

Science and Mathematics Education Centre

**A Study of the Effect of Culture on the Learning
of Science in non-Western Countries**

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ABSTRACT

The research for this thesis was born of a desire to understand how a student's cultural background might influence the outcomes of science education. Of particular interest to me was the apparent paucity of academic achievement by many indigenous students as they study science through Western style schools and curricula, resulting in what I have termed 'educational alienation', which is evidenced by poor grades and slow rates of progression through the curriculum, and by some students displaying a high degree of antagonism toward the education system. I have sought to understand the causes of educational alienation by means of an interpretive inquiry based on a Grounded Theory methodology, using an Integrative Research Review as the primary means of data collection, supplemented by personal experience, data analysis and interview methods.

The outcomes of the Grounded Research have caused me to re-think my understanding of culture and my tacit acceptance of conceptual change theory. Three distinct themes emerged as being significant to learning: Language Use, Traditional Beliefs and Life-world Knowledge. I have presented evidence suggesting that Language Use, Traditional Beliefs and Life-world Knowledge are largely subsumed within one's worldview, and that the term 'culture' lacks the specificity needed to explore the notion of educational alienation. I suggest that worldview is not only cultural, but is a dynamic belief system of the individual that is shaped by cultural forces and personal reflection, resulting in a re-organisation of knowledge throughout one's life. I propose that a constructivist view of learning and knowing presents us with a plausible explanation of worldview development and educational alienation, and I conclude with suggestions for further research and pedagogy that might develop the discourse and consequently improve the outcomes of science education for indigenous, non-Western students.

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A final acknowledgment to my friend and colleague Frank Rodie who ably supported the science teachers on my staff when I was a school Principal in the Solomon Islands, and who has allowed me to use some of his data and the products of our many discussions as a touchstone for my own thinking.

RESEARCH PHASE ONE

CHAPTER ONE

INITIAL INVESTIGATIONS

INTRODUCTION

This research study grew out of my concern that many non-Western¹ students whom I met between 1985 and 1993 in Australia and the Western Pacific did not appear to achieve the sort of results from science education that I observed among Western¹ students. As a result of this concern, I wanted to understand *if* and *how* a student's cultural background might influence the outcomes of science education. I pursued my concern by means of a Grounded Theory (Glaser & Strauss, 1967) project using a variety of data sources, including personal experience, to construct, in the style of a *bricoleur* (Denzin & Lincoln, 1994), a text that describes and interprets aspects of the relationship between culture and formal education. My personal experience is used in different ways throughout the text. In the Background and Rationale section my experience forms part of the research narrative - setting the scene. In the interpretation of published data my personal experience was called upon to help me 'make sense' of other researchers' findings. In my exploration of the notion of worldview and its implications for education I have called upon my personal experience of work in the field to provide anecdotes that suggest certain behaviours on the part of those whom I have observed. Throughout, my research and writing was undertaken with an unashamedly tentative and exploratory frame of mind. I undertook the task principally to answer my own questions and, while confident that the text I have constructed has potential to advance the understanding of classroom practitioners, I look forward to the sort of critique and further investigation that will refine the perspectives I have put forward. This thesis is presented in two parts. Phase One pursues the initial question:

- **"Does the culture of the learner affect the outcomes of science education?"**

Phase Two pursues the emergent question:

- **"What is the impact of worldview on teaching and learning?"**

¹Western and 'non-Western' categories are explained in Ch. 1 (see page 7).

BACKGROUND AND RATIONALE

During the 1980s I became involved as a science teacher, Board member, Head Teacher and consultant in the development of independent Christian schools in Australia and overseas. I also had the opportunity to observe schools in different parts of New South Wales, Queensland, the Solomon Islands and Vanuatu, where I saw a range of schools and systems, and was able to discuss their strengths and weaknesses with key people.

In 1993, I was appointed Principal of a National Secondary School in the Solomon Islands, the country of my birth. My family and I moved to the island of Malaita and, during our time of sickness and enduring friendships. I sought, among other things, to understand why Melanesian students were wrestling with a curriculum that was clearly foreign to their own cultural experience. This, together with previous experiences in Australia and the Western Pacific, drew my attention to a problem that I refer to as *educational alienation*: the situation where few indigenous students attain measurable success in formal education, despite having the necessary perceptive and intellectual faculties. Whether among Aboriginal children in Condobolin, New South Wales, or Melanesian children in Malaita, Solomon Islands, educational alienation is evidenced by poor grades and slow rates of progression through the curriculum and, in some situations, especially in Australia, by students displaying a high degree of antagonism toward the education system.

In the Solomon Islands and Vanuatu, many indigenous students value education for its potential to move their families into the cash economy. This view has concerned educators in the Solomon Islands for decades, prompting a public comment that citizens should not see education as an “investment in the narrow sense” (EPRC, 1972, p.30).

One of the disturbing effects of our present system of education is that education is regarded by many people as being something which enables one to gain employment. (EPRC, 1972, p.30)

Twenty years later I found that ‘education-as-investment’ remains strong in the thinking of Solomon Island students and their parents. I also found that Solomon Island and Ni Vanuatu students are generally attentive to their lessons and spend a lot of time studying and looking for the ‘right’ answers, yet a ‘real understanding’

of subjects such as science and mathematics appeared elusive to many. My observations match those of the anthropologists Watson-Gegeo and Gegeo (1992)² who claim that, "*Going to school may carry positive symbolic meaning for children, but studying and learning in school may not be meaningful*" (p.19, italics added). The science and mathematics curricula studied by indigenous students in the Solomon Islands, Vanuatu and Australia reflect typically Western, rather than local, views of teaching and learning. "The focus of science education [in third-world countries] has remained on the nature of the disciplines rather than on the nature and circumstances of the learner" (Ingle & Turner, 1981, p.358). Such curricula appear to suit and reward those who are able to adapt their thinking to the teaching and learning styles one might find in a Western school. Many non-Western students do not readily adopt the assumptions of problem solving and inquiry learning that under-pin much Western educational thinking. Instead, they often spend hours memorising de-contextualised lists, formulae and teacher-directed procedures; activities which make little sense but which are seen by students and teachers as essential to the *education process*.

In Australia I have heard similar accounts. During visits to schools, and during time attached to the Curtin University Centre for Aboriginal Studies, I listened as Aboriginal and Torres Strait Islander (ATSI) students spoke of their feelings of alienation from the school curriculum. Many of my informants spoke of the procedural and teaching/learning expectations of schools that left them feeling like outsiders looking in, not really identifying with, but always expected to conform. These students were often in trouble with the authority structures of schools, and left at the earliest opportunity, a move which affected permanently their career and income earning opportunities. This observation is supported by Aboriginal leaders such as Peter Yu (1996, see App.1) and Ken Wyatt (1996), and by researchers such as Beresford and Omaji (1996, see App.1). They paint a bleak picture of an Australian education system unable to meet the needs of many indigenous students, resulting in increasing educational alienation for indigenous individuals and communities, and rising rates of criminal activity among indigenous youth:

² Accounts by Watson-Gegeo & Gegeo derive their reliability both from Gegeo's heritage as a Kwara'ae of North Malaita, Solomon Islands, and their shared scholarship in anthropology and education.

A set of behaviours is not recognised by the dominant culture, and is seen as maybe negative behaviour, and that starts to perpetuate a cycle then of misunderstanding. (Wyatt, 1996).

During my travels, particularly in Vanuatu, it became apparent to me that much of the school curriculum provides a Westernising influence on students' thinking. By this I mean that Western ideas, artefacts and life-styles are communicated through the curriculum because they are viewed as pre-requisites for success in a modern, technological world. I refer here to Vygotsky's (1978) use of the term 'artefacts', meaning the ideas and physical entities passed on from one's forbears. The Westernising influence of schools, however, seems insufficient to equip many non-Western high school graduates for the further study of science or science education. Rather, it seems to encourage students to become uncritical consumers of the ideas, artefacts and life-styles of other societies, perhaps contributing to a breakdown of the natal culture and cultural expectations. As a community elder in Ambae, Vanuatu said to me, "It is very difficult to send a child to high school, and then tell him to go home and cut copra." Caught between a desire to experience a Western lifestyle and the doubtful economic value of the education they have received, many young people in Pacific nations drift toward the cities and unemployment. I have only recently come across this argument clearly put, by Drori (1998, p.62), and am encouraged to see the problem and its consequences more widely recognised. Drori asks:

How does science education contribute to and expand underdevelopment... it provides education that is not applicable to local needs and it channels the labor forces towards a narrower, rather than wider, range of occupational opportunities.... Such poor skills are applicable only for the absorption of transferred technology, rather than for local innovation.

Relatively few indigenous science teachers or research scientists can be found in Australia or in Pacific nations, yet the citizens of those same nations consume imported goods and services at a rapidly increasing rate. In societies that have otherwise been quite inventive and adaptive (Baker, 1996), there appear to be few indigenous people inventing or adapting modern technological ideas to suit local needs; a situation that could rob entire communities of the value of a local perspective in a scientific world. My observations led me to consider two

deficiencies apparent in the wholesale importation of Western school curricula for non-Western students:

1. little effort is made to construct a curriculum that is appropriate to the needs, aspirations and assumptions of local people; and
2. little attempt is made to develop teaching strategies that reflect the cultural norms of non-Western societies and help encourage an indigenous scientific community.

Concern about the effectiveness of high school education in the preparation of non-Western students for further study is not unique to Australasia. In response to the U.S. debate over affirmative action in tertiary entrance criteria, the June 9, 1997 edition of Time magazine (Gwynne, 1997, p.64) reported a significant 80% fall in "black enrolments", and a 50% and 32% fall in Hispanic enrolments in each of Berkeley and UCLA universities. Commenting on the dramatic decline since these universities ceased using an affirmative action enrolment plan, Abigail Thernstrom is quoted as saying that the public schools are to blame. "Our high schools graduate black and Hispanic students who are way behind whites and Asians in basic cognitive skills." This study raises questions regarding the extent to which schools in Australasia can fairly be blamed for the low indigenous representation in tertiary science courses and post-graduate research.

In order to 'make sense' of observations concerning non-Western students in Australasia, I sought the informal opinions of parents, teachers and education officials. During my time visiting rural Australian towns, and in Vanuatu and the Solomon Islands, I often stayed in people's homes and spoke with recognised community and government leaders. In all of these situations I asked people about their impressions of the work that schools were doing. I was disturbed to find that most were critical, and many referred vaguely to 'cultural problems' for which they blamed a variety of influences including the students' home environments, supposed social or cultural deficits, or low intellectual ability.

Although I often heard criticism leveled at teachers and school administration, few of my informants appeared to consider that teaching methods or curriculum emphases might contribute to educational alienation, apparently accepting the curriculum as a fixed body of unchangeable knowledge and practice. Many of these people seemed to resist any notion that the education system should

become more culturally appropriate. Instead, most apparently believe that the best future for non-Western people lies with a rapid transition to Western thinking, and that a more 'relevant' curriculum would result in 'lower standards'; a complex argument that is discussed by Knamiller (1984) who suggests that curriculum relevance should be that "part of education that attempts to keep school children in touch with the common man, with their parents and their communities." - in other words, with their *cultural roots*.

To better understand the relationships that might exist between culture and formal education, I resolved to research the issue in depth, however, two major socio-political obstacles presented themselves. The first obstacle reflects the dependent relationship that has evolved between education, economic development and international aid (Drori, 1998³ ; Swift, 1992). Because formal education is considered crucial to the economic development of many Pacific Island nations (EPRC, 1972), but is dependent upon outside agencies for much of its funding, small nations are understandably reluctant to approve freelance educational research into the effectiveness of their respective education systems. The second obstacle reflects an awakening concern about the methods and purpose of academic research into indigenous culture. In Australia and the Solomon Islands there exists among indigenous people a widespread reluctance to support research seen by many as intrusive, irrelevant and opportunistic. Typical of these views is the following statement by Cheri Yavu-Kama (1988):

While we as a people continue to allow white Australia to study us in their microscopes for the sake of doctorates, degrees, prestige and status, we will always remain disempowered. (p.94)

As a result of the socio-political difficulties mentioned above, and my conviction that researchers have already gathered and published a great deal of field information pertaining to my question, I resolved to undertake research using existing data about the education of non-Western students. This decision was neither a 'mere convenience' nor evidence of distaste for fieldwork, which I have been conducting in one form or another for the past ten years. It was born of a sincere belief that the information is already available, so further significant

³ see Drori (1998) for a helpful "critical appraisal of science education for economic development".

intrusion is unjustifiable. If, as Cheri Yavu-Kama implies, we have reached the point where field research among indigenous people is often exploitative, simply a gathering of observations and data for a singular, self-serving academic purpose, I felt a moral obligation to use existing data where possible, make the most of my years of personal experience as a form of fieldwork, and limit my further observations to very specific issues. My research goal, then, was to interpret existing information and personal experience in such a way as to inform myself, and other interested science educators, about an issue affecting the formal education of non-Western students. As I began reading, it became clear to me that little research has been done that seeks to explain the interaction between culture and formal education (Duit, 1987), but a literature does exist that describes various people's experience or observation of that interaction. This justified, to me, the value of pressing on with a study that would seek to understand *if* and *how* culture affects the outcomes of teaching and learning in science education programs.

SOME DEFINITIONS

Throughout the text I have used a number of terms in ways that require definition and clarification. Of special significance are the terms 'Western', 'non-Western', 'indigenous' and 'science education'.

Western and non-Western: I believe that the Western European academic tradition, rooted in the Renaissance and Enlightenment, exerts considerable influence upon modern science and technology and, therefore, the shape of the 'technological society' (Ellul, 1990). I have chosen to use the term 'Western' when referring to European and 'second world' academic traditions and 'non-Western' when referring to non-European traditions and ways of knowing. These terms are widely used but not well defined in academic literature (Cobern, 1996a; Greer, 1992; Jegede & Okebukola, 1991; Maddock, 1981):

The coming of science to the Western world is the story of the lives and work of Copernicus, Kepler, Galileo, Newton and Liebnitz, to name but a few. It is especially the work of Bacon and Descartes who articulated and elevated the scientific method and the use of 'objective rationality' almost to the level of deities.

(Simonelli, 1994, p.1)

Simonelli (1994) concludes that, “the implicit proposition of science was that Western science is the highest form of knowing” (p.2).

Throughout this study I use the term ‘Western’ in the same manner as Simonelli, to refer to ideas and practices whose origins can be traced to European traditions of science, knowledge, teaching and learning. This is in contra-distinction to non-Western, referring to “the traditions and outlooks of non-European cultures” (Simonelli, 1994, p.2): in other words, any culture that is not grounded in Western European traditions, especially academic traditions.

Indigenous: The word ‘Indigenous’ is commonly used to refer to a people or culture that is native to a specific location. The United Nations Working Group on Indigenous Populations refers to Indigenous communities, peoples and nations as “those which, having a historical continuity with pre-invasion and pre-colonial societies... consider themselves distinct...” (quoted in ATSIC, 1998, p.61). I have used the term in that sense occasionally in this document, but more often to describe non-Western people whose recent history includes an oral, rather than a written, tradition. Very often there exists among indigenous peoples a desire to maintain and refer to those traditions and culture that were previously transmitted orally. This desire is reflected in the UN Working Group’s form of words: “[they] are determined to preserve, develop and transmit to future generations their ancestral territories and their ethnic identity...” (quoted in ATSIC, 1998, p.61). With these defining statements in mind, I have used the term ‘indigenous’ as a subset of the term ‘non-Western’: all indigenous students referred to in this study are non-Western, but not all non-Western students are indigenous.

Science education: In this study I have used the term ‘science education’ to mean the teaching and learning of Western scientific ideas and skills in the context of a formal education system. In other words, science education takes place whenever schools and teachers attempt to introduce students to scientific explanations and concepts as part of a formal school curriculum.

CHAPTER TWO

THE RESEARCH METHODOLOGY

In this chapter I outline the research methodology used for the collection and analysis of data, justify the use of an interpretive methodology, and describe the structure of the thesis and the style of presentation.

THE RESEARCH ENVIRONMENT

Educational researchers today are in a fortunate position. In recent years, a wide range of methods and styles have become acceptable vehicles for research, enabling researchers to break free of the often deterministic traditions of Western scholasticism. It is now more widely recognised that no single discourse, method or theory can lay claim to a privileged place in the world of knowledge and ideas (Richardson, 1991). Ultimately, the selection of a research method and style of presentation depends as much upon the preference of the researcher and the purposes for which the research is conducted as upon the nature of the phenomenon to be investigated. Both will vary with time, place and participants, so the outcomes of the 'research act' (Denzin, 1978) are shaped largely by what I refer to as the 'research environment'.

The research environment for this study, as discussed in *Background and Rationale* (Ch.1), is the world of formal education for non-Western students. That world is situated within the classrooms of most countries, but of particular interest to me were Australia and some South Pacific nations, with reference also to parts of Asia, the United States of America, Canada and Africa. In each of these locations concern has been voiced since the early 1960s about the outcomes of formal education, particularly the education of indigenous students. In order to address this concern, I felt it appropriate to investigate, analyse and interpret the experiences of teachers and researchers concerning the provision of formal education for non-Western students. To do this I have used a multi-method, qualitative research approach (Denzin & Lincoln, 1994). According to Denzin and Lincoln (p.2), qualitative research is, "Multi-method in focus, involving an interpretive, naturalistic approach to its subject matter". *Multi-method* because qualitative research is able to harness the benefits of a range of techniques and strategies for observing and analysing phenomena; *interpretive* because

qualitative researchers acknowledge that interpretation is essential to discovering meaning; and *naturalistic* because qualitative research is research *in situ*.

CONSTRUCTING A *BRICOLAGE*

Discussing the use of multiple research methods within a qualitative research framework, Denzin and Lincoln refer to the qualitative researcher as a *bricoleur*, meaning one who "produces a *bricolage*, that is, a pieced-together, close-knit set of practices that provide solutions to a problem in a concrete situation" (1994, p.2). They refer to Becker (1989), Levi-Strauss (1966) and Weinstein and Weinstein (1991), to illustrate the *bricoleur's* method as pragmatic, strategic and self-reflexive, involving the use, and sometimes the invention, of relevant tools:

The *bricoleur* is adept at performing a large number of diverse tasks, ranging from interviewing to observing, to interpreting personal and historical documents, to intensive self-reflection and introspection.

(Denzin & Lincoln, 1994, p.2)

The *bricoleur* understands that research is an interactive process shaped by his or her personal history, biography, gender, social class, race and ethnicity, and those of the people in the setting.

(Denzin & Lincoln, 1994, p.3)

I have conducted this research and written the text after the style of a *bricoleur*. The product of my labour is text that represents my "images, understandings and interpretations of the world or phenomenon under analysis" (Denzin & Lincoln, 1994, p.3). I have produced a hermeneutic text representing my interpretation of sources that disclose specific worlds or phenomena, as if I were peering through a window and describing my interpretation of events seen from that vantage point. My purview is specific but the emergent theory is relative. My *bricolage* does not, therefore, pretend to provide more than an interpretation of the educational alienation observed among specific indigenous students.

The search for grand narratives will be replaced by more local, small-scale theories fitted to specific problems and specific situations.

(Denzin & Lincoln, 1994, p.11)

The Hermeneutic Process

Hermeneutics can be defined as 'the science of interpretation', with its roots in the interpretation and application of the Biblical text. Textual interpretation lies at the heart of an Integrative Research Review, so it is fitting that I reflect on the place of hermeneutics in the construction of my *bricolage*. Commenting on the value of a hermeneutic approach to science education research, Eger (1993) shows that hermeneutics "supports the cognitive seriousness of science [rather] than endangers it". "A hermeneutic approach may show more convincingly... that science is after all about the world... not about its own ways" (p.4).

The claim to a hermeneutic process implies that the researcher is constantly evaluating and interpreting text, informants and lived experience, seeking to make sense of their contribution to the research process by looking closely and 'wholistically' below the surface of what is said and written. This interpretive process is not merely a repeating of what has been said or written, but it looks to the context of the utterance and compares and contrasts that with utterances made by others, in a range of contexts, times and places. The 'goodness' of this dialectic process relies upon the researcher identifying his or her *a priori* assumptions, and, as it were, placing them on the table for others to see as they, in turn, evaluate the resultant text.

My own prior assumptions are outlined in the section titled *Background and Rationale* (Ch.1). I commenced the study with the assumption that culture might in some way impact upon science education for non-Western students. I did not know how that might happen, so my original challenge was to determine *if* and *how* culture might influence learning. As the study progressed, my perspective and understanding of the problem altered in response to my use of the hermeneutic process.

My use of personal experience as a background into which I draw the experience and research findings of others is discussed on page 22 of this text and is justified by reference to Clandinin and Connelly (1994), Taylor, Chen and Aldridge (1998) and Van Manen (1990). I have chosen to explicate my interpretations of the inter-relationship between my own experience and the experience of others by means of a narrative mode that suits a hermeneutic style of research and presentation. I have been informed by, but have not adopted the style of hermeneutic-phenomenological presentation that is gaining currency

through the writing of my colleagues, Taylor and Geelan (1998), and which is based on the work of Max Van Manen (1990) and Polkinghorne (1992). I do, however, agree that:

This interpretive approach [hermeneutics] to understanding the nature of a social phenomenon involves the researcher in making explicit the meaning of a particular lived experience and generating a pedagogical thoughtfulness in his or her readers.

(Taylor & Geelan, 1998, p.3)

It is my belief that the interaction of personal data with data external to my lived experience provides a rich account from which one might reach pragmatic conclusions. While I do not believe that I need to use (or feel comfortable with) the style of the impressionistic novel, I claim hermeneutics as the metaphor informing my reflection and writing.

The Value of a Qualitative Methodology

As noted above, I proceeded throughout this research as a *bricoleur*, piecing together personal experience, observations, interviews and literature analysis to form a complex collage that invites interpretation to find meaning. In so doing, I place myself squarely in the qualitative, interpretive tradition - a tradition that must be pursued carefully if one is to avoid the charge of idiosyncrasy.

Qualitative researchers are called journalists, or soft scientists. Their work is termed unscientific, or only exploratory, or entirely personal and full of bias.

(Denzin & Lincoln, 1994, p.4)

In contrast to qualitative research methods, Minnis (1985, p.189) notes that, "Quantitative approaches to data collection and analysis tend to reduce the complexity of human experience to statistical analyses and the verification of facts". Some, of course, are wary of the subjectivity of qualitative research. Cizek (1995) has expressed a view that qualitative research might be "informative, necessary and rigorous", but it is also at risk of being 'hijacked' toward irrelevance. He claims that; "qualitative research has become inextricably linked with sociopolitical causes...qualitative researchers are often not so much practitioners as *believers*" (p.27). The debate about epistemic relevance is summarised by Eisner (1997) in the following manner:

Issues of epistemology have political ramifications as well as intellectual ones (Eisner, 1988). Yet from a purely intellectual perspective, the exploration of alternative forms of data representation is simply a symptom of a fertile imagination seeking to discover its limits. (p.5)

While I have taken note of Cizek's warning, I have taken heart from Eisner. It is as a *bricolage* of qualitative techniques that I hope this text will be read, as my purpose throughout has been to 'make sense' of the issue at hand, regardless of the political ramifications. My *bricolage* consists of lived events such as my discussions with key people in education throughout Australasia (p.4; p.45), the observed outcomes of a culturally relevant field-trip (p.94) and my observation of students in the Solomon Islands (p.122), and interprets these in the light of data from the Integrative Research Review and other relevant sources. In this light my results can only ever be exploratory and tentative, putting forward reasons born of interpretation and challenging myself and others to test the results in classrooms. Like Tobin (1991):

What led me to interpretive research was awareness that there were factors influencing science learning that were not amenable to the traditional methods of research in science education. (p.199)

DENZIN & LINCOLN'S RESEARCH PROCESS

I have found Denzin and Lincoln's (1994) research process to be particularly powerful as an explanation and justification of an interpretive methodology. They acknowledge that, although "qualitative researchers deploy a wide range of interconnected interpretive methods, always seeking better ways to make more understandable the worlds of experience that have been studied" (1994, p.12), such researchers also need some structure to situate them in the world of research. Behind this structure "stands the biographically situated researcher" (1994, p.12), so they suggest five levels of activity, or practice, that will vary slightly between researchers according to the biography of each person. In Table 1 I have identified, from Denzin and Lincoln's description of the research process, those elements that I have used to guide me in my research efforts and I present them in bold type for easy identification. I then proceed to discuss the way in which they have been used to construct the research text.

Table 1. The Research Process (Denzin & Lincoln, 1994, p.12)

1. The Researcher as a Multicultural Subject

- **history and research traditions**
- **conceptions of self and the other**
- **ethics and politics of research**

2. Theoretical Paradigms and Perspectives

- positivism, postpositivism
- **constructivism**
- feminism(s)
- ethnic models
- Marxist models
- cultural studies models

3. Research Strategies

- study design
- case study
- ethnography, participant observation
- phenomenology, ethnomethodology
- **grounded theory**
- biographical method
- historical method
- action and applied research
- clinical research

4. Methods of Collection and Analysis

- **interviewing**
- **observing**
- **artefacts, documents and records**
- visual methods
- **personal experience methods**
- data management methods
- **computer-assisted analysis**
- textual analysis

5. The Art of Interpretation and Presentation

- **criteria for judging adequacy**
- the art and politics of interpretation
- **writing as interpretation**
- policy analysis
- evaluation traditions
- applied research

1. The Researcher as a Multicultural Subject

Denzin and Lincoln speak of the researcher as “socially situated” (1994, p.12), guided and constrained by traditions that locate him or her historically. The researcher is effected by the often complex and contradictory history of research while simultaneously confronting contemporary ethics and the politics of research. I have presented the elements of this step in the Research Process (Table 1) in bold type because all three elements serve to frame my own biography. My place in the history and traditions of research, my conceptions of self and others, and my perception of the ethics and politics of research have helped to shape this study and are made explicit throughout the text.

2. Theoretical Paradigms and Perspectives

While justifying the use of an interpretive methodology, as distinct from one that is empirical and quantitative, it is easy to forget that, ultimately, “All research is interpretive, guided by a set of beliefs and feelings about the world and how it should be understood and studied” (Denzin & Lincoln, 1994, p.13). The paradigm one uses shapes not only the assumptions one carries into the research act, but also the questions asked and the way in which the answers will be framed.

Denzin and Lincoln (1994, p.13) provide us with a helpful analysis of various interpretive paradigms, their assumptions, criteria for evaluating research, and their typical form of narration. They describe in this way Positivist/postpositivist, Constructivist, Feminist, Ethnic, Marxist and Cultural Studies models.

As indicated in Table 1, I have located my research within the constructivist tradition, which I discuss further in Chapter Six and which Denzin and Lincoln define in the following terms:

criteria for evaluation - trustworthiness, credibility, transferability, confirmability;

form of theory - substantive-formal;

type of narration - interpretive case studies, ethnographic writing.

Denzin and Lincoln’s ‘criteria for evaluation’ are understandably similar to those of Guba and Lincoln (1989), who refer to ‘credibility’, ‘dependability’ and ‘confirmability’ as subsets of “the *trustworthiness* criteria” (p.233). Guba and Lincoln have, with their trustworthiness criteria, attempted to parallel the “rigour criteria that have been used within the conventional paradigm for many years”

(p.233). Guba and Lincoln (1989) explain in the same place that they actually prefer 'authenticity criteria', namely; 'fairness', 'ontological authenticity', 'educative authenticity' and 'catalytic authenticity' as criteria of goodness for constructivist evaluation. I have chosen, however, to retain the use of Guba and Lincoln's 'trustworthiness criteria' as my measures of 'goodness' or 'quality', despite a criticism of their "hermeneutic neo-tradition of *trustworthiness*" (Taylor & Geelan, 1998, p.5). I believe that the 'authenticity criteria' are more relevant to the field of ethnographic evaluation where the various stakeholders are more readily available for reflection and feedback. Research that is significantly dependant upon texts as data sources is, in my opinion, better served by the 'trustworthiness' criteria.

Within the trustworthiness criteria, *credibility*, *dependability* and *confirmability* replace the more positivist criteria of *internal* and *external validity*, *reliability* and *objectivity* as criteria for judging the value of the research process and its resulting text. As discussed in the following sections of this chapter, I have sought to maintain throughout my research a high standard of 'goodness' or 'quality' while recognising that constructivist research is founded upon a subjective epistemology, and the very text produced is open to re-interpretation.

Constructivism -

Ontology or Epistemology?

Constructivism, like any research paradigm, is limited by its own characteristics. Denzin and Lincoln summarise the model as one that assumes "a relativist ontology (there are multiple realities), a subjectivist epistemology (knower and subject create understandings), and a naturalistic (in the natural world) set of methodological procedures" (1994, p.14). In the case of constructivism, it is often difficult to distinguish between ontological and epistemological assumptions. That the observers of an event construct understandings at variance with each other is well argued (Clark, 1993; Taylor, 1993; von Glasersfeld, 1993). To extrapolate this argument to the point of postulating multiple realities, however, becomes a definitional problem, as discussed by von Glasersfeld, "whatever an independent ontological reality may do, it is not something we can visualise or understand" (1993, p.28). What exactly is meant by 'multiple realities'? Are we saying that, because each person sees the world through an "evolving conceptual lens" (Taylor, 1993, p.2) there exists no real, measurable world, or are we saying that

'objects' are perceived in different ways in different contexts, and so provide a different 'experiential reality' (von Glasersfeld, 1993, p.28)? One's answer to this question predicated the way in which information concerning the world will be interpreted. I choose the latter explanation, not because I consider myself aligned with von Glasersfeld's 'radical constructivism', but because, with von Glasersfeld, I see no harm in remaining a realist, as long as I do not assume that my perception of reality is the one others must perceive or will experience.

