

History of Mathematics Education

Patricia Paraide · Kay Owens · Charly Muke
Philip Clarkson · Christopher Owens

Mathematics Education in a Neocolonial Country

The Case of Papua New Guinea

 Springer

History of Mathematics Education

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History of Mathematics Education aims to make available to scholars and interested persons throughout the world the fruits of outstanding research into the history of mathematics education; provide historical syntheses of comparative research on important themes in mathematics education; and establish greater interest in the history of mathematics education.

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Foreword

We cannot build a nation simply from technology; we cannot build a nation purely [based on] the wheel and ... the steam engine. We must build this country; we must build our civilization on values, which have been passed on to us from generation to generation. And I say this: that if we do not, ... if it is not now the basis and the stem upon which we nurture and grow our children, then I say there will be no future for this country.

Narakobi, 1991.

This book, a collaboration between Patricia Paraide, Kay Owens, Charly Muke, Philip Clarkson, and Chris Owens, provides a significant milestone for mathematical education in Papua New Guinea (PNG). The quote by Bernard Narakobi is an apt way to describe what this book aims to provide, namely a history of teaching and learning of mathematics in the home, the schools, and tertiary institutions in PNG. It is a gallant effort in that the authors firstly identify that thinking and processes of logic and making meaning mathematically existed within PNG among the numerous distinctive cultural groups. Secondly, the introduction of western mathematical knowledge and its processes through colonization (schools and schooling) provisioned a deliberate and gradual annihilation of Indigenous processes of logic and meaning making. What is even more audacious is the enunciation by the authors to identify that Papua New Guineans educated in schools have and continue to contribute to the demise of what were original and ancient mathematical ways of knowing and making meaning. Thirdly, the authors provide an opportunity to seek redress in the current context of the neocolonial situation to deny one's own culture in favour of the colonizer's ways.

Each chapter, and there are 13 in total, is given a title followed by a short abstract and keywords of the chapter for the reader. What is unusual for such a publication but appropriate for this study is that for each chapter there is one or more sections that are called "a cameo from ..." one of the authors or others. This is a rather ingenious way to engage with the reader through a personal encounter of one of the authors or others involved with mathematics education in PNG. Experiences within PNG by each author is shared and is in the context of the chapter. The ideas of logic and mathematical thinking and processes are humanized by this strategy—sharing of experiences through stories is a Papua New Guinean way and is a real bonus to this book.

Some of the key progenitors to Indigenous mathematics in PNG, including Glen Lean, are included and referenced. Together with these pathfinders, experiences in relation to changing colonial systems to include Indigenous ways of mathematical thinking and sense-making in other cultures are also shared—especially with our nearest neighbour, and PNG's nemesis, Australia, in its loss of Indigenous ways of mathematical logic.

This book provides hope, and a commencement to the realization of wisdom from the pantheon of PNG's finest, Bernard Narakobi; we must rebuild and give hope to our future.

Michael A. Mel
Mbu Noman
Mt Hagen, Papua New Guinea

Reference

Narakobi, B. (1991). Issues in education and development. In B. Avalos & L. Neuendorf (Eds.), *Teaching in Papua New Guinea: A perspective for the nineties* (pp. 19-28). Port Moresby, Papua New Guinea: University of PNG Press.

Series Preface: The Place of this Book in Springer’s History of Mathematics Education Series

This is a particularly important book in Springer’s “History of Mathematics Education” series. The authors, Patricia Paraide, Kay Owens, Charly Muke, Philip Clarkson, and Chris Owens, raise two questions which one might think would have clear answers—those questions are: (a) “What is mathematics?” and (b) “What factors need to be taken into account to assist students to learn mathematics well?” The questions, with possible answers, are *writ large* on almost every page of this book, which looks at mathematics and mathematics education dimensions for the nation of Papua New Guinea (PNG), from cultural, historical, and mathematical vantage points. The authors argue, persuasively, that different forms of mathematics have been developing, for thousands of years in that part of the world which is now called Papua New Guinea.

Remarkably, there are almost 1000 different languages spoken within Papua New Guinea, and each has its own counting system, ways of thinking about, and expressing, numerical, visuo-spatial, measurement, and forms of reasoning. The authors’ overwhelming and clear message is that ethnomathematical considerations need to be taken seriously by *all* teachers of mathematics. This book is particularly strong in its treatment of how language and cultural factors *should* frame the teaching and learning of mathematics because those factors inevitably mould how students think, how they learn, how they live, and how they communicate with others.

There are sections in the book which will be valuable to teachers who work with students for whom the language of instruction is not their first language. The view that whenever possible a student will learn best when he or she understands the language which the teacher is using is argued strongly (and, probably, controversially, for some readers). Impressive historical analyses of mathematics education documents from Papua New Guinea over the past 150 years are provided. Oral histories and lived experiences support the analyses.

Books in Springer’s series on the history of mathematics education comprise scholarly works on a wide variety of themes, prepared by authors from around the world. We expect that authors contributing to the series will go beyond top-down approaches to mathematics and history, so that emphasis will be placed on the learning, teaching, assessment, and wider cultural and societal issues associated with schools (at all levels), with adults and, more generally, with the roles of mathematics within various societies.

In addition to generating texts on the history of mathematics education written by authors in various nations, an important aim of the series is to develop and report syntheses of historical research that has already been carried out in different parts of the world with respect to important themes in mathematics education—for example, “Historical Perspectives on how Language Factors Influence Mathematics Teaching and Learning,” and “Historically Important Theories Which Have Influenced the Learning and Teaching of Mathematics.”

