in the Gulf Province in PNG. The administration time for the first questionnaire was 40 minutes while the second questionnaire took about 160 minutes with the researcher available to answer respondents' questions. However, the answering of the questionnaires did not pose any major problems. The first questionnaire upon completion was coded, verified and analyzed in terms of frequencies and percentages. The responses to the second questionnaire was entered into a file and stored in a computer.

Building a framework

The major thrust of the study was the identification of the village elders' and secondary school students' explanations of natural phenomena. The interview questions formed the single source of data for the village elders whereas the students' source of data came from their responses to the two questionnaires. During the transcribing and translation of the interviews from '*Toaripi*' into *English*, all the main ideas and explanations relating to the ten natural phenomena were sought as a means to discover and identify systematic patterns or relationships among categories (Agar, 1996). In this instance, four main categories were identified by means of phenomenological analysis, under which the ideas, beliefs and explanations were tabulated as spirits, magic spells and sorcery; personal experience; religion; and modern science. It was found that there were similarities amongst explanations for the personal experience category with that of modern science. For example, inland rivers and creeks are blocked due to the felling of trees for food gardens and as a result the water cannot assist in the deposition of sand downstream and onto the beach. The following section shows two examples of how the ideas and explanations were sourced from the interviews on natural phenomena.

RESULTS - VILLAGE ELDERS' INTERPRETATION OF NATURAL PHENOMENA

Erosion/Deposition of sand along the beach (Miri folo ma sa faveai/foreovai)

To probe the village elders' understanding of 'erosion and deposition', they were asked the following questions in stages from which the following explanations were derived.

Our village 'Lelefiru' used to be an island in the deep sea. But because of the sea continuously crashing on the beach, it has taken the sand on the beach away to another part of the beach. What do you think makes the tide come up and then down the beach. When the tide crashes on the beach, where do you think it takes the sand to. The tide breaking on the beach makes the sea come in closer to the village and the houses. So what makes the tide hit the beach and when it hits the beach, where does it take the sand to? The sea waves, when they crash on the beach, the sand on the beach does not stay there. Where do you think the sand goes. The sea waves, what makes it hit the beach.

Category 1: Explanations using spirits, magic spells and sorcery

- * Three of the village elders said that traditionally and nowadays magic spells ('seseva') was used to move the sand along the beach. The sand moves or walks depending on the waves and rapids of the water and deposits it at the requested place. Interestingly, another elder said that without the use of magic spells, the sand will remain in one place and not get eroded.

Category 2: Explanations relating to Christianity

- * Three of the village elders mentioned that it was a punishment from God ('Ualare-Iehova') as most young people are turning away from God.
- * Three other village elders interpreted that in former days, there was no erosion because the old people's beliefs in God were positive and respectful and as a result they were blessed with good things.
- * Three other village elders said that nowadays too many young people have turned away from God and do many wicked things. So as a punishment, the sand on the beach continuously erodes away.

Category 3 and 4: Explanations relating to personal experience and modern science

- * Three of the village elders said that changes in the wind directions and tides cause the erosion and deposition of the sand on the beach.

- * Four other village elders said that inland rivers and creeks are blocked due to the felling of trees for food gardens and as a result, the water cannot assist in the deposition of sand downstream and on to the beach.
- * Three more village elders said that only tidal waves caused by the wind erode the soil on the beach.
- * Five other village elders mentioned that the erosion and deposition of sand on the beach is the result of tidal changes caused by the south-west and south-east trade winds.
- * Five of the villager elders said that strong river currents take the sand down to the sea.
- * Three of the village elders said that erosion occurs at the mouth of rivers during heavy rainfall.
- * Four of the village elders said that river currents help build the sand up on the beach.

Red sunrise/sunset (Sare patei eata fauki ta soa kauri ovosesei)

To probe the village elders' understanding of 'red sunrise' and 'sunset', they were asked the following questions in stages from which the following explanations were derived. *When you wake up in the morning, you see the sun rising and it is very red. Why is this so? When we burn the bush and in the morning when the sun comes up, you see that it is very red. Because there is haze all around created by the smokes from the burning fires. This is the same when the sun sets. What do you see? What is happening around us? What do you think the sun is? When we see the sun rising and then setting in the evening, what do you think the sun is. The sun when it rises in the morning, we follow it until it sets in the evening. What do you think is the sun? What does it mean? Does the sun stay in one place or it has many places? When we see the sun in the sky, does it follow one path or has many paths? We say the sun is very hot, like when we light our fires with hot roaring flames to cook our food. Do you think the sun is very hot?*

Category 1: *Explanations using spirits, magic spells and sorcery*

- * A village elder interpreted that a spirit ('*Epe Savora*') helps and directs the sun in its path from sunrise to sunset. When the sun sets, the place becomes dark. The sun is looked after by the eponymous ancestor ('*Epe Savora*') of the '*Savoripi*' clan;

hence the honorific title for menfolk of the clan. It is the traditional term for '*ivuta*', the iguana (Brown, 1968).