Being a realist at heart, I research with the assumption that I can interpret and describe a world that I experience. I can also benefit from others' interpretations of the world so long as I remember that they are grounded in their experience and reflect something of their personal context. I accept that my interpretation will vary from that of an individual with a different 'conceptual horizon' because our respective experience takes place in varying geographical, social, cultural, political and personal contexts, and must, therefore, be described by each person in terms of their subjective epistemology (cf. Cobern, 1993). With that understanding made explicit, I locate my research efforts within a constructivist framework, and accept its ontological constraints.

3. Research Strategies

According to Denzin and Lincoln, "Strategies of inquiry put paradigms of interpretation into motion" (1994, p.14). I have chosen Grounded Theory (Glaser & Strauss, 1967) as my primary strategy of inquiry, using it as a framework within which I construct my *bricolage* using a multi-method approach. This approach allows me to make use of my personal experience, small-scale investigations, interviews and an Integrative Research Review to collect data (see Fig.1, p.20), an approach that is compatible with a constructivist-interpretive paradigm, allowing for a data-driven mode of inquiry rather than a theory-driven mode. This grounded theory mode of inquiry resulted, in this instance, in the proposing of theory to explain the possible relationship between formal science education, culture and worldview. Based upon Denzin and Lincoln's proposal that the value of interpretive research is particularly evident in the development of local, small-scale theories of specific context (1994, p.11), I have formed the opinion that I do not need to "operationalise" the outcomes of my research. Instead, I used grounded theory to explore the research questions and to propose theory that might further the discourse and contribute to my future research. The product of

my work as a *bricoleur* is a text that informs and challenges, and which I hope will, itself, be challenged. It is not a construction of immediate utilitarian value to the classroom, but I believe that it could contribute to a useful discussion that might, in the longer term, be of value to indigenous students and their teachers.

Grounded Theory Inquiry

Since its inception in 1967, the grounded theory methodology has been seen by many as an appropriate way to organise data about people and their situations with a view to generating theory. It is a qualitative inquiry process that enables the researcher to come to an area of interest and to be informed by the situation rather than constrained by a general theory. Spector (1984) has described grounded theory as employing an *inductive* reasoning process in contrast to the *logico-deductive* process employed in most quantitative research. In this type of research, theory is generated *from* the data rather than proven *by* the data:

Grounded theory is a research strategy for generating substantive theory from qualitative fieldwork data...it seeks to discover basic social-psychological problems and processes assumed to be inherent in various groups. (Wilson & Hutchinson, 1991, p.267).

In recent years, Glaser and Strauss have disagreed in their perceptions of the conduct of grounded theory research (Glaser, 1992), possibly due to widespread experimentation with the original model, as evidenced by the range of topics and data-collection styles that are published as grounded theory. Concern has been expressed (Robrecht, 1995) that, "attempts to refine the method have gradually shifted the focus of the researcher's attention toward procedures rather than data", a shift that I have been eager to avoid. Of particular interest in my search for an appropriate model of grounded theory is the precedent set by Wiener (1981) who used published contemporary documents as her primary data source in a study of alcoholism. Wiener believed that her study of the politics of alcoholism could best be advanced through a study of the reports and research previously conducted into alcoholism, its causes and community responses. Studying the phenomenon of alcoholism through new field-work might have done little more than duplicate previous studies, but a study of previously published work held out the potential for Wiener to uncover themes that might previously have been overlooked. Similarly, the underlying factors involved in the science and mathematics achievement of non-Western students might be understood by

reviewing a range of literature that describes the phenomenon in various contexts, searching for themes that shed further light on the phenomenon. Strauss and Corbin (1994) describe grounded theory as:

a *general methodology* for developing theory that is grounded in data systematically gathered and analysed. Theory evolves during actual research, and it does this through continuous interplay between analysis and data collection. (p.273)

Wilson and Hutchinson (1991) state, in the context of using grounded theory inquiry with an hermeneutic emphasis, "In grounded theory, researchers use theoretical sampling and collect data from... any other document that can inform the study" (p.270). In this light, I analysed published data sources that had been subjected to the peer review process, confident of their trustworthiness as sources of research information.

In my study, I assumed that the basic process of grounded theory inquiry should take the same form as the natural analysis that we regularly apply when we listen to a story (Robrecht, 1995). Natural analysis, according to Robrecht, involves personal interaction with the data (after Schatzman, 1991), which assumes that the researcher will attempt to make sense of the story as it progresses by analysing its themes with reference to personal experience.

The process of grounded theory inquiry that I have used is as follows:

- identification of an unfamiliar problematic situation, namely, the perception that few indigenous students appear to achieve high academic success in the study of science or mathematics;
- the adoption of a perspective, namely, that it is not good that an identifiable group of students are not well represented among science and mathematics graduates and researchers;
- an investigation of the problem, and its context, gathering data in a manner that is organised for efficiency yet inclusive of all available sources;
- a continual analysis, sorting, reflection upon and coding of the data and my own lived experience, looking for emergent themes; and
- letting themes determine the direction of further data collection and analysis .

In order to extract themes from the discourse with some degree of accuracy, it was necessary for me to make copious notes that were then condensed into headings. The headings were grouped into common ideas, and from these ideas were extracted the over-riding themes. This process was as much reflective as analytical because, throughout, my own experience of education in Australasia was called upon to identify and associate relevant ideas and themes.

I have sought to illustrate, in Figure 1 the Integrative Research Review process as I have used it. Although the process is, by its very nature, subjective, I am sure that any researcher who cares to analyse the same published research will inevitably identify similar themes. Whether that researcher attributes to them the same importance, or orders them identically to another researcher, is the point at which subjective interpretation will shape the outcomes of the research act.

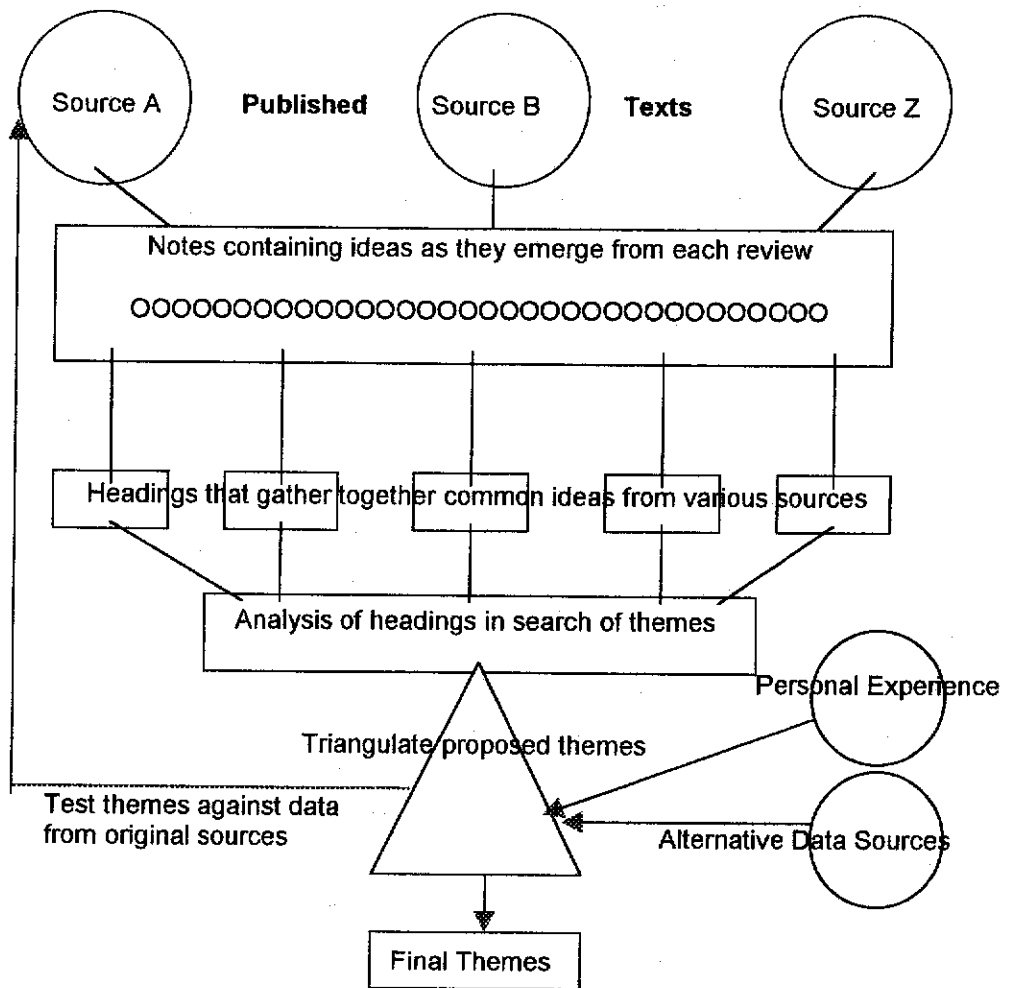


Figure 1. Diagrammatic representation of the Integrative Research Review process used in this study

Grounded theorist-explorer

In addition to using the *bricoleur* metaphor as a tool to better understand the implications and operation of grounded theory, I have also used the metaphor of a 'theorist-explorer'. According to this metaphor, 'quantitative' and 'descriptive' research methods can be likened to the work of the engineer and the surveyor, respectively. When given a problem they are able to use certain well-tried techniques to design a solution to a known problem, or to accurately chart a known place. On the other hand, the grounded theorist-explorer might have a vague notion that something is 'out there', and set out to locate and identify it. In order to 'make sense' of the journey the grounded theorist-explorer attempts to code the collected information in ways that are internally consistent and, where possible, link them to existing theory. The results of such an exploration contribute to the construction of a journal, or textual *bricolage*.

The Role of Literature in this Study

Pre-existing literature informed four principal areas of my investigation.

1. Literature that informed my initial investigations and which constitutes the literature review that is normal to all research projects. This literature is cited throughout Chapters One and Three, and led me to believe that a further study of the initial research question was warranted.
2. Literature pertaining to the methodology employed in this study and cited throughout Chapter Two and occasionally elsewhere.
3. Literature that contributed to the collection of data through an Integrative Research Review (IRR) process. The IRR is quite distinct from, and should not be confused with, a literature review. It is a process of analysis and comparison of data relevant to the study. This process is discussed in the next section (p.22ff) and the data is summarised in Chapter Four.
4. Literature that contributed to the discussion of culture and worldview. This literature was discovered by searching various databases and by following the citation trail of other researchers (see p.26) and was used after the manner of grounded theory investigation, to inform the discourse and to provide themes that directed further inquiry.

4. Methods of Collection and Analysis

To assist me in the construction of my *bricolage* I have brought to bear three principal strategies for data collection and analysis:

- reflection upon my own personal experience and observations;
- small scale investigations and interviews; and
- an Integrative Research Review.

Personal Experience Methods

Clandinin and Connelly point out that “the social sciences are founded on the study of experience” (1994, p.414). They appeal to Dewey, for whom, they claim, “education, experience and life are inextricably intertwined” (p.415). The study of life, then, is the study of experience, which is intensely personal in nature. For Clandinin and Connelly “stories are the closest we can come to experience as we and others tell of *our* experience” (p.415). Their discussion then proceeds to the issue of research established upon the personal experience of others, but much of what they say applies to research that includes the personal experience of the researcher. “It is important, therefore, for us to understand the autobiographical quality of our own experience” (p.417), which is a reflection of Clandinin’s (1993) observation that:

In personal experience methods we must acknowledge the centrality of the researcher’s own experiences; their own tellings, livings, relivings and retellings. (p.4)

Clandinin and Connelly’s (1994) argument provides, I believe, sufficient epistemic warrant for me to use in the research, and include in the text, stories and understandings gained from my personal experience of living and teaching among indigenous people. That experience is accessed through diary notes, letters, discussions with those who shared my experience, unpublished papers (including research toward the award of a Masters degree in Educational Administration), and memories of events that have shaped my present understandings and practices in education. The veracity of such stories and understandings is dependant upon the clarity and honesty of their presentation, the accuracy of the researcher’s notes and memory, and the reputation and transparency of the individual. Decisions concerning the relevance and reliability

of my personal experience will be made by the reader during the unfolding of the research text. This requires that I reveal enough about myself to inform the reader of my place in the research act, but not so much as to dominate the story that I seek to unfold. More is said about the criteria for judging adequacy in the next section entitled *The Art of Interpretation and Presentation*.

Observations and Interviews

I have drawn into the research text the results of several observations and interviews carried out during the life of the study. Examples of the former are recounted in quite specific terms, but much of the latter (interviews) forms part of the background to the 'tale that I tell' (Taylor, 1997).

Observations that contribute directly to the text include an episode involving 40 Form 1 students in a Solomon Island school (p.122) and a biological field-study conducted by teaching staff at the Curtin University Centre for Aboriginal studies (p.84). I share these tales with the reader to provide examples of the conclusions drawn from the variety of data available to me. Examples of interviews providing background understandings can be found in 'Background and Rationale' (Chapter One) where I refer to interviews with Australian Aboriginal informants (p.3) and various Aboriginal and Melanesian community leaders (p.4; p.83). These interviews were semi-structured in that I asked similar questions of each informant in any given sequence of interviews, and recorded his or her response in the form of either field notes or tape recordings, while seeking to maintain an informal and conversational tone to each interview. Another example of a semi-structured interview that has informed the research study is Marie's story (p.41), gathered in Vanuatu as a 'piece-meal disclosure' over a period of three days spent living in the household where Marie worked for her 'wantok' relatives. In this series of interviews, in the presence of her 'cousin-sister', Marie expressed in Bislama her experience of formal education and some of her feelings about her post-school life, always looking at her work while speaking, and seldom speaking directly to me, as if the recounting of her story to no-one in particular would release her from her custom obligation to not complain to outsider.

I have also included into the text verbatim excerpts of recorded interviews (Cheryl's story p.39 and Rodie's story p.83) in order that the voices of four of my informants might be heard with minimal interpretation from me. Into those

excerpts I have inserted editorial notes to explain my understanding and use of the data that is embedded within each specific discourse.

By means of these investigations, observations and interviews I have sought to add texture to my research and to the text. Their inclusion opens a window through which the reader can see something of the human side of my story, and can understand that I have sought to interpret a wide variety of sources in my representation of the issues that have motivated my inquiry.

Computer-Assisted analysis

Only one computer-assisted analysis was carried out during the course of the research. Its results are interpreted in the text and can be found in Chapter Three (p.35) where I discuss the findings of a search of the attendance records of the Education Department of Western Australia conducted using the department's central computer. The data from this search was downloaded to my own PC and analysed using the SPSS software package. The premise behind my analysis of departmental records was a conviction that the Education Department uses the wrong criteria when speaking of 'retention rates' from Year 10 to Years 11 and 12. My analysis of the department's data supports my conviction that published retention rates are skewed, since the Department of Education compare Year 12 figures with Year 10 figures, quite ignoring data showing that Aboriginal students drop out of school in significant numbers from late primary [elementary] school. This departure trend, and a discrepancy of some 12% between Department of Census and Statistics numbers of Aboriginal children and Education Department enrolment data, are factors that do not effect non-Aboriginal students (Baker, 1994).

Integrative Research Review

In order to ensure some structure in the analysis of published data I adopted the Integrative Research Review (IRR) technique, as described by Cooper (1982), as a tool to explore and analyse the written discourse about education in non-Western cultures. The discourse was accessed between 1989 and 1995 through published papers and journal articles, each of which represents a distillation of the author's experience at its time of writing.

I am aware that some consider the Integrative Research Review (IRR) technique to be most appropriate as a method of content analysis (Cooper, 1989). However, as noted by Manning and Cullum-Swan (1994), "Content analysis has been unable to capture the *context* within which a written text has meaning" (p.464). I have attempted in this study to interpret not only the *content*, but also the *context* of each piece of research, since the contexts of location, population and purpose are factors which help one to understand the findings of each researcher. In so doing, I have viewed researchers as my informants and their published works as their 'field texts' (Clandinin, 1993).

Integrative Research Reviews have proven to be well suited to the study of culture and learning. IRR studies have focussed on the human aspects of health, programs for the handicapped, education, and business management, enabling researchers to synthesise existing views or infer generalisations about substantive human issues (Jackson, 1980). Out of this interpretive process can emerge theories that are grounded in recurrent themes.

Literature Selection

Having chosen an Integrative Research Review (IRR) as the means of data collection for Phase One of this study, it is important to explicate the process that I followed to identify and obtain my literature sources for the IRR as well as other literature used throughout the inquiry. While outlining his seven steps to follow when conducting IRR research, Ellis (1991, p.228) emphasises the importance of establishing the inclusion/exclusion criteria and the retrieval and search procedures used to gather data.

Inclusion/Exclusion Criteria: When searching for literature suitable for analysis I used the following criteria, in this order:

- studies that measured or interpreted some aspect of learning in a non-Western environment, or involved a comparison between Western and non-Western education;
- studies that involved some form of qualitative or quantitative study rather than a theoretical discussion or a literature review;
- studies that were available through journals held in the libraries of the University of Newcastle or the universities of Western Australia, or through the Educational Resources Information Center (ERIC) document system; and

- studies that are available through the various Departments of Education in Australia.

I excluded from the IRR papers that are purely theoretical in content because they tend not to contain the primary research data on which I wished to base this part of the study.

Search and Retrieval Procedures: Two principal search methods were used throughout the study. The first involved the use of computerised and printed databases, and the second used the 'citation trail' of other writers and researchers. I consider printed and computerised databases to be adequate search tools because of the increasing tendency for published research to be catalogued, and because their use ensured that my sources will be readily available to others. Thus, I felt that sources such as projects and essays that are not readily available in journal, book or ERIC document form would not be appropriate.

The databases interrogated for the study were:

- Educational Resources Information Center (ERIC)
- Australian Public Affairs Information Service (APAIS)
- First Search
- Dissertation Abstracts International

These databases were chosen for their availability to me, as mentioned in the inclusion/exclusion criteria, and for their general availability and representative nature for other researchers. As a result of the search I have, in Phase One of the study, identified and reviewed 34 research reports, representing 23 publication sources. I found that four of my sources had published an ongoing dialogue concerning cross-cultural science education: *International Journal of Science Education*, *Science Education*, *Journal of Research in Science Teaching* and the National Association for Research in Science Teaching (NARST). A summary of the review outcomes is presented in Chapter Four.

5. The Art of Interpretation and Presentation

Criteria for Judging Adequacy

Considerable debate exists about what constitutes good interpretive research. Morgan (1983) expresses the opinion that there has not yet been sufficient attention given to evolving criteria for assessing the rigour of interpretive research, while Roberts (1982) points out that a minimum requirement of good research must be the sound argumentation of well founded observations. Hammersley (1992, p.57) suggests that one's opinion of interpretive research is influenced ultimately by one's philosophical position, which Denzin and Lincoln (1994, p.479) summarise as 'positivist', 'postpositivist', 'constructivist', 'postmodern' and 'poststructural'. In a preceding section, I have identified my own philosophical position as constructivist, and have tried to ensure that my research is trustworthy without having to use the terminology and techniques of a positivist research paradigm.

The use of any qualitative research process is, according to Lythcott and Duschl (1994, p.447), as good as "the coherence of the relationships between correctly applied methods, legitimate warrants employed in the interpretation of data, and the sources and soundness of the arguments...". To maintain this coherence I have used two of Guba and Lincoln's (1989) trustworthiness criteria (credibility and dependability) as metaphors to guide me toward what I would previously have referred to as 'rigour' in the conduct and reporting of the research. I have chosen not to use the 'confirmability' criterion because confirmability is as difficult a criterion to apply to naturalistic research as 'objectivity' is to conventional inquiry. It is difficult because its usefulness hinges upon the requirement that "data, interpretations, and outcomes of inquiry are rooted in contexts and persons apart from the evaluator" (Guba & Lincoln, 1989, p.242). In a study based upon the interpretation of a range of sources, not all of which are derived from outside the researcher, such a criterion is problematic, so I have decided to rely only upon the 'credibility' and 'dependability' criteria to establish trustworthiness.

Credibility

Guba and Lincoln (1989, p.236) use *credibility* as a parallel to the positivist criterion of *internal validity* to establish a congruence between the "constructed realities of respondents and those realities as represented by the evaluator and attributed to various stakeholders" (p.237). Guba and Lincoln refer to six

strategies for enhancing credibility. Because they are written in the context of *evaluation*, not all are appropriate to this grounded theory study, especially to the collection of textual data, but the following have proven to be helpful strategies for the maintenance of credibility.

Prolonged Engagement: Guba and Lincoln (1989) describe this strategy as:

Substantial involvement at the site of the inquiry... to establish the rapport and build the trust... and to facilitate immersing oneself in and understanding the context's culture. (p.237)

I believe it fair to say that my credibility in this field of study is enhanced by the time that I have spent working, interviewing and purposefully observing non-Western students in Australia and the Pacific region. My prolonged engagement, and immersion, as presented in *Background and Rationale* (Chapter One), has enabled me to gain more than a cursory understanding of the events and culture of every day life experienced by those students, and justifies the use of personal experience methods in the gathering and recounting of my research data. It is one thing to observe a people from the comfort of a western life-style in a modern, third world city, quite another to live among a people, and to engage with some of the momentous events in their lives. I will never forget, for example, the cultural window that opened to me when a child in my school died of cerebral malaria and I unexpectedly became part of a community of 400 people mourning his death and enduring the processes of recrimination and adjustment.

Persistent Observation: Guba and Lincoln write that, "The object of persistent observation is to add depth to the scope which prolonged engagement affords" (p.237). This is achieved by first identifying and then focussing often upon those elements that are most relevant to the study. In other words, it is good to ensure that one is not distracted by background events to the extent that one is not able to observe the underlying factors of interest. Throughout the field-work and research review components of this study I have constantly sought meaning rather than simple facts, in order to add depth and lead me toward a clearer understanding of the subject of my inquiry.

Negative Case Analysis: Revising working hypotheses, or, in this study, emergent theories, takes place throughout the process of grounded theorising. By its very nature, grounded theory provides for a 'review and synthesise' / 'review and reject' operational method. The grounded theorist is continually

making decisions about the comparability of new data to existing data, seeking themes and looking for congruence. If the research is to be credible, the researcher must assure readers that data items that do not fit emergent themes are adequately explained or, if of sufficient persuasion, have resulted in the modification of theory. Guba and Lincoln (1989) point out, however, that just as no one achieves statistical significance at the .000 level, neither will all qualitative data perfectly fit the emergent themes. An example from this study is the problem created when one considers indigenous individuals who have made significant contributions to their chosen field, especially in the sciences. As I have sought to understand their success in the light of convincing evidence of indigenous student under-achievement, the direction of my thinking and therefore, my theorising, has altered, leading me to explore the notion of worldview.

Peer Debriefing: Guba and Lincoln (1989, p.237) refer to peer debriefing as the "process of engaging, with a disinterested peer, in extended and extensive discussions of one's findings." The purpose of this debriefing process is to test one's findings with a person who does not have a stake, or "contractual interest" in the research or its conclusions. I am indebted to colleagues in the Curtin University Centre for Aboriginal Studies and the Science and Mathematics Education Centre for their willingness to read and critique sections of my research findings. In particular I am indebted to Dr David Geelan for his reading and insightful critique of much of this text.

Member Checks: I have used two separate methods for the conduct of member checks. To ensure that my transcription and interpretation of words and events is close to the intentions of my sources I have, in the first instance, reflected to them my understanding of what is being said or done, inviting clarification and expansion. For example, before finalising the field notes concerning a culturally relevant field trip (p.93) I spoke with the various stakeholders, including a number of the students, about what I understood to have taken place. Their comments helped to refine my interpretation of the event. In the second instance I have asked many of my sources to review the text produced from the interviews, giving each the opportunity to comment upon my interpretation. For example, the section entitled Rodie's Story (p.83) has been shaped by my continued contact with Rodie after his return to the Solomon Islands as we continued our discourse via facsimile. In this way Rodie entered into the discourse and his refining of my

interpretation has contributed directly to the text and to its credibility. His response to my member checking was:

I read your field notes and was impressed with your interpretation of my view of science education in general. In this regard, I have nothing more to contribute except to say that I fully support the way you have interpreted my views about science and my school experience.

(Rodie, personal communication, 1998)

Triangulation: Conflicting views exist concerning triangulation, even within the qualitative research literature (Flick, 1992; Guba & Lincoln, 1989). Denzin and Lincoln (1994) see triangulation as an example of multi-method research, and therefore, appropriate to the construction of a *bricolage*. They point out that, "Triangulation is not a tool or a strategy of validation, but an alternative to validation" (p.2). In the context of 'fourth generation evaluation' Guba and Lincoln (1989) do not advocate triangulation, believing at that time (1989) that it "carries too positivist an implication" (p.240). They suggest that triangulation is only of value when "cross-checking specific data items of a factual nature" (p.241); but I have reached the conclusion that it is possible to triangulate for more than just 'factual items'. For example, Mathison (1988) notes, after Denzin (1978), that triangulation can take the form of *data, investigator, methodological* and *theory triangulation*. Of particular relevance to my inquiry is Mathison's reference to the use of time, space and person as 'triangulating agents', because each contributing piece of literature is the product of different times, locations and researchers. I am confident that my use of triangulation is appropriate to the construction of a *bricolage*, providing a 'thick description' of phenomena by accessing a wide range of data sources.

Dependability

This criterion is described by Guba and Lincoln (1989) as parallel to the conventional criterion of reliability "in that it is concerned with the stability of the data over time" (p.242). In other words, the methods used to collect and process data were not whims of the moment or the result of tiredness or boredom, but were "established, track-able, and document-able" (p.242) such that a colleague following the same process in the same context would encounter recognisable data. I have deliberately emphasised 'context', because a naturalistic inquiry is

context-dependent, and 'recognisable' because interpretation must always give rise to the possibility of multiple conclusions.

Dependability is concerned not with changes that occur as a result of 'overt methodological decisions' on the part of the researcher because, in naturalistic research, especially using grounded theory methods, one should expect that the research act will mature and shift in emphasis over time. Dependability in this study is provided by the use of stable data sources (published research) triangulated with descriptions of clearly defined events that have been accessed through a range of methods: interview, personal experience and observation.

Writing as Interpretation

By writing in different ways, we discover new aspects of our topic and our relationship to it. Form and content are inseparable.

(Richardson, 1994, p.516)

Richardson speaks of writing as a dynamic, creative process. I certainly found it so. As I wrote and re-wrote the form of my text I found that my understanding of the content of my research deepened, opening up further avenues of investigation. However, writing as an act of research has not always been acceptable to the research community or to me. Richardson (1994) outlines the historic conflict between advocates of scientific and literary genres, culminating in 'experimental writing' in which conventions and genres are blurred resulting in "different forms for different audiences and different occasions" (Richardson, 1994, p.521).

While I am not inclined toward mixed genre writing for its own sake, Richardson's justification of this style of presentation, and her explication of writing as a form of knowledge development, has assisted me immensely. I feel free, in the context of her explanation, to present my text as an account of my research journey without hiding the fact that many helpful insights were derived through the actual writing. I can no longer pretend that the real work of research is done in the data collection phase and that the writing represents no more than the presentation of solidified argument. The style of research and presentation advocated by Richardson enables me to construct a text consisting of personal anecdote, interviews, data analysis and theoretical constructions. I attempt to weave this 'mixed-bag' of writing into a readable text that hopefully will inform the reader about my investigations and contribute to further investigation.

...writing is a process of discovery. My purpose is not to turn us into poets, novelists, or dramatists - few of us write well enough... Rather, my intention is to encourage individuals to accept and nurture their own voices. The researcher's self-knowledge and knowledge of the topic develops through experimentation with point of view, tone, texture sequencing and metaphor. (Richardson, 1994, p.523)

Whilst writing this text I used the first person voice wherever it seemed appropriate, together with a narrative style which is gaining in popularity for educational research writing. Martin and Brouwer (1991) claim that the narrative mode strives toward "the creation of shared experience between the writer and the reader" (p.711), and Taylor (1997) describes a form of research writing "in which the field-worker attempts to portray, through the lens of his own experience, the lived experiences of the persons of his inquiry" (p.1). I have chosen a narrative style because, as Richardson (1994) says, "Qualitative research has to be read, not scanned; its meaning is in the reading" (p.517). It must, therefore, be readable, hence the desire for parsimony! Richardson claims that it is most unsatisfactory for a researcher to spend months or years doing research that makes no difference to anything but the author's career. I hope that those who read this research text will share something of my own and my informants' experiences as we worked together to understand the issues of culture and education.

Jean Clandinin (1993) makes the point that narrative research texts are more difficult to write than the 'objective', third person variety, and I agree. Narration is essentially story-telling, and as such it is more revealing, reflecting what Taylor (1997) refers to as the 'self' of the 'thoughtful-emotional field-worker'. A story is not necessarily less accurate than an objectively written report, but its telling highlights an intangible relationship between the author, the subject, and the audience. "This concern for relationship is at the heart of personal experience methods in research for teaching" (Clandinin, 1993, p.1). My writing style, then, is one more tool that I use in the construction of a *bricolage* that helps me to not only understand, but also communicate, the issues effecting science education for non-Western students.