The mission for the series can be summarized as:

- To make available to scholars and interested persons around the world the fruits of outstanding research into the history of mathematics education
- To provide historical syntheses of comparative research on important themes in mathematics education
- To establish greater interest in the history of mathematics education

In this book, the authors tell a story of the history of mathematics education in PNG, paying special attention to cultural and language factors. Of particular interest are the profound effects these factors have had, and continue to have, on fundamental issues which affect mathematics in PNG schools today: “What should be the intended mathematics curriculum in a school?” Should it be the same curriculum as in any other school? What about outcomes-based education? Standards-based curricula? Learning progressions? “Should the intended curricula be the same for all learners?” And, “Who should be responsible for bringing about changes to school mathematics?” Although the context for the book is mathematics education in PNG, it provides an excellent model for future books in this series—studies which address critical periods in the historical evolution of mathematics education in different cultures and different parts of the world.

We hope that the series will continue to provide a multi-layered canvas portraying rich details of mathematics education from the past, while at the same time presenting historical insights that can support the future. This is a canvas which can never be complete, for today's mathematics education becomes history for tomorrow. A single snapshot of mathematics education today is, by contrast with this canvas, flat and unidimensional—a mere pixel in a detailed image. We encourage readers both to explore and contribute to the detailed image which is beginning to take shape on the canvas for this series.

Any scholar contemplating the preparation of a book for the series is invited to contact Nerida Ellerton (ellerton@ilstu.edu), in the Department of Mathematics at Illinois State University or Melissa James, at Springer's New York office.

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Abbreviations

ATE	Association of Teacher Education
AusAID	Australian Aid, now part of Department of Foreign Affairs and Trade
BSc	Bachelor of Science
CHE	Committee for Higher Education
DOE	Department of Education, Papua New Guinea
GEEP	Gender Equity in Education Policy
GESP	Gender Equity Strategic Plan
ICT	Information and Communication Technologies
IDCE	Institute of Distance and Continuing Education (UPNG)
LMS	London Missionary Society
MAB	Multibase Arithmetic Blocks (Dienes Blocks) including 2, 4, 5, 6, and 10 bases
Med	Master of Education
NDOE	National Department of Education. It is also covering Ministry of Education and Department of Education
NEB	National Education Board
NES	National Education System
NHS	National High Schools (schools for Years 11 and 12 only)
NSW	New South Wales, State of Australia
OBE	Outcomes-Based Education
PhD	Doctor of Philosophy
PNG	Papua New Guinea
PRIDE	Pacific Regional Initiative for Delivery of Education
QLD	Queensland, State of Australia
SA	South Australia, State of Australia
SBE	Standards Based Education
UN	United Nations
UNDP	United Nations Development Programme
Unitech	PNG University of Technology
USA	United States of America (note abbreviations to States in the publication list refer to the States of USA if not stipulated)
UOG	University of Goroka
UPNG	University of Papua New Guinea
Vic	Victoria, State of Australia



Chapter 1

Introduction to the History of Mathematics Education in Papua New Guinea

Abstract: Papua New Guinea, with its ancient cultures and recent colonization, has a unique history. It provides a revealing, and fascinating, case study of how mathematics and mathematics education have changed over a long period of time. We present reasons for claiming that Indigenous forms of mathematics and mathematics education were present well before colonization. PNG's ecology and multiple diverse languages and cultures provide the backdrop for a discussion on practices, policies, and politics which affect education, including mathematics education. Discussion will focus on specific areas of mathematics education that have been influenced by policies, research, circumstances, and other factors. The methodology for developing the book involves personal reflections and oral histories, as well as diverse records from first contact, archaeology, anthropology, official documents, and journal articles. Recent history of mathematics education in Papua New Guinea has been influenced by the nation's short but complex colonization, its achievement of independence, reform policies, aid agencies, and Government ambitions. This chapter introduces the country and outlines the chapters and the structure of each chapter which intertwine documentary research with cameos of reflection and oral history.

Key Words: Colonial impact · Ethnomathematics · History of Papua New Guinea · Language of instruction

There exists, if I am not mistaken, an entire world which is the totality of mathematical truths, to which we have access only with our mind, just as a world of physical reality exists, the one like the other independent of ourselves, both of divine creation.

Charles Hermite, nd¹

Beginning This Book

Papua New Guinea is a nation and we, the authors, have all proudly contributed to the recent mathematics education of its people—which we acknowledge actually began thousands of generations ago. We are all fascinated by the history of mathematics education before and since European contact. The history of the nation and its education has twists and turns that astound us. From this history, key issues emerge which have been faced, and continue being faced, by many developing nations, especially those with multicultural communities. We expect that the details of our historical research will carry readers through the issues and provide food for thought on

¹From <http://www-history.mcs.st-and.ac.uk/Quotations/Hermite.html>

ways of improving mathematics education for future generations both within and outside of Papua New Guinea.

First, we need to set the scene for education in this incredible country, which has been variously called a “lost paradise,” “the land of the unexpected,” and “the place of a million different journeys” (tourism slogans over the years). Its diversity is second to none in the world. The land itself covers tropical islands, coral reefs, swamps, high steep mountains, and wide lowland and highland valleys. There are rich soils and poor soils for agriculture, and there are earths full of mineral deposits. There is plentiful water, too much water, and not enough water. Its forests, corals, and unique wildlife still abound.

The cultures and languages of PNG are multiple, deep, and colorful. Its riches and diversity are extraordinary. The possibilities for subsistence living continue for most. Adaptations and innovations abound. The cultures are among the longest surviving in the world.