Category 2: *Explanations relating to Christianity*

- * Five of the village elders said that God created the sun which is hot and burns all the time and gives warmth to living things.
- * Two other village elders said that the red sunset and sunrise is a sign interpreted as a punishment from God
- * An elder mentioned that it is God's plan for the sun to rise and set.

Category 3 and 4: *Explanations relating to personal experience and modern science*

- * Six of the village elders said that the sun stays in one place and follows the same path. Interestingly, they mentioned that the earth revolves around the sun.
- * One of the elder's observations when interpreted indicated that the sun when observed follows a different path due to its tilt from January to June and from July to December.
- * Five of the elders said that the red sunrise and sunset were due to the results from burning which gives off smoke into the atmosphere. The smoke causes the redness of the sun in the sky when it rises and sets.
- * An elder mentioned that the sun is a very hot burning furnace.
- * Two of the elders said that during rainfall, the rain causes all smoke, smog, haze to disappear. There is bright sunshine after the rain.

RESULTS - SECONDARY SCHOOL STUDENTS' INTERPRETATION OF NATURAL PHENOMENA

The following section shows two examples of how students responded when they were given the four situations to choose from identifying the particular place they have heard the explanations used on *erosion/deposition* and the *sun*.

Responses to the first questionnaire

Question 5: Erosion/Deposition

Four statements (Table 1) of explanations about ‘*erosion*’ and ‘*deposition*’ were given and students were asked to choose in which particular place they have heard these explanations being used. The following situations were given: 1) Home/family/village; 2) School; 3) Church; and 4) Have not heard it used.

Table 1: Students’ responses in percentages to statements in Question 5 on ‘*erosion*’ and ‘*deposition*’.

Statements	Home/ family/ village	School	Church	Haven’t heard it used
5A. People cast spells or ‘ <i>seseva</i> ’ and utter magical words to move the sand on the beach in my village. As the sea water hits the sand, it makes the sand walk and move along the beach. The sand settles in the requested places and builds up	66.2	0.9	0	16.7
5B. The changes in the winds direction and tides cause the sand on the beach in my village to be eroded. This removes the sand and deposits it somewhere on the beach. The two processes help to built up the sand on the beach in my village.	27	32.4	0.5	19.9
5C. The sand on the beach in my village gets eroded and deposited somewhere all the time. This is a punishment from God because the people do not worship God. If people worship God, then the sand will built up again on the beach.	10.6	0	0.5	35.2
5D. The currents from the rivers near my village have become weak. This is because trees are cut which fall into the river. As they fall in, they block off the flow of the river. This stops the eroded sand being taken down to the open sea. Therefore it does not help build up the sand on the beach in my village.	24.1	29.2	0.5	37.0

For statement 5A of the question on ‘*erosion*’ and ‘*deposition*’, over two thirds (66.2%) of the students have heard the explanation been mainly used at home, in the family and in the village. Another 0.9% of the students have heard it been used in school and interestingly about 16.7% of the students have not heard it been used. This is because the have not associated well with the elders and are disinterested in their traditional beliefs.

For statement 5B, about 32.4% of the students have heard it been used in school while another 27% of the students have heard it at home, in the family and in the village. About another 0.5% of the student have heard it been used in church and again interestingly about 19.9% of the students have never heard of this explanation. This is because students do not see natural forces at work, which erodes the sand on their beach and deposits it in another place. Students may be combining what they hear at school with what they have learnt at home. They could be substituting 'wind' for 'spirit' when they talk about this.

For statement 5C of the question on 'erosion' and 'deposition', about 10.6% have heard at been used at home, in the family and in the village. Another 34.3% of the students have heard it been used in church while another 35.2% of the students have never heard of this explanation. Most of the students do not believe that the sand on the beach in their villages gets eroded which as a result is a punishment from God.

For statement 5D, about 24.1% of the students have heard it used at home, in the families and in the village. Another 29.9% of the students have heard it been used in schools while another 0.5% of the students have heard it in church. However, again another 37% of the students have never heard of this explanation been used which is very interesting. This stems from the fact that they do not see natural forces at work again eroding the sand on their beaches and depositing it in another place.