THE RESEARCH STRUCTURE

The course and structure of my research is illustrated in Figure 2, as it progressed from the initial research question through to the construction of the text. Chapters One to Seven record my exploration and development of the research questions, using a grounded theory approach throughout. Chapter Eight contains what I perceive to be the implications arising from the study, and will undoubtedly shape the direction of my next research efforts.

Phase One - Chapters 1 to 4

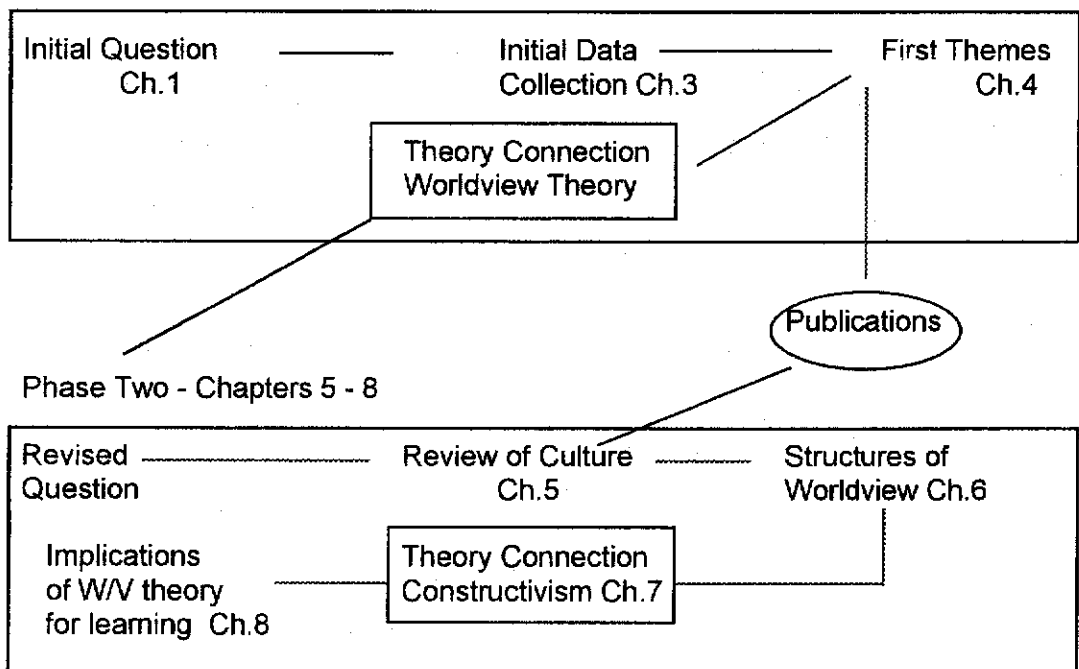


Figure 2. Diagrammatic representation of the research process.

Phase One

The first phase of the study was a search for answers to the initial research question, "Does the culture of the learner affect the outcomes of science education?". An initial literature review (Chapter Three) established the problematic nature of science education in non-Western countries and justified the conduct of an Integrative Research Review to search for possible underlying causes. Completion of the Integrative Research Review (Chapter Four) produced three themes - Language-use, Traditional Beliefs, and Life-world Knowledge - as factors indicating that the culture of non-Western students does affect the

outcomes of science education. I concluded, however, that the notion of 'culture' lacks sufficient specificity for theory development in this context.

Phase Two

Because it became apparent in Phase One that 'life-world knowledge' and 'worldview' are very similar concepts, the second phase of the study explored the concept of 'worldview' through the emergent research question: "What is the impact of worldview on teaching and learning?" The result is a model of worldview structures that owes its theoretical origins to Kearney (1984) and Cobem (1991a), is located within a constructivist theory of teaching and learning, and has pedagogical implications for cross-cultural science education.

CHAPTER THREE

THE PROBLEM IN PERSPECTIVE

In Chapter Three I present the results of my preliminary literature search, focussing on Australia, North America and the Pacific Islands. This literature search suggested that widespread concern exists among many of the stakeholders in education about the impact of formal education upon indigenous students, demonstrating a warrant for the conduct of further research.

INDIGENOUS EDUCATION IN AUSTRALIA

Australia, like Canada and the U.S.A., is a technologically developed nation whose dominant culture has evolved mostly from a Western European tradition. Within each of these nations there lives a minority indigenous population who are the descendants of the original inhabitants (First Nations), and whose culture remains more or less different from that of the dominant population. Researchers and teachers have recognised for some years that indigenous students often experience difficulties with formal education, particularly in science and mathematics (Burton, 1994; Charles, 1964), difficulties evidenced by relatively high drop-out rates, and by outcomes that are significantly different from those of non-indigenous students (Currie, Kissane, & Pears, 1991).

In my opinion, past government policies in Australia have largely ignored the specific social and educational needs of Australia's indigenous population. The policies of successive Australian governments since colonisation have attempted to either exclude Aboriginal people from or assimilate them into the dominant culture, and education systems have not, until recently, acknowledged the uniqueness of Aboriginal students' needs. This unsatisfactory state of affairs is reflected in the wording of the foreword to the National Aboriginal and Torres Strait Islander Education Policy Statement (1993):

The historically-developed education processes of Aboriginal and Torres Strait Islander cultures have been eroded in many communities for a variety of reasons. The education arrangements and procedures established from non-Aboriginal traditions have not adequately recognised and accommodated the particular needs and circumstances of Aboriginal and Torres Strait Islander people. (NATSIEP, 1993)

Referring to his experience of Aboriginal education in the Northern Territory of Australia, Darvall notes that what is needed to counter the erosion of Aboriginal culture by schools is a "genuine commitment to Aboriginal education from all authorities and institutions". Such a commitment must allow the "Aboriginal communities to reassess and reaffirm their values and beliefs in terms of the technological changes that are occurring around them" (1990, p.3).

Aboriginal Students in W.A. Schools: 1982 - 1993

Clearly, many educators and indigenous people are concerned that formal education and indigenous culture in Australia are not in harmony (Yu, 1996). To test this concern I obtained permission of the Director of Education Services Division (Education Department of Western Australia) to analyse their enrolment figures for the years 1982 to 1993 (Baker, 1994).

In late 1994, using departmental data and computer analysis, I tracked the 1982 cohort from their first year of school in 1982 until their final year (Year 12) in 1993. In order to reduce potential fluctuations due to the small size of the Aboriginal cohort relative to the non-Aboriginal cohort I averaged three year's enrolments to obtain a figure for each median year. For example, for the year 1982 I averaged 1981 - 83 figures; for 1983 I averaged 1982-84, and so on to 1993. I have then expressed each year's mean figure as a percentage of the Year Two enrolment. I chose Year Two as the datum year because of the unusual pattern of Year One enrolments of Aboriginal students, as evidenced in Table 2 and Figure 3. When the data are plotted they show a number of disturbing trends for Aboriginal students.

Demographic Considerations

The place of Aboriginal people in the demography of Western Australia has changed from 100% prior to 1829, to 2.6% in 1991. Following a long period of declining numbers, Aboriginal people in this state have experienced a population growth rate of about 11% in the five years 1986 - 1991, during which time the state population increased 12.8%, due largely to overseas and interstate immigration. During the period under consideration, the non-Aboriginal student population of Western Australian increased by about 16%, inflating the apparent Year 12 retention rate to about 82% for non-Aboriginal students. Because this

rising apparent retention rate has not been reflected in Aboriginal student enrolments a number of government programs attempt to encourage Aboriginal students to remain at school, and to achieve qualifications suited to their personal aspirations. Programs such as Fastrack, Aboriginal Secondary Assistance (ABSEC) and Aboriginal Study Assistance (ABSTUDY) have attempted to improve access, while the Aboriginal Tutorial Assistance Scheme (ATAS) and the provision of Aboriginal Counselors in specific schools seek to assist students to overcome difficulties they might experience at school. Unfortunately, these programs do not seem to result in a significant proportion of students remaining at school to Year 12, according to this study. The purpose of this small study was to compare retention and loss trends of Aboriginal and non-Aboriginal students. It was not an attempt to arrive at an accurate retention rate for either group.

The 1982 Cohort

In semester two of 1982 there was an actual number of 1326 Aboriginal students enrolled in Year 1 in W.A., representing 5.8% of the total state enrolment. By semester two of Year 2 this same cohort had reduced to 1014, or 4.5% of total enrolments. This pattern of high Year 1 enrolments for Aboriginal children is evident in every calendar year, but reduces steadily from 24% to 4.4% over a ten-year period. In semester two of 1993, an actual 226 (22.3%) of the 1982 cohort of Aboriginal students were enrolled in Year 12. This was 1.2% of all students enrolled in Year 12 in Western Australia, a greater number than usual which was not repeated in 1994, hence the lower Table 2 figures.

The enrolment trend for this cohort can be seen in Table 2, and is graphically represented in Figure 3 as it progresses from Year 1 to Year 12, however, caution should be exercised in light of the difference in population sizes between Aboriginal and non-Aboriginal enrolments. In Table 2 the row labelled 'Av' represents the three-year average of Aboriginal enrolments; the row labelled '%2' represents the percentage of the Year 2 enrolment of Aboriginal students; and the row labelled '%tot' represents Aboriginal enrolments as a percentage of the total enrolment of their Western Australian cohort.

Table 2. Three-year average Aboriginal enrolment trends
1982 - 1993, Western Australia

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12
	<u>82</u>	<u>83</u>	<u>84</u>	<u>85</u>	<u>86</u>	<u>87</u>	<u>88</u>	<u>89</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>
<u>Av.</u>	1281	1055	1010	1014	1028	1021	998	1025	937	789	410	197
<u>%2</u>	121.4	100	95.7	96.1	97.4	96.7	94.5	97	88.8	74.7	38.8	18.6
<u>%tot</u>	5.9	4.9	4.7	4.7	4.7	4.6	4.4	4.4	4.0	3.4	1.9	1.1

Table 2 shows the quite large (21.4% in 1982) over-enrolment in Year One compared with Year Two. It shows a reasonably stable enrolment through most of primary school, followed by a quite rapid fall-off, both numerically and as a percentage of the state enrolment of their cohort, starting in the late primary years. This data is graphically illustrated in Figure 3.

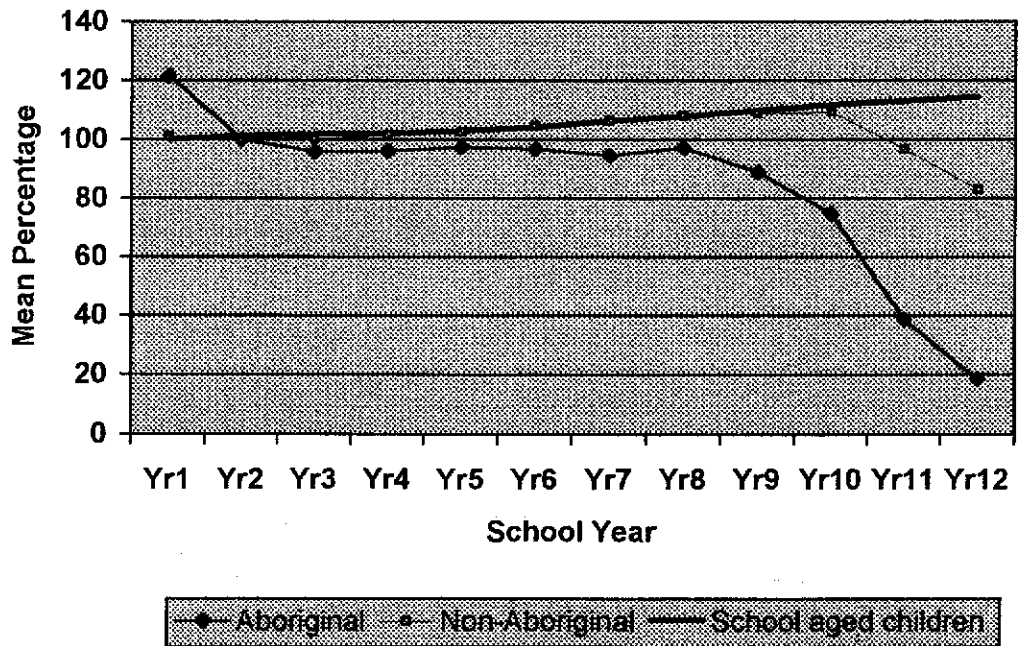


Figure 3. Enrolment and population growth trends for the Western Australian 1982 cohort

The data, shown in Table 2 and Figure 3, has led me to the following conclusions concerning the (averaged) 1982 cohort of Aboriginal students in W.A.

- many Aboriginal students repeat their first year of primary school;
- more than 10% of Aboriginal students do not complete Yr 9;
- Aboriginal students begin to 'drop out' of secondary school from late Yr 8, whereas fewer than 1% of non-Aboriginal students leave school before Yr 10;
- whereas 83% of non-Aboriginal students from the averaged 1982 cohort completed Year 12, only 18% of the Aboriginal students completed Yr 12. Other data obtained from the Western Australian Secondary Education Authority indicated that seven Aboriginal students from this cohort gained a matriculation score sufficient to access a university.

This data does not encourage me concerning the state of Aboriginal education in Western Australia, however, talking with students, such as Cheryl, gives the data a more human perspective, which, in Cheryl's case, is a positive perspective.

Cheryl's Story

To put a human face to the preceding data I interviewed a young Aboriginal lady whom I will refer to as Cheryl, who lives in a suburb of Perth and studies Tourism at a College of Technical and Further Education (TAFE). During her secondary school education Cheryl moved quite often, living in both urban and rural Western Australia, which meant that she attended four different high schools between Years 8 and 11. When I met Cheryl in Perth she kindly told me about some of her school experience. I feel that Cheryl's experience opens a small window that helps me to understand aspects of the data pertaining to the 1982 cohort.

David: Cheryl, Why did you leave high school at the beginning of Year 11?

Cheryl: I wanted to try something different so I went to TAFE to study a different course... a tourism course.

David: When you were at school, how did you feel about subjects like Maths and Science? *Cheryl:* They taught us stuff we didn't know... the science was kind of hard, I didn't really like it - it wasn't my subject. I liked art, dance, sports, English was good, and social studies.

David: Do you feel that what you are studying in the tourism course is relevant and helpful to you? *Cheryl:* Yes. Its an Aboriginal course and I'm learning cultural things I didn't know before.

It would be inappropriate to assume from the 1982 cohort data that all Aboriginal students who leave school before the completion of Year 12 do so only to 'drop out' of education, or because they cannot cope academically with the school curriculum. Cheryl describes her school experience as positive, but she found that the program at school did not meet her needs to the same extent as a vocational course. Her preferred subjects suggest that Cheryl's interests lie in the creative fields, and she has decided that she can best pursue these fields in a specialised course.

David: Can you think of any teachers who were really special to you during your high school years? *Cheryl:* Yes. There was a sports teacher who was good to the students and good to me, but Mr X, one of the teachers, one of the maths department teachers, was kind of bossy, and none of us got along with him... he didn't know how to communicate properly with some of the students.

The ability of individual teachers to relate well, and to communicate their concern as well as their subject, was important to Cheryl. Cheryl also spoke of the important role her cousins and friends played in her school life. It became clear to me that her relationships at school contributed greatly to Cheryl's positive experience and outlook, "we were all cousins... we kind of all stick together." Cheryl also had many non-Aboriginal friends, especially those who shared her dance class. Despite a good deal of anecdotal evidence of school-based racism, mentioned informally by teachers, Cheryl did not experience much racism at the personal or organisational levels.

David: Did you experience any negative racial relationships, like name-calling, from other students? *Cheryl:* Oh, sometimes, but I didn't pay any notice to it. I was friends with a lot of white kids.

In the light of Cheryl's story it cannot automatically be assumed that Aboriginal students are leaving school because of a racist school environment or hostile teachers. It can be assumed, however, that relationships, especially with other Aboriginal students and with teachers, can be an important factor in school retention. Conversely, poor relationships and channels of communication might

have an adverse effect on retention. Another important matter to Cheryl was her subject selection and the way each subject was taught. My conversation with Cheryl has impressed on me the importance of considering underlying personal and relational issues when discussing the question of school retention for Aboriginal students. While I am sure that many other reasons for early school departure can be uncovered, issues pertaining to the student's relationship to, and feelings of identification with, the curriculum, the teachers and the students appear very significant, and might help explain some of the 1982 cohort data.

Conclusions

Enrolment patterns for Aboriginal students are changing, but very slowly, and continue to present a bleak and ambiguous picture in the light of past research indicating that a high intellectual potential exists among indigenous students (Boulton-Lewis, Neill, & Halford, 1988; Havighurst, 1957; Kearins, 1986). If the Western Australian experience is typical, it is apparent that the various Australian education systems are not yet able to develop that high intellectual potential into recognised academic achievement by indigenous students, a point that has not escaped public notice, as the following indicates.

In a recent Australian newspaper (Martin, 1998), the Western Australian Education Minister, Mr Colin Barnett, made the following acknowledgment:

The education system has failed Aborigines. Mr Barnett told a Legislative Assembly Budget estimates committee this week that despite about \$500 million being spent on Aboriginal education around Australia during the 1990's, Aboriginal children were not staying at school.

(p.5 - see Appendix 1)

To me this admission speaks of a problem, reflected in my study of Aboriginal enrolments, that will not go away through minor re-structuring of the organisation or funding of indigenous education. "Department director-general Cheryl Vardon said about \$7 million a year was being spent on initiatives to increase retention rates. But it was often individual teachers with an empathy for Aboriginal culture who made the critical difference..." (p.5). Clearly, matters of culture and relationship are significant to the education of Aboriginal children, and must be considered carefully by education providers.

INDIGENOUS EDUCATION IN NORTH AMERICA

After summarising Professor Deloria's essays entitled *Indian Education in America*, the researcher, Simonelli concludes:

Indian education at the present time is completely immersed in the American educational system. The American system is characterised by approaches, practices and values with which Indian people must live, often in conflict with their own traditions. There are many constructive aspects of the American system, but from the viewpoint of Native cultures quite a few attitudes are destructive to those coming from tribal traditions. (1991, pp.14,15)

Simonelli characterises the American education system as one that embodies a set of 'technical beliefs' which produce 'professionals' but not 'whole people', when viewed from the perspective of Native American values. If Simonelli is correct, there exists among indigenous North Americans a perception that is not dissimilar from that expressed in the National Aboriginal and Torres Strait Islander Education Policy Statement (1993), that formal education, as it is currently perceived, is in conflict with indigenous cultures.

It certainly appears, as one reads various literature sources, that a cultural conflict has been identified in specific areas of science education in America.

As many Native Americans remain in school through the upper grades and into college, it is apparent that many have an unusually difficult time in Biology classes. (Burgoyne, 1988, p.315)

Cultural alienation and inappropriate education have been identified as key factors in the under achievement of Native American students.

(quoted in Allen, 1995, p.3)

One of the factors, says Alcoze, is that Native people and cultures find certain aspects of science education confrontational and contradictory to Native traditions. (Greer, 1992, p.14)

Alienation is a frequent theme in the literature concerning science education for Native American students. This theme is consistent with my own observations of 'educational alienation' in Australasia (see p.2).

Ogbu (1992) has developed a taxonomy that attempts to explain the sense of alienation and conflict experienced by American immigrants by referring to three broad categories of minorities; *autonomous*, *voluntary* and *involuntary*. He suggests that involuntary minorities exhibit *primary* and *secondary* differences from the dominant culture in which they live. Primary differences are those that exist between members of any two cultures regardless of their contact one with the other. Secondary differences are those that have developed as a result of contact, often as a form of *cultural inversion*, in which there is a tendency to regard certain behaviours, beliefs, symbols and meanings as inappropriate *only* because they originate from the dominant group. This behaviour is oppositional, and is evidenced by resentment, anger, obstruction and non-compliance.

The level of anger and oppositional behaviour of some American and Australian indigenous students, who could clearly be described as an involuntary minority, suggests that Ogbu's theory might also have some relevance for indigenous students who perceive formal education to be part of an imposed system of values to which they do not assent and in which they are not understood (Hudsmith, 1992; Castle, 1993; Wyatt, 1996).

Caste-like or involuntary minorities are people who were originally brought into United States society involuntarily... American Indians, black Americans and Native Hawaiians are examples (emphasis mine).
(Ogbu, 1987, p.321).

Ogbu's taxonomy, however, fails to explain why indigenous students who are part of a majority culture, such as Solomon Island Melanesians, perform less well in science education than do their Western counterparts, or why some minority indigenous students apparently succeed with formal education while others do not. The existence of Native American Professors with earned doctorates is ample evidence that some have found success in formal education that belies any attempt at stereo-typing.

INDIGENOUS EDUCATION IN THE WESTERN PACIFIC

Marie's Story

In 1990 I visited Vanuatu for the second time as part of a project to help an island community establish a school. Whilst there I met a young lady, Marie, from Ambae, who had come to Port Vila to complete her secondary education. As Marie worked in the house I chatted with her, in the presence of her married sister, using my imperfect Bislama and her sister's fluent English. As we talked about Marie's experience of school on her island and in Vila it became evident that Marie felt a sense of failure emanating from her educational experience. Not academic failure, but a feeling that she had failed her family.

Marie's education had contributed to a fluency in Bislama and in French, as well as in her local dialect. She had a reasonable recall of European and Ni Vanuatu history, a 'commercial' level of mathematics that she was rapidly losing and a rudimentary knowledge of science, especially as it applied to hygiene. Marie felt that she could not go back to her village because she was now better educated than her family, but neither could she go on to further education or obtain a 'status' job - of which there were too few. When I met Marie she was working as a 'domestic' for a well-to-do Ni Vanuatu family. Marie is a bright young lady, but her education was not able to deliver to her the sort of job she desired, and much of what she had learned was disappearing. The competitive and Euro-centric education system imported into Vanuatu had not, apparently, served Marie well. Her formal education had been, to Marie, culturally foreign. It had removed her from the cultural context of her island community to such an extent that she no longer felt able to return. Marie had not acquired many of the skills necessary to village life, she had instead immersed herself in the development of skills necessary to an urban lifestyle in a Western-style cash economy. At the completion of her education, Marie found herself caught between two cultures, not really understanding the new, but not equipped to operate in the old.

The preceding anecdote is included to illustrate the dilemma that I have observed, and others, like Marie, have expressed, concerning formal education in the Western Pacific. Marie and her family saw education as her key to the cash economy and future prosperity. Marie found that her education 'promised' more than a largely agrarian economy could deliver.

Pacific Voices

Unlike Australian and American indigenous people, the inhabitants of South Pacific nations are an indigenous majority. Despite recent colonialism they have retained control of their land and culture, and most have attained full democratic nationhood. Nevertheless, Pacific nations also experience fundamental problems with their (imported) education systems. In a 1973 paper, the educational consultant G.D. Bishop stated:

In the South Pacific, also, came the plea for reform. Here... so much of what was being taught was irrelevant to the background and needs and aspirations of the countries of the South Pacific. (Bishop, 1973, p2.)

In a similar vein, with an eye toward culture, the ex-teacher Sir Geoffrey Henry, Prime Minister of the Cook Islands, said of educational history in his country:

Let's face it. The educationists, men of goodwill they all were... appear to have wanted a system that would teach us to be suitable New Zealand residents, to achieve standards that would serve not our needs so much as that of the New Zealand economy. (1992, p.13)

In the same year, an ex-patriate teacher, Aaron Hayes, wrote about the apparent contradiction between the work of skilled expatriate teachers in the Solomon Islands and the low level of success experienced by Solomon Island students in tertiary science courses in Australia, Fiji and Papua New Guinea, a problem he attributes to "a dissonance between the traditional Melanesian approach to learning and the process of scientific inquiry which science teachers wish to nurture in their students" (1992, p.85).

What happens when Western models of schooling, replete with their own concepts of knowledge, communication and social organisation are imported to these various Pacific societies? New problems are posed, and transformations occur. (Falgout and Levin, 1992, p.7)

These comments indicate that the curriculum and teaching practices in some South Pacific nations appear to clash with the culture and aspirations of many local people, but in my experience not everyone agrees that the clash is important. In a private communication to me, an expatriate American resident of Port Vila, whose children attended a 'successful' local school, wrote:

Adjusting the education system to fit the culture is always a challenge. It is interesting to note, however, that by far the most successful schools in Vanuatu make little or no effort to adjust to the culture, but expect the students to adjust to the school system, something they seem able to do very well. (Beardsley, 1991)

This comment from an expatriate involved with education in the Pacific is disconcerting, but I do not consider it to be universally true. I have observed in Vanuatu and Solomon Islands schools that students who adapt best to formal education are those whose families lead a Western life-style and who have been introduced to literature-based learning from an early age; in other words, the children of teachers, public servants and business people, many of whom are very successful in their fields. In terms of the overall school population, however, these children are numerically in the minority, so it seems unwise to assume that all children are able to 'adapt very well to the school system'. To assume so is to encourage a system that promotes those who are most able to assimilate Western thinking, at the expense of the majority who come from a more traditional, rural background.

CONCLUSION

It is clear from the reading to this point that further research into the effect of culture upon formal education is warranted. Despite the best efforts of educators for most of the twentieth century, and longer in some places, it appears to me that education systems have not been able to develop a culturally appropriate science curriculum capable of providing both a general science education for the majority of indigenous students, and adequate preparation for students who choose scientific careers.

One wonders why science education appears to have been so poorly exported by Western science educators when I know from experience that a plethora of paid consultants have been engaged in educational reform in developing countries for at least three decades. Snively (1990) suggests that educators do not have a better understanding of the relationship between culture and science education because researchers have been hesitant to study the relationship, being more willing to study the beliefs of students in 'mainstream' society and then apply these principles universally. If this is the case then it is time the educational

needs of indigenous students became the subject of a greater research effort, a contention also expressed by Trueba who says:

What we need is to search for a cohesive theory of culture that permits an understanding of culture's crucial role in the process of knowledge acquisition and its ultimate link to the developmental processes of children's cognitive skills. (1988, p.282)

Chapter Four documents my search for themes that might expose the underlying issues that appear to affect the outcomes of science education in non-Western cultures. The chapter constitutes a major part of my own search for a cohesive theory that can explain "culture's crucial role in the process of knowledge acquisition" (Trueba, 1988, p.282).

CHAPTER FOUR

EMERGENT THEMES

In Chapter Four I identify three themes that have emerged from my interpretation of the Integrative Research Review data and supporting literature, and give reasons for believing them to be helpful to my understanding of the effect of culture on the outcomes of science education. In support of each theme I have summarised a selection of studies from those listed in Table 3 and have given reasons for my interpretation of the data contained in each study. To ensure that my interpretation is informed by a broad research base I have used and cited data and opinions drawn from a wide range of published work. The themes discussed in Chapter Four are:

- Language-use;
- Cultural Explanations; and
- Life-world Knowledge.

It is important to note that each theme was established *from* the data, not used as a framework to *order* the data, and supporting papers have been used to triangulate the themes. Referring back to Figure 2 (p.33), this section of the study is located within Phase One, and pursues the question, “Does the culture of the learner affect the outcomes of science education?”

DATA SOURCES

Grounded theory research is dependent upon ‘themes’. These become evident as the researcher sorts data and interprets their meaning, trying to make sense of information gleaned from various sources. As themes are identified and confirmed they determine the form and focus of further research efforts. I am able to categorise my sources in retrospect in a way that was not possible during the study. Below are listed my source documents according to their dominant theme, although many documents actually contained several themes.

Table 3, following, identifies each of my literature sources according to the author, date of publication, geographic location of the original research and a brief description of the method used to gather data for that research.

Table 3: Data Sources Used in the Integrated Research Review

Theme 1: Language-use

<u>Authors</u>	<u>Date</u>	<u>Location</u>	<u>Method</u>
Collison	1974	Ghana, Africa	Language Analysis
Mori <i>et al</i>	1976	Japan/Thailand	Language analysis
Ross & Sutton	1982	Nigeria & U.K.	Language Analysis
Hewson & Hamlyn	1984	Sotho, Africa	Concept Profile Inventory
Bamgbose	1984	Nigeria, Africa	Longitudinal study
Rutherford & Nkopodi	1990	Sotho, Africa	Test of Preferential Thinking Style
Marshall & Gilmour	1990	P.N.G.	Case study of student work
O'Shane & Bickford	1991	Australia	Questionnaires & Interviews

Theme 2: Cultural Explanations

<u>Authors</u>	<u>Date</u>	<u>Location</u>	<u>Method</u>
Charles	1964	U.S.A.	Culturally Biased Science Test
Maddock	1977	P.N.G.	Environ't Phenomena Attitude Scale
Harris	1981	Europe	Concept analysis
George & Glasgow	1989	Caribbean	Language Analysis
Okebukola & Jegede	1990	Nigeria, Africa	Socio-Cultural Environment Scale II
Snively	1990	Canada	Participant observer
Jegede & Okebukola	1991	Nigeria, Africa	Traditional Cosmology Test

Theme 3: Life - world Knowing

<u>Authors</u>	<u>Date</u>	<u>Location</u>	<u>Method</u>
Greenfield	1966	Senegal, Africa	Piagetian conservation
Prince	1969	P.N.G.	Conservation & Observation
Hudsmith	1992	Australia	Observation
Za'rour	1976	Lebanon	Interviews
Shimpo	1978	Australia	Observation & Interviews
Champagne <i>et al</i>	1980	U.S.A.	D.O.E. (Conceptions of motion)
Ehindero	1982	Nigeria, Africa	Tangrams (Piagetian)
Acuna	1983	Philippines	Children's Embedded Figures
Solomon	1983	Britain	Life-world analysis
Kearins	1984	Australia	Interviews
Hewson & Hamlyn	1984	Africa	Interviews about instances
Lynch <i>et al</i>	1985	India / Australia	Test of Preferential Thinking Style
Kearins	1986	Australia	Visual Spatial Memory Skills Test
Haukoos	1986	U.S.A.	Science attitude Inventory
Okebukola	1986	Nigeria, Africa	Learning Preference Scale
Thijs	1987	Zimbabwe	Pre-Post tests
Haukoos & Chandayot	1988	U.S.A.	Science Attitude Inventory
Ninnes	1994	Solomon Is	Participant observer
Waldrip & Taylor	1994	Solomon Is	Interviews

LANGUAGE-USE

The Integrative Research Review uncovered data suggesting that language-use affects learning in two specific contexts. The first context is that of an 'introduced' language. This is experienced in many nations with a colonial history where it is commonplace to use a second, usually European, language as the official medium of instruction. The second context is that of students who learn in their mother tongue, but where the day to day connotation of a word is different from its scientific and textbook meaning (cf. Rollnick, 1998³).

