CHAPTER 3

LITERATURE overview

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Introduction

In this literature review I present an overview of the areas of knowledge (not discussed in the Theoretical Framework of Chapter 2) that pertain to the study. Lemke (2001:303) points out, "it is important that familiarity with the classical literature of the contemporary social sciences …is fundamental (for research in science education)" – hence the literature scope enlarges. Because the study incorporates a wide range of issues this review presents a general overview of each domain and not a thoroughly comprehensive discussion of each area. I have also included emergent relevant literature in Part 2 in the Themes.

Science Education Context

Science Education in South Africa

Ever since the introduction of missionary schools in Africa the dominant paradigm of science education in South Africa at least up until 1994 has been one of logical positivism with the imposition of Western values, beliefs, languages and epistemologies (Kallaway, et al., 1997; Taylor, 1998; Odora Hoppers, 2001a). This hegemony of Western science has closed down the possibilities of reflecting on alternative ways of knowing and on other ontological perspectives. While acknowledging the liberalizing effects of Western education in Africa, Mazrui (1978) claims: " … it has also been a case of intellectual dependence." This he goes on to define as: "excessive reliance on an alien reference-group for ideas and analytical guidelines." It is ironical that this amounts to a most unobjective teleological bias towards objective science. Odora Hoppers (2001b) warns that in elevating the status of Western knowledge African perspectives are annihilated. The text books used traditionally in schools and universities in South Africa provide evidence for this claim. (See for example: Brink & Jones, 1987; Serway & Faughn, 1995.) Over the past few years there have been some significant shifts in the presentation, content and contexts used in text books and materials. Exemplary Units produced by GIED[3] and books such as ‘Science and Technology for All’ (Moodie & Thomas, 2002), have included relevant contexts and been sensitive to multiculturalism and a variety of learning styles. However, it is still the dominant culture (in South African science education this is *Western* culture) “that decides who learns what and how” (Lynch, 2001).

The perception of the superiority of Western science has taken hold to the point of being invested with all sorts of status and axiomatic truth values by educational institutions and the public, so that it has a degree of support from the very communities who are marginalized and disadvantaged by its hegemony (Rollnick, 1998a). Odora Hoppers (2001:b) claims that the teaching of Western science in African schools has the deliberate political agenda of “rewarding mimicry, docility and passive assimilation”. The problems of rote-learning and passive acceptance of power relationships and curricula in schools rest largely on pedagogy (Kuiper, 1998) and not only on the politics of promoting Western science. It is this problem (of transmission teaching styles) that many new text books are trying to address, perhaps more than the needs of marginalized African communities. When the curriculum is alienating, rote learning may be the result.

Odora Hoppers (2001b) sees as negative influences on African education not only the process and legacy of colonization but also the current process of globalisation. She claims that globalisation inculcates and is driven by individualism, indifference to others, and competitiveness. These ideas are shared by Roddick (2001) who draws the dichotomy not so much between Western and African interests but between ruthless and powerful corporations and poor communities everywhere. These accusations ignore benefits of globalisation such as electronic communication (even if not enjoyed by poorer communities, these communities may benefit by more efficient processes of administration and delivery) and the sharing of knowledge and resources as is evident in the World Summit on Sustainable Development in Johannesburg (WSSD, 2002).

Odora Hoppers recommends that there be an exploration of knowledge and values that will draw on an African perspective to support democracy and that there be dialogue between knowledge systems. (Odora Hoppers, 2001b) This increase in dialogue is supported by concepts of globalisation.

[3] Gauteng Institute of Educational Development (See “Where our Footprints come from” or “Working Together Scientifically”.)

Consequences of globalisation are not only economic and educational but also sociological (Hallak, 2000; Watson, 2000), impacting on schools and curriculum. The communities participating in this study fall into a category described (by Hallak) as 'left out by globalisation', but perhaps they are moving towards 'being globalised' by his third category, 'those who globalise'. The reaction to globalisation he describes as "social schizophrenia", as it contributes to the weakening of the family and national identity. Education can counter this by promoting respect for cultures, both one's own and others'. Other effects of globalisation are a trend towards the growing use of English internationally and increasing disparity between rich and poor (Nzimande & Mathieson, 2000; Watson, 2000; Malcolm, 2001b; Roddick, 2001). Such trends should not go unexamined in the design of education policy and curriculum. Programmes that attempt to cater for different needs and contexts need to take care not to increase the gulf between privileged and excluded communities. Some traditional divisions may in this regard be unhelpful and need to be reassessed, for example, between academic education and vocational training (Christie, P., 1997).