So, we start by providing a brief overview of the geography, cultures, and recent history of Papua New Guinea.

Geography

Papua New Guinea consists of the eastern half the island of New Guinea and several large islands such as New Britain, New Ireland, and the Autonomous Region of Bougainville (ARoB), together with thousands of smaller islands from the size of Manus to only a few hectares. It lies close to the north of Australia, just south of the equator. It experiences heavy rainfall in most areas, creating lush rainforests, fast flowing rivers, and swamps. It lies on the moving plates of the earth’s crust and has high mountain ranges, upland valleys, and numerous active and inactive volcanoes. It shares a border on the mainland with West Papua,² which is under Indonesian occupation.

The main island and many others formed part of Sahul with Australia in times past with a short straight of water dotted with islands to the west (south-east Asia) and another extended land mass joining Bougainville Island with the Solomon Islands further to the south. It is known that, since time immemorial, people have moved between these places in this area. To do so required not only some form of water-craft but also the ability to adapt to walking long distances in different and difficult terrains. Furthermore, through the millennia, inhabitants adapted to the end of the ice age and the following mini-ice age. Occupation sites have been found across this country dating from 40 000 years ago, and further south in Sahul to 60 000 years ago.

Cultures

Currently, PNG has a population of approximately nine million people which has doubled since Independence from Australia was achieved in 1975. It is one of the world’s most linguistically diverse nations, with more than 850 vernacular languages and cultures (National Statistical Office, 2014). Indigenous languages are used, with much pride, as a form of identity and solidarity in all Indigenous communities. Indigenous languages also provide a bond for Indigenous groups in urban areas throughout PNG.

Languages are classified into two broad groups. There are a large number of Papuan languages, also called “Non-Austronesian,” and these languages are in several phyla, the largest and most recent one being the Trans New Guinea Phylum. However, the diversity of these languages is astounding and even a glimpse of their structures, and associated counting systems and dances,

²We use this term as the one most commonly used by the Indigenous peoples of the western half of the island and surrounding islands. They are Melanesians as are Papua New Guineans, and there are similarities of culture and languages within their diversity.

reveal this diversity. Linguists have determined that a Proto Trans New Guinea language existed at least 10 000 years ago.

The remaining languages are classified as “Austronesian Oceanic.” These developed in the New Britain area around 6 000 years ago and spread through New Ireland to Manus, to the northern coastline of New Guinea, and south around the Papuan coast, and across to Bougainville, the rest of Near Melanesia or Island Melanesia, then out as far east as Fiji. Around Tonga, with other influences on Proto Oceania’s daughters, the Polynesian languages developed and spread around the other Pacific Islands and in some cases returned to Island Melanesia. These Oceanic migrations are often associated with the material culture of pottery with some distinct styles (called “Lapita,” which is the name of the place where it was first found) and obsidian, a hard dark-colored rock.

Surprisingly, unlike the Papuan languages, these Austronesian Oceanic languages have similarities despite the thousands of kilometres of ocean which separate them. There are connections between some of the languages, and in some ways to other Austronesian and Pacific languages in Polynesia and Micronesia. Finally, it is known that some of the Papuan non-Austronesian languages have influenced the Austronesian languages, and vice versa, especially through trade and migration, and these changes point to further influence and use of mathematics over the millennia and in more recent history.

Overview of Recent History

Don Jorge de Meneses, a Portuguese explorer, is said to have discovered the principal island of Papua New Guinea in 1526 or 1527 CE. Subsequently, three European countries colonized New Guinea. These were the Netherlands followed by Indonesia, in the western half of the island; Germany in the north of the eastern half and the neighboring islands (from 1884); and, later, England in the south of the eastern half and adjacent islands. This southern section was once known as British New Guinea, and administered through Queensland, Australia. In 1905, after Australia had become an independent Federated nation in 1901, it became the Australian Territory of Papua.

The colonies started well before 1900 with missionaries and traders. Visits were also made by researchers, such as the British Expedition to the South Seas. Governments provided law and order, which was mainly applied to the traders. Missionaries formalized the early, pre-existing localized schemes of education—the London Missionary Society (LMS), for example, began schools in Papua, and the Methodists in areas of New Britain which were to come under German control. Lutherans set up on the nearby mainland and on islands off these shores, and the Catholics moved into some of the village areas. England, through Queensland (which was later to become a State of Australia), ran the Papuan Territory using education as a means for protecting the “natives”³ from the exploiters, plantation owners and others. These three European countries—The Netherlands, Germany, and England, brought different approaches to education but they also had intertwined histories as far as Papua and New Guinea were concerned, due to the two World Wars.

During the First World War (1914–1917), Australian troops captured Rabaul and took control of German New Guinea. Further educational developments occurred during Australian colonization of the Mandated New Guinea Territory and the Papuan Trust Territory, including a period after the Second World War when they were jointly administered, and during the preparation for Independence from Australia. The two territories became the Territory of Papua and New Guinea with the passing of the *Papua and New Guinea Act* by the Australian Parliament in 1949.

³None of the authors would use this term when referring to Papua New Guineans because, during our life times, this was a derogatory term. It is sometimes used during the earlier part of this book to reflect the language of the expatriates and colonial government. We prefer to refer to someone by their cultural group, or as “Papua New Guinean,” or as “local.”

The country was named Papua New Guinea in July 1972, in preparation for self-government and then independence which was finally achieved in 1975.