The Context of a Second Language

In order to explore the relationship between a second language and concept development, Collison (1974) conducted a series of experiments involving 85 Ghanaian schoolchildren aged between 12 and 14 years. Each group was taught a scientific concept in either the vernacular or English, and that same concept was taught to the other group of students in the opposite language medium. The process was then reversed with a new and different concept.

Collison's theoretical approach was based on Vygotsky's (1962) theory of language and concept development, and analysed the number and complexity of statements used by the students to explain a recently learned concept. Collison determined that the students were best able to learn and explain scientific concepts in the vernacular.

The bilingual problem explored from the conceptual perspective reveals consistently that when English is the language of education the majority of the experimental subjects were not able to use their conceptual potential. On the other hand, the vernaculars, Ga and Twi, were more fruitful media for enhancing the language-thought interaction.

(Collison, 1974, p.454)

Judging by the number and complexity of statements that Collison recorded in English and vernacular, it is clear that the students in this study learned and expressed scientific concepts much more readily, and at a conceptually more difficult level, in the vernacular.

³ For a recent discussion at the 'cutting edge' of the language question read Marissa Rollnick.

In an experiment designed to determine whether students learned best when taught using English or vernacular as the language of instruction, Rutherford and Nkopodi (1990) surveyed 736 North Sotho high school students' ability to recognise 16 concept definitions relating to the nature of matter. Half of the sample were required to respond to an English version of the survey, and half to a North Sotho version. Rutherford and Nkopodi's methodology was based on the assumption that the ability to recognise and respond correctly to scientific definitions is an accurate indicator of concept understanding. The authors conducted a multivariate analysis of the data, and a summary of the results is reproduced below.

Table 4. General Linear Model analysis

Variable	F-value	Probability at .001 level
Language	43.29	significant
Environment	1.46	not significant
Socio-economic status	1.03	not significant
Sex	2.9	not significant
School attended	48.17	significant
School year	142.01	significant

Rutherford and Nkopodi's data suggests that the most significant variable affecting students' ability to comprehend science concepts is the number of years of education that the student has received - specifically, the number of years spent using the language of instruction for the purpose of learning.

Ross and Sutton (1982) have also explored the connectedness between language and ideas, with a view to understanding the effect that learning in a second language has on conceptual formation. To do this, they adapted Schaefer's (1979) method, and collected free definitions and free associations from about 200 students aged 13 and 15 in England and Nigeria. The authors note, however, that "the cultural background of the pupils had an even greater effect than language" (Ross and Sutton, 1982, p.312).

Ross and Sutton's study compared the concept development of children whose language of instruction was different from their mother tongue with children who

were taught in their mother tongue. In each case the researchers found that the greater the disparity of use between the language of the science classroom and the language of every day the less likely students were to form an adequate understanding of a concept that relies for its communication upon a given word. "The problem is that knowledge has to be *used* to become real and internalised" (Ross & Sutton, 1982, p.312).

In their study of Aboriginal and Torres Strait Islander (ATSI) students, O'Shane and Bickford (1991) surveyed 205 students in Northern Queensland and the Torres Strait islands (p.5). They found that 68.4% of their sample spoke a traditional language or Kriol as their first language, and a further 15% spoke non-standard English. This means that only 16.6% of indigenous students in that part of Australia speak Standard Australian English (SAE) as a first language. As a result of this observation, the authors note that:

Language differences underlie all other issues in indigenous education, and a resolution of the crossed lines between student and education delivery constitutes one of the greatest challenges in indigenous education today. (p.12)

Students interviewed as part of O'Shane and Bickford's study spoke of their frustration that their own language was not apparently valued by teachers. Other language/culture difficulties identified by the students are illustrated in Table 5.

Table 5. Students' perception of foremost source of language problems in class

Type of problem	Frequency	Valid %
Teachers not understanding non-verbal language	61	44.5
Teachers assume students understand them because students speak some English	35	27.6
Unknown terms and jargon	33	27.3
Teachers unaware of students' non-English speaking background	19	16.0

(O'Shane & Bickford, 1991, p.18)

O'Shane and Bickford found that it is not merely the words of a second language but the total process of communication that interferes with student understanding. Table 5 illustrates the students' concern over non-verbal issues. Other interviews,

with parents and teachers, show that concern is also expressed over various aspects of formal and social learning of SAE language and, pertinent to this study, the difficulties these students experience in the learning of concepts when language forms a barrier rather than a clear means of communication.

Children may have the ability to do the reasoning, but if they don't understand the work or the references they're lost... Teachers should always teach children new words and concepts before they start work in that area. (O'Shane & Bickford, 1991, p.19)

In many countries an explicit assumption exists that students must learn a European language in order to study science (cf. Crystal, 1997). In Solomon Islands, for example, it remains mandatory for English to be used as the medium of instruction in the classroom. The reason given to me by teachers and Ministry of Education officials is that local languages are not capable of supporting technical concepts, a notion that is reminiscent of Levy-Bruhl's (1965) 'primitive mentality' or 'pre-logical' theory, whereby people who share a traditional culture and unwritten language are assumed to operate in a pre-logical mentality.

While more recent researchers might not acknowledge their acceptance of Levy-Bruhl's theory, similar interpretations are evident in the neo-Piagetian studies of many. For instance, Gardner (1971), in his study of non-technical vocabulary among indigenous high school students in Papua New Guinea, concludes that the translation of ideas into local languages is difficult because the non-technical nature of the students' mother tongue affects their ability to comprehend scientific concepts in English, an idea that one could also link to the Sapir-Whorf hypothesis that language predicates worldview in a mechanistic relationship.

In contrast to the language limitations attributed to 'primitive mentality', Arca, Guidoni, and Mazzoli (1984) suggest that "all formal languages are abstract", and preserve their own particular "ontological mark... because of their very origin, since they derive from the real world" (p.316). In other words, every language is capable of communicating abstract ideas relevant to that culture, since language does not merely name or label objects and occurrences, but communicates agreed, abstract meanings. "Communication is about meaning... everything that has cultural significance enters into communication" (Kress, 1988, p.4). For example, during the 17th and 18th centuries, English was considered inadequate

as a language of scientific expression. Major works such as Newton's *Philosophiae Naturalis Principia Mathematica* (1687) were originally written in Latin and, during the 19th century, French was required of anyone wishing to read or publish scientific papers. Despite its perceived handicap, English has adapted to science, and science to English, to the extent that relatively few papers are now written in any other language. If a concept can be perceived or imagined it can surely be expressed within any language, because language is dynamic within a changing world: "The vernacular language of each culture reflects the ways in which language is used to 'make sense of the world'" (Crawford, 1990, p.2).

Because language is important to the construction of meaning, it follows that as children acquire proficiency in a language they will have greater access to its intended meanings. This notion was tested by Bamgbose (1984), who conducted a six-year longitudinal study of school children in Nigeria, comparing the performance of indigenous children taught in English with those taught using indigenous languages. He found that those who learned in their mother tongue attained a higher measurable outcome in all subjects, especially in science and mathematics. In this context, Hewson concludes that:

Learning a subject in a second language is particularly difficult when the first language is inherently very different from Western-based languages. Specialised terminology, which is not necessarily congruent between the two languages, poses considerable problems for teachers and significant learning difficulties for students. (1988, p.318)

In a later study Rollnick and Rutherford (1996, p.102) found that:

the use of the vernacular language is a powerful medium for exploring existing ideas. Without its use some students' alternative conceptions would remain unexposed.

Perhaps unexpectedly, however, they also found that some of the best communication in the science classroom took place when mixed languages were used as the situation demanded, suggesting perhaps, that effective classroom language is dynamic when it uses all of the word-stock available to it.

The study of science in a second language involves the mastery of not only a new subject, but also a new set of language symbols that, on their own, might make little sense to the student (cf. Fensham, 1988, p.19). This suggests to me that the student's mother tongue is helpful as a medium to communicate science, particularly in the introductory stages of scientific study. As Rollnick and Rutherford (1996, p.102) have suggested, the use of mixed language discussion might also assist. The advantage of the mother tongue is that children have been immersed in its implied meanings from a young age, but even it is not without its problems. Students whose mother tongue is English also often interpret scientific language in ways that differ from their teachers, as documented by Ross and Sutton (1982, p.322), who found that both British and Nigerian students "displayed an almost total lack of spontaneous linkage" to the scientific meanings of commonly used words. Osborne, Bell and Gilbert (1983) have investigated the concepts that Western students bring, with their language, to the science classroom. They suggest that "the everyday language of our [Western] society often leads children to have a view distinctly different to the scientists' view" (p.2). If language is so important to meaning, how much more would one expect a student in a non-Western culture, using a second language, to have "a view distinctly different to the scientists' view", considering the Western nature of scientific language?

The Context of Connotations

As the theme of Language-use developed, it became clear to me that it is not only proficiency with a language that is significant to learning, but the way in which language is used on a day to day basis, in other words, the connotations of words and sentences to the hearer. In order to explore the confusion that can arise from the connotation of scientific words, Mori, Koyima and Tadang (1976) studied the effect of day to day language in the formation of scientific concepts, in particular, the concept of speed, by comparing the understanding of Japanese speaking and Thai speaking children for words that denote speed in their mother tongue. The study is of interest because the Japanese words for *fast* and *early* have the same pronunciation, whereas the Thai language uses distinctly different words for *fast* and *early*. The study found that Japanese children confused the concept of speed twice as often as Thai children. Mori *et al.* conclude that language-use significantly effects interpretation and, therefore, learning in

science. They suggest that the words are not as important to learning as are their culturally applied connotations.

Students who took part in the study (63 Japanese; 29 Thai) had a mean age of five years and were enrolled in Kindergarten programs. Two experiments were conducted to test the conceptual understanding evoked by the use of the target words. The response by the children in each language group was significant, and Table 6 below reproduces Mori *et al's* results.

Table 6. Comparison of Japanese and Thai responses ($p < .001$)

Experiment 1		Experiment 2		
	<u>Japanese</u>	<u>Thai</u>	<u>Japanese</u>	<u>Thai</u>
Correct %	14.3	55.2	12.7	69.0

(Mori, Koyima and Tadang, 1976, p.533)

The data presented in Table 6 suggests that a significant relationship exists between language and concept development for the subjects of this study. The experiments further suggest that the ways in which a word is used in daily language might effect the way in which an associated concept is understood in the classroom. For example, in a study of science-related cultural beliefs and language in the Caribbean, George and Glasgow (1989) make the statement:

It is well known in the West Indies that the word 'science' connotes other things than Western conventional science. To many, the word suggests a whole world of 'spirits' and spirit-dominated practices, beliefs and superstitions. (p.115)

They conclude from their study that 'street science', and its associated language, has a far-reaching impact on school science. Even the word 'science' has an everyday meaning that is different from the school meaning.

The idea that the cultural connotation, or everyday meaning, of a word or concept has significant impact on the interpretation of scientific ideas is consistent with the work of Hewson and Hamlyn (1984). They found that the Sotho people of southern Africa use a particular heat metaphor "which may be seen as based on experiences of living in a hot, arid part of the country" (p. 260). As a result of their

eco-culture, the language of the Sotho people includes words for heat whose connotations are rooted in the experience and beliefs of the community and its individuals. By comparing their results with those of Harris (1981) concerning the tendency of Westerners to adopt a caloric understanding of heat, despite the prevailing kinetic theory in Western educational curricula, Hewson and Hamlyn conclude that:

Most Sotho students do not have to unlearn outdated scientific notions of caloric heat, which are deeply rooted in Western thinking, before being able to acquire the contemporary kinetic view of heat. (p.261)

The reason Sotho students do not need to unlearn concepts that are incompatible with a scientific explanation can be explained because their everyday understanding of heat is very similar to the kinetic understanding of the scientific community. The implications of this finding are significant to my understanding of the effect of language in science education. Connotations, or everyday cultural meanings applied to words and concepts, have the potential to affect science education by influencing the personal construction of knowledge by students in the science classroom.

Acculturation and Enculturation Through Language

In Rutherford and Nkopodi's (1990) study, reviewed above, the most influential variable in their multi-variate analysis was the amount of time spent in formal education, suggesting that the *time* spent using a language to study science influences comprehension far more than the identity of the language. It appears from Rutherford and Nkopodi's analysis that a process of *enculturation* into the thought patterns and modes of expression used in a second language takes place during formal education (cf. Acuna, 1983). Enculturation and acculturation are like two sides of the same coin for non-Western students who study within a Western school curriculum.

Acculturation is the process of borrowing ideas and practices between cultures, usually resulting in the modification or subsumption of one culture by another, more dominant culture. The process of acculturation appears significant to the education of members of a minority culture (Littlesoldier, 1985), resulting often in the loss of cultural identity, knowledge and language. Enculturation, on the other hand, takes place within every society, and is the process of socialisation that is a

normal part of the education of the young. Non-Western students experiencing enculturation into the dominant thinking of a Western education system can expect to simultaneously experience acculturation, or the dilution of their natal culture. Littlesoldier sees this process as unnecessary and harmful for Native American students.

Acuna (1983) makes a case that, in the Philippines, acculturation has a complex effect on the education of both rural and urban children. Those children “who have neither the advantage of a traditional culture nor the advantage of urbanisation” were seen by Acuna to be disadvantaged (p.427). Acuna makes the case that children who have been partially acculturated are caught, as it were, between two cultural paradigms, and are less able to take advantage of the opportunities of either cultural setting.

Littlesoldier (1985) argues that indigenous students' cultural reasoning patterns are subsumed by the dominant culture of schools. He has observed that, as a result, many native American students either lose their cultural identity, or, more often, find themselves between cultures, succeeding in neither. Furthermore, those students who do not spend sufficient time in formal education, or who find the implied meaning and reasoning patterns of the second language difficult, appear to gain little from their education, and often drop out of school. Maddock's (1983, p.567) conclusion, that time is a critical factor in the development of attitudes and understanding in school science education, appears to confirm Littlesoldier's assertion, and supports the notion expressed by Hawkins and Pea (1987) that science education exhibits many of the properties of a culture. For these reasons I have formed the opinion that the language of instruction plays a significant role in the process of enculturation and acculturation.

Stevens (1976) sheds light on the problem of learning in a second language by making a distinction between *linguistic difficulties* and *socio-linguistic difficulties*. Linguistic difficulties are those encountered by students as a result of the structure of the language of instruction, while socio-linguistic difficulties are those encountered when both the structure and the commonly agreed meanings of the language are foreign to the student. Most students studying science in a second language have to learn not only the grammar, syntax and morphology of the language, they must also learn to think about science using the reasoning and implied meanings represented by that language. These constitute considerable

hurdles that most Western students do not have to jump. The inferiority of a second language for learning in science education is exacerbated when students struggle to understand the new concepts attached to science education while learning the language. Strevens' analysis suggests that problems associated with language in science education are not simply related to understanding the dialogue of the science classroom, but are related to the meanings, often implied, that the language of instruction represents.

I interpret the literature concerning enculturation to mean that the more time spent working in, and making sense of, a second language, the more a student is able to use that language as a tool for learning and communicating with those who share in its cultural representations. This proposal implies that gaining an understanding of science is both language and time dependent. The risk to indigenous students, however, is the weakening or loss of cultural understandings, and the risk that, if the language of instruction is a second language, real understanding and personal knowledge of the subject could be elusive.

CULTURAL EXPLANATIONS

The Integrative Research Review identified 'cultural explanations' as significant to the understandings acquired through formal education. Ingle and Turner (1981) express the view that, "If any progress is to be made in the improvement of science education in Third World countries, then... an understanding of traditional modes of belief about the natural world is necessary..." (p.362).

In this vein, Snively (1990) conducted a study paying close attention to six target students whom she determined had different orientations, or modes of belief, from each other concerning their understanding of the seashore. By orientation, Snively refers to "a tendency for an individual to understand and experience the world through an interpretive framework, embodying a coherent set of beliefs and values" (p.44). Referring to a Grade Six group in British Columbia, she says:

Only a few students held beliefs about seashore relationships which were quite similar to accepted science ideas; most held strong beliefs which were quite different; (1990, p.45)
and:

Students with a spiritual orientation would reject certain scientific claims altogether. (1990, p.54)

Snively determined that a student of Native Indian heritage, named Luke, demonstrated a spiritual orientation toward the seashore. She then set out to describe and understand the background and characteristics of this orientation in order to teach Luke other ways of seeing the seashore, including a scientific orientation. Snively found that Luke's social and cultural background had a significant impact on his perceptions and explanations of various phenomena. Despite instruction, Luke retained a preference for spiritual metaphors to explain seashore phenomena, but was also willing to relate his cultural understandings to the scientific explanations if they appeared compatible.

Snively's observations of her students show that cultural explanations play an important role in students' understanding and acceptance of science. When compared with Maddock's Papua New Guinea research, I conclude that the tenacity of cultural explanations, and the power of school science to alter students' perceptions, depends upon local factors, which could include the local view of education as a means of improving one's personal situation, the attractiveness of the cultural context to each person, and the power of the extended family to maintain the inter-generational transfer of the beliefs and practices of local culture.

Snively's conclusions are similar to those of Jegede and Okebukola (1991), who used Ogunniyi's (1987) Traditional Cosmology Test to collect data from 319 students with a mean age of 16.9 years. These students were all enrolled in pre-degree programs in science, and were asked questions designed to measure their commitment to a traditional cosmology. The same students were given a Test of Observational Skills, and the data from the two tests were correlated.

Jegede and Okebukola found that students with a high level of traditional belief scored less well in the observation tests than those with a low level of traditional belief. They suggest, as a result of the study, that the causative factor affecting student scores is the extent of their belief in traditional cosmology, superstitions and taboos. They also suggest that:

certain preconceived notions about the objects upon which the observational tasks were built constrained or hindered the subjects with a high level of belief in African traditional cosmology from making careful, systematic and critical observations. (p.44)

If a high level of belief in African traditional cosmology prevents students from making careful, systematic and critical observations, it certainly will have an effect on the outcomes of science education, considering the almost universal curriculum emphasis on observation, hypothesis and reporting. These skills are generally considered important for the development of 'scientific thinking', a concept that Horton (1967) distinguishes from 'traditional thinking'. Horton identifies six attitudes that distinguish traditional from scientific thinking:

- attitudes toward the prediction of events;
- attitudes toward cause and effect;
- attitudes toward experimentation;
- attitudes toward the confession of ignorance;
- attitudes toward coincidence, chance and probability; and
- attitudes toward time.

Horton's underlying premise is that traditional thinkers resist change, whereas scientific thinkers embrace change in order to test or modify existing theory.

Beliefs about the natural world have been described by Horton (1971) as representations of reality based upon prototype experiences. It is a matter of observation that many of those representations are shared by most members of a cultural group (Prince, 1969, p.102) whether that culture is ethnic, organisational or academic. For this reason, I prefer to use the term *cultural* explanations, rather than *traditional* explanations, or misconceptions, to mean those explanations agreed upon by members of an identifiable group who share a common culture. Unlike cultural explanations, misconceptions might simply be explained in terms of a personal and unique interpretation by the student. Cultural explanations, however, seem to be far more widely shared, appear to be highly tenacious, and conflict with science education in at least three ways, which I have identified as *belief, epistemology* and *taboo*

Conflicting Beliefs

Snively (1990) has proposed that different individuals will tend to understand and experience the world through an interpretive framework that embodies a coherent set of beliefs and values, most of which will be derived from their natal culture. She refers to these interpretive frameworks as *orientations*, and proposes six: scientific, utilitarian, spiritual, aesthetic, recreational, health and safety. Each orientation is typified by beliefs that are sometimes contrary to accepted scientific beliefs. The observations made by Snively suggest to me that the cultural beliefs of many non-Western students will often cause them to reject classroom ideas unless teachers attempt to reduce the conflict between the two.

In a 1964 study designed to "investigate a hypothesised relationship between [their achievement status] and their acceptance of traditional Indian religious and mythological beliefs" Charles (1964, p.261) found that the cultural beliefs concerning natural events that were held by certain Native American students correlated with poor scores in the National Achievement Tests in Science (NAT-S). Charles' research emerged from his concern that various studies in the early 1960's suggested academic retardation among certain Native American children, a conclusion that Charles believed to be erroneous. He suggested instead, that "the learning difficulty seems to refer to what might be called a 'cultural barrier'" rather than an inability to learn (p.261).

To conduct his study into the 'value-belief' aspect of Native American education, Charles constructed a 'Culturally Biased Science Test' the answers to which would indicate a bias toward Anglo-American or Native American explanations of events. The study used a sample of 301 students in mixed race classrooms. Charles found that Native American children scored lower than Anglo children in terms of 'scientifically correct' responses, and they favoured 'culturally attractive' answers. While Charles was unsure about the causative factors behind the low achievement status of Native American students, he clearly blamed schools for their inadequate accommodation of their students' beliefs.

A primary factor in this inadequate accommodation may be found, it would seem, in the schools' failure to recognise basic differences between Indian and Anglo cultures, and in their reliance upon instructional programs traditionally used with Anglo groups. (p.263)

Charles has suggested that an indigenous student's value-belief system favours cultural explanations over school explanations of scientific phenomena. This suggestion provides an alternative to the notion that non-Western students are in some way inherently unable to learn scientific ideas.

Maddock (1977) found, among students who took part in several studies using the Environmental Phenomena Attitude Scale, that cultural explanations were strongest among students and parents who were least involved with the formal education system. Those who had spent the greatest amount of time at school were the most likely to reject cultural explanations or hold dualistic perspectives of natural phenomena. These students were also most likely to adopt scientific explanations and to view village people as backward and ignorant (cf Waldrip and Taylor, 1994).

I interpret Maddock's findings to mean that cultural explanations are significant to students unless and until they are subsumed by school science explanations. As this subsumption progresses students are less likely to accept cultural explanations, but if subsumption does not occur, scientific explanations will be either accommodated within cultural explanations or rejected.

Maddock (1983) found that a direct relationship exists between the strength of cultural beliefs and attitudes to learning, and Haukoos (1986), who studied the correlation between attitude and performance in science education for Native American students, reached similar conclusions. George and Glasgow (1989) found clear evidence that cultural beliefs or 'street science' will often conflict with conventional science education in the West Indies. They note the difficulty, for instance, of "convincing students that some beliefs are actually harmful in their effects" (p.118).

I have found, however, that a conflict of belief need not always result in the rejection of scientific ideas. In some circumstances indigenous students resolve the issue of conflicting belief not through rejection, but through accommodation or dualism. Maddock (1983) and Marshall and Gilmour (1989) introduce their readers to students who are willing to present both the school view and their cultural view, each in its own context, and who appear to believe that each is valid. Jegede (1994) refers to the ability of many students to accept conflicting explanations as *collateral learning*, which he defines as:

the process whereby a learner in a non-Western classroom constructs, side by side and with minimal interference and interaction, western and traditional meanings of a simple concept. (p.13)

I am sure that Jegede is describing a real, cognitive phenomenon experienced by many non-Western students as they seek to make sense of two interacting worlds - traditional culture and the classroom: "My theory of collateral learning explores the *cognitive* explanation of how the act of cultural border crossing takes place, especially in environments where cognitive conflicts arise from different cultural settings (school culture and home culture)" (Jegede, email, 14/7/97).

I conclude that a conflict of belief occurs when a student is confronted by two or more explanations of the one phenomenon, one of which is a cultural belief that pre-dates the classroom explanation. This cultural belief is a true *alternative explanation* when it is in conflict with Western scientific thought, and is likely to be resolved by rejecting the novel in favour of the known, by accommodating traditional and scientific views in a compartmentalised fashion, or by assimilating traditional and scientific views to construct a new and different perspective.

Conflicting Epistemologies

The second potential for conflict occurs when the student's *cultural epistemology*, or *ways of knowing*, considered normal within a culture, is in conflict with the epistemology of a scientific discipline. Greer (1992, p.14) discusses the problem that can arise when an indigenous student is told, for example, that the normal way to know about frogs is through dissection. If the student's cultural perspective identifies a frog as sacred, or as a relative, and his or her epistemology says that the normal way to understand a relative is to observe and communicate, not to dissect, the result is epistemological conflict.

As noted above, Okebukola and Jegede (1990) have shown that the cultural background of Nigerian students shapes their reasoning patterns. They suggest that reasoning that accepts particular metaphysical beliefs impairs students' adoption of an empirical methodology and affects their performance in science education. In a further study, Jegede and Okebukola (1991) suggest that a 'traditional worldview' might cause many Nigerian students to become selective when making observations. They believe that this effect might be due to the

epistemological perspectives inherent in a student's worldview which... "colour and shape the phenomena they observed during the experiments" (p.44). Compare this with Gauld (1986) who has suggested that a student's memory of an observation is frequently adjusted to fit existing beliefs. The findings of Jegede and Okebukola (1991) support those of Ogunniyi (1988) who suggests that rural African communities explain natural phenomena through non-rational means, and Barlex and Carre (1985) who argue that we do not see things as *they* are, but as *we* are.

Many social science researchers accept the notion that indigenous students function within a different epistemology from their Western counterparts. Kidwell (1994, p.43) states that, "Every system of the world is underlain by basic presuppositions concerning the nature of man and the nature of nature." She then details ways in which the epistemology of many Native Americans is at variance with that of the dominant society, resulting in very different interpretations of the same events. Frankel (1993) points out that:

How one judges the value of a particular line of research or the introduction of a new technology depends in large part on the way one sees, interprets and evaluates information and events - perspectives shaped largely by one's experiences and cultural traditions. (p.2)

In a more recent paper, Chin-Chung Tsai (1998) analysed the science achievement and epistemological beliefs of 202 Taiwanese eighth grade students. He found that students whose epistemology was more aligned with a naive constructivism showed a richer and more sustained understanding of science concepts. Those whose understanding was based upon recall were faster to answer, but showed less comprehension of the scientific concept. Chin-Chung suggests that prior understandings, in the form of epistemological beliefs, are important to the learning of science. Chin-Chung's findings are particularly interesting in the light of a study by Bagchi (1997) of the relationship between the preferred cognitive styles of students and their biographical history. Bagchi concludes that:

The varied modes of cognition which students of biology use to acquire knowledge in India predominate for recall which could imply an acceptance of scientific information without consideration of its implications, applications or limitations. (p.77)

When evaluated against the findings of Lynch *et al.* (p.72 in this text), Bagchi's findings suggest that a cultural, or widely held pedagogical, bias exists in India that might encourage a certain epistemology to predominate among Indian students. There is, therefore, evidence from various continents to support the notion that an individual's epistemology has, consciously or unconsciously, a powerful effect on interpretation and, therefore, science education.

Taboos

I had not long lived in the Solomon Islands before I learned that classroom group-work considered simple in an Australian classroom could become unmanageable due to the pervasive rules of 'tambu' (Pijin for taboo). Even those who had deliberately forsaken the animism of their forbears and professed a sincere Christian faith came under the influence of socially determined taboos. Whether doing duties around the school or in the science classroom it was commonplace to be told that two students could not work, sit or talk together. The penalties for ignoring socially normative rules were often harsh and decisive, with frequent calls for certain students to be put out of the school for infringements that another society might consider minor or irrelevant. Through observation of social and classroom activities, I saw the power of taboo to affect the way one views any activity, including formal learning. The classroom performance of female students, for example, was significantly affected by their refusal to participate until male students finished, and their refusal to compete with male students. I interpreted this as a perception by the girls that the male students must 'legitimise' the females' participation by indicating that they were finished, and related this to my understanding of village taboos pertaining to the roles of men and women. The tendency to defer to male students was most obvious among girls from rural areas and least evident among urban students. Similarly, claims that students were breaking taboo were most often made against urban students.