Question 7: Sun

Four statements (Table 2) of explanations about the *sun* were given and students were asked to choose in which particular place they have heard the explanations being used. The following situations were given: 1) Home/family/village; 2) School; 3) Church; and 4) Have not heard it used.

Table 2: Students' responses in percentages to statements in Question 7 on the '*sun*'.

Statements	Home/ family/ village	School	Church	Haven't heard it used
7A. My everyday observations tell me that the sun follows different paths. This is due to the tilt of the earth from January to June and from July to December. Therefore the sun	4.6	68.5	1.9	6.0

stays in one place. Our earth revolves around the sun.

7B. The sun is looked after by an ancestral spirit called ' <i>Epe Savora</i> '. ' <i>Epe Savora</i> ' is the tribal ancestor of the ' <i>Savoripi</i> ' clan. It is also the title of honor for menfolk of the clan. ' <i>Epe Savora</i> ' helps direct the sun from sunrise to sunset.	43.5	0.9	0.9	37.5
--	------	-----	-----	------

7C. The sun was created by God in the beginning. The sun is hot and gives light and warmth to all plants and animals on earth. We depend on the sun because sunset means we can rest till morning. When the sun rises again, we wake up and go on with our daily work.	13.4	8.3	50.5	1.4
--	------	-----	------	-----

7D. The sun is like a very hot fire burning in a furnace. The sun does not stay in one place but visits many places. When the sun sets, that means it has gone to another part of the world.	12.0	35.2	0.9	30.1
--	------	------	-----	------

For statement 7A of the question on the *sun*, about 4.6% of the students have heard it being used at home, in the family and in the village. Interestingly over two thirds (68.5%) of the students have heard it been used in school while 1.9% of the students have heard it in church and another 6% of the students have never heard of this explanation.

For statement 7B of the question on the '*sun*', about 43.5% of the students have heard it been used at home, in the family and in the village. Another 0.9% of the students have heard it been used in school and in the church while another 37.5% of the students have not heard this explanation. This is probably due to their lack of interest in associating with village elders to know more about their traditional knowledge.

For statement 7C of the question on '*sun*', about 13.4 % of the students have heard it been used at home, in the family and in the village. Another 8.3% of the students have heard it been used in school and about half (50.5%) of the students have heard this explanation been used in church. Finally about 1.4% of the students have not heard of this explanation.

For statement 7D of the question on '*sun*', about 12% of the students have heard it been used at home, in the family and in the village. Another 35.2% have heard it been used in

school while another 0.9% of the students have heard it in church. Finally about 30.1% of the students have said that they have never heard of this explanation.

Responses to the Second Questionnaire

The following section gives three examples of how students' responses to the questionnaire with open-ended questions on 'erosion', 'deposition' and the 'sun' were sourced.

Erosion

Students were asked that in their science lessons, they may have heard and used the word 'erosion' to help explain various activities within their natural surroundings.

a) The first part of the question asked students to give the 'Toaripi' meaning or word for 'erosion'. About 30.8% of the students gave the meaning similar to 'mea ma sa ovi soeai' (soil carried away by water) and 'mea faveai' (soil eroded). Another 19.6% of the students gave other meanings such as 'favi' (of soil sand, to dig up and 'foforukai' (fall into pieces). Interestingly half (51.3%) of the students did not know the 'Toaripi' meaning or word for 'erosion'; this was most noticeable among the grade 9 students (24.3%) who may be fluent in their own language but cannot easily interpret the meaning into *English*.

b) The second part of the question asked students to describe 'erosion' in their own words. About 73.8% of the students, mainly from grade 9 (37.4%) responded and said 'soil washed away by water, rain or flood' while another 9.3% of the students gave other responses such as 'water that comes up surrounding the house'. Another 16.8% of the students did not respond to the question.

c) The third part of the question asked students about an old person telling them that someone in their village can make the sand move to another part of the beach. This person may cast magic spells or use 'seseva' to move the sand. Then the students were asked if they thought this could happen and give a reason why. As shown in Table 3, 47% of the students responded 'yes' and said that this old person may be angry with someone for stealing his things or the old men's relatives may be involved in a fight so

he takes revenge. Also village people do not respect village elders or they may be jealous. An interesting response given by a student who experienced it in 1994 when an old man who came from a different village got married to an old woman from the student's village. When the old woman died, the old man said some magic spells and the beach in the student's village went right inside. However, 27.5% of the students responded 'no' and said that they have never heard such stories like this before and have not seen it with their own eyes. Furthermore they also said that they do not believe in magic and that sometimes traditional stories are not true as these are natural processes working and only God can remove it, not man.