As colonies around the world were gaining independence, the Australian government began to consider what should happen with Papua and New Guinea. Initially issues revolved around whether the Territories should become part of Australia as a constituent territory or state, with the same rights and privileges as the other Australian states, or whether an independent nation should be legally established. People began to favor a gradual approach for working toward the latter. Policies and funding needed to be worked out first. Education, administration, leadership in terms of an elected Assembly, and associated infrastructures, were all on the agenda.

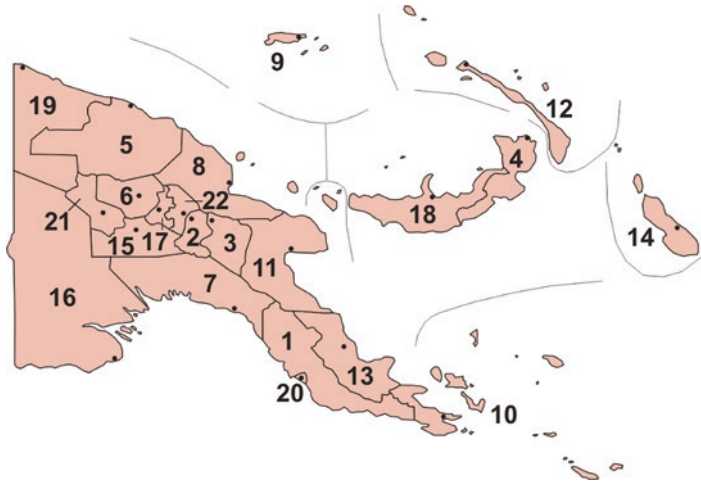
Australia saw the Westminster style of democracy with an independent judiciary, a governor general, and two houses of parliament, as an appropriate method of government for this only recently colonized, but nevertheless soon-to-be independent, nation. An independent set of government departments headed by professionals would be needed. Towards that end, in the 1960s some Papua New Guineans were trained in law and in higher education. The “Bully Beef Club” and the *Pangu Pati* were set up to establish the idea of party politics and to decide how complex rules of debate should be introduced and enforced. The House of Assembly would have elected members with an increasing number of Papua New Guinean representatives, albeit that some were illiterate in English and in languages other than their own vernaculars (Hastings, 1971). It was argued that there would be enough Papua New Guineans who had been well-educated and privileged by earlier colonizers, to meet immediate needs.

As the 1960s progressed there was increasing pressure from the United Nations for colonizers throughout the world to give independence to their colonized territories (Rannells & Matatier, 2005) and this helped to generate increasing talk of independence for PNG within Australia. In the early 1970s, political leadership in Australia changed for the first time in over two decades, and the new Whitlam Government stipulated that the time for New Guinea’s independence would be the mid-1970s. Decisions were made which were aimed at preparing the new nation for the inevitable administration and leadership responsibilities. These had an impact on education policies, with recognition that the country would need schools, technical and administrative colleges, and universities. Teacher education, for both primary school teachers and teachers in the beginning secondary schools, would also need upgrading. In 1973, the country attained self-government and on 16th September 1975 the independent nation of Papua New Guinea came into existence. It was still supported by Australian aid and many second-level administrative positions were still held by Australians and others from overseas. The Australian “kiaps” who had maintained administration and lawfulness in Districts were phased out over a period of several years after Independence.

In preparation for Independence, the original 19 provinces and National Capital District (areas 1 to 20 in Figure 1.1) were formed. These provinces, grouped into four regions for some administrative purposes, are shown in Figure 1.1, with the superscript numbers in the following list referring to the areas indicated on the map:

- *Southern Region*: Central¹, Gulf⁷, Milne Bay¹⁰, Western¹⁶, and Oro¹³ (Northern);
- *Highlands Region*: Southern Highlands¹⁵, Western Highlands¹⁷, Simbu² (Chimbu), Enga⁶, and Eastern Highlands³.
- *Mamose Region*: Morobe¹¹, Madang⁸, East Sepik⁵, and Sandaun¹⁹ (West Sepik).
- *New Guinea Islands Region*: East New Britain⁴, West New Britain¹⁸, New Ireland¹², Manus⁹, and North Solomons¹⁴ now known as the Autonomous Region of Bougainville⁴.

⁴At the time of writing a vote for Independence from PNG had been taken with a large majority in favor, although the PNG Government has yet to endorse it.



Source. Wikipedia

Note. 1 Central, 2 Simbu (formerly Chimbu), 3 Eastern Highlands, 4 East New Britain, 5 East Sepik, 6 Enga, 7 Gulf, 8 Madang, 9 Manus, 10 Milne Bay, 11 Morobe, 12 New Ireland, 13 Oro (formerly Northern), 14 Bougainville (formerly North Solomons), 15 Southern Highlands, 16 Western, 17 Western Highlands, 18 West New Britain, 19 Saundau (formerly West Sepik), 20 National Capital Territory, 21 Hela, 22 Jiwaka.

Figure 1.1. Provinces of Papua New Guinea.

In 2012, Southern Highlands became two provinces, Southern Highlands and Hela²¹, and Western Highlands became Western Highlands and Jiwaka²². It should be noted that author Patricia Paraide comes from East New Britain and has travelled extensively throughout the country; author Charly Muke comes from Jiwaka Province and has also travelled; Kay and Chris Owens lived in Morobe Province for 15 years and have had a further 15 return visits for various research projects with colleagues. Kay has stayed in 15 provinces; and Phillip Clarkson lived for a shorter period in Morobe Province but has travelled to many parts of the country.