My observation of taboos at work led me to believe that they are significant to the *process* of formal education. Jegede and Okebukola (1991) suggest that taboos are also significant to the *content* of formal education. They conclude from their study of 319 Nigerian secondary science students that:

A subject in this study who is afraid of an object to be observed, owing to certain taboos or philosophical or religious beliefs, may end up making totally variant observations as a result of the attendant feeling of dread or foreboding. (p.44)

Burgoyne (1988) outlines for us some of the content issues that he has observed in the education of Native American tertiary students:

Any specimen, alive or preserved, may not be looked at or handled by some students... Blood typing, collecting saliva... or urine tests will cause some students to leave the lab. Some may just happen to be absent every day photographs are to be taken. Introductions... violate taboos for some Native Americans. (p.315)

Taboos, or socio-cultural constraints, exist within all social groups, so they are not reliant upon any specific cultural context or epistemology for their power. My own experience within Australasia suggests that a spiritual orientation is more likely to enhance a person's response to taboos due to a fear of the intangible. By contrast, adult Western society, with an individualistic and materialistic orientation, implicitly encourages its members to ignore taboos or to find ways around them. Although the effect of taboos seems not to have been exhaustively researched in the context of science education, I conclude that it is an important issue that helps shape student participation in, and interpretation of, science education.

LIFE-WORLD KNOWING

The final theme to become evident through the Integrative Research Review is the notion that I have labeled 'life-world knowing' (Shutz & Luckmann, 1973). In their studies of children's science, Gilbert, Watts, & Osborne (1982) have found that the "dominance of the students' prior understandings... [can] often lead to quite unintended interpretations of what is being taught".

The philosophical framework concerning 'prior understandings' is based upon the work of David Ausubel (1968), and is supported by Schutz and Luckmann's (1973) publication in which they argue that people typify experiences according to their foundational knowledge in order to create meaning structures. Assimilation of experiences forms a *life-world* knowledge that is acceptable to the individual and is resistant to change. Life-world knowledge becomes, therefore, a set of taken-for-granted assumptions that form the basis of daily decision-making and automatic response. Schutz and Luckmann also suggest that, during the process of school education, *symbolic* knowledge is presented which may or may not correlate with personal life-world knowledge. Since life-world knowledge consists of those understandings that pre-date symbolic knowledge, life-world knowledge can be equated with Osborne's (1981) 'children's science', whereas symbolic knowledge can be equated with 'teacher's science'. Schutz and Luckmann propose that, in situations of conflict between life-world and symbolic knowledge, the former will tend to subsume the latter. The extent to which prior life-world knowledge can affect the learning of scientific concepts, and produce understandings which differ from teachers' science, appears significant to the relationship between culture and science education, if we assume that culture is prior knowledge to the student, and science education is symbolic.

Solomon (1983,1984) conducted a series of studies among 14 - 15 year old British students to explore the relationship between their life-world and symbolic knowledge of the topic *energy*. Using Schutz and Luckmann's (1973) categories, Solomon found that most students (62.7%) described an energy chain using language from the symbolic domain. A further 18.6% were able to move between the symbolic and life-world domains with understanding, and 18.7% used language from the life-world domain. Solomon then compared these results with the students' examination results, and found that students who had previously used symbolic language, or who moved between the symbolic and life-world domains readily, achieved significantly better results than those whose language showed that they were thinking of energy only in life-world terms.

Solomon's findings suggest to me that her students who were able to readily use symbolic language were those who could identify and remember the relationship between the concepts and their accompanying language, while those who showed a deeper understanding of the topic were those who could relate the

symbolic domain to their life-world experience. Solomon concluded from this study that:

1. Life-world structures of meaning will tend to subsume symbolic structures over time;
2. Students using symbolic language do not necessarily comprehend the concept more fully, but know how to use language appropriate to the symbolic environment; and
3. The ability to think and express concepts in both domains is indicative of deeper understanding.

In her follow-up study, Solomon (1984) devoted considerable research effort to finding ways to *cue* students to move between the life-world and symbolic realms in science education. Solomon found that all students could be cued to move from one domain to the other by the use of appropriate 'cue words'. This skill, which I understand to be similar to using mnemonics as a trigger to recall memorised information, appears to improve the student's ability to use symbolic language by relating it to their life-world domain.

In a more recent study of students' conceptual reorganisation of the chemistry curriculum, Stavridou and Solomonidou (1998) express the opinion that:

it was difficult for the pupils to transpose this scientific concept [chemical reaction] to another context, and especially to the everyday context... it is important to confront common-sense conceptions, and to encourage pupils to apply and use scientific concepts to describe and explain everyday life phenomena and situations in a more systematic way.

(p.220)

Stavridou and Solomonidou found that the ability of students to express an understanding of chemical equations was generally, but not exclusively, related to their age and school level, but that students tend to reorganise their thinking in quite personal ways. This, it seems to me, points to the influence of personal life-world experience and its influence on knowledge construction.

I interpret Solomon's work, and that of Stavridou and Solomonidou, to mean that life-world knowledge is pervasive and is normally dominant in the thinking of students. Solomon's studies with British students seem to me to be relevant to

non-Western students also, since they too develop a life-world knowledge that Ehindero (1982) refers to as a set of reasoning skills and knowledge at variance with those valued within science education. Ehindero suggests that “efforts be directed at reinforcing those reasoning strategies which each group’s eco-cultural framework has aided in developing” (p.456). This strategy is not characteristic of science education in non-Western countries to date (Swift, 1992).

Although the term ‘life-world knowledge’ is not widely used by other researchers, its underlying premises are evident in much of the educational and sociological literature. Acuna (1983), for example, considers cultural differences to be, “a result of the tendency of each cultural group to develop the *skills* and *concepts* that it needs most” (p.415); Ehindero (1982) shows that African students exhibit strengths in those *concept areas* which are relevant to their eco-culture; Okebukola (1986) emphasises, “the primacy of society and the contributions of cultural factors to learning modes” (p.510); and Haukoos (1988) has observed that reservation-bound Native Americans have “different experiences in life from which to organise beliefs about science” (p.10). A student’s life-world knowledge will, therefore, influence the way in which he or she relates to, or learns, science. It will shape the student’s learning style.

Learning Styles

In his study of Nigerian students, Okebukola (1986) reports on the effect of culture on preferred learning modes, or styles, and the effect of cooperative and competitive learning environments on performance in science education. He concludes that students’ preferred learning styles are shaped by their eco-culture, which Ehindero (1982) describes as:

the interaction of individuals with their habitats (ecological) and the group-shared behavioural patterns that are adapted to the group’s habitat (cultural).... (p.451)

According to Okebukola (1986), teaching environments should complement learning styles if effective learning is to take place. For example, if the cultural meaning of ‘work’ implies group effort and cooperation, it would be counter-productive to insist on a competitive and individual classroom environment. He concludes that it really does not matter whether a student prefers a competitive or

a cooperative learning style, so long as they are not forced to operate in a manner contrary to their preference.

In a compelling cross-cultural study that involved 1635 English-speaking Australian students and 826 Hindi-speaking Indian students, Lynch, Chipman and Pauchury (1985) have shown that non-Western students are often at a cultural disadvantage when studying Western science curricula. In an attempt to discern and compare the preferred thinking styles of Hindi and Australian science students Lynch *et al* used a multiple-choice questionnaire that presented students with four possible responses that could be categorised according to three levels of reasoning: *generalisation*, *membership* and *partial association*.

In their study, Lynch, Chipman and Pauchury have defined their terms such that 'membership' is very similar to Solomon's (1983, 1984) use of the term 'life-world knowledge', 'generalisation' is similar to her use of 'symbolic knowledge', and 'partial association' is an interim stage, not to be confused with Solomon's students who were able to express their ideas in both domains. The study confirmed that students do exhibit preferred learning styles, but the mean achievement score of the Hindi sample was significantly lower than that of the Australian sample despite being of a similar average chronological age and having studied similar (Western) curricula. The difference in the levels of understanding used by each group to describe scientific concepts caused Lynch *et al.* to conclude that students have preferential learning styles that differ between individuals and also according to their cultural background. Their study suggests that Western science curricula are structured for a learning style that is more typical of Western children than Hindi children.

I interpret the work of Okebukola and Lynch *et al.* to mean that a science classroom where the learning environment is culturally attuned to the preferred learning style of students is conducive to the construction of meaningful scientific knowledge. If learning style is, as Okebukola claims, a product of one's eco-culture, then it clearly is an aspect of a person's life-world knowledge, which Schutz and Luckmann (1973) suggest is the assimilation of experiences in order to create meaning structures. In Okebukola's (1986) study, the meaning structure used by students to make sense of 'work' in their daily life-world resulted in a learning style that involved cooperative effort. This suggests that a cooperative classroom environment, that is, one that values group effort and agreed

outcomes, as opposed to a competitive classroom that values individual achievement, would best support those students. On the other hand, in Lynch *et al.*'s study, the meaning structures used by students to make sense of the symbolic knowledge of 'science' were not always compatible with the meaning structures framed by the curriculum writers, creating a less supportive learning environment. Although students might not be able to explain the reason for their preferred learning styles, they use them constantly as part of their intuitive activity of making meaning. Accordingly, their life-world knowing shapes their learning.

From Okebukola and Lynch *et al.* I have come to believe that learning style is shaped by one's life-world knowledge and is an intuitive, culturally effected response to the need to make sense of new experience. Life-world knowledge acts as a powerful agent of interpretation when the individual is confronted with new ideas or behaviours. A student's life-world knowledge is likely to subsume any new symbolic knowledge through a process of filtering, re-shaping and sometimes rejecting the novel in favour of the known; the counter-intuitive in favour of intuitive knowledge consistent with previous experience.

The power of intuitive life-world knowledge is demonstrated by its persistence, regardless of the natal culture of the student. Solomon (1983) and Champagne, Klopfer, and Anderson (1980) show that, in Western societies, students form a life-world knowledge that is often inconsistent with the symbolic knowledge of science education. "These common-sense intuitive ideas, based on years of experience with moving objects... [are] quite different from the formal system of Newtonian mechanics that the physics course seeks to teach" (p.1077). Champagne *et al.*'s reference to 'intuitive ideas based on years of experience' suggests life-world knowledge that is shaped by the student's native environment, or scheme of perceived reality. Intuitive life-world ideas are those that are normal to a person's *natal* experience, in contra-distinction to those ideas that are external, or foreign, to their every-day experience. For this reason, it seems to me that life-world knowledge is a universal construction that influences formal education according to the 'conceptual distance' between the students' life-world knowledge and the symbolism of the curriculum. The conceptual distance is determined, it appears, by eco-cultural factors, as evidenced by Acuna's (1983) study of rural and urban Filipino children:

The child's socio-cultural environment and schooling both have a consistently strong association with children's performance... [but] a distinction must be made between the group of skills and concepts reflected in the scales that are emphasised in school - the formal reasoning type - and those that can be learned outside of school from observations, traditional cultural explanations, and social interactions.

(p.419)

Waldrup and Taylor (1994) have explored the difference between life-world and symbolic knowledge among Melanesian students and noticed, as did Maddock (1983), that students express their thoughts in terms dictated by their environment. These observations suggest that the symbolic knowledge of the school curriculum is at risk of being subsumed by life-world knowledge when students return to the influence of their extended families and the exigencies of life without reference to scientific theory. Ultimately, therefore, when specific symbolic knowledge is no longer needed for the passing of exams it is likely to be discarded or simply forgotten. I have observed this phenomenon at work among Solomon Island students and consider that many forget or discard scientific ideas faster than their Western counterparts in Australia. I believe this is due to a lack of cohesion between their life-world and scientific thinking. In other words, science is more 'foreign' to the life-world of indigenous students than it is to most 'white' Australian students and is, therefore, more easily discarded.

Shimpo (1978) and Haukoos (1986) also discuss the notion that formal education might be counter-intuitive or foreign to the life-world experience of indigenous students. Shimpo notes that many of the presuppositions of Australian teachers concerning behaviour, time, relationships, and classroom teaching/learning styles are foreign to the everyday experience of both urban and rural Aboriginal families. Haukoos says, in the context of Native American students, that:

Most often attitude, behaviour, and values are interpreted in the light of the attitude, behaviour and values of the dominant culture.... If components of science could be identified in the cultural traditions, these could be incorporated into specific curriculum useful to native students and their developing attitude toward science. (1986, p.8)

Science education, indeed the entire Western style of education, could well be foreign to non-Western students because of its underlying presuppositions about behaviour, attitudes and values. When these presuppositions are contrary to the life-world knowledge of students they are counter-intuitive; and can become a hindrance to further learning.

In a study of Australian Aboriginal students, Hudsmith (1992) found that academic and personal success in the school environment is achievable when:

Pupil/teacher relationships are characterised by sensitivity, respect and allegiance to common goals. In such classrooms Aboriginal student learning styles, sociolinguistic etiquette, experience, values, and social identity informs teaching processes and strategies. (p.11)

Hudsmith has shown us that when the life-world knowledge of specific students is used as a major referent for further learning the risk of conflict can be reduced.

IN SUMMARY

My interpretation of the Integrative Research Review data leads me to believe that language-use, cultural explanations and life-world knowledge exert considerable influence upon learning. These three aspects of culture appear to reflect the standards which a society considers normal to its eco-culture, and which are communicated through its cultural epistemology and in the meanings implied by particular metaphors that are passed on through time-honoured interpretations of reality. Consequently, language-use, cultural explanations and life-world knowledge have a profound impact upon formal education, especially science education.

Language-use

The Integrative Research Review suggests that a relationship exists between language-use and concept development in science education. It suggests that the meanings constructed through science education are related to the linguistic background of the learner, to the compatibility of the learner's language with the language of science education, and to the amount of time spent using a language for the study and expression of science. There is a clear implication that a student's mother tongue is more effective in the communication of meaning than

a second language, enabling students to develop their scientific concepts without the necessity of simultaneously learning a new language.

My inquiry suggests that a process of enculturation takes place as students spend time using language to manipulate concepts that are integral to a course of study. The corollary of *enculturation* is *acculturation*, suggesting that the more often students use the symbols of a second culture the further they are likely to move from the meanings implicit within their natal culture. My inquiry also suggests that language-use impacts upon science education through the socially constructed connotations that apply to the use of certain words or phrases. For this reason, scientific concepts are not always easily translated into new languages. Sometimes the literal translation might contain implied meanings that distract from the original scientific principle.

Cultural Explanations

The explanations and beliefs that typify the members of a cultural group appear to influence the acceptance and interpretation of new ideas, particularly when they relate to prediction, cause and effect, probability, and time. The Integrative Research Review data suggests that three aspects of cultural explanation are significant to science education; these are beliefs, epistemologies and taboos. Of these, the greatest influence appears to stem from the epistemology shared by the group members. I conclude that the epistemology, beliefs and practices derived from one's social milieu will impact upon science education by interacting with the taken-for-granted epistemology, beliefs and practices of the science classroom. It appears to me that their impact can be detrimental or beneficial according to the ability of educators to adapt their pedagogy to suit the needs of the students while maintaining curriculum integrity.

Life-world Knowledge

To me, the most convincing interpretation of the Integrative Research Review concerns the effect on formal education of *life-world knowledge*. It is apparent that life-world knowledge is both socio-cultural and experiential in origin, and that it represents a form of prior understanding. Prior understandings are shown to influence students' perceptions and interpretations of events (Gilbert, *et al.*, 1982; Jegede and Okebukola, 1991; Shutz & Luckmann, 1973; Solomon, 1983, 1984).

The connection between life-world knowledge and learning styles is made explicit by Okebukola (1986) and Lynch, Chipman, and Pachaury (1985) who separately demonstrate that culturally developed learning styles impact upon science education, sometimes to the detriment of student performance.

CONCLUSION

I conclude that culture does influence science education through language-use, cultural explanations and the life-world knowledge of each individual learner. Life-world knowledge, in particular, appears to influence learning by shaping the development of students' cognitive structures and learning style. This conclusion is consistent with Hewson (1988) who suggests that:

The evidence for the fact that students often hold conceptions which are alternative to those being presented in science classrooms is overwhelming. Individual differences between students account for many of the divergent views. However, group differences that may be based on history, religion, geographic location, socio-economic status, or culture, may well be factors that play a role in the development of particular conceptions. (p.322)

Hewson goes on to discuss the conceptual change model, a model of teaching which I investigate in Chapter Six. What she and other researchers do not seem able to explain is why some students from non-Western cultures appear to excel in science and mathematics while most clearly do not. (Okebukola, 1990; Castle, 1993; Gwynne, 1997).

I am not convinced that the notion of 'culture', on its own, has the power to explain the dilemma faced by indigenous students, and referred to by Okebukola (1990) as their "achievement deficit". Due to a lack of specificity attached to the notion of culture, I do not feel able to formulate theory from the inquiry so far, but have noted a similarity between the notions of *life-world knowledge* and *worldview*. I consider, therefore, a closer look at 'worldview' and its relationship to knowledge warranted. The exploration of worldview and knowledge constitutes Phase Two of my research, and is presented in Chapter Five, commencing with a discussion that seeks to 'unpack' the notion of culture and the ways in which culture is viewed in the context of learning and formal education.

RESEARCH PHASE TWO

CHAPTER FIVE CULTURE AND EDUCATION

In this chapter, I explore the meaning of the term *culture* and its past application to the enterprise of teaching and learning, together with its ability to shed light upon the reasons for the “achievement deficit” of non-Western students (Okebukola, 1990).

TOWARD AN UNDERSTANDING OF CULTURE

The term ‘culture’ is used in a wide variety of contexts. The meaning attributed to the word varies from the ‘cultural ecology’ of Steward (1955) and Wallace (1970), who express culture in terms of mankind’s ability to articulate and manipulate the environment, to the dialectical views expressed by Darder (1991), who speaks of culture as “a dialectical instance of power and conflict over material conditions and the form and content of everyday life” (p.29). Some other interpretations of ‘culture’ include, in chronological order:

Geertz (1973) - culture is a set of symbols;

Grassby (1973) - culture is synonymous with one’s ‘heritage’ or ‘way of life’ after Tylor (1871);

Vygotsky (1978) - culture consists of the social meanings and functions that are shared collectively but used individually according to need;

Sutton (1981) - the bones of culture are the principles of things, such as how people bring up children, pattern their roles, and interact, rather than the form of these things;

Acuna (1983) - culture consists of the skills and concepts that a group most needs to function effectively;

Arca, Guidoni, and Mazzoli (1983) - culture is the sum of a group’s experience, language and knowledge;

Power (1992) - culture provides the shared knowledge and values that enable the members of a group to communicate effectively with one another;

Jegade (1994) - culture consists of a distinct group of activities with a commonality of purpose, views, visions and practice;

Taylor (1994) - culture provides the myths that reproduce the appearance of a single social reality;

Weiner (1995) - culture is a label for subjectively perceived differences.

Aikenhead has also summarised some of the definitions of culture used to inform science education research, and suggests that culture includes the following attributes: communication, social structures, customs, attitudes, values, beliefs, worldview, skills, behaviour, and technologies (1995, p.9).

One could be forgiven for thinking that a good deal of confusion exists about the meaning of 'culture', even within the multi-cultural literature. I have chosen to align myself with those who include in their definition of culture 'the distinctive way of life of a social group, including its shared values, morals, beliefs, conventions and artefacts' (Arca, Guidoni, & Mazzoli, 1983; Eckermann, 1988; Geertz, 1973; Phelan *et al*, 1991). My emphasis here is on the shared nature of culture, since the culture of a group distinguishes its members and is expressed through relationships and behaviours that have significance to the group members and provide them with an ongoing sense of identity and purpose. Common to all discussions of culture is the implication that a relationship exists between the shared beliefs and customs of a social group, and the form and content of their daily lives. In other words, belief is central to culture and a nexus exists between belief and social customs. In this vein, it is not uncommon for researchers to refer to the practice and/or teaching of science as a cultural activity in conflict with the beliefs and activities of members of other cultures (Aikenhead, 1995; Hawkins and Pea, 1987; Jegede, 1994; Maddock, 1981).

In the context of culture and education, Aikenhead (1995) has recently suggested that science is actually a distinct Western sub-culture, and that successful science education consists of 'border crossings' from the student's natal culture to the sub-culture of science. This term certainly resonates well with my own experience of non-Western students. I have discussed scientific notions of cause and effect with students and have observed that their responses to test questions are framed as if a scientific explanation is taken for granted. I also know that some of those same students will take part in traditional activities related to the spirits of ancestors that night, and they will attend Christian morning devotions the next day with the conviction that each activity is appropriate in its context. For those students, life has many borders that must be crossed in order to access perceived cultural benefits, and I have no doubt that many cross the 'border' of science education for the time needed to reap its benefit. I would argue however,

from my experience, that many students choose to become only 'temporary residents' of the territory occupied by science education, which suggests to me that some might also choose to not border-cross in the first place (for a recent discussion of this issue see Cobern and Aikenhead, 1998). Despite Aikenhead's thought provoking remarks, and the burgeoning literature dealing with multiculturalism and education (Atwater & Riley, 1993; Hodson, 1993; Matthews, 1993; Stanley & Brickhouse, 1994; Williams, 1994), I am not convinced that we who teach science to non-Western students have yet understood the interaction between culture and formal education to the extent that we can confidently suggest the mechanism by which culture impacts the science classroom.

The variety of ways in which the term 'culture' is used has not helped me to be specific about its meaning when applying the term to classrooms, curriculum or learning. I note with concern that the term is often used as if culture is somehow *external* to the individual; something by which people are *affected* rather than an integral part of their shared beliefs and practices. For example, Haukoos (1988) suggests that:

Factors beyond the classroom may need to be examined since *culture* and *tradition* may be having a greater influence on school achievement than is currently recognised by educators. (p.4, italics mine)

The words, "factors beyond the classroom", suggest to me that Haukoos refers to the *external elements*, or *traditions*, that distinguish a particular culture, such as dance, ceremony, law or art, so locating 'culture' outside of the individual. These external elements of culture are often treated as though they are the whole of culture, which I am convinced they are not. While part of the fabric of culture, they are, I believe, analogous to Chomsky's (1966) *surface structures*. If one continues this analogy, taken from linguistic research, *deep structures* represent cultural meanings, or understandings of such things as religious beliefs, loyalties, social responsibilities and kinship systems; the issues of *ontology* and *axiology*, of *self* and *non-self*. It is among the deep structures of culture rather than the surface structures that I believe we will find answers to how and why culture impacts upon formal education, and any analysis of the deep structures of culture leads to a consideration of *worldview*, a term used by many researchers, including Jegede (1994) when he maintains that:

School science, as currently being taught, projects only one form of worldview - the western view which holds claim to superiority over any other form of studying nature. (p.4)

CONSIDERATIONS OF CULTURE IN EDUCATION

As I have shown in Phase One of this inquiry, many teachers and researchers believe that cultural factors affect the formal education of non-Western students. Formal education for non-Western students has been shown to be problematic in many countries, and is usually characterised by poor academic performance.

Since the 1960s, poor academic performance has been ascribed to discontinuities between the student's natal culture and the culture of the classroom (e.g. Basalla, 1967; Cazden, 1982). Researchers worldwide have sought to explain the notion of discontinuity by advancing a range of 'deficit theories' which suggest that minority children form a 'disadvantaged group' due to 'cultural deprivation' (Bloom, Davis & Hess, 1965). Cultural deprivation has supposedly been caused by one or more factors such as upbringing, home environment, poor mothering, inferior genetics or inferior reasoning abilities (Bloom, Davis & Hess, 1965; Cazden, 1982; Jensen, 1969; Hess & Shipman, 1968; Hunt, 1969; Porteus, 1966; Riesman, 1962).

In opposition to these theories, Keddie (1973) states that:

One of the pervasive uses of the concept of cultural deprivation has been as an explanation of failure at school among children of various ethnic and social-class groups, and it is possible that the institutionalisation of the concept has increasingly put these children at a disadvantage in terms of what is expected from them from the day they enter school. (p.7)

Keddie could have added that deficit theories contribute to, and do little to remedy, the ethno-centric nature of formal science education by reinforcing ethnic stereotypes. Despite the integration into educational policy documents of notions of 'field dependency/independency' (Witkin, 1959) and 'socio-economic disadvantage', these notions have not, apparently, proved capable of remedying the supposed cultural deprivation of indigenous students. Recent data indicates that the performance gap between indigenous and non-indigenous students in

Australia is widening (O'Shane & Bickford, 1991; Martin, 1998). There are now those who suggest that it is time we moved on from 'programs for disadvantaged students' to find answers to problems that seem to be as much *pedagogical* as *cultural*. "It is simply not enough to provide more schooling, or increase the number of grants, if the system itself continues not to really cater for Nyoongah [Aboriginal] needs" (Irrluma, 1988, p.107).

There appears to be adequate evidence to suggest that most attempts to construct alternative education programs for indigenous students fail, or are less effective, due to their 'superficial nature' (Martin, 1998; McTaggart, 1991). Discussing the tendency of educators to merely "tinker with the infrastructure", Hewson (1988) suggests that it is "more important to face what actually goes on in the minds of learners when presented with Western science" (p.323). It is, in my opinion, more important to consider what goes on in the mind of learners than in the mind of bureaucrats and administrators, as rhetorically asked by Cobern (1998, p.1), "Whose interests are being served by science education?"

It is possible that our paucity of provision for non-Western students is due to our lack of effort to find a workable theory to explain the *mechanism* by which culture and formal education interact. It appears that we do not understand what is happening in the minds of non-Western students who study science because we do not spend sufficient time and resources to find out. Despite Elkana's (1981) claim that "no such theory can exist" (p.91), I believe that it is possible to understand the interaction between culture and science education. We must first be willing to abandon some of our pre-conceptions about the meaning of the terms 'culture' and 'worldview' and be willing to re-define their relationship to 'knowledge'. While I have suggested in this research text that certain cultural artefacts are significant to learning and teaching, it is clear that there is more to culture than usually meets the eye or the ear of teachers, as noted by Chevallard:

Now, by invoking unspecific social and cultural factors, one falls short of providing a satisfactory explanation of the pupil's (and the teacher's) behaviour. (1990, p.24)

Chevallard (1990) refers to culture as a 'concept on probation' when applied to the field of mathematics education. In his opinion, "the concept of culture... is not yet a fully-fledged concept of the theory of mathematics education: it still carries

deep-rooted ideological attitudes” (p.4). Chevallard might well be referring to the fact that ‘culture’ has long been a field of interest to anthropological and social researchers, but has only recently generated interest among educational researchers.

The task of analysing the impact of culture in education is made more difficult because “the term ‘culture’ will generate a surplus of meanings” (Sachs, 1989, p.19). A common theme, however, is *difference* (Acuna, 1983; Allen, 1995; Charles, 1964; Davies & McGlade, 1982; Geertz, 1973; Harris, 1992; Jegede, 1994; Kearins, 1984; Ogbu, 1992; Power, 1992; Sutton, 1981; Weiner, 1995). A person’s culture implies a certain difference between themselves and people of other cultures. I believe this difference is important to formal education, yet we must recognise, as noted by Wilson (1981, p.40) and Jordan (1985, p.105), the difficulty of leaping from cultural and scientific data to educational practices that can be installed into ordinary classrooms and result in improved achievement. Despite this difficulty, I think it appropriate to look briefly at some arguments and examples in favour of a culturally relevant pedagogy.

Rodie’s Story - Field Notes

Rodie is a Solomon Island national man in his late thirties who was born in the Western Province and attended a respected church-run school. Although I knew of Rodie during my times in the Solomon Islands, our paths did not cross until he came to Perth to attend to his post-graduate studies at Curtin University. During his two years in Australia, we often met to discuss our experiences and exchange views. During these occasions Rodie spoke of his experience of science education as a student, a teacher and a curriculum developer, and agreed to allow me to use excerpts from our discussions as data for this study. What Rodie has to say about the cultural context of science education is significant to my study for the following reasons:

1. Rodie’s perspectives have influenced my thinking and shaped the direction of some of my grounded research;
2. Rodie is a well qualified and experienced educator, an ‘insider’ when it comes to discussions of indigenous education in his country, with insights commensurate with that experience; and

3. Rodie enjoyed science throughout his student life, unlike many of his peers, and is now among the few Solomon Island nationals who has pursued science or science education at the post-graduate level. He brings to the discussion a 'positive outlook' born of positive experience.

David: Rodie, tell me what going to school was like for you.

Rodie: I had mixed feelings about going to school. First, it was exciting because the school provided me with an opportunity to learn things which were not taught in a traditional setting... a variety of activities that I was involved in were quite different from what I usually did at home with my parents. But, as I moved from one grade to another, I found the classroom environment strange. I saw my teachers as dominant figures who did most of the talking and explaining while we sit and follow their orders. The teachers had a lot of authority and sometimes I disliked the way they conducted their lessons... unlike at home where I had the freedom to do whatever I wanted within the norms of my society. The teaching [at school] was more formal. Teachers were more conscious of time and even expected me to learn the topics within a specified time. While I was with my parents I learned at my own pace and time.

Going to school was especially difficult for me when I was sent to another island. I often became home sick... there were cultural differences that tended to be a barrier between me and the other students and teachers, who were mainly expatriates. Sometimes I thought that the school was indoctrinating me with so much information, most of it was alien to me. I had to adapt to new changes, which I did reluctantly.

When I finally got into high school I became more aware of the importance of schooling. I realised that I need education to fit into a society experiencing a lot of change. My dad used to tell me that it was important to attend high school so that I became better prepared for future challenges. It was probably for this reason that my dad never thought of me as an investment like some other parents who often regarded their children as investments.

Rodie has shown me through this interview that his formal learning at school and his informal learning at home had quite different emphases, for example, the

management of time and ways of relating to authority. Rodie was excited about the prospect of school, but found it to be alien, requiring change in order to benefit from the program. This is similar to the comments by Watson-Gegeo and Gegeo (1992) about the positive *symbolic* meaning of education for many children - comments that are especially relevant because Gegeo is also a Solomon Island national, a member of the Kwara'ae language group of Malaita.