Table 3: Percentages of types of responses to the question: An old village person might have told you that someone in your village can make the sand move on the beach to another place. This person may cast magic spells or use 'seseva' to move the sand and place it on another part of the beach. Do you think this can happen? Why?

Type of response	<u>Grade levels</u>			
	7	8	9	10
Yes. This person may be angry for stealing his things, this person's relatives may be involved in a fight, village people have no respect or this person and because of jealousy.	3.7	14.2	18.7	10.4
No. Never heard of stories like this, don't believe in magic, traditional stories are not true and it is a natural process only God can move the sand.	3.7	5.2	11.9	6.7
Did not answer/don't know	5	4	16	1

Deposition

Students were asked that in their science lessons, they may have heard and used the word 'deposition' to help explain various activities in nature.

a) The first part of the question asked students to give the 'Toaripi' meaning or word for 'deposition' 21.8% of the students gave the meaning starting with 'mea' (soil), 'mea ma sa ovi se mai ve ape voa eavi lea iri voa la miri posa la uriai foromai vei' (water carries the soil down to the mouth of the river and lets it settle there and builds up the beach). If deposition was defined within a 'Toaripi' context then it would mean 'mea ma sa toa ti eta mea everave arori voa eata ou topiari loi' (soil hit by water and then taken and deposited onto the top of the previous layer). Another 6.8% of the students gave other meanings such as 'orai' (boil), 'miri posa' (sand bank), 'mipairoi' (to plant). Interestingly the majority (71.5%) of the students, mainly grade 9 (35.4%) did not give

a response to this question. This response could be due to that most of students could not identify what the '*Toaripi*' meaning for the English term '*deposition*'.

b) The second part of the question asked students to give the meaning of '*deposition*' in their own words 45% of the students, mainly grade 9 (21.2%) responded and said that '*deposition*' is 'the building up of soil carried down by river' or 'when eroded soil comes to a certain place'. They also said 'settling down of materials caused by erosion and deposited at mouth of river'. Another 24.5% gave other meanings such as 'something to change' or 'washing away soil' or 'an object or thing not in correct position to where it was' or 'caused when factories throw waste into river' or 'adding nutrients to the soil' and 'when you want your money to be kept at the bank'. Another 30.5% did not give a response to the question.

c) The third part of the question asked students to respond to the question when they were asked about a young villager telling them that he or she can cast magic spells or use '*seseva*' to move the sand and *deposit* it on another part of the beach in their villages. Then they were asked if they believed that this person can do it and the reason why. As shown in Table 4, 19.6% of the students said 'yes' and said that this person may be angry with people collecting shellfish or fishing in the river or all the village people know this person can do it as he's got the spirit of magic spells so he can be a powerful magician. Another 37.1% of the students said 'no' and said that they have seen anybody doing this as this person is too young to use magic so he cannot do it, only God can as it occurs naturally and they do not believe in '*seseva*'. Interestingly another 43.3% of the students did not give an answer to the question. The table below shows the percentages of responses across the grades.

Table 4: Percentages of types of responses to the question: A young villager may have told you that he/she can cast magic spells or use '*seseva*' to move the sand and *deposit* it on another place of the beach in your village. Do you think this person can do it? Why?.....

Type of response	<u>Grade levels</u>			
	7	8	9	10
'Yes. Angry with people collecting shellfish or fishing in the river/all the village people know th person can do it/he's got the spirit of magic spells/he can be a powerful magician	1.4	5.6	10.5	2.1
No. : 'They have seen anybody doing this/ young	5.6	5.6	15.4	10.5

to use magic/he cannot do it only God can/occur:
naturally/do not believe in 'seseva'.