This discussion outlines the field-of-play in investigating marginalized interests and in designing new curricula in conjunction with interested participants. There is clearly a need to weigh up the pitfalls of subscribing uncritically to the process of rampant economic globalisation while making sure no one is left out of the game (Mebrahtu, Crossley, & Johnson, 2000). Through sharing information and in-depth discussions this research project hopes to shed light on these conflicting issues.

Education Policy

This is a most fortunate time for educationists in South Africa as repressive outdated policies have been replaced with ones that are based on equity and democracy and encourage innovation, multiculturalism, learner-centredness, integration and contructivist pedagogies. The National Curriculum Statements for Grades 1-9 (the General Education and Training Phase) – which is the group we primarily worked with in this study – is based on the following principles:

- Social transformation
- Outcomes-based education
- *High knowledge and skills*
- Integration and applied competence
- *Progression*

- *Articulation and portability*
- Human rights, inclusivity, environmental and social justice
- Valuing Indigenous Knowledge Systems
- *Credibility, quality and efficiency*

(DOE, 2003:1 -my italics)

Those points that I have italicized are ones that will prove to be a challenge to our intervention project. The remaining five are strongly supported in our study. This is not to say that the four italicized are not possible in my proposed model – but they are the ones that have received questioning and are problematic from various perspectives. I discuss this in the Epilogue.

Three sets of outcomes outlined in the NQF[1] policy are pertinent in this study: the Critical outcomes; Developmental outcomes; and Physical Science learning outcomes. In summary these are:

Critical outcomes:

- Identify and solve problems and make decisions using critical and creative thinking
- Work effectively with others ….
- Organise and manage themselves and their activities …
- Collect, analyse, organize and critically evaluate information
- Communicate effectively using visual, symbolic and/or language …
- Use science and technology effectively and critically showing responsibility the environment and health of others
- Demonstrate an understanding of the world as a set of related systems…

(DOE, 2003:2)

It is interesting that in these outcomes, common for all learning, science and technology are particularly mentioned. These outcomes formed the underlying basis for our curriculum work with students and community, as do the following NQF requirements: (also shortened)

Developmental outcomes:

- Reflect on and explore a variety of strategies to learn…
- Participate… in local, national and global communities
- Be culturally and aesthetically sensitive…
- Explore education and career opportunities
- Develop entrepreneurial opportunities

[1] National Qualification Framework

(DOE, 2003:2)

Physical science outcomes:

These align to the foci of ‘doing, knowing, and being’.

(DOE, 2003:13/14)

These three sets of outcomes resonate with the project’s human rights, democracy and social justice framework. They also provide encouragement for working in rural communities. However, challenges remain in the interpretation and implementation of the policies. For example, balancing local and global issues and opportunities in poorly resourced rural areas, or developing learner-centredness (which, although generally accepted by teachers, is practised in form rather than in spirit (Chisholm et al., 2000). For the main, teaching remains teacher-centred (Taylor & Vinjevold, 1999); it would be hoped that “co-operative learning is more than students working in groups” (Bybee, 1993:108). The type of curriculum that can foster the prescribed outcomes remains persistently elusive.

Curriculum Studies

Traditional knowledge and Western science have common aims in interpreting, explaining and predicting events and phenomena (Aikenhead & Solomon, 1994; Horton, 1971). The characteristics that provide the various dimensions of Western science are also common to traditional knowledge. These dimensions are: characteristic knowledges, activities, contexts, purposes, structures and belief systems (Brown & Miller, 2001). In each domain, however, (Traditional Knowledge and Western science), the character and content of these dimensions are different. The *belief* in science concepts, has received perhaps less attention than some of the other dimensions. Brown and Miller (2001) contend that there is a shared system of assumptions and beliefs in science that alienate and exclude those who are not acculturated into them. Gauld (2001) makes a similar point about the style of science textbooks which generally assume to be presenting the one and only Truth. In spite of the apparent hegemony of Western science, there is contention even within established conventional science curricula: the nature of science is not unambiguously agreed upon (Osborne et al., 2001). (I discuss this in greater detail in the section on Nature of Science.)