The move away from family and traditional support structures is an unfortunate requirement of education in many countries where education facilities are sparse, but the move clearly added an additional burden to Rodie's learning experience. I was interested, therefore, to note the attitude of Rodie's father to education and Rodie's comment that many other families appeared to view education, indeed their male children, as an investment. This comment supports my observations of parental attitudes to education gained as a school Principal in the Solomon Islands. (cf. p.2).

David: When you were at school did you notice any difference between the ways natural events were explained in the text books and the way they were explained at home as you grew up?

Rodie: Absolutely! In my village, my parents or elders explained natural events from their own perspective - their ancestors' perspective really - about how or why things occur. My people tend to relate natural phenomena to a 'god', either the spirits of ancestors or God the creator.

Many of my people's explanations are quite shallow... like a legend or myth. There are exceptions though. Some of our traditional knowledge of ecology for example is sort of related to modern science. My parents explained how rain is formed by telling me that the 'earth' is heated by sunshine and produces *rovuzu*, which is humid air, which rises with the help of wind into *aukale* (the sky). To me, this explanation became the basis for my understanding of the scientific explanation of how rain is formed. It became part of my prior knowledge in understanding the concepts of evaporation and condensation.

Other natural phenomena like storms, earthquakes and tides were not well understood by my people and may not be linked to scientific explanations. Mostly, people believed that these events were controlled by the 'gods' of

their ancestors. All in all I noticed a marked difference between the way natural events were explained as I grew up and the way my science teachers explained them during science lessons.

Rodie's experiences, as recounted in this section of our interviews, lends weight to the view that prior knowledge is significant to learning (e.g. Osborne & Freyberg, 1985). A sound understanding by teachers of the cultural knowledge of specific students could help many more to make sense of their science education.

David: Was science ever taught with reference to cultural explanations?

Rodie: As I recall, science was taught with little reference to culture. It was evident to me that cultural explanations were ignored - probably there were good reasons for doing this. All my science teachers at high school were expatriates and weren't aware of cultural explanations. That is not to say that they didn't teach using local examples and context, but I failed to hear them asking us whether we were aware of cultural explanations of events that could be related to science.

David: Did you think that your science teachers think the same way you did or was it different?

Rodie: I believe that my science teachers wanted to make us think the way science 'ought' to be. I think they were mindful that it is not easy to find students who think the same as their teachers. I have come to realise through my schooling that as a student of science there has to be some consensus or agreement in the way we think of science. In other words, the expected outcome of science teaching is to influence students to think scientifically. At the same time we need to respect the views of other scientists, but we ought to come to some agreement.

Rodie has expressed in this section the view that science education performs a normative function, introducing students to the agreed meanings of the science community. For him this was a positive experience, due possibly to his personal fascination with and determination to learn science. The absence of interest, on the part of his teachers, in exploring the prior understandings of their students is of concern to me as this implies that they viewed their students as blank slates without prior understandings that could either help or hinder their students'

learning. Rodie's response to this concern of mine was expressed to me in the course of member-checking my field notes. He reiterates that expatriate teachers might not consider cultural explanations to be important because of their own cultural experience, and therefore do not acquire local knowledge that might help them to understand their students' point of view. Rodie suggests that the apparent indifference of expatriate teachers might have influenced national teachers to treat the question of cultural explanations in the same way, so perpetuating a Euro-centric pedagogy. He also feels that few national teachers would have been taught at Teacher's College to look for prior understandings as a tool to more effective teaching. In short, Rodie challenges me to recognise that the style of teaching that he has described is not necessarily deliberately biased, but is, itself, the result of enculturation.

David: Did you find science education to be foreign to your thinking, or was it easy to see what science was saying?

Rodie: As a child I was always interested to find out why things happened. I used to give my parents a difficult time because I was experimenting on some of their personal effects. I remember once when I mixed their lime for chewing betel nut with water and then bush lemon juice to see what happened. I ended up pouring it on my hair and discovered without anyone telling me that the solution bleached my hair. I also developed a love for animals and plants and used to have lots of pets like parrots, sea turtles and even pigs. I also made lots of toys from local materials.

When I went to high school I just accepted science education as a way of finding out things. One of the things that seemed difficult to me, though, was to understand how science knowledge could be applied in the real world. I was not quite sure of the connections at the time. I realised later that this was partly due to the weakness of some of my science teachers who portrayed science from their own perspective.

The way teachers portray science to students is important. If it isn't portrayed well, then students are liable to develop negative attitudes and some misconceptions about science. I can still remember a science teacher who was going to demonstrate the effect of pressure by using an oil tin containing boiling water. He told us that he was going to demonstrate a 'white man's magic'. I asked why it was white man's magic and he said that

it was a white man who came up with the idea. This is a classic example of regarding science as a foreign subject.

David: Do you think that most of your peers felt the same as you or different about science? What do you think was their opinion of science?

Rodie: From our conversations it was clear to me that most students thought of science as a formidable subject which only the bright students can do. I found some topics difficult but because of my love for science and my attitude toward science I regarded science as my best subject. Many of my friends didn't though. Some even said, "Unless you want to be a scientist in the future there is no point in learning science."

It appears easy in any culture to forget the place of natural curiosity in children's learning, and clearly, curiosity encouraged and fed can grow into a healthy attitude to science. Rodie is fortunate that his curiosity was not quenched by the apparent disconnectedness that he mentions, and that many of his peers felt, concerning the science curriculum. I have also observed this dis-connectedness, and have heard in my time as a school Principal the complaint from students that science is not a fitting subject for Solomon Island students - it is just too complicated.

David: Did your education give you a greater or lesser understanding and appreciation of your parent's culture?

Rodie: I was led to believe by some people that my education would alienate me from my people and my culture. I have confessed this on several occasions, but on other occasions I have contradicted myself by saying that my education has not alienated me from my culture. Let me show you something I wrote in my journal at Curtin [University].

It really fascinated me how the human brain functions enabling us to recall the changes that have happened or experienced within ourselves and our society during the past years. I still remember, as a 12 year old boy, I was about to board a ship to go to school. As I shook hands with my grandfather who was about 70 years old to bid him farewell he said to me, "Grandson you will be exposed to a total new life, very different from our village life. Please look after yourself and remember your roots." I never realised what he meant until 10 years later.

I had successfully completed my study and was back in my village during the Christmas holiday in 1982. I have been away for some time and it was good to be back in my village and be with my family and relatives. It was nice to be home at last! Unfortunately, my dad and grandfather had died. As I moved around the village I began to realise a very strange feeling inside me. I began to feel awkward about the way my people dressed or were doing things. A lot of changes have taken place. I disliked the daily routine of village life. I realised that my exposure to a totally different culture through my education had eroded me away from my culture so I began to feel like a stranger in my own village. There seemed to be a voice in my head saying, "You are a changed man and don't belong to the village." I began to realise what my grandfather meant when he bid me farewell.

Having re-read this journal I still think that the education I have received has enabled me to form a balanced view of my parent's culture and the new culture that I have fitted myself into. In this regard I think I have a high respect for my parent's culture and I'm sensitive to the changes and influences that have intruded into our society. I am also mindful of the need to adapt to changes and be prepared to make adjustment when necessary. My education prepared me to make the changes. As they say, "If you are in Rome do what the Romans do."

Rodie's story shows me quite clearly that, for him, science was very much a context-dependant activity. Fortunately for him, Rodie was able to understand and make the most of the school-science context, giving his strong natural curiosity the opportunity to explore the subject despite his uncertainty about the relationship between science and the world outside the classroom. Although his teachers did not apparently help Rodie to make connections between cultural understandings and school-science, Rodie's prior knowledge, and his belief that science was a worthwhile pursuit that would equip him for a changing world, helped him to make sense of the experience.

Clearly, Rodie's education moved him from one culture into another and changed the way in which he viewed his world. I understand from my association with Rodie that the worldview of Rodie-the-student and Rodie-the-adult changed over time. The single greatest variable during this time was, according to Rodie, his

educational experience. While there exist certain continuities from childhood to adulthood, Rodie acknowledges that “the education I have received has enabled me to form a balanced view of my parent’s culture and the new culture that I have fitted myself into.” I believe that Rodie’s worldview changed to accommodate beliefs and understandings that are more scientifically compatible than those of his cultural roots, and the change is directly attributable to his education. Furthermore, Rodie-the-adult would experience great difficulty living with, working with and leading the people of his language group who have not experienced a similar worldview shift.

Science as a Context-dependent Activity

Masakata Ogawa, of Japan, is of the opinion that there should exist in the world various types of science education. He argues that we would profit by adopting a science-culture perspective rather than a science-society perspective.

This replacement will make it clear that the science education as it is practised in western societies does not represent a standard for all science education. (Ogawa, 1986, p.114)

It is commonly argued that, in order to achieve culturally-sensitive teaching, teachers must ensure that they understand their students, and their students’ cultural ‘base’. Arca *et al.* (1983) have stated that formal education should be planned “to maximise reference of the ‘particular’ to its ‘common base’.” In other words, all instruction should start from the learner’s present cognitive and cultural position. The challenge for indigenous education is to understand those positions. Cobern (1991) is of the opinion that:

it is important for science educators to understand the fundamental, culturally based beliefs about the world that students bring to class... because, science education is successful only to the extent that science can find a niche in the cognitive and socio-cultural milieu of students. (p.10)

Cobern’s opinion is certainly borne out in Rodie’s story. Although Rodie is proof that exceptions do exist to any generalised rule, science education did not find a niche in the socio-cultural milieu of many of his peers. One can ponder the possible outcomes had his teachers more fully understood the prior understandings of their students.

In a recent study of native science beliefs among Ghanaian students, Anamuah-Mensah (1998) records a number of beliefs that he suggests might influence science learning. He recognises the importance of the task for science teachers to “make effective instructional use of the personal and cultural knowledge that students bring into the classroom...” (p.122). I am a little concerned, however, at the tone of his next suggestion that “there needs to be a two-pronged attack on the community outside the school boundaries and the individuals within the formal school system.” Anamuah-Mensah appears to assume the position that scientific explanations can supplant native beliefs through a forceful education program, a notion that appears problematic in the light of the African experience of science education and Ogawa’s (1986) argument in favour of a science-culture perspective.

Smith also speaks about the importance of understanding the student’s cultural base. “In the science class a teacher should become aware of the child’s ‘base of operation’. This can be done by accepting all the child’s answers. If some answers seem strange ask the child how he ‘knows’” (Smith, 1982, p.15).

Much is also said about understanding the student’s *social* context:

Knowledge makes sense only as it is linked with local conceptions of self, personal identity, and social and political relations. Whereas Western schools assert the value of knowledge in and of itself... in these Pacific societies the ultimate value of knowledge lies in its application, results and products. (Falgout & Levin, 1992, p.5,6)

In other words, learning science is a context-dependent activity, and when it is taken out of a context that is understood by students, formal teaching might make little sense to them. “World view theory argues first for an understanding of the world as students understand it” (Cobern, 1991a, p.115). Of course, one could argue, as does Chevallard, that this is simply good teaching in any culture.

Culture conflicts and culture shocks - let us say, in the face of mathematics and mathematics education - may and do arise *even in the case of Western societies....* (Chevallard, 1990, p.4, italics mine)

Chevallard's opinion that Western students also experience culture conflicts is shared by Champagne, Klopfer and Anderson (1980), who write about the Aristotelian notions retained by Western students despite 12 years of formal education. I further address the issue of culture conflict in science education throughout Chapter Six.

To be effective, it would appear that science education must help students to understand:

- their own culture;
- that science is, itself, a cultural expression about the nature of the world;
- examples of conflict between science and traditional cultures; and
- problem-solving techniques that help students to master scientific thinking (cf. Ogawa, 1986).

'Two-Way' Schools

Ogawa's insights remind me of the literature in Australia concerning 'Two-Way' or 'Both-Way' schools. These terms originated from the teacher education program of Batchelor College in the Northern Territory and describe a bi-cultural process of Aboriginal origin whereby schools deliberately maintain cultural domains within their daily curriculum activities. Two-Way schools seek to teach Aboriginal understandings alongside a Western curriculum, while using Aboriginal styles of teaching throughout. Cultural knowledge and 'law' is taught so that children might understand their cultural heritage and take their place among their people, and English as a second language, mathematics, science and social studies are taught within a Western domain so the children can understand how to function in the dominant society. The latter subjects are always taught as skills for functioning in 'white' culture, not as if their mastery will define the value of the individual, or as if those skills are indispensable to future living. Two-Way schooling, however, is not without its critics, both Aboriginal and non-Aboriginal, (Japangardi Poulson, 1988; McTaggart, 1988). It is, however, a sincere attempt to address the effect of culture on formal education, and the effect of formal education on the culture of indigenous students and communities. Christie (1988) suggests the following strategies for Aboriginal education, which might also be relevant to teachers considering the practical issues of teaching in other indigenous, non-Western cultures:

- Learning through Unity. Unity is at the heart of Aboriginal cultural life, so learning is fundamentally a group activity, with much emphasis on the seeking of consensus and the establishment of joint experience.
- Learning through response to real situations. Aboriginal learning is not planned, it is activities that are planned, and learning takes place in context - almost coincidentally. For that reason a good deal of learning can be centred on the daily activities of the entire community and on their re-telling, as demonstrated at Punmu school in the late '80's (Vallance & Vallance, 1988).
- Learning through harmony and continuity. Aboriginal learning ties together the various threads of community life, providing understanding about identity, kinship, community roles and expectations.
- Learning about 'both ways'. Many Aboriginal parents want their children to learn Aboriginal and non-Aboriginal social skills and knowledge, and be able to gain access to the 'cultural capital' of the dominant society without losing their own cultural identity.
- Learning without coercion. Aboriginal people take pride in teaching their children to be independent at an early age, so they do not learn well if pushed to conform to the values of those for whom they have not built respect.

Almost without exception, those who have worked with non-Western students write and speak about understanding and valuing the students' context. "The implications of this argument favour multicultural classrooms in which learner's views are identified and respected, and negotiated knowledge acquisition is facilitated." (Hewson, 1988, p.325). A good example that I have witnessed took place in 1994 while I was teaching and researching in the Curtin University Centre for Aboriginal Studies.

A Culturally-relevant Field Trip

Within the Curtin University Centre for Aboriginal Studies, a unit in Ecology is taught as part of the science program for Aboriginal students who have not achieved matriculation. One of the centre's course coordinators recognised the importance of valuing and encouraging further understanding of Aboriginal perspectives, and arranged a field trip that could serve as a model for other teachers of indigenous students.

The field trip was to visit a small lake in order to conduct wildlife population counts and water and soil purity tests. The students were met at the lake by an elder of the Nyoongah family group who claimed traditional ownership of the lake, and by the Biological Sciences lecturer. The students were first given a tour of the lake by the elder, who bestowed permission to visit, explained the history of the lake, the ecological changes his people had seen since white settlement, and the stories of the lake's wildlife. The elder did not stop working with the students until he felt that each had an appreciation of the lake's story, and its significance as a cultural system involving people, place, wildlife, vegetation and spirituality. After lunch, the students learned that Aboriginal perspectives and scientific techniques are both relevant when they were introduced to methods of population and water purity sampling, taking appropriate samples back to the laboratory for further analysis.

I saw this field trip as an example of good cross-cultural science teaching because, in Hewson's (1988) words, it was a learning experience that identified and respected indigenous knowledge and negotiated further knowledge development. The students completed this learning sequence with a clear perception that at least one aspect of scientific investigation is compatible with an indigenous cultural perspective. In fact, in the case of these Aboriginal students, their own indigenous understandings were enhanced by the experience, which is a feature of good cross-cultural teaching. Their view of themselves as Aboriginal people was enhanced, and their view of the world was enlarged as they formed individual opinions about their experiences of science and culture.

In Chapter Six I look more closely at what is written about worldview, and I give an account of my exploration of the implications of worldview for science education.

CHAPTER SIX TOWARD A WORLDVIEW THEORY OF LEARNING

DEFINING WORLDVIEW

Of particular value to me in my exploration of worldview is the work of Cobern (1991a), and Kearney (1984) upon whose empirical research Cobern has drawn. Throughout this study, I have chosen to write *worldview* as one word. I recognise from previous reading that it is an English rendition of the German words *Weltanschauung* (world philosophy of life) and *Weltbild* (world image), each of which is a single word. Cobern (1991a, p.8) also addresses this issue, and quotes Wolters (1989) in support of the use of a single word, although, for reasons of American usage, Cobern chose to separate the words and write them as *world view*.

Like culture, definitions of worldview are many, are often vague, and tend to reflect each researcher's ideological perspective. To the impoverishment of science and mathematics education, the concept is not taken very seriously by many outside the fields of philosophy and social anthropology. Kilbourn (1976, p.115) is quoted by Proper, Wideen, and Ivany (1988, p.547), lamenting that, at the time of writing, "there seem to be no studies in science education dealing centrally with the comprehensive and systematic notion of world view". It is commonly agreed, however, that everybody has a worldview, whether they know it or not.

All people possess worldviews. These are germane to what they think and do. Such views are acquired through a variety of influences including the family, media, interpersonal relationships and through ways our institutions are structured and the way they function.

(Proper *et al.*, 1988, p.547)

Not only do all people apparently possess a worldview, people who share a cultural background tend to also share at least some aspects of their worldview.

Every system of the world is underlain by basic presuppositions concerning the nature of man and the nature of nature.

(Kidwell, 1994, p.43)

Sire suggests that:

A world view is composed of a number of basic presuppositions, more or less consistent with each other, more or less consciously held, more or less true. They are generally unquestioned by each of us; rarely, if ever, mentioned by our friends; and only brought to mind when we are challenged by a foreigner from another ideological universe.

(Sire, 1988, p.17)

Most definitions of worldview that are used by researchers follow the socio-cultural trend, defining worldview in terms of basic presuppositions about the world, self and others, that are corporately held and culturally formed. Examples of these are:

Christie (1984):

Worldview... the ideas and beliefs which a group of people holds about its world and the people and things in it. (p.3)

Kearney (1984):

the... basic assumptions of a people that determine much of their behaviour and decision-making. (p.1)

Aikenhead (1995):

Worldviews are culturally validated presuppositions about the natural world (p.5)

In short, worldviews tend to develop central, unifying themes (Witherspoon, 1974, p.46) about everything observed or experienced by individuals and communities. As a result, researchers write as if worldview is exclusively collective and cultural. However, beliefs, ideas and knowledge exist within the mind of the knower and they cannot be reified or separated from the mind except through their expression. Since belief is personal, and is at the heart of worldview, I suggest that worldview must also have a personal element. That this should be so is consistent with personal construct theory (Kelly, 1955), supported by the work of Osborne and Freyberg (1985), whose theories concerning "children's science" are built upon the constructivist view that all perceptions are theory-laden:

In many ways every concept that we hold incorporates a mini-theory, its complex structure, its particular exemplars, the connotations which its label (word) evokes, all contribute to the picture of how we perceive that specific portion of our world. (p.132)

The notion that knowledge exists in both social and personal contexts is not new. Whether one conceives of knowledge as an identifiable body of ideas after the positivist position, or as a construct of individual minds, according to the constructivist position, one is obliged to agree that knowledge is simultaneously personal and social. Once shared, negotiated and accepted, specific ideas form a small part of the common culture of that social entity (Driver *et al*, 1994). This draws together some of the often competing claims represented in personal construct theories and the social constructivism of, for example, Solomon (1987).

Dealing specifically with the sharing of scientific ideas, Kuhn (1970) speaks of *paradigms* as shared ideas of the scientific community, which implies a similarity of meaning between 'ideas', 'theories' and 'beliefs'. I understand Kuhn to be saying that a paradigm is a shared construct or framework concerning a given phenomenon or concept that can act as a window to further understandings of the world. The term 'paradigm' is generally used in the context of the social construction of knowledge within a community of theorists, however if, as I have stated above, ideas reside within the mind of the knower, the actual construction of a paradigm must take place within the minds of individuals, perhaps in consultation with others.

Despite the fact that the conceptual change research of those who have followed Posner, Strike, Hewson and Gertzog (1982) draws on Kuhn's discussion of paradigms, it appears to me that the notion of 'paradigm' is also similar to my discussion of worldview. Points of similarity include references to the culture in which theories are generated, the shared nature of theories, their use as a framework for further theorising, their normative role in the interpretation of new theories and the possibility of conflict between viewpoints. If paradigms do reflect, as well as influence, the thinking of individuals, and if they are changeable, and if 'worldview' is contiguous with 'paradigm', it is clear that worldview must also be simultaneously cultural, personal and changeable.

Attempts to separate the implicit cultural aspects of worldview from the consciously held beliefs of the individual have tied worldview debate in philosophical knots for decades. Wilhelm Dilthey (1957), referred to by both Kearney (1984) and Cobern (1991a), was particularly influential in this debate, proposing that each individual's world-image (*weltbild*) is shaped by their life-world (*lebenswelt*). Upon reflection, the individual develops a philosophy of life (*weltanschauung*) that is explicit and changeable. Because this tri-partite understanding of worldview still underpins current thinking, it is important that educators question the meanings ascribed to the terminology of worldview debate, and perhaps show a willingness to challenge the accepted wisdom if it does not adequately match observation. To better understand the nature of worldview I believe we should seek to understand how it is formed.

The Formation of a Worldview

Seagrim and Lendon (1980) speak of worldview formation as a 'furnishing of the mind', and emphasise the role of important others in the process.

We conclude that this furnishing of the mind occurs at the mother's knee and that its integrity and energy depend upon the integrity and depth of the affective bond that can be formed there. (p.214)

'Furnishing of the mind' implies to me the establishment of cognitive structures, and linkages between various concepts, in order to make sense of observation and experience. Early learning, therefore, will shape further learning for each child, which emphasises the importance of the role of parents and socio-cultural climate in the construction of the foundations of future knowledge and values.

As a result of her unique research into the child-rearing practices of Aboriginal people, Kearins (1984) also contends that mothers play a very important role in the establishment of values, practices and norms of behaviour in their children. Although passed on through individuals from generation to generation, these norms are cultural and vary from one social group to another. The foundation of a person's worldview, therefore, is made up of 'deeply sedimented' ideas and beliefs (Shutz & Luckmann, 1973) that have formed within the mind of the individual from earliest childhood. It is shaped by the culture in which one lives, as argued in the previous section, but is not synonymous with it, which begs the

question, "Can an individual's worldview differ from the worldview of others who share the same culture?" Bereiter (1994) argues that:

There is ample evidence from Piagetian and neo-Piagetian studies that young children work out a substantial knowledge of the physical world well before they could have gained much of it from the surrounding culture. (p.21)

My inquiry to this point suggests that an individual's worldview can, and often does, differ from the worldview of others who share the same culture. A serious consideration of the role of worldview in learning must include the possibility that worldview is personal, as opposed to collective, yet is socially constructed, reflecting the negotiated mores and perspectives resulting from involvement with a cultural group.

A Fresh Definition of Worldview

The ideas expressed in the previous sections acknowledge the effects of cultural environment and personal reflection upon the construction of ideas, and lead me to propose an alternative definition of worldview that I believe is more appropriate to education:

Worldview is the dynamic belief system of the individual, formed and shared through life-long interaction with one's culture, society, and environment, which disposes individuals and communities toward acceptance or rejection of actions and ideas.

It is important to note that, according to this definition, worldview is a *belief system* and is *dynamic*, affecting daily life. Its dynamism resides in the fact that, as members of communities, the beliefs of individuals are both challenged and affirmed regularly and, as rational, thinking creatures, individuals re-form their beliefs according to a complex web of interacting perceptions and allegiances.

I do not imagine that science educators will universally welcome my definition of worldview, based as it is upon individual interpretations and cultural backgrounds. The idea that individuals might construct different worldview perspectives, much less different scientific 'realities', infers relativism to an extent that many Western educators might find difficult to manage. "If thought is so much out in the world as this, what is to guarantee its generality, its objectivity, its efficacy or its truth?"

(Geertz, 1983, p.153). Yet, a worldview theory linked to a general theory of learning might offer the best hope of understanding the "achievement deficit" experienced by many indigenous students (Okebukola, 1990).

As I have shown (pp. 41, 81), many indigenous students demonstrate an unrealised intellectual potential that deficit theories have failed to resolve. If there exists a relationship between worldview theory and learning that offers hope of understanding "achievement deficit", I think it will be uncovered by exploring the relationship between worldview and those aspects of culture identified as significant to formal education, namely, Language-use, Cultural Beliefs and Life-world knowledge. In the remainder of this chapter, I analyse each in turn.

LANGUAGE AND WORLDVIEW

Data from the Integrative Research Review suggested to me that language-use is a significant factor affecting the outcomes of science education for non-Western students. It was noted in Chapter Four that the use of language is not simply the sharing of a structured set of labels and sounds, it is the communication of values and ideas through the use of *agreed* symbols and words that communicate *agreed* cultural meaning.

The language might be understood in terms of the literal meanings of the words and sentences, but the underlying concepts and values might not. The meaning is embedded in the social context or culture.

(Sayers, 1983).

'Meaning' is central to language and it is also central to the notion of worldview as noted by Mathiot (1979):

Worldview is the general way of thinking about the world that underlies all cultural behaviour. Linguistic behaviour, then, is one type of cultural behaviour that manifests worldview. (p.163)

Mathiot's observation assumes a link between worldview and language, but raises the historically vexed question of whether worldview shapes language or language shapes worldview, as proposed in the so-called Sapir-Whorf hypothesis. Whorf, in consultation with Sapir, proposed that all languages can be categorised according to their structure and morphology, and that the beliefs and

worldview of language users is determined by the structure of their language; a relationship described as 'ideology follows phoneticism' (Carroll, 1956, p.13). Examples of this supposed relationship are drawn from various people's perceptions of time, space and matter.

The assumption that worldview is shaped by the structure and morphology of language is, I believe, difficult to sustain. The Sapir-Whorf hypothesis suggests that language pre-disposes people to a limited range of perceptions, but I suggest the reverse, that worldview shapes language as a tool to communicate that which one already perceives. "It is the deep structure underlying the actual utterance, a structure that is purely mental, that conveys the semantic content of the sentence" (Chomsky, 1966, p.35). I think it is helpful to describe world view, language and perception as existing in a dialectical inter-relationship, with world view as the most influential partner, and language as its most usual form of expression, as illustrated in Figure 4.

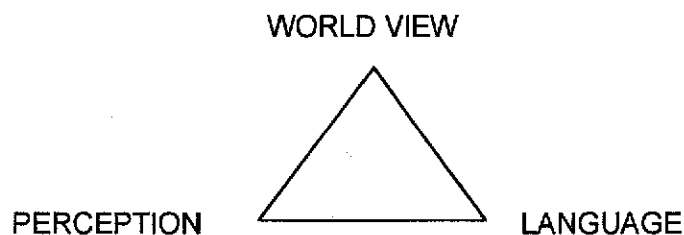


Figure 4. Relationship between Worldview, Language and Perception.

In Figure 4, Worldview has been given the superior position, influencing Perception through prior understandings and through meanings interpreted from language. Language, being a vehicle for ideas, is dynamic in response to changing ideas and observations. As a result, Perception and Language can affect and bring change to Worldview. Worldview, therefore, is not only influential, it is also dynamic and changeable.

The dynamic relationship between language and worldview is significant to science education. History shows that a language unable to convey the meanings needed for effective communication will change to accommodate new meanings, however, change can take place only within acceptable limits imposed by the dominant culture. The worldview of an individual, however, might be at variance with the dominant culture, resulting in the development of new theories and the language to explain them, and ensuring that questioning, research and science

continue. For example, can I assume that Galileo's acceptance of, and commitment to, Copernican theory, formed such a part of his changing worldview that he was prepared to accept house arrest in preference to reverting to the Aristotelian worldview promulgated by the dominant academic culture? I assume this to be so, and that his commitment to a new perception of the world contributed to a change in the language and perceptions of the dominant culture.

As a tool for the expression of ideas, language communicates personal perceptions, clarifies meanings, and makes effective education possible:

For [teaching] to be successful the students must comprehend the essential words we use, for it is these words which express the concepts, and it is the interrelationships between these words which express the conceptual structures of physics. (Marshall & Gilmour, 1990, p.330)

Despite their apparent agreement with the Sapir-Whorf hypothesis, Watson and Wade's (1989) observations are helpful concerning the connection between language and worldview. They maintain that Indo-European languages express a perceived separateness between subject and object, as if describing a spatially separate world that can be verbally and cognitively dissected (p.15). The philosophical structures associated with these languages allow for the theoretical and physical dissection of the world, resulting in a science that is often verbally and spatially disconnected from its subject matter. In contrast, certain Aboriginal languages (Yolngu Matha) describe a perceived world of inter-relationships verbally associated by the names given to objects and elements within that world. Watson and Wade maintain that these biases are evident in the dominant worldview of people within those cultures. As a result, Europeans have developed a post-enlightenment assumption that defining the natural world is a valid role of the scientific community. By accepting exclusively the jargon, methods and definitions used by that community, Western educators display a confidence in the science curriculum, and a lack of confidence with Aboriginal accounts, that Watson and Wade claim has caused the latter to be disregarded as non-science and, therefore, unreliable (Watson and Wade, 1989, p21ff).