Did not answer/don't know	2.8	15.4	14.7	10.5
---------------------------	-----	------	------	------

Sun

Students were told that the sun appears to rise in the morning in the east and set in the evening in the west. The sun gives light and keeps us warm during the day. Without this, there would be no life, no light, no weather and no warmth.

a) The first part of the question asked students to give the 'Toaripi' word or meaning for 'sun'. Most (73.2%) of the students gave the 'Toaripi' word 'sare' for 'sun'. About 2% of the students mentioned 'Epe Savora', the spirit that looks after and guides the 'sun' while another 17.8% of the students did not give a response to the question.

b) The second part of the question asked the students to describe the *sun* in their own words - 18.7% of the students described and said that the sun is the biggest star in the solar system while another 9.4% of the students said that the *sun* is a planet and part of the solar system. Interestingly, the majority (46.3%) of the students said that the *sun* is round and source of light while another 26.8% did not give a response.

c) The third part of the question asked students if the *sun* stays in one place and why. The majority (42.8%) mainly grade 9 (26.5%) of the students responded and said 'yes' and said that the earth orbits the sun. Another 25.8% said 'no' and said that it is because the sun orbits, rises and sets in different directions while another 31.3% of the students did not give a response. Table 5 gives the types of students' responses across the grades.

Table 5: Percentages of types of responses to the question: Does the *sun* stay in one place?. Why?

Type of response	<u>Grade levels</u>			
	7	8	9	10
Yes because earth orbits around 'sun'.	2.7	4.8	26.5	8.8
No because 'sun' orbits around earth and sets in different directions.	4.8	7.4	6.1	7.5
Did not answer/don't know	2.7	13.0	9.5	6.1

d) The fourth part of the question asked students if it was possible that an old person might have told them that the 'sun' is looked after and guided by a spirit called '*Epe Savora*' and why. About 3.9% of the students gave a positive answer and stated that it is a legend and they have heard village people talking about it. Another 20.1% of the students gave a negative response and stated that they have never heard this story while a great number (75.9 %) of the students did not give a response. This is probably due to the fact that students are disinterested in traditional knowledge and say that it is for old people.

RESULTS FROM THE VILLAGE ELDERS AND THE SCHOOL STUDENTS

The village elders provided explanations for the natural phenomena in terms of spirits/spells/magic, personal experience and religion for most of the 11 concepts of natural phenomena. Typically, most elders gave explanations of many of the phenomena in terms of **spirits** (e.g., a spirit called '*Epe Savora*' guides the Sun from sunrise to sunset/a bright full moon signifies a spirit woman called '*Lou Lumori*'), **spells** (e.g., spells cast by an old person can make the waves big so that when they crash on the beach, they move the sand to another part of the beach [erosion/deposition]), **magic** (e.g., magic words uttered by a rainmaker will bring/stop rain and lightning/lightning destroyed a line of coconut trees from the beach to the swampy mangroves - an elder experienced this as a young boy at that time), and **religion** (e.g., a rainbow signifies the great flood during the time of Noah/Sun is the Father/Moon is the Son).

In addition, elders used **personal experiences** to explain phenomena (e.g., formation of many dark clouds causes thunder and lightning and brings rain/puddle of water when heated by the sun dries and disappears. The vapour rises and is cooled by the cool air in the sky. This changes and forms black clouds and bring rain). The personal experiences of the village elders in many ways were synonymous with scientific descriptions (e.g., puddle of water in the forest when heated by the sun dries and disappears. The vapour rises and is cooled by the cool air in the sky. This changes and forms black clouds.) and scientific explanations (e.g., Sun heats the water and changes into steam. The steam rises into the air, moves around and forms clouds. As the heavy clouds approach the

mountains, the water falls down as rain again. Flows into rivers and down to the sea [water cycle]).

It should be noted that none of the elders had attended school beyond Grades 4-6 and there was no science education in the school curriculum in those days (Bray, 1993; Crossley, 1993; Thomas, 1993).

Secondary school students' responses to the 11 questions in the first questionnaire were categorised in terms of where they obtained their ideas, whether these were from the home/village/family or school, or church, or that they have never heard of it. The majority of the 179 school-aged students choose scientific explanations of natural phenomena in terms of what they had learned in school or from personal experience. For example, on *erosion* and *deposition*, over one third (32.5%) of the students said they had learnt the following explanation at school: 'The changes in the winds direction and tides cause the sand on the beach in my village to be eroded. The two processes helps built up the sand on the beach in my village.' For the *sun*, over two thirds (68.5%) of the students again responded that they had learnt the following explanation at school: 'My everyday observations tell me that the sun follows different paths. This is due to the tilt of the earth from January to June and from July to December. Therefore the sun stays in one place. Our earth revolves around the sun.'

However, many students choose explanations of the same phenomena about spirits, spells and magic that came from the village, family or home, and other explanations about religion that came from the church. A small number had no explanations because they had never heard the ideas expressed. However, when students claim that they haven't heard about something, it could be the result of religious education by which they think that it is uneducated to express verbally a belief in traditional ideas.