The provision of compulsory general education for all in South Africa takes as axiomatic the benefit of institutionalized learning. It is policy-makers' and educationalists' responsibility to deliver on this expectation. In traditional village life a child's education unfolds with progressive assimilation towards a clearly defined role (Wanjohi, 1981). Can we be sure where our school science curriculum is leading students or that the supposed direction is appropriate for those students?

> *"We will speak quite cheerfully of a child having received six or seven years of education when what we mean is that he has sat more or less regularly in a school building for that length of time, sheltered from the rain and from other educational influences within his community."* (Hawes, 1979:1)

Taylor (1998) extends this criticism saying curriculum trivializes a student's beliefs and experiences. These claims point to a need to make curricula not only relevant but affirming. A science curriculum should ensure that it prepares students for realistic roles they may play after school. Taylor's view is that constructivism as a pedagogy is too limited, as it excludes ethics of emancipation and care. He proposes that teachers engage students in a meta-discourse that examines social reality. From interviews with students (University Durban-Westville Upward Bound Evaluation, 2002), it appears that science students in Kwa-Zulu Natal would welcome such debate and are willing to engage in discussions on their interests and beliefs. Taylor (1998) proposes that debate be used to free students from repressive and unacceptable myths of traditional beliefs. (I take up discussion of this view later.) So while I agree that discussion and debate is beneficial just *whose* views, and *what* views, are 'repressive and unacceptable' is contentious! The way forward rests on real dialogue and negotiation where everyone is prepared to learn and draw on strengths from different cultures and knowledge bases.

The need for developing curriculum arises from acknowledging that 'science for all does not mean one size fits all' (Lynch, 2001; Fensham, 2000). Students in particular situations have needs and interests pertaining to their environments. However, Rollnick (1998b) warns that limiting science curricula to issues of everyday life might limit students. The large international survey reported by Sjoberg (2002) supports the contention that students in developing countries, unlike students in First-world countries, are interested in a wide variety of phenomena. This is an encouraging starting point for the development for curriculum in rural communities. A problem remains that we do not know specifically (in relation to context) what the goals of science education *are* for South African children.

Dos Santos (2002) takes these ideas further by questioning the roots, motives and goals of science education (which he sees as political). He asks if science education is simply to adapt a student to an existing technological world where corporate values are promoted above human and environmental concerns. He argues that science education needs to be dialogical. I suggest that it is equally valid to extend this proposition to apply to the research process into science education. This perspective is given a particular focus by Cook-Sather (2002:3) who advocates that students be given "…authority to participate both in the critique and in the reform of education". It is however sobering to note that little has changed after three decades of attempts at curriculum reform (van den Akker, 1998).

Kyle and Malcolm (2003) in a presentation within the framework of human rights and democracy presented these principles:

> *"Science educators ought to ensure that their efforts are ultimately oriented toward self- and social-empowerment. This would contrast with the technical, rational, objectivist perspective that has dominated science education reform and science education research to date.*

Science education ought to:

- *foster critical and participatory democracy*
- *enable students to change, transform, and reinvent the world they are inheriting*
- *enhance our youth's ability to work collectively toward a better society."*

Although not unaligned to the National Department of Education's policy statements, these goals have been slanted towards a political-emancipatory purpose – with an incitement to activism. Such goals still need to be translated into specific curricula. It is not only difficult to discover what is relevant, it is difficult to know *who* to ask and *what* to ask.

Taking a different approach from the large international questionnaire inventory-type study, Barton and Osborne, (2001) used story writing as an input for ideas on relevant science in a high poverty community. They found that all efforts of curriculum reform needed to negotiate within the complex dynamic relationships between schools, families, communities, and children. This extends concepts of learner-centredness to include all aspects of learners' lives and relationships.

Pedagogical Frameworks