Based on her experience among remote Aboriginal people, Sayers (1988) has expressed the opinion that the worldviews of Aboriginal and non-Aboriginal people are distinctly different. She suggests that the meanings attributed to

language are derived from the context and culture of the speakers. The words of a person from another culture might be understood, but not the intended meaning of the speaker. This, of course, is very significant to education, "in order to understand the language practices of the classroom it is important to examine the way in which something is said as well as what is being said" (Chapman, 1993, p.42).

The forgoing examples illustrate ways that language reflects the worldview and eco-culture of its native speakers, and explain why different cultural and sub-cultural groups often hear, speak and write the same language in different ways, and with different intended meanings. If science instruction is language-dependent it must also be worldview-dependent and open to a variety of interpretations based solely upon a mismatch between the worldviews of the learner and the teacher and/or curriculum.

CULTURAL BELIEFS AND WORLDVIEW

The work of Jegede and Okebukola (1991), among others, suggests that traditional (cultural) beliefs reflect a person's eco-cultural world. These beliefs are lived out through daily activities and have the potential to affect students' interpretations of their observations.

Horton (1971) has identified six issues that differentiate traditional and scientific thinking. To recap, these are:

- attitudes toward the prediction of events;
- attitudes toward cause and affect;
- attitudes toward experimentation;
- attitudes toward the confession of ignorance;
- attitudes toward coincidence, chance and probability; and
- attitudes toward time.

A closer examination of Horton's differentiations suggests that each constitutes a belief. Indeed, his use of the word "attitude" suggests as much. In Chapters Three and Four, I have noted that the beliefs of indigenous students are influenced by cultural milieus other than science education, which could conceivably cause students to interpret phenomena in ways that differ markedly from those committed to 'scientific thinking'. Traditional thinking, like all thinking,

is influenced by one's worldview: "The bedrock of perception and belief is worldview" (Kearney, 1984, p.134). Perceptions and belief appear to act as powerful filters to further learning (Rogers, 1969; Kelly, 1955) and, like language, suggest a variety of meanings to students. If worldview is the bedrock of perception and belief, then one's beliefs about science, and one's perceptions of scientific activities, will most certainly be influenced by one's worldview.

LIFE-WORLD KNOWLEDGE AND WORLDVIEW

It would appear that very little difference exists between the notions of life-world knowledge and worldview. Although 'life-world knowledge' has only a limited literature in the field of education, the term *life-world* is not new, being typically used to differentiate between the '*subjective*' and '*objective*' worlds (cf. Husserl, 1954). Schutz and Luckmann (1973) identify the life-world with "that province of reality which the wide-awake and normal adult simply takes for granted" (p.3), and it is this 'taken-for-granted-ness' - a subjective acceptance of one's milieu - that is crucial to the notion of 'life-world'.

The everyday reality of the life-world includes, therefore, not only the 'nature' experienced by me but also the social world in which I find myself. (Schutz and Luckmann, 1973, p.5)

Life-world *knowledge* consists of the meaning structures or interpretations ascribed *post facto* to the events of daily living. These meaning structures are reflexive in nature, intimating that, without reflection, novel events do not automatically have meaning:

As long as I am engaged in lived experiences and directed toward the Objects that are intended in them, these experiences have no meaning for me (apart from the particular meaning and time-structure of action).

(Schutz and Luckmann, 1973, p.16)

Schutz and Luckmann's assertion that meaning is constructed largely after the event rather than simultaneous with it has important implications for learning theory. If we identify the formal curriculum as *symbolic* knowledge then it becomes clear that the construction of meaning takes place only upon reflection and only after comparison (even subliminal) with one's existing life-world knowledge. In this way, one's life-world knowledge determines that which is 'self-

evident', and one's 'kernel of self-evidency' acts as an *horizon* which, for the present, shapes one's view of the world. Just as the invention of the aircraft and man-made satellites has re-shaped our scientific understanding of the physical world due to the change they have provided to our physical horizon, or limit of sight, so a change, no matter how subtle, to an individual's life-world understanding changes that individual's conceptual horizon. This makes life-world knowledge a construct internal to the individual, but shaped by personal and social interactions, that in turn defines all new experience.

In contrast to Shutz and Luckmann's assertion that the term 'life-world knowledge' refers to meanings constructed from every day experience, the phenomenologist Weber Marx (1992) has proposed that "man is able to exist in many life-worlds simultaneously" (p.41). He maintains that in every life-world there exists "an order of Being which pertains to all relations - those of law... morality and religious dogmas - in short: the common culture and everything that is sedimented..." (p.73, 74). If Shutz and Luckmann's use of the term 'life-world knowledge' is *internal* and *personal*, Marx's use is *external* and *general*. Marx's view appears to me to limit 'life-world knowledge' to dichotomous, socially determined 'sectors', causing the individual to accept as a matter of course different realities for different situations. While some evidence exists to support the notion that individuals can express apparently conflicting ideas simultaneously (Elkana, 1981; Maddock, 1982), Shutz and Luckmann's presentation of 'life-world knowledge' leans toward the *amalgamation* of experiences rather than their *dissociation*. I would suggest that Marx is describing 'multi-cultural survival' or 'situated cognition' (Furnham, 1992) rather than life-world knowledge, so I favour Shutz and Luckmann's use of the term.

The life-world knowledge of each individual appears orderly and sensible to that person, even though, to an outsider, it might not appear to be at all consistent. Cobern (1991a, p.5), after Hills (1989), uses the term 'common-sense theories' in similar fashion to Shutz and Luckmann's 'life-world knowledge'. For these theories to remain orderly and consistent, individuals must be able to construct a schema, a mental map or cognitive structure, to make sense of daily experience, metaphors that are more consistent with a constructivist view of learning than Schutz and Luckmann's use of the 'sedimentation' metaphor. Because individual life-world schemas differ, there exists in any inter-subjective relationship a

'reciprocity of perspectives' (Schutz and Luckmann, 1973, p.60), or exchange of ideas, that reflects the worldview of each person and is communicated through the use of language. This reciprocity of perspectives must ultimately affect a social group's 'cultural landscape', resulting in the possibility of a slow but steady change in some of their shared aspects of worldview.

I have presented evidence in the two preceding sections which suggests that language-use and cultural belief help shape, and are shaped by, worldview, but each is ultimately subordinate to it. In this section I conclude that little difference exists between 'life-world knowledge' and 'worldview', except that researchers have tended to ascribe the former to the individual sphere, and the latter to the social sphere. I believe, based upon the literature to which I have referred, that they are simply different terms describing the same phenomenon, each having emerged from different research traditions, but the term 'worldview' is of greater use to the field of science education due to its wider currency. Cobern (1991a) has explored the relationship between worldview and science education at some length. His research suggests that worldview is significant to student outcomes in science education, so it seems appropriate to analyse Cobern's model more closely to further understand the nature of that significance.

COBERN'S WORLDVIEW MODEL

Cobern has investigated the effect of worldview on the teaching of school science, seeking to understand why scientific understanding so often competes poorly with commonsense theory (Cobern, 1991a, p.7). Despite a tendency within the literature to relate worldview to matters of gender or culture, Cobern believes that 'worldview theory' can also shed light upon misunderstandings and miscommunication in science education. To Cobern, "Worldview research means seeking to know more about students' presuppositions about the world, their *epistemological macrostructures*" (1991a, p.10). Cobern has based his worldview research upon the empirical studies of Kearney (1984) in order to, "give a credibility lacking in other approaches to worldview" (Cobern, 1991a, p.11). The goal of Cobern's research is to develop a "theory of worldview that can direct analysis" (p.11), and with this in mind he has adapted Kearney's logico-structural model to provide a "theoretical framework for directing science education research with regard to students' untutored beliefs, students' scientific understanding, and the development of science interest and attitude" (p.11a).

Attempts have been made to find alternative terms for what I refer to here as 'worldview', such as 'world hypothesis' (Pepper, 1970), which I have found too prescriptive and scientifically oriented, and 'common-sense theory' (Cobern, 1991; Hawkins, 1978; Hills, 1989) which I have found a little more helpful. Elkana (1981) claims that common sense "cannot be considered as simply unsystematised knowledge. It is simply less systematised than science" (p.38). I am concerned, however, that what is deemed 'common-sense' in one culture is considered absurd in another. Common-sense might be culturally defined.

The term 'worldview' has settled into reasonably common usage since its inception in the early 19th century, but it remains largely a part of the language of philosophy and anthropology. Cobern is among the first to take the term and apply it specifically to science education. In so doing he has followed the anthropological traditions of Franz Boas (1858-1942), referring to worldview in terms of the "many environmental factors that influence children and adults" (Cobern, 1991a, p.18). Following Wallace (1970) and Kearney (1984), Cobern uses the term 'worldview' to mean "the culturally-dependent, *implicit*, fundamental organisation of the mind" (p.19). However, anthropologists are not principally concerned with the ways in which people learn but, rather, with how they behave, so their use of the term 'worldview' reflects their emphasis: people in society, rather than people in formal education. As a consequence, I have rejected the idea of worldview as 'culturally-dependent' and have proposed the alternative definition found on page 99.

Worldview is Lived and Articulated

Cobern's definition implies that the development of worldview is the result of one's cultural environment, and, being quite different from beliefs or philosophy, it is unaffected by conscious, individual reflection. That view fails to explain how it is possible for individuals of the same cultural background to live and express differing worldviews, although not all researchers would agree that a lived worldview is the same as an expressed worldview.

In order to illustrate the historic difference in usage between worldview as a picture of the world (*weltbild*), and worldview as the sharing of ideas (*weltanschauung*), including scientific ideas, Cobern (1991a, p.17) refers to the philosophical writing of Kok (1988). Kok coined the terms *lived world view* to

explain *weltbild*, and *articulated world view* to explain *weltanschauung*. Unfortunately, Kok does not show us how the lived and articulated worldviews inter-relate. He leaves me with the impression that worldview is an ambiguous term used to describe at least two quite different phenomena. On the one hand, the term is used to describe a phenomenon so implicit to the mind of the individual that it is virtually undetected and is not the result of a conscious mental process. On the other hand, it is used to describe the phenomenon of reflective, philosophical thought and its expression and debate. How these two quite different views inter-relate is not sufficiently explained by either Kok or Cobern. Cobern attempts to resolve the dialectic by assuming that “the malleableness of a worldview begins to decrease [with adulthood]” (1991a, p.21), and that beliefs are part of the world of philosophy, not part of one’s worldview. This statement is necessary if Cobern is to maintain that worldview is an unconscious, implicit learning system developed in childhood. If, however, we are to take constructivist learning theory seriously, there is no justification for the assumption that learning, even the learning that results in deeply held assumptions, ceases or even declines with age. Nor is it justifiable to assume that worldview is not made up of beliefs, even deeply sedimented beliefs (to use a life-world metaphor) that, like all beliefs, are changeable.

After reflecting upon the literature cited to this point, I suggest that the apparent dialectic between lived and articulated worldviews is best explained if we rid ourselves of the pre-supposition that worldview is cultural, unchangeable and wholly implicit. Ridding ourselves of this cultural presupposition would enable us to recognise that Kok, in his 1988 paper, was describing the two most usual expressions of the one phenomenon when he wrote about ‘lived’ and ‘articulated’ worldviews. In other words, a person’s worldview is both lived and articulated. As a lived worldview it is composed of taken-for-granted understandings about the world. As an articulated worldview it becomes explicit upon reflection, discussion and expression. While it might require a good deal of reflexive energy to re-visit many of the more ‘deeply sedimented’ layers of one’s worldview and to analyse their impact upon one’s current attitudes and behaviour, it is clearly possible to do so, and for change to result. The usual term applied to such a deep change process is *catharsis*. Were it not possible for one’s earliest attitudes and taken-for-granted assumptions to be reviewed and changed it would not be possible for a child born into a criminal environment to resist crime, or a racist to accept those

of another race, or for an individual to affect a genuine religious conversion. Attitudes concerning the value of others, the sanctity of their lives and property, the meaning of their dignity, or the understandings of faith do not consist of cold rationalism: "Faith is not rationality, but spontaneous religious experience" (Jung, 1958). The more 'deeply sedimented' is the understanding, the greater is the catharsis required for change to occur in the 'landscape' of one's worldview.

Similarly, education is neither solely implicit, nor solely explicit. Education involves reflection upon taken-for-granted assumptions and the construction of new understandings, powerful activities resulting from the interpretation and re-formulation of ideas and activities, an assumption upon which both Piagetian and constructivist views depend. I am, therefore, confident to suggest a worldview theory that recognises the importance of one's cultural environment in its initial construction as well as the dynamic interplay between culture and reason in the re-formulation of one's worldview throughout life. Accordingly, worldview is both cultural and personal, both lived and articulated. To the extent that one is willing to reflect and act upon one's most fundamental beliefs and assumptions, worldview is also dynamic and changing, resulting in a variety of personal worldviews among the members of any socio-cultural group. In the same way that Cobern was happy to draw upon the recent traditions of social and personal constructivism in his development of contextual constructivism (Cobern, 1991b), I suggest that further research into the role of worldview in science education must draw upon the notions of a *culturally influenced* but *personally determined* worldview if we are to understand the relationship between worldview and formal learning. None of my investigations has, however, enabled me to suggest the exact components of a person's worldview. If worldview is *the dynamic belief system of the individual*, as I have proposed, can those beliefs be categorised in any way that is universal? Kearney (1984) believes so, and has proposed a model, based upon empirical research, to support these categories.

KEARNEY'S LOGICO-STRUCTURAL MODEL

Kearney's worldview research was driven by three questions:

The first of these is, What universal cognitive categories are necessary dimensions for cross-cultural comparisons of world views? The second, What kinds of forces determine or shape the contents of these categories? And third, What relationship exists between these worldview universals and socio-cultural behaviour? (1984, p.65)

In short, Kearney set out to find categories that would describe the components of worldview for people the world over, regardless of their cultural background, and to note the effect of each category upon social behaviour. This goal, if met, means that Kearney's research contains implications for education, since educators, especially those practising from a constructivist epistemology, are interested in the prior understandings of students in order to more effectively communicate the science curriculum.

As a result of his research, Kearney has developed seven universal categories of worldview and has proposed a structure within which they relate. He has based his work upon an historical analysis of theories of worldview, together with case studies of various socio-cultural groups, in order to identify their structural relationships.

Logico-structural Categories

Kearney (1984, p.68ff) has identified seven universal categories that, together, constitute a person's worldview. They are Self, The Other, Classification, Relationship, Causality, Space and Time. These categories exist, according to Kearney, in an interdependent structure that he models according to Figure 5 below. Kearney refers to these relationships as an *integration* of universals, "the backbone of a worldview is the opposition and integration of the Self and the Other" (p.106). Kearney then makes the point that other universals depicted in his model derive from "the presence of Self and Other." Clearly, then, Kearney's model recognises the reciprocal relationships between various aspects of a person's worldview, but ascribes primacy to the Self/Other relationship.

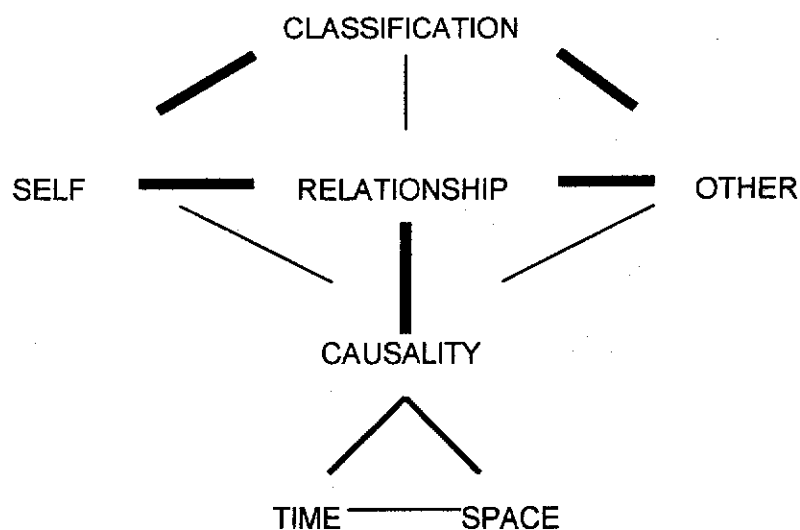


Figure 5. Integration of World-View Universals
(Kearney 1984, p.106).

While Cobern (1991a, p.43) has somewhat modified Kearney's diagram to show a more general interdependence, Kearney's original model emphasises the importance of the Relationship universal, which pertains first to the interaction between Self and Other, then to the universal structures of Classification and Causality. Cobern, on the other hand, has centralised the Classification universal in his depiction of Kearney's model, because, "The Self - NonSelf differentiation is the clearest, perhaps most significant example of a presupposition in the universal category Classification" (Cobern, 1991a, p.46). Despite this small difference, both Cobern and Kearney illustrate the importance of the individual's perspective of self in relationship to others, and the world around them, in the organisation of a worldview. The particular value of Kearney's model resides in its claim to universality, which, if warranted, means that it can be used to understand and describe worldview orientations regardless of their cultural milieu.

INDIGENOUS AND NON-INDIGENOUS STRUCTURES

Cobern (1991a, p.43ff) presents an accessible and readable discussion of each of Kearney's logico-structural categories but, unlike Kearney, also offers typical examples of differing worldview perspectives as they might impact formal education for indigenous students. Taking Kearney's logico-structural model, and Cobern's (1991a) interpretation of it, as my starting point, I have distilled, from a range of literature, statements that typify *perceived* differences between

indigenous and Western worldviews. In so doing, I am not stating that *all* non-Western persons share all of these worldview structures. I am saying, however, that I agree with Cobern's observations that many indigenous students share at least some of these structures with other indigenous students, but few of these structures with Western students, and the attached references indicate that I am not alone in this thinking. Furthermore, I conclude that worldview differences are most pronounced when comparing Western and Indigenous worldview structures, "Yupiaq ways of thinking about the world reflect a worldview distinct from the Western way of thinking" (Kawagley *et al.* P.137), but conclusions reached from that comparison might also apply to other populations.

Table 7. Typified structures of worldview.

Kearney's structure	western	indigenous	references
Self	disconnected	connected	Christie, 1984
	rational	intuitive	Cobern, 1991
Other	material	spiritual	Parish, 1991
	divisible (reductionist)	inter-dependent	Greer, 1992
Relationship	objective	subjective	Watson, Wade, '89
Classification	non-personal	personal	Harris, 1990
Causality	mechanistic	mystical	Sniveiy, 1990
Time & Space	abstract	participatory	
	linear (measurable)	eternal	Carroll, 1956

I have presented elements of Table 7 at an indigenous higher education conference (Baker & Koolmatie, 1994) and at a university conference for teacher educators (unpublished) with encouraging support from both indigenous and experienced non-indigenous teachers and students, so it is with confidence that I present it here in full.

Both Cobern and Kearney refer to the central role of 'Classification', 'Relationship' and 'Causality' to one's thinking about the world. In my extensive

review of the literature that has informed this grounded theory inquiry I have noted the frequent use of language suggesting that each of Kearney's categories can be further sub-categorised according to a person's understanding of knowing (epistemology), being (ontology) and valuing (axiology). I suggest, therefore, that epistemology, ontology and axiology are, in this context, sub-categories of worldview (cf. Jegede, 1994, p.8). The purpose of the sub-classifications illustrated in Table 8 is to more finely illustrate that teaching science cross-culturally is a worldview issue with implications at every level of understanding.

Table 8. Sub-categories of Classification, Relationship and Causality.

sub-category	western	indigenous
epistemology	intellectual	intuitive
	analytical	experiential
	individual knowledge	social knowledge
ontology	physical	metaphysical
	material relationships	spiritual relationships
axiology	self-determined	revealed
	impersonal / objective	personal / relational

If they are correct, as I believe that the evidence to this point suggests, the categories depicted in Tables 7 and 8 could influence formal learning in the following ways:

- Students with an indigenous worldview might respond to the empirical, objective nature of science education differently from Western students;
- The materialist explanations offered by science education might conflict with the spiritual worldview of many non-Western students;
- Science as 'personal research' might be less accessible to students whose worldview orients them toward shared knowledge and interdependence;
- The apparently impersonal values inherent in much text-book science might be in conflict with the person-centred values of many indigenous students;

- Those indigenous students who view life as an inter-relationship of all living things might find the observation, classification and dissection of specimens difficult; and
- The empirical processes of science might be counter to the intuitive nature of some indigenous students.

The preceding six points are consistent with the observations of Maddock (1981), who writes that:

Science, and being scientific, is not only a matter of knowledge and techniques but it is also a particular attitude to the world: that science has its own values, particularly patterns of behaviours and basic assumptions which are unique as far as any community of the non-Western world is concerned. (p.17)

Researchers have been concerned for some time about the apparent impediments to science for non-Western students (cf. Stone, 1967). Kearney's logico-structural model provides an empirical tool with which to explore that concern, but it does not help us to differentiate between the personal and socio-cultural aspects of worldview. I suggest that the personal nature of life-world experience and knowledge construction is such that no two people share identical worldviews, even those from the same cultural background. If this were not the case, change would never take place in any culture, since conservatism requires that alternative perspectives should either not exist, or should be subjugated by the dominant philosophy. Rather than representing dualistic, culturally-determined alternatives, the western and indigenous stereotypes presented in Tables 7 and 8 exist somewhere on a continuum, with very few people positioned at the extremes. It is possible, therefore, that each person within a cultural group might present a slightly different *worldview profile*. In using the term 'worldview profile' I have in mind a bar graph, on which, if it were possible, one could represent for an individual the relative strength of indigenous or Western perspectives in each of the structures of worldview. I have not, however, uncovered evidence to suggest that a 'worldview profile' might exist that is in any way similar to Ross and Sutton's (1982) 'concept profile', although my own observations lead me to believe that individuals seldom express a worldview whose elements are wholly Western or wholly non-Western.

The answer to the question, "How is it that some members of a cultural group master western scientific thought while others do not" appears to have less to do with intelligence, or cultural deficit, than with the similarity or disparity between the worldview of the individual (which is influenced by cultural factors and personal reflection) and the worldview of the curriculum and teacher (influenced by different cultural factors and personal reflection). If the aim of science education is to communicate western scientific thought, either to encourage 'scientific literacy' or to lay foundations for future scientists, I believe that it is crucial for science educators to understand the personal and shared worldviews present within the classroom, and the implications of worldview differences between Teacher, Curriculum and Student.

CONCLUSION

As a result of the preceding discussion, I conclude that language-use, Cultural beliefs and life-world knowledge are all aspects of worldview. Each is also an aspect of culture. Just as 'culture' provides collective meaning and "webs of significance" (Geertz, 1973) to the members of a society, I suggest that a person's worldview provides the reference points necessary for the making of personal meaning for an individual. Furthermore, I suggest that there exists an inter-relationship between culture and worldview, but they are not synonymous. Culture influences and helps shape each individual's worldview, and the interaction and agreement between the worldview of many individuals shapes their cultural landscape.

This inquiry has led me to understand that worldview is significant to formal education. Worldview determines the meaning attributed to events and communication, yet is not immutable, and is itself re-shaped by formal education. This suggests that uniformity of outcomes within a classroom is a problematic assumption due to the range of worldview interactions that will take place within a lesson. Constructivist theories of learning offer a framework by which to explore the role of worldview as *prior knowledge*, and its implications for teaching and learning, a perspective that is further developed in Chapter Seven.

CHAPTER SEVEN

WORLD VIEW AND CONSTRUCTIVISM

In this chapter I explore the relationship between worldview and constructivism in the context of science education. I suggest that constructivism provides a plausible explanation for the development of worldview, while maintaining that conceptual change theories do not provide adequate explanations or pedagogies for use in cross-cultural science education. The purpose behind this chapter is not to critique constructivism or compare it with alternative theories of knowledge development. As I have acknowledged in Chapter Two, I deliberately chose a constructivist paradigm because of its ability to inform and provide discipline to a subjectivist epistemology. My goal in this chapter is to explore similarities between the formation of one's worldview and the construction of knowledge in general. These similarities lead me to suggest constructivism as a referent for the understanding of worldview and its implications for the science education of indigenous students.

CONSTRUCTIVIST THEORY

Constructivism proposes that prior knowledge influences the development of new understanding by the individual learner. The metaphor of construction implies that a foundation exists upon which new structures will develop, since no-one comes to a new learning situation with a mind that is *tabula rasa*. That foundation is variously referred to as 'prior knowledge' (Gilbert *et al*, 1982; Osborne *et al*, 1983), 'alternative conceptions' (Driver and Easley, 1978), 'untutored or non-scientific beliefs' (Hills, 1989; Lawson and Weser, 1990), or common-sense theories (Coburn, 1991a; Hawkins, 1978; Hills, 1989).

Regardless of the metaphor used, there is general agreement by constructivists that previous ideas and experiences influence the way that new ideas are interpreted. This interpretation ultimately determines whether an individual accepts, rejects or modifies new ideas. As a result, knowledge, whether personally or socially constructed during a learning activity, might not represent perfectly the teacher's intentions, and almost certainly will not be an exact representation of the natural phenomenon that is the focus of the learning activity. Bodner (1986) argues that:

Social knowledge such as the days of the week or the symbols for the elements can be taught by direct instruction. It can even be argued that this is the only way that children can learn social conventions, but physical and logico-mathematical knowledge cannot be transferred intact from the mind of the teacher to the mind of the learner. (p.876)

While social constructivism in its various forms emphasises the role of social interaction in the construction of knowledge, personal constructivists posit that knowledge consists of cognitive structures formed in the minds of individuals (Kelly, 1955) or conceptual structures built upon prior knowledge (Ausubel, 1968) that, "cannot exist outside the bodies of cognising beings" (Bodner, 1986; Tobin, 1991, p.201). All of which leads to Bodner's pertinent question, "If individuals construct their own knowledge, how can groups of people appear to share common knowledge?"

The key to answering this question is remembering that knowledge must 'fit' reality. Construction is a process in which knowledge is both built and continually *tested*. (Bodner, 1986, p.875)

In past years personal and social constructivism have been viewed almost as polar opposites. More recently, however, I note a tendency to draw these explanations of learning together. In their exploration of the learning process, Driver *et al.* (1994) discuss the "interplay among the various factors of personal experience, language, and socialisation in the process of learning science in classrooms" (p.5). In other words they recognise that learning involves personal interaction with society and culture – personal knowledge construction in a social context (see Tobin & Tippins, 1993). Such a view of learning and knowledge resembles my definition of worldview, suggesting a connection between knowledge and worldview.

In the preceding discussion we see a move by researchers toward accommodating both the individual and social contexts of knowledge construction. Taylor (1993) goes further by referring to a *cultural* context:

Although knowledge has its (continual) genesis in the individual knower's mind, it also is intimately associated with culture, or the collective mind, that mediates its construction. (p.3)

Taylor's development of a critical constructivist view of learning increasingly makes use of imagery that I believe is as relevant to the construction of worldview as to the construction of knowledge. Taylor (1993) speaks of a "state of mind that provides a dynamic and evolving *conceptual lens* through which the natural and social world is perceived" (p.2). He notes that knowledge is not *transmitted*, but is *constructed* by learners "as a result of interpreting their experiences in relation to their extant knowledge" (p.3). The learner's extant knowledge has itself been shaped by those who "populate the learner's experiential world" (p.3); those who occupy Geertz's (1973) *webs of significance*.

The observations by Bodner (1986), Driver *et al.* (1994) and Taylor (1993) concerning the interaction between individual knowledge and cultural, or social, knowledge, resemble my definition (in Chapter 4) of worldview:

Worldview is the dynamic belief system of the individual, formed and shared through life-long interaction with one's culture, society, and environment, which disposes individuals and communities toward acceptance or rejection of actions and ideas.

I interpret from the preceding text that a person's worldview is best understood as a form of knowledge, which I suggest develops through a process of social and personal construction. I maintain that worldview construction takes place in the mind of the learner and in the context of the learner's socio-cultural milieu (Vygotsky, 1962). Constructivism, therefore, provides a plausible explanation of the way in which worldview develops and its effect on further learning. In the context of science education, this means finding ways to understand the worldview of students in order to teach the accepted canon of scientific thought in ways that are *intelligible*, *plausible* and *fruitful* to non-Western students, without displacing their pre-existing cultural foundations.

WORLDVIEW AND CONCEPTUAL CHANGE THEORY

Taking a lead from Taylor (1993), I think it is helpful to picture each learner as an 'individual-in-society'. Knowledge is constructed in the mind of the individual-in-society that is not necessarily an accurate representation of nature but an interpretation shaped by prior understandings and current social influences. As well, prior understandings are themselves a composite of personal and social construction:

It is likely that if prior knowledge exists as a consequence of cultural and personal beliefs and theories, then different groups will likely have different prior knowledge and alternative conceptions which need to be discussed during instruction. (Snively, 1990, p.44)

Prior knowledge, or prior understanding, is significant to classroom learning:

We are coming to realise how much children's responses to real-world science situations are guided by their own private ideas rather than by the propositions we have been at such pains to 'teach' them.

(Freyberg & Osborne, 1985, p.149)

What then is the function of these important prior understandings or 'private ideas'? Prior understandings are clearly personal knowledge brought to a situation as taken-for-granted explanations and are used implicitly (Garrard, 1987) in the interpretation of new ideas and experiences. Prior understandings, as noted by Snively, vary from group to group. I suggest that if prior knowledge exists as a consequence of cultural and personal beliefs it will not only vary from group to group, but will also vary from individual to individual. Prior knowledge will help shape one's present view of the world.