Major Changes in Education Since Independence

Since the 1960s—i.e., even before Independence was granted—certain reports and policies were prepared for the purpose of shaping the future of education in the new nation. The most significant of this early planning was a report by a committee established in 1974 and chaired by Alkan Tololo. It recommended a recognition of community in education and that education should prepare students for their life after school.

The Tololo Report was not, however, adopted and a more conservative—one might say elitist—approach to education for the new nation was put in place according to a 1976 plan. More will be presented on the Tololo Report and the effect of the adopted plan later in this book.

In the 1980s came the Matane Report *A Philosophy of Education for Papua New Guinea*,

- Self-reliance which was to be achieved through a community-based education program;
- Forms 1 and 2 (to be renamed Grades 7 and 8) were to be transferred from high schools to community schools with the aim of accelerating the process of universal community education;

- The language of instruction in the first three grades was to be in the functional language (i.e., the *Tok Ples*) of the local community;
- Opportunities for education were to be extended to all Papua New Guineans including girls, children from isolated areas, and disadvantaged children; and
- Intended, implemented and attained curricula that were “relevant to the life that students will have to live after school” should be developed.

A World Bank report followed. These reports led to structural and curricular reforms at the end of the 20th century. Further policy and implementation changes occurred after 2013—which, later in this book, we will refer to as the “revised reform” or “standards-based education period.”

The Purposes of This Book

This book expands on the historical narrative to explore important issues relevant to future policymaking and implementation plans for mathematics education for PNG and other countries with colonial pasts or developing multicultural societies. Indeed, the authors of this book offer a case-study of changes in mathematics education in a very multicultural, colonized but now independent nation whose people are nearly all Indigenous. Over its period of Independence, since 1975, PNG has had very few non-Indigenous members of parliament or heads of Government departments. However, there have been significant impacts from colonization, aid, globalization, politics, lack of infrastructure, and a small but fast-growing population. A number of themes with various strengths and weaknesses arose during each period.

Although this case study could be compared and contrasted with what transpired in other nations, the colonial period in Papua New Guinea was relatively brief (around 100 years) and the achievement of independence was bloodless and seemingly rapid. The Indigenous cultures are very old and relatively continuous. For these reasons, offering a longer history is relevant, and something which could motivate change in other nations.

However, the main purpose for this book is to ensure that current and future Papua New Guinean educators, politicians, government decision-makers, and the general public and families have access to relevant historical narratives based on research as they make decisions for the future. There is an old adage that history repeats itself and it is hoped that, knowing their past history, people will learn from the past, follow up on strengths of the nation’s diversity, history, and culture, avoid mistakes, and make wiser decisions. We believe that generating an understanding of the nation’s history is vital for the future of the country because that can help ensure people’s cultural heritage is recognized, maintained and strengthened for the common good. It will also provide background for studying the mathematics education of the nation and the range of cultures within Papua New Guinea.

In this book, the following issues will be recurrent:

- What is education and what are the purposes of education in Papua New Guinea?
- How can Indigenous forms of language, culture and mathematics be documented and used to advantage within the nation?
- What should be the languages of instruction in PNG’s education institutions?
- Who should be educated (e.g., an elite, or every child) and for how long?
- What needs to be done to ensure social justice and the development and maintenance of human rights—particularly for gender equity, for persons living in remote locations (especially with groups with a small number of speakers of a language, or limited resources, or major cultural differences from others)?
- What needs to be done to ensure the development of a harmonious multicultural nation?

- How can the demands of global forms of education in PNG be reconciled with those of local forms of education?
- Who should administer and pay for education?
- What values and perspectives on education should be present with decision-makers, especially in relation to their views on the purposes of education and mathematics education?

Some of these issues will be discussed in almost every chapter. There will be a specific chapter on language.

Brief Historical Overview of Western Education in PNG

Geoffrey Smith (1975) pointed out differences between Indigenous and Western education. First, he described Indigenous education in the following way:

Knowledge was imparted when the learners needed to use it ... Learning was casual and unplanned as young children had few duties and were often left to amuse themselves in the care of an older child or with their own age group. They learned how to fight or swim through play and picked up skills of canoeing or keeping garden through observing and imitating their parents when they happened to accompany them. As the children grew older, they were increasingly involved in these activities and taught the rituals which would bring success to their tasks. (pp. 1–2)

Smith (1975) also described modern or Western education in the following statement:

The modern school system is far more selective in determining which children will be educated and to what levels, but far less selective in ensuring that the knowledge transmitted is relevant to their situation. (p. 4)

Before Independence, some Papua New Guinean people did not think much of mission education and did not encourage their children to attend mission schools. Instead, they provided their own education which prepared their children for adult lives in their communities. They did not have to learn Western knowledge and skills to be able to function well as intelligent human beings in their own ecocultural environments. They gained a wealth of knowledge and mastered appropriate life-skills, primarily from observation, trial and error, and working alongside their fathers, mothers, other relatives, and peers in their communities.

During the period of colonization colonial authorities began to provide health and educational services. Unlike the missionaries—who were usually happy to use the local *Tok Ples*, or something similar to that, when teaching—the language of instruction was less an issue for the colonizers, so debates inevitably arose over what should be the most suitable language of instruction in formal education settings (Barrington-Thomas, 1976; Smith, 1975). The aim of the missionaries, by and large, had been to educate the people, primarily about Christianity, but a wider view of the curriculum would be needed after Independence.