The explanations given by these 179 students were dependent of context, referring to spirits, spells, and magic, and religion in providing explanations of natural phenomena in the home, family or village and scientific explanations from school. It seems that the explanations given by many of the students when referring to spirits, spells and magic did agree with those given by the elders. This is because students stated that they have heard of these explanations at home with the family in the village. Furthermore, parents

of these students may know of these stories from the elders and so are able to pass them on to their children. Moreover most of the explanations of natural phenomena based on the elders' personal experiences were mainly dominated by school science as indicated by the students. A few explanations referred to church and at home/family/village because most students come from families where the Christian religion is strong.

The study reveals that students' ideas about natural phenomena are strongly governed and controlled by their school science knowledge in the school setting. This is evident in the types of responses given by students on questions on *erosion*, *deposition* and the *sun* in the second questionnaire (e.g., a majority (73.8%) of students when asked to describe *erosion* said 'soil washed away by water, rain or flood; about 40.9% of the students said that *deposition* 'is the building up of soil carried down by a river' when they were asked to describe what *deposition* was and finally another 42.8% of the students when asked about what the sun is said that it is 'the biggest and hottest star in the solar system.'

SUMMARY

The research identified similarities amongst village elders' explanations for the personal experience category with that of modern science; for example, in response to questions on erosion and deposition, inland rivers and creeks are blocked due to the felling of trees for food gardens. As a result, the water cannot assist in the deposition of sand downstream and on to the beach making the river get shallow.

Some village elders still hold on strongly to their traditional beliefs which can be seen from the way they perceive, interpret and explain their natural environment surroundings. In addition, because they have lived closely within their natural environments they are able to give explanations of natural phenomena from their own perspective and perception which complement with those of science. Traditional beliefs are those where the sun and the moon are looked after by spirits, magic spells ('*seseva*') are used to move the sand on the beach near the village, or sorcery ('*maeasiri*') (pointing the bone) is used to kill people. Interestingly, George's (1991) study supports and states that traditional beliefs are still strong among PNG tribes where the universe and everything in it were created by a powerful spirit called '*Patip/Yangela*'. Each

component of the universe is associated with its own spirit, like the spirit of the garden, spirit of the animal, spirit of weather and spirit of the forest. The spirit of lightning is considered to be an angry spirit and this makes people fearful of him. Several village elders gave numerous and interesting explanations for the Christianity category based on their active involvement in church activities with the village United Church and which is also evident from the education they received from the village mission schools they attended.

Most school-aged students choose scientific explanations of natural phenomena in terms of what they had learnt at school or from personal experiences. However, many students choose explanations of the same phenomena about spirits, spells and magic that came from the village, family or home.

This study, like those conducted in many other developing countries (e.g., Baker & Taylor, 1995; Cobern & Aikenhead, 1998; George, 1991; Waldrip & Taylor, 1999a; 1999b) again raises the dilemma of whether or not the school science curricula is serving the needs of students when their school learned knowledge is in conflict with that learned in the village, home or church or from their village elders. This research reinforces previous studies showing that students view Western science as superior (Siegel, 2002) or containing knowledge that they do not process (Waldrip & Taylor, 1998a) However, in school science classrooms this traditional knowledge may exist in parallel with but be dominated by school science knowledge. It is likely that students' own traditional knowledge cannot be identified in a school setting. A better approach would be to administer questionnaires to students in their villages (as opposed to school) in the students' local language.

EDUCATIONAL SIGNIFICANCE

So as not to diminish the value of traditional knowledge, science education programs are needed that are able to consider and harmonize traditional knowledge with school science. To retain traditional knowledge, it is important to take advantage of rural village settings where local knowledge is still strong. Elders in these villages who possess valuable knowledge on natural phenomena should be identified so that interviews can be conducted to record this knowledge. The knowledge may be that of

plants and animals found in the immediate locality which can be used as an introduction to modern science education. School students may be encouraged to carry out projects and compile this information into learning materials such as a natural history book. Here the use of vernacular names, description of patterns of distribution and narration of myths and folk stories in respect to the plants and animals could be promoted. This natural history book can form the basis of a study of all the plants and animals in the local area as a viewpoint in harmonising traditional knowledge with school science. The first author is now engaged in a science curriculum development project that in part considers these ideas.