Constructivism has much to contribute to the work of curriculum developers and classroom teachers. It has the potential to explain in useful terms the relationships between teaching and learning, between personal knowledge and socially agreed knowledge, and between the symbolic nature of explanations and the lived nature of experience. Constructivism, however, fails the non-Western student when it fails to differentiate between scientific theory and worldview; when educators consider alternative explanations to be misconceptions, and hastily explore ways to change them without understanding their worldview origins. The idea that students will construct knowledge that is often at variance

with 'teacher's science' will continue to be a cause of concern to curriculum developers, but that concern does not justify inappropriate pedagogy.

The problem with constructivism arises when one tries to look at the logical consequences of the assumption that knowledge is constructed in the mind of the learner. (Bodner, 1986, p.874)

The conceptual change literature represents a significant school of thought that embodies constructivism and impacts significantly upon science education. As I reviewed this literature I realised the extent to which I had uncritically accepted much of the research of the past two decades. Conceptual change research has focused on developing pedagogical models directed toward adjusting students' *misconceptions* or *alternative conceptions* which seem to resist traditional modes of instruction (see reviews by: Driver and Easley, 1978; Driver and Erickson, 1983; Gilbert and Watts, 1983; Osborne and Wittrock, 1983; Pfundt and Duit, 1987), without investigating the cause and tenacity of those alternative conceptions.

Conceptual change models are predicated on two assumptions:

1. that instruction should commence with, and maintain, a focus on students' prior conceptions; and
2. the normative principle of education is *initiation* into the culture of Western science.

These principles are problematic for students of non-Western cultures, as the first assumes that the teacher fully understands the prior conceptions of the students, and the second assumes the superiority, or at least the universality, of a scientific view of the world. For this reason projects such as the Children's Learning in Science Project (CLISP) are doubtfully appropriate, especially in a classroom which includes students of non-Western cultural background. Inappropriate because, as Joan Solomon (1987) argues, the early conceptual change models of, for example, Posner, Strike, Hewson and Gertzog (1982), are based on a narrow rationalist perspective of cognitive psychology, whereas many non-Western people explain natural phenomena through non-rational means which are not easily susceptible to a didactic model of teaching (Ogunniyi, 1988).

Another cause for concern is the strongly individualistic nature of much of the conceptual change literature, arising as it does from Kelly's (1955) personal

construct theory. Solomon (1987) argues that the persistence of students' alternative frameworks, despite careful refutation by experiment and argument, is evidence of the failure of personal constructivist pedagogies in addressing important aspects of their life-world knowing. Solomon argues that the individual's perception of reality is constructed *intersubjectively*, that is, socially negotiated between those who share meanings and social perspectives. In other words, much of a student's knowledge is constructed 'in community', and the strength of the community bond has a bearing on the student's openness to ideas from outside the community, a characteristic of indigenous communities that has particular relevance to this study (cf. Christie, 1984). Driver (1990) acknowledges the power of cooperative class room strategies, but, like Osborne and Freyberg (1985), discusses the classroom as if it were a 'culture-free zone'. My experience of students in the Solomon Islands leads me to believe that the classroom is a 'culture-rich zone' and suggests that Joan Solomon's explanation of intersubjective construction is very relevant to science education.

The following account illustrates to me the extent to which many indigenous students' knowledge is constructed 'in community', regardless of the imported teacher's wishes. In an experiment involving 40 Solomon Island Form 2 (Year 8) students, I completed a teaching unit on plant types by giving them a 'cloze exercise' in which words had been deleted from a selection of plain language text. The students were asked to insert a word, any word, that made sense in that sentence and showed their understanding of the characteristics of various plant types. After class I saw, and confirmed through interviews, that most students went from one to the other seeking a consensus of suitable words. My observation and subsequent questioning of individual students suggested that this was not simply a case of comparing answers. Students evidenced a genuine angst at this novel (to them) teaching method. Their behaviour was consistent with my previous classroom observation that students considered the lesson complete when they had perfectly copied down the teacher's notes and instructions. An open-ended question became, therefore, a cause of uncertainty, which was resolved through recourse to a trusted social setting. My observations are supported by Ninnes (1994), who notes that "other learning systems such as those found in Western-style classrooms may be at least partly dysfunctional for children from non-Western cultures" (p.677).

In his study of informal learning modes used by Solomon Island children, Ninnes (1995) notes that 'observation', 'imitation' and 'maintaining good relationships' are powerful strategies in the natal teaching/learning process. My Solomon Island students employed a traditional epistemology when they sought to collectively determine the 'one right answer' for each blank space, revealing the intersubjective nature of knowledge construction by some indigenous people, and the importance of a culturally relevant pedagogy.

A third cause for concern about conceptual change theories relates to the integrity of non-Western knowledge and world views. The early conceptual change literature appeared to imply the superiority of a Western scientific view of the world, and dismissed alternative views as *misconceptions*. This *scientific* position remains pervasive, despite the more recent re-structuring of conceptual change assumptions (see Driver, 1988, 1990; Driver *et al.*, 1994). Although researchers increasingly acknowledge the importance of language and social interactions in the science classroom, the continuing conceptual change goal is to *restructure* students' alternative ideas in favour of the (provisional) scientific, or *authoritative* view (see Hewson *et al.*, 1998). The notion of restructuring implies that the goal of instruction is to re-configure ideas, knowledge and beliefs to make them compatible with scientifically acceptable views. In a cross-cultural context there is a danger, therefore, that conceptual change teaching might serve as little more than an agent of cultural imperialism, referred to by McTaggart (1988) as 'colonisation of the mind' (cf. Baker & Taylor, 1995), since colonisation is about subjugation by the dominant authority. Instead of introducing students to science as the product of Western-styled inquiry, a conceptual change model risks introducing science as *truth* in contrast to *indigenous myth*. Instead of assisting students to develop skills and knowledge based upon scientific principles, but which are compatible with their own cultural perspective, a naive conceptual change model could tacitly supplant indigenous culture with scientific culture and is, therefore, inappropriate if non-Western students are to maintain their cultural identity as scientists. Above all, a conceptual change model risks bringing about the rejection of science by indigenous students as they react against ideas, ways of knowing and values that are not consistent with their own strongly held prior understandings.

So, on the basis of its inappropriate rationalism, individualism and a lack of cultural integrity, I conclude that conceptual change theory can be problematic when used uncritically as a theoretical framework for science education among some non-Western students. I suggest that the issue for indigenous students is not conceptual change, but worldview change, or the willingness to accommodate perspectives from a different worldview.

While many Westerners accept that scientific explanations are culturally neutral and objectively true, justifying the desire to correct students' alternative explanations, the implicit cultural bias of many scientific explanations might make no more sense to a person from another culture than traditional explanations would to a Western educator (see Rodie's Story, p.83). While a Western educator might maintain that science cannot make allowances for non-science, the fact remains that non-Western students tend to either reject deterministic teaching or to hold their life-world and symbolic knowledge in tension, applying each as the situation demands (Maddock, 1977). The reason behind this dualism is belief in the literal reality of a metaphysical world; a belief that is widely held among all populations, but especially those of non-Western tradition (Nida, 1954; Snively, 1990; Overend, 1991a).

Recognition of the power of worldview to shape knowledge construction could assist teachers to communicate science in terms that are fruitful and plausible to indigenous students. Rather than label as a misconception every idea that appears to compete with 'scientific knowledge', it would be more helpful if science educators were to acknowledge that the explanations found in science texts are derived from a *scientifically-compatible* worldview (Cobern 1996b, p.585). That is, they represent the taken-for-granted assumptions implicit in a scientific explanation of the world, and are shared by most members of the scientific community of teachers and researchers, but are not wholly shared by many non-Western students. Such an admission can enable science educators to lay a foundation which can be built upon by non-Western scientists from the perspective of their own culture, for, as noted by Ogunniyi (1988, p.3) "The African concept of causality, chance and/or probability, is based upon a different logic from that of science". In other words, it is based upon a different worldview, and might give rise to different meanings.

WORLDVIEW AS KNOWLEDGE

As I have indicated in the preceding two sections, there appear to be similarities in the development and structure of 'knowledge' and 'worldview'. According to Proper *et al.* (1988), "The concept of worldview is central to education because it is closely related to the concept of knowledge" (p.547). If we accept that knowledge in a constructivist sense is personal knowing intersubjectively constructed, and since it has been demonstrated by Kearney (1984) and Cobern (1991a) that worldview structures are "cognitive categories" (Kearney, 1984, p.65), it stands to reason that worldview is a specific type of knowledge.

It remains, then, to ask, "What type of knowledge is worldview?" Miller and Kandl (1991) maintain that real conceptual understanding involves a knowledge of the *what*, *how* and *why* of experience. I suggest that any reflection upon the *why* of experience is shaped by, and in turn shapes, one's worldview. Worldview is, therefore, a specific and dynamic knowledge *of* rather than *about* events. Based on the constructs of worldview depicted in Tables 7 and 8, worldview is the knowledge of life, culture and meaning that is evidenced in the *underlying* issues of epistemology, ontology and axiology. Worldview is that "dimension of the stock of knowledge" (Shutz & Luckmann, 1973, p.146) that ascribes meaning and value to all other ideas and experience and thereby influences further learning, affects actions and contributes to knowledge construction to further "provide the meaning-structures of the daily life-style" (p.127). Consistent with the findings of Miller and Kandl (1991), that students gain a clearer mathematical understanding as they experience activities that demonstrate the *why* of a mathematical concept, I suggest that worldview is built upon the 'experiential knowledge' of the individual rather than 'theoretical knowledge'. Even the knowledge formed through the stories of infancy can be described as experiential since their value and veracity depends upon the relationship between the story-teller and listener, and upon the ability of the story-teller to involve the listener.

Reflecting on my understanding of worldview-as-knowledge prompts me to investigate 'meaning', since the making of meaning is important to learning. Constructivists say that the construction of meaning takes place 'within the mind of the learner' (Ausubel, 1978). Indeed, the value of any information is determined by its meaning to the individual, and meaning cannot be simply transferred between individuals, due to the risk of distortion. Hardy and Taylor

(1997) argue from radical constructivism that people cannot share or construct *identical* meanings but, rather, *compatible meanings* (p.142). In like manner, two individuals cannot form identical worldviews, but they might form compatible worldviews.

It has been shown by Arca (1983) that a learning experience, no matter how scientific the focus, is not merely the receipt of technical information. According to Arca, making meaning involves a 'deep restructuring' of one's cognitive [or conceptual] structures, "In proceeding from common to scientific structures... a total restructuring always occurs" (p.374). The function of each student's worldview in formal education is to interpret symbolic explanations in light of the student's existing 'meaning structures'. Previously constructed knowledge of the world, together with knowledge *about* the world, shapes future knowledge construction. If we view the learning of science as a simple process of learning 'factual knowledge', or of changing 'prior knowledge', and neglect the role of worldview as a 'filtering agent' in the learning process (cf Rogers, 1969), we will not understand the crucial role of worldview in the making and re-making of meaning and the construction and re-construction of knowledge.

Put simply, worldview is that aspect of one's stock of knowledge that ascribes value to the events of daily life, interprets events and ideas in the light of existing meaning structures, and plays a role in the further construction of knowledge. As such, worldview is knowledge that has been constructed over time, is taken for granted, and is drawn upon as a 'touchstone' of reliability against which new ideas are consciously and sub-consciously compared. As knowledge, one's worldview is changeable, depending upon the ability or willingness of the individual to reflect upon taken-for-granted assumptions in the light of a novel idea or fresh evidence. Because it is knowledge, an individual's worldview will vary, if only slightly, from the worldview of others. Compatible worldviews, on the other hand, will often be found among individuals who share a cultural heritage or who know similar life experiences. If teachers are to help students, particularly indigenous students, to construct scientifically compatible knowledge they must understand the shared worldview of their students and be prepared to accept that differences in worldview will be a characteristic of any classroom.

WORLDVIEW AND THE LEARNER

To me, worldview theory explains an aspect of learning that has, to date, been insufficiently considered in cross-cultural curriculum development and pedagogy. Each person's worldview enables them to make sense of the events of daily life, including formal education, by comparing them with accepted understandings and beliefs built up through prior learning experiences. Worldview is a knowledge structure that pre-dates formal learning and is usually accessed unconsciously in the form of taken-for-granted assumptions about the meaning of ideas and actions, yet it continues to change and develop throughout life, responding to reflection and informing perception. Worldview, therefore, is a significant factor in science education, and the notion of worldview conflict appears to explain 'educational alienation' and Okebukola's (1990) "achievement deficit" among indigenous students.

Having concluded that the "achievement deficit" of many indigenous students is real and is the result of conflict between the worldview of the student and that of the teacher and/or the curriculum, I am left with a dilemma of *praxis*. How do I, as a teacher steeped in a Western perspective of science, with a worldview shaped by experiences quite dissimilar from those of my indigenous students, help them to develop a scientific understanding that is *intelligible, plausible and fruitful*, without erecting barriers to learning or separating them from their own cultural roots? Surely an understanding of this dilemma is crucial if educators are to assist non-Western students develop a knowledge of the Western scientific tradition and conduct 'science' that reflects an indigenous perspective. If this is the case we educators must resist the temptation to reduce worldview awareness to another normalising process within education, simply replacing 'conceptual change' with a mistaken desire to bring about deliberate 'worldview change'. Cobern (1991a) pursues many of the implications of worldview theory in his monograph, emphasising the importance of contextualising science education and alerting us to the danger of using science education as a tool to, in some way, 'homogenise' all thinking toward a so-called 'scientific worldview'.

If teachers intend science to be accessible to all students, our pedagogy needs to reflect the diversity of our students' worldviews. Cobern (1996b) says, "My concern is not about cultural change *per se*, but about unwarranted influence" (p.302). I am concerned that non-Western students should have genuine access

to a useful understanding of scientific explanations and processes, a necessity if indigenous students are to understand scientific principles to the extent that they can be successfully applied to indigenous concerns, without finding that a complete worldview shift is a pre-requisite to understanding scientific ideas.

STUDENTS' VIEWS ABOUT SCIENCE AND CULTURE

Research into Students' Views of Science

A friend and colleague, one of few Solomon Island nationals with degrees in science education, recently conducted an unpublished study of the attitudes to science education among 444 Solomon Island secondary students (Rodie, 1997). His study reveals some concerning and contradictory results.

1. Most students (between 70 and 90 percent, depending on the question asked) indicated that they have a high opinion of science, expressing the belief that science is exciting, that they look forward to science lessons and they wish to achieve high grades. Despite these responses, students generally score poorly in state and school-based examinations.
2. It is evident from Rodie's analysis of students' responses that a significant number of students lack understanding of basic science concepts and principles to be able to answer exam questions. (Rodie, 1997, p.21).
3. Students indicated strongly that they see the study of science as important, and would like to follow a career in science, but there are currently fewer than 100 students studying secondary school science at the pre-university level, and the majority of these are doing so, according to Rodie's observations, to boost their final results rather than as a precursor to tertiary science courses.
4. Although students indicated that "indigenous science is useful" they also responded ambivalently when asked whether people from "different cultures practice different sciences" and quite negatively to questions that asked whether science can be practised by other than science teachers, science students or scientists.
5. Students described the teaching style of their teachers as teacher-directed, heavily biased toward the giving of notes, and involving the students in little practical scientific investigation.

Rodie and I agree that the students' responses are consistent with our experience in that country. We have each observed that students have not been encouraged to value or explore the relevance of their traditional explanations, to engage with science education as a problem-solving activity or to view science as having its own cultural context. Students have not been exposed to a view of science as a system of investigation and description deeply rooted in Western cultural traditions, and we have observed the inclination to view science as a fixed body of universal facts that should be memorised rather than understood.

Rodie's findings are not, it seems, specific to non-Western students. In his recent paper, Aikenhead (1997) found that Canadian students demonstrated very similar attitudes. Aikenhead concludes that only a minority of students appreciate the "pervasive influence of culture on scientific thinking" (p.424). Aikenhead's Canadian students demonstrate the same idealistic view of science and scientists as Solomon Island students, American students interviewed for the Yager studies from 1983 to 1988 (e.g., Yager & Pennick, 1988), and African students interviewed by Jegede (1989) and Talukdar (1995). Why? Because that is the way science is taught by teachers who themselves have been schooled in a detached and deterministic model of science education, as pointed out by Hawkins and Pea (1987):

Science teaching which neglects the link between science and the students' every day life appears to transform school science into a set of inert ideas [that] are not generative, not interactive with the explanations children have constructed themselves for natural phenomena. (p.298)

It would appear that, for at least some Western students, there are 'cultural borders' that must be crossed in order to enter fully the domain of classroom science (Aikenhead, 1995; Chevallard, 1990). Many students, whether Western or non-Western in culture, appear to consider science to be the domain of those who think scientifically. Many do not appear to see readily the connection between science and culture, but appear to view science as a body of facts to be learned (Yager & Pennick, 1988), whereas culture is something one lives. The ways in which science is presented to students of Western and non-Western cultures appears to unnecessarily discourage many from further study of the sciences. If this is indeed the case, the impact of worldview on the study of science is much wider than I at first imagined, lending weight to the argument that

science education exhibits many of the properties of a culture (Hawkins & Pea, 1987). Worldview conflict is most noticeable among non-Western students, but might also affect students of Western cultural heritage whose worldview is at odds with the culture implicit in the science classroom.

It seems to me that my desire to understand the reasons behind the educational alienation of many indigenous students has led to a more general application of worldview theory. While worldview conflict in formal education seems most noticeable among indigenous students, it also appears to exist among other non-Western and some Western students, a conclusion that has implications for future research concerning worldview and learning. It appears to me, based on this research study, that the further a student is culturally situated from the cultural assumptions of science education the greater is the probability of worldview conflict (cf. Greenfield, 1996).

I now consider my grounded theory research to be complete. I have arrived at a point where I can summarise the work and propose a theory that is capable of answering the research questions, an undertaking I attempt in Chapter Eight.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

In this, the final chapter, I review Phases One and Two of the study, summarising my findings and showing how the research questions have been answered. The chapter concludes with a number of questions whose pedagogical implications are derived from this research study and have the potential to inform science teachers in non-Western cultures. These questions will form the basis of my further research efforts.

My initial purpose for conducting this study was to explore the research question, "*Does the culture of the learner affect the outcomes of science education?*" Phase One of the research consists of a literature review (Ch.3) and the interpretation of data derived from an Integrative Research Review (Ch.4). The data emerging from this review were analysed and interpreted, together with my personal experience of indigenous education in Australasia, using a Grounded Theory Research model. Three major themes became apparent - Language-use, Cultural Explanations, and Life-World Knowledge - as a result of which a second research question emerged: *What is the impact of worldview on teaching and learning?* This question was pursued in Phase Two of the inquiry through a continuation of the Grounded Theory method, analysing literature concerning worldview, and pursuing the emergent themes.

PHASE ONE

Phase One of the study consisted of two parts, each exploring the first research question, "Does the culture of the learner affect the outcomes of science education?" The first part of Phase One was a literature review, which is presented in Chapter Three, entitled *The Problem in Perspective*. My goal at that time was to find literature that might shed light on my observations and concerns. My reading of the literature concerning indigenous education in Australia, North America and Western Pacific nations, together with my later exploratory study of the enrolment patterns of Aboriginal children in Western Australia, confirm to me that a problem exists in the education of indigenous students that vindicates my use of the term 'educational alienation', and justify further exploration of the relationship between culture and science education.

Identifying the Alienation

The first part of Phase One confirmed the existence of alienating factors in the educational experiences of many non-Western students. It did not, however, identify the factors. As I have stated on page 46, "It is clear from the reading to this point that research into the affect of culture upon formal education is warranted." To fulfil this warrant I embarked upon the collection and interpretation of data through an Integrative Research Review (IRR) whose methodology is described in Chapter Two, *The Research Methodology*.

As I embarked upon the second part of Phase One it became clear to me that all but the earliest of my sources (e.g., Greenfield, 1966; Prince, 1969) had moved away from Piagetian methodologies and their implied universal conclusions, finding that Piagetian measures of cognitive development, such as the notion of conservation, are Euro-centric and culturally invalid for non-Western children (Kearins, 1986). Later researchers have focussed instead on cultural factors affecting formal education, the most significant of which the IRR has shown to be Language-use, Cultural Beliefs and Life-world Knowledge. I have interpreted these themes in Chapter Four, where I have also listed my principal sources for the Integrative Research Review (IRR), early results of which have been published (Baker & Taylor, 1995).

Cultural Conflict

The themes interpreted in Chapter Four, Language-use, Cultural Beliefs and Life-world Knowledge, each contain a number of implications for pedagogy. Factors that appear significant to the formal education of non-Western students are:

- the use of a second language for formal education;
- the connotations of commonly used words;
- beliefs that conflict with scientific theory;
- epistemologies that differ from that of Western science curricula;
- taboos; and
- learning styles of the students.

Each of the three themes in Chapter Four also suggests some form of 'worldview conflict'. Whether we are looking at the effect of language-use, cultural beliefs or prior life-world knowledge, we see structures of prior knowledge that are often in

conflict with the knowledge assumptions of Western curriculum and Western trained teachers. It would appear that it is not necessarily the subject material of the curriculum that results in 'educational alienation' for non-Western students, nor is it their innate intellectual capacity that results in an 'achievement deficit'. Instead, this study suggests that 'educational alienation' and 'achievement deficit' result from a conflict between the student's taken-for-granted world and the constructed world of Western science education.

I am confident that Phase One of the study answers the first research question by suggesting strongly that the culture of the learner affects the outcomes of all learning experiences, specifically science education, by contributing to the construction of a worldview that can assist or impede the outcomes of formal education. Phase One suggests that students would benefit from studying science in the language they have used from earliest childhood because early exposure to a language enculturates the student into the symbols and implied meanings of the culture that 'owns' and develops the language. Phase One also suggests that conflicting beliefs and epistemologies influence the student's perceptions of natural events, sometimes resulting in an interpretation at odds with the sequence of observed events. Life-world knowledge was shown to have a normative effect upon knowledge construction, often resulting in the rejection of new ideas in favour of the old, a process which has been described in terms of a conflict between the symbolic knowledge of formal education and the life-world knowledge of the student (Solomon, 1983).

In Phase One of the study, I was unable to explain 'how' or 'why' a student's language-use, cultural beliefs and life-world knowledge might result in educational alienation. Phase One showed only that language, cultural beliefs and life-world knowledge contribute to the formation of an individual's worldview. 'How' and 'why' worldview can result in educational alienation necessitated Phase Two of the research project.

PHASE TWO

The second phase sought to explore the emergent question, "What is the impact of worldview on teaching and learning", and began as a study of the relationship between culture and formal education, especially science and mathematics education. As a result of Phase Two I tentatively conclude that, in the context of

formal education, culture is a tenuous, multi-faceted notion that lacks the specificity needed to explain the 'educational alienation' experienced by many non-Western students. "The variety of ways in which the term 'culture' is used has not helped me to be specific about its meaning when applying the term to classrooms, curriculum or learning" (see, p.80). I suggest that 'worldview' provides a more comprehensive basis for understanding educational alienation because language-use, cultural beliefs and life-world knowledge shape, and are shaped by, one's worldview. It remained, then, to explore the notion of worldview to discover whether it could, in fact, explain educational alienation more adequately than could the notion of culture.

My study of worldview uncovered Kearney's (1984) seven structures of worldview. Each structure represents an infinite number of possible taken-for-granted assumptions that might form the foundations of each individual's thinking, or worldview orientation. These assumptions influence the way in which a student will interpret new ideas and experience, resulting in beliefs that ultimately shape actions. Tables 7 and 8 suggest that students of similar cultural heritage might share similar orientations in one or more worldview category or sub-category, enabling me to speak about 'typical' Western and indigenous worldview orientations.

Throughout Chapters Five and Six I have explored and documented the meaning of worldview, and suggest that it is the student's individual, dynamic worldview interacting with the culture of the classroom that affects the outcomes of formal science education. This interaction would influence the rejection, accommodation or assimilation of ideas and would need to be addressed if we are to make science education more accessible to non-Western students.

Learning is Shaped by Worldview Interaction

As a result of the inquiry summarised in the preceding section, I feel that a well-warranted claim can be made that a focus upon 'culture' in learning does not help us to understand 'educational alienation'. Worldview theory, on the other hand, appears to be helpful, because it has the power to explain how and why language-use, cultural explanations and life-world knowledge influence the outcomes of formal education. This power is derived from an understanding of

worldview as specific knowledge, the formation of which is understood through a constructivist explanation of learning.

A major concern with using a constructivist explanation of worldview is that it could be assumed to support conceptual change pedagogies, against which I argue on the grounds that they are likely to fail the non-Western student due to an inappropriate rationalism, individualism and a lack of cultural integrity. I do acknowledge the shifting position of many researchers within the conceptual change movement, particularly Rosalind Driver and colleagues (Driver *et al.*, 1994), and would not wish to typify their position as deliberately Euro-centric in its explication of conceptual change. I simply wish to point out that the results of this inquiry do not suggest that a naive conceptual change strategy is a solution to students' achievement deficit in science. Instead, this study challenges me to adopt a *pedagogical change* which calls for a review of the ways in which language-use, cultural beliefs and prior life-world knowledge are treated, both within the classroom and in the preparation of curriculum materials.

I propose that considerations of worldview as an implicit, culturally determined framework that governs thought and action without due cognizance of the implications of constructivism are not helpful to educational research. I propose that worldview is a specific type of knowledge, constructed and re-constructed from early childhood. I suggest that worldview is changeable through personal reflection, and that it is not only one's natal culture that contributes to its formation, but also the cultures in which the individual participates throughout life: school culture, work culture, and the culture shared by a group of science professionals.

A study of worldview can explain 'how' and 'why' culture affects the outcomes of science education as teachers and students interpret the curriculum. In this process novel ideas are compared and contrasted with existing 'taken-for-granted' assumptions about the world and are accommodated, assimilated or rejected in relation to the known. The acceptance of new ideas could result in a fundamental change in the organisation of the individual's worldview, a process that I have described as 'cathartic reflection'. Accordingly, I propose a fresh definition of worldview:

Worldview is the dynamic belief system of the individual, formed and shared through life-long interaction with one's culture, society, and environment, which disposes individuals and communities toward acceptance or rejection of actions and ideas.

Awareness of the sort of worldview perspectives that might exist among non-Western students is the first step toward using positively the cultural and personal precepts of students to advance their understanding of science education.

Pedagogical Implications

Some specific questions that arise from my research, whose answers have the potential to inform science education for non-Western students, are:

1. What is the nature of my own and my students' worldview orientations?
2. How compatible are these orientations?
3. How might I encourage my students to recognise the distinctives of their own personal and cultural worldview perspectives?
4. How might I use and value cultural perspectives that could act as 'bridges' to learning science while valuing the student's culture?
5. Do I understand the ways in which language is locally used, and the interaction between local language and the language of the classroom, especially regarding its enculturation/acculturation effects?
6. Can I identify specific cultural behaviours and taboos that might impinge upon the classroom setting?
7. Are there specific cultural teaching and learning styles that students have previously experienced that I should understand in order to better teach?
8. What are the classroom implications of the idea that science is part of the cultural capital of the West and should I, as a teacher, encourage students to view scientific skills and information as having a cultural context?
9. By what means can schools help teachers and families to recognise that the cultural capital of a society is stored in its stories and literature, and that the early immersion of children in that culture through cultural activities, reading where appropriate, and language, helps shape the child's worldview in a given direction?

10. How might I structure my teaching to ensure adequate exposure to scientific ideas without destroying indigenous students' natal culture?

11. If it is ultimately the students who will choose to 'cross borders' into the culture of science, how might schools make this possible but not mandatory?

Each of the preceding questions is the result of my interpretation of the data available to me and contains implications for my future teaching and inquiry.

Theoretical Outcomes of the Inquiry

On page 15 I note some of Denzin and Lincoln's (1994) criteria for constructivist inquiry:

criteria for evaluation - trustworthiness, credibility, transferability, confirmability;

form of theory - substantive-formal;

type of narration - interpretive case studies, ethnographic writing.

In my opinion, these criteria have been met, and the result of my inquiry is substantive theory pertaining to the interaction of culture and formal education. The perspective on worldview, culture and education explicated through this text is, I believe, new to the science education debate. Specific issues have been identified in the text that, if taken up by myself or others as grounds for further investigation, have the potential to positively affect the way science is taught to and learned by non-Western students. I have raised issues for debate, and have challenged a number of commonly accepted views concerning culture and worldview. By defining worldview as personal knowledge, and explaining its development in terms of constructivist theory, I have provided a theoretical perspective with the potential to explain the achievement deficit and educational alienation of many non-Western students. By so doing, I have also provided opportunity for educators to review their own perspectives and to further the discourse by challenging my findings and by ensuring that sufficient justification exists for their own positions. I look forward to continuing the research and published debate that I believe will emerge from this line of inquiry.

Note: For copyright reasons Appendix One containing the following newspaper articles, has not been reproduced.

Brown, Maxine, Aboriginal youth 'deeply scarred', Sunday Times, 11.2.96.

Martin, Roger, Aboriginal education 'a failure', West Australian, Saturday, May 30, 1996.

Yu, Peter, Gates that block a path to learning, West Australian, 14.9.96.

(Co-ordinator, ADT Project (Retrospective), Curtin University of Technology, 4.12.02)

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