Many years earlier, Albert Hahl, the German Imperial Governor, had proposed to the heads of missions the payment of subsidies to help spread the German language in German New Guinea, which is now known as the Mamose, Highlands and New Guinea Islands Regions. In Papua, which is now known as the Southern Region, Governor Murray initiated a scheme a few years later to promote literacy in English. The German scheme was frustrated by the First World War, but most missions in German New Guinea cooperated with the language policy. The British and later Australian colonial authorities wanted English as the formal language of instruction. In Papua, English was taught in the upper grades where European staff were posted (Smith, 1975)—although vernacular languages and lingua franca were often, perhaps unofficially, used in lower grades by local PNG or Pacific Islands teachers.

From a postcolonial perspective, teaching in vernacular languages or a lingua franca like *Tok Pisin* would have disrupted the colonial authority's power over the Indigenous people because they could not communicate with them in those languages as well as the missionaries did. In fact, most Australian kiaps and police could use the lingua franca of *Tok Pisin* or *Hiri Motu* depending on where they were placed in remote areas. Records of the British and Australian governments show that McGregor, Murray, and others in charge, requested that local languages and associated counting systems be recorded (Owens, Lean with Paraide and Muke, 2018). It could be argued that authorities who perceived that their influence over the people was weak, categorized people, and used English as the language of power (Fellingham, 1993; Foucault, 1978, 1987).

Many of the early missionaries and others, such as traders in the north east of the main island, spoke German, and some others spoke other European languages or other South Pacific languages. Most of the Indigenous Papua New Guinean people spoke only their own languages. Often, the expatriates expressed their opposition when English was first proposed as the formal language of administration, and for instruction in schools. Missionaries tended to favor having education taught through local languages or local lingua franca, arguing that that would be more meaningful to the people—especially for spreading the gospel but also for giving the people power over exploitive and, in some cases, cruel traders.

Changes in Language Policies With Respect to Education

From the onset of colonization, the language of instruction in formal education became an issue. Around Port Moresby in the late 18th century, the missions used *Hiri Motu*. In German New Guinea the missionaries used local lingua franca and German. In 1907, a Royal Commission of Enquiry endorsed Administrator Macgregor's policy, which was "that the teaching of English be made compulsory in mission schools, and 'native' children be compelled to attend schools at which English is taught" (Smith, 1975). Much debate concerning the language of instruction for schools continued during the colonial and pre-independence era (Barrington-Thomas, 1976; Smith, 1975). An administration-mission conference in 1927 regarding native education resulted in a review of education for the natives, in 1929, by B. J. McKenna (the Queensland Director of Education). Data for this review were gathered mainly from the Rabaul area and the findings were questioned by Johann Flierl, a German Lutheran missionary, because McKenna did not include the Lutheran Missions and Catholic Divine Word Mission schools on the New Guinea mainland in the review (Ralph 1978). Ralph (1978) argued that "McKenna's aim was to have the government schools in Rabaul, with only white teachers, using exclusively the English language as the medium of instruction" (p. 308).

Despite these criticisms, McKenna's Report was accepted, and "stands as a landmark in the development of secular, government education in the Mandated Territory" (Ralph, 1978, p. 309). Despite all these criticisms, the pressure to use English as the language of instruction increased after the Second World War. In 1952, the Education Ordinance was endorsed. "English was to be the language of instruction, with teaching in vernacular limited to infant classes" (Ralph, 1978, p. 309). However, this policy was shelved and a policy that *all* grades—even with infant classes—use English as the language of instruction was implemented (Barrington-Thomas, 1976; Ralph, 1978; Smith, 1975).

Before, during and after the time that the colonizers were deciding on an "appropriate education for the natives," and "the most appropriate language of instruction for formal learning" (Dickson, 1976, p. 23), Papua New Guineans continued their informal village ways of education, using their own languages, and teaching about mathematics in context through the various village technologies, trades, and activities required for life in their sociocultural environments.

After Independence, there continued to be external influences on education in PNG. The following chapters provide an overview of the strengths and negative results of these influences. Overall, PNG remains an education system in which administrators, policy makers, governments and teachers struggle to provide the best for the children and students of the nation. In 2015, only 63% of children attended school (UNESCO, 2015). However, the complexity of the national languages and cultures as well as the richness of foundational mathematical knowledge and school education provides for valuable historical analyses into mathematics education in PNG.

The Processes Adopted for Developing This Book

A research book is expected to critique published information across various fields. However, this can only be done for written knowledge. Reviewing Indigenous knowledge is different because such knowledge comprises complex sets of technologies which have been developed and sustained by the Indigenous civilization. Much of the information is passed on orally through the generations. As Marie Battiste (2002) stated, “knowledge is transmitted through the structure of Indigenous languages passed on to the next generation, through modelling, practice, and animation, rather than through the written word” (p. 2).

Battiste identified the limitation of some research information, and argued that Western research cannot reveal an understanding of Indigenous knowledge:

It is a knowledge system in its own right with its own internal consistency and ways of knowing, and there are limits to how far it can be comprehended from a Eurocentric point of view (p. 2)

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

During colonial times, Indigenous knowledge systems were usually classified as “primitive,” and were considered a hindrance to Western progress and development (Barrington-Thomas, 1976; Ralph, 1978; Smith, 1975). Now, however, Indigenous knowledge areas, including mathematics, are acknowledged as important in defining intended curricula (Beach, 2003; Bishop & Seah, 2003; de Abreu, Bishop, & Presmeg, 2002; Kaleva, 1998; Rosa & Orey, 2020). For example, Lean (1992) carried out a detailed study on Tolai and other PNG and Pacific Indigenous mathematics. He referred to reports from Codrington (1885), Ray (1891), and Parkinson (1907) concerning the complex counting system used by the Tolai people. This counting knowledge is confirmed by author Paraide, a Tolai. Some of PNG’s counting systems are discussed in Chapter 3 of this book, and in Owens, Lean, with Paraide and Muke (2018).