Nevertheless in developing countries, conflicting explanations related to traditional knowledge or school science knowledge do exist. Viewing this apparent conflict, it is imperative to appreciate that the science context is important *and* that students' cultural backgrounds can provide a rich array of thinking that can be different to a typical Western classroom (Lees, 1999). One could argue that education typically found within Papua New Guinea and other Melanesian countries tends to reflect the curriculum of the West and that this education can provide hope and strengthen culture *but* it can also help to destroy both hope and culture (Kyle, 1999). In asking how one could provide a balance for this conflict and contextualise science for Melanesian students, one Melanesian educator explained:

[It is important] for educators to use science concepts already in existence within the student's village environment and building science vocabulary from their everyday life. Example - Talk about a canoe and how it is made in the village...It's a pity that Science educators are still overlooking this basic approach in the villages (W. Wilikai, 2001, personal communication).

Certainly the solution to an appropriate science curriculum in PNG schools is not simple and it is important that students' prior ideas are acknowledged and investigated. It is important to be cognisant of and utilise, but not be restricted to, traditional or indigenous knowledge and learning styles to enhance the learning process. This means that in science classes, including any fieldwork, teachers should involve students in discussion to explore learning consistent with their interests. In this way, indigenous elders' and students' knowledge and views are respected and can be utilised in the learning process; possibly the elders can become involved in the school learning process. Consistent with Aikenhead's (2000) position, teaching science in this manner includes

making explicit and facilitating border crossings between traditional and scientific explanations. The research reported in this article has shown the kind of framework that science teachers can use for probing understanding of scientific phenomena when students are cognisant of explanations based on both Western science and traditional knowledge. We believe that this study is particularly significant because it adds to the paucity of research into Papua New Guinea education, particularly science education.

REFERENCES

- Agar, M. H. (1996). *The professional stranger: An informal introduction to ethnography*. (2nd ed.). San Diego: Academic Press
- Aikenhead, G.S. (2000). *Integrating Western and Aboriginal science: Toward a bi-cultural pedagogy*. A paper presented to the annual meeting of the American Education Research Association, New Orleans, LA.
- Aikenhead, G. (2001, March). *Cross-cultural teaching: Prais*. A paper presented at the annual meeting of the National Association for Research in Science Teaching, St Louis.
- Baker, D. & Taylor, C. S. (1995). The effect of culture on the learning of science in non-western countries: the result of an integrated research review. *International Journal of Science Education*, 17 (6): 695-704.
- Boeha, B. B. (1987), *Students Belief in Science - a third world perspective*, Paper submitted to the 4th International Symposium on World Trends in Science and Technology Education, University of Kiel, Institute of Education
- Bray, M. (1993). Education and the vestiges of colonialism: self determination, neocolonialism and dependency in the South Pacific. *Comparative Education*, 29(3), 338-348
- Brown, H. A. (1968). *A dictionary of Toaripi with English - Toaripi Index Part 1 and 2* (Oceania Linguistic Monograph 11). Sydney: University of Sydney.
- Central Intelligence Agency. (2004). *The World Fact Book 2003*. Washington, D.C.: CIA.
- Cobern, W.W. (1993). College students' conceptualizations of nature: An interpretive world view analysis. *Journal of Research in Science Teaching*, 30 (8), 935 -951
- Cobern, W. W. (1996). Worldview theory and conceptual change in science education. *Science Education*, 80 (5), 579-610.

- Coburn, W.W. & Aikenhead, G. S. (1998). Cultural aspects of learning. In B. J. Fraser and K. G. Tobin (eds.), *International Handbook of Science Education*, Kulwer Academic Publishers, Great Britain.
- Crossley, M. (1993). Introduction: comparative and international studies and education in the South Pacific. *Comparative Education*, 29 (3), 227-232
- Driver, R., Leach, L., Millar, R. & Scott, P. (1996). Young people's images of science. Open University Press, Buckingham.
- Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). *Making sense of secondary science. Research into children's ideas*. London: Routledge.
- Emery, A. L., & Associates. (1997). *Guidelines for environmental assessments and traditional knowledge* (Report). Canada: Centre for Traditional Knowledge to the World Council of Indigenous People.
- Erickson, F. (1986). Qualitative methods in research on teaching. *Handbook of research on teaching* (3rd ed.), New York: Macmillan.
- Flannery, T. (1998). *Throwim way leg - an adventure*. Melbourne: Text Publishing.
- Gee, J.P. (2004). Language in the science classroom: Academic social languages as the heart of school-based literacy. In E.W. Saul (Eds.) *Crossing borders in literacy and science instruction: Perspectives on theory and practices*. Arlington, VA: National Science Teachers Association.
- George, C. (1991). School education and ethnoscience, *Journal of Science and Mathematics Education in South East Asia*. 24 (2), 27-36
- Harris, S. (Ed.). (1992). *Going about the right way - decolonising Aboriginal school curriculum process*. Suva, Fiji: Institute of Pacific Studies.
- Jegede, O. J. (1995). Collateral learning and the eco-cultural paradigm in science and mathematics. *Studies in Science Education*, 25, 97-137.
- Jegede, O. J. (1997). School science and the development of scientific culture: a review of contemporary science education in Africa. *International Journal of Science Education*, 19 (1), 1-20.
- Kelontii, B. T. (1996). *Ethno-science and the 'force' concept in Papua New Guinea upper secondary school physics*. Unpublished Master of Science (Science Education), Curtin University of Technology, Perth.
- Kiki, A. M. (1963). *Kiki ten thousand years in a lifetime - a New Guinea autobiography by Albert Maori Kiki*. Melbourne: Chesire.

- Koosimile, A.T.. (2004). Out of school experiences in science classes: problems, issues and challenges in Botswana. *International Journal of Science Education*, 26(4), 483-496.
- Kyle, W.C. (1999). Science education in developing countries: access, equity and ethical responsibility. *Journal of the Southern African Association for Research in Mathematics and Science Education*, 3(1), 1-13.
- Lee, O. (1999). Equity implications based on the conceptions of science achievement in major reform documents. *Review of Educational Research*, 69(1), 83-115.
- Maddock, M. N. (1981). Science education: An anthropological viewpoint. *Studies in Science Education* 8, 1-26.
- McLaughlin, D. (1995). Teaching for understanding: the Melanesian perspective. *Papua New Guinea Journal of Teacher Education*, 2(1), 3-17.
- McLaughlin, D. (1996). Making the education experience for overseas students more meaningful: a Papua New Guinea case study. *Australian Journal of Adult and Community Education*, 36(1), 3-18.
- Morauta, L. (1984). *Left behind in the village - economic and social conditions in an area of high out migration* (Monograph 25). Port Moresby: Institute of Applied Social and Economic Research.
- Naijke, S. (2004). Learning science in a secondary school in Papua New Guinea. Unpublished PhD thesis. Brisbane, Australia: Queensland University of Technology.
- Ogawa, M. (1986). Toward a new rationale of science education in non-western society. *European Journal of Science Education* 8, 113-119
- Ogbu, J. U. (1992). Understanding cultural diversity and learning. *Educational Researcher*, 21 (8), 5-14, 24.
- Okebukola, P. A. O. & Jegede, O.J. (1990). Eco-cultural influences upon students' concept attainment in science. *Journal of Research in Science Teaching*, 27, 661-669.
- Pauka, S. (1988). *A study of primary school children's ideas about natural phenomena*. Unpublished Master of Applied Science (Science Education), Curtin University of Technology, Perth, Australia.
- Pauka, S. (1999). *Village elders' explanations of natural phenomena in Papua New Guinea*. Paper presented at the Western Australian Science Education Association 24 Annual Conference, Curtin University of Technology, Perth, Australia.

- Roth, W-M. (2004). Gestures; The leading edge in literacy development. In E.W. Saul (Eds.) *Crossing borders in literacy and science instruction: Perspectives on theory and practices*. Arlington, VA: National Science Teachers Association.
- Ryan, D. (1989). Home ties in town: Toaripi in Port Moresby. *Canberra Anthropology*, 12 (1 & 2), 19-27.
- Seigel, H. (2002). Multiculturalism, universalism, and science education: In search of common ground. *Science Education*, 86, 803 – 820.
- Thomas, R. M., (1993). Education in South Pacific: the context for development. *Comparative Education*, 29(3), 233-248
- Vlaardingerbroek, B. (1990). Ethno-science and science teacher training in Papua New Guinea. *Journal of Education for Teaching*, 16(3), 217-224.
- Waiko, J., & Jiregari, K. (1982). *Conservation in Papua New Guinea: Custom and tradition* (Monograph 16). Port Moresby: Institute of Applied Social and Economic Research.
- Waldrip, B. G., & Talyor, P. C. (1999a). Permeability of students' worldview to their school views in a non-Western developing country. *Journal of Research in Science Teaching*, 36(3), 289-303.
- Waldrip, B. G. & Taylor, P. C. (1999b). Standards for cultural contextualization of interpretive research: a Melanesian case. *International Journal of Science Education*, 21(3), 249-260.