There is now a wider recognition of the value of Indigenous knowledge, but it is not universally accepted as yet. Myer (1998) and Nakata (2004) argue that Westerners’ growing interest in Indigenous knowledge contributes to the elevation of its status. Their interest is largely driven by research into sustainable development practices in developing countries, and the scientific community’s concern about the loss of biodiversity of species and ecosystems and future implications for the planet Earth. However, there is also a darker side. Many Western pharmaceutical companies wish to mine Indigenous knowledge so they can research and exploit potentially worthwhile, in monetary terms, flora and fauna that point to new medicines that can be profitably produced in the West. Other overseas companies wish to establish other exploitative practices like mining but are expected to negotiate access to the land and people’s rights. However, even when the emphasis is on sustainable development, there is clearly too little emphasis on culture, cultural survival, languages, or social and cultural diversity. Nakata (2004) has further asserted that, in humanitarian and scientific areas, scientists recognize that Indigenous knowledge needs

to be recorded and validated if it is to be incorporated into scientific bodies and used. Also, agencies that are working in developing countries show an interest because they realize the importance of local knowledge in solving problems at the local level.

Battiste (2002) offered another dimension to Nakata's (2004) discussions on Indigenous knowledge:

The recognition and intellectual activation of Indigenous knowledge today is an act of empowerment by Indigenous people. The task for Indigenous academics has been to affirm and activate the holistic paradigm of Indigenous knowledge to reveal the wealth and richness of Indigenous languages, world views, teaching, and experiences, all of which have been systematically excluded from contemporary institutions and from Eurocentric knowledge systems. (Battiste, 2002, p. 4)

Battiste (2002) further stated that Westerners generally think that only they "can progress, and that Indigenous peoples are frozen in time, guided by knowledge systems that reinforce the past, and do not look towards the future" (p. 4). Battiste also argued that Westerners have not acknowledged the fact that Western knowledge consists of some knowledge that is of non-European origin. For example, the Greek alphabet is largely of Syrian/Lebanese origin, and some Western mathematical knowledge is of Mayan, Hindu, and Arabic origin. Battiste (2002), Nakata (2004), and other Indigenous academics, have supported the preservation of Indigenous knowledge because it is of interest and is valuable in its own right to the Indigenous people, irrespective of what worth it has to Westerners.

Indigenous knowledge was often viewed negatively in the past, which resulted in the non-use and loss of much valuable Indigenous knowledge, especially when it belonged to people with an oral history, such as Indigenous Papua New Guineans. Battiste (2002) suggested that one way of preserving culture in her homeland, in Canada, is through integration with the school curriculum. This strategy is now being implemented in Canada. However, that too is not without its problems. Lyn Carter (2011) among others has argued forcefully that this can be viewed as a continuation of colonialist thinking, whether those involved, with the best intentions in the world, realize this or not. Authors, including Carter, have warned that much care is needed in this process (Dei, 2011). The need to preserve culture has been embraced in curriculum reform in PNG and in other parts of the world.

Indigenous knowledge is discussed here because it is valuable to the people of Papua New Guinea and how they use such knowledge in their everyday lives. From the authors' perspective, the recognition and acceptance of the value of Indigenous knowledge and practices, and their inclusion in the PNG school curriculum is a positive step toward the validation of the various bodies of Indigenous knowledge. Students who acquire Indigenous knowledge may then be able to easily relate it to Western and other knowledge bodies that are learned in formal education, and be able to expand on and explore that collective body of knowledge further. They may compare knowledges from different Indigenous societies within PNG.

Care needs to be taken, nevertheless, with respect to *how* Indigenous knowledge is incorporated into the schooling of students. It cannot be devalued in comparison with Western school knowledge, as can be the case when Indigenous knowledge is only used as just an introduction to a Western concept, and then forgotten about as the Western concept is fully analyzed and incorporated into the growing network of ideas of the students. The Indigenous knowledge needs to be fully worked through either in the school context or in the village. Village school authorities, especially teachers, need to recognize this and value what is happening outside the classroom walls. This can be a difficult process, one which is often under-valued in the preparation of intended, implemented, and attained curricula.

Battiste (2002) also commented on this dilemma when she stressed that caution should prevail when integrating Indigenous and Western knowledge. Although there are similarities that

can be easily accommodated for educational purposes, there are also differences that are unique to each culture. These differences cannot be separated or compared with Western cultures but should be recognized as vital components in their own particular cultures. Mathematics is a body of knowledge that is present in all cultures and yet it too, although often not recognized by Western experts, is culture-dependent (Bishop, 1988).

The Researchers and Authors

Patricia Paraide. The Papua New Guinean authors have been involved for many years in mathematics education in practice and research. The first author, Patricia Paraide, worked as a teacher, a curriculum adviser and a member of the PNG National Research Institute before joining Divine Word University as Associate Professor. She retired at the end of 2019 and now acts as an educational consultant. She speaks *Tolai* or *Tinatatuna* fluently. It is an Austronesian Oceanic language and culture. Her doctoral thesis raised the importance of culture and language in the development of mathematical skills, and the kinds of skills teachers require to teach mathematics well in bilingual situations. However, a critical lens on the power of domination over the less powerful, as discussed by Smith (2012), Barrington-Thomas (1976), Fellingham (1993), and Said (1993), has been a major background consideration for this historical study of mathematics education in PNG. Thus, her background strengthens the discussion on the key area of language in education, and of culture in mathematics education. Significantly, she brings a postcolonialist critique to the development of mathematics education in PNG. Several chapters, in particular those on language, reform, and Chapter 12 on neocolonialism, draw on her thesis (Paraide, 2010). As we prepared this book, she summarized her point of view:

My people journeyed through the changes in education before and during the colonial era, and following Independence. My people, like other PNG and Indigenous peoples, had their own system of education before the colonizers arrived. As Tololo (1976) discussed earlier, our young people learned their life-skills through observation, imitation, and participation. The skills that they learned growing up were useful and appropriate for their adult lives. Geoffrey Smith (1975, p. 3) made similar observations regarding the teaching strategies used by PNG's Indigenous people to educate their young people. Tololo and Smith acknowledge that everyone in the community contributed to the education of the young Indigenous people. Peers working together and working alongside experienced adults on specific tasks were encouraged through Indigenous education. However, this changed with the arrival of the missionaries. (Paraide, personal communication, November, 2018)

Charly Muke. After his University of Papua New Guinea Diploma in Education, Charly Muke was a high school mathematics teacher, completed further studies and lectured at the University of Goroka. For his Master of Education from the University of Waikato, in New Zealand, he studied in-depth the counting systems of his own people raising several important and previously undocumented aspects of those counting systems. He followed this with his doctoral study at Australian Catholic University on how teachers used language and Indigenous cultural practices when teaching mathematics as they moved from using many *Tok Ples* (local languages) to introducing English at Year 3 of school. Subsequently he has been involved in elementary school mathematics and technology professional development for teachers. He taught mathematics in Australia for 15 years teaching mainly Australian Indigenous students—that experience provided him with a comparative understanding of mathematics education for Indigenous students. Charly's first language is *Mid-Wahgi* or *Yu Wooi* language, which is a language of the Papuan Trans New Guinea Phylum, East New Guinea Highlands

Stock, Central Family, Wahgi Sub-Family. Recently (in 2020), Charly was appointed to the position of Provincial Education Advisor in Jiwaka Province.

Kay Owens. The preparation of this book seemed timely while the three authors who are expatriate to Papua New Guinea were able to initiate and support the development of such a history while maintaining regular connections to the country. Kay and Chris Owens lived, worked and raised their family in Papua New Guinea for 15 years and have both returned to work with their PNG colleagues to do further research and promote educational advancements. Kay taught mathematics at the PNG University of Technology, and mathematics education, health education, and education studies at Balob Teachers College. She taught in a community school, supervised practicums in village and town schools. She planned and led many professional development sessions for teachers in various parts of PNG. It was through teaching health education and her awareness of cultural impacts on health and values that raised her interest in culture-based mathematics education. During their 15 years in PNG both Kay and Chris enjoyed many bushwalks to villages all over Morobe Province. They also made trips to Buna and Popondetta in Oro Province, the Trobriand Islands in Milne Bay, Sepik River villages by motorized dugout canoes and Wosera by PMV, to Yombu Selden's village out of Tufi in Oro Province by sailing canoe. They also visited Mt Wilhelm and Mt Michael in the Highland provinces, Lake Kutubu in the Southern Highlands, and Simbine village in Madang. Kay wrote booklets and ran numerous inservices on mathematics for nurses in many hospitals from Sandaun to Oro Provinces. She wrote *Healthy Lifestyle for Tertiary Students*. Both the nursing mathematics booklets and the booklet for tertiary students were used for many years.

During her doctoral studies, Kay studied visuospatial reasoning of primary school students in Australia and in a PNG community school; the PNG sample provided significant insights into the grounded-theory qualitative analysis she undertook. This study helped to establish the importance of responsiveness during problem solving. She spearheaded an elementary teachers' professional development project with a number of her PNG colleagues, including Charly Muke. Her other research in PNG over the last two decades has included a study of architecture students' problem solving and reasoning in designing and making a paper-cardboard sculpture (1997). This happened while she was lecturing at Balob Teachers College and living at PNG University of Technology. A study on measurement and space conducted with Wilfred Kaleva, between 2006 to 2008, demonstrated the importance of cultural identity and visuospatial reasoning for self-regulation and mathematical thinking.

With Rex Matang and others between 2000 and 2003, she developed a website for the Glen Lean Ethnomathematics Centre, University of Goroka, through a USA National Science Foundation grant to the Pacific Resources for Education and Learning (PREL), Hawaii, for assisting with digitizing ethnomathematics studies in the Pacific. She worked on data collected by the late Glendon Lean, prepared an electronic database, and extended his thesis on the counting systems of Papua New Guinea, establishing a significant history of number with Patricia Paraide and Charly Muke (Owens, Lean, with Paraide, & Muke, 2018).

From 1998 to 2003, she worked with former PNG colleagues, Wilfred Kaleva and Theresa Hamadi, with Philip Clarkson and Ron Toomey on the evaluation of the Primary and Secondary Teacher Education Project collecting and preparing data for two of the teachers colleges, and teachers in the field, analyzing the data and writing up sections of the reports on these colleges.

In 2003, she set up a Master of Education program with Wilfred Kaleva, Api Maha and other lecturers from University of Goroka's (UOG) Unigor, and taught an "Introduction to Research" course to the 40 Teachers College lecturers in the Virtual Colombo Plan program run by Charles Sturt University, UOG, and TAFEglobal as an AusAid program.

Between 2006 and 2008, Kay, working with Wilfred Kaleva, investigated and documented the measurement systems of PNG cultures and languages. This involved her in making several village field trips, and conducting numerous interviews with students at UOG who had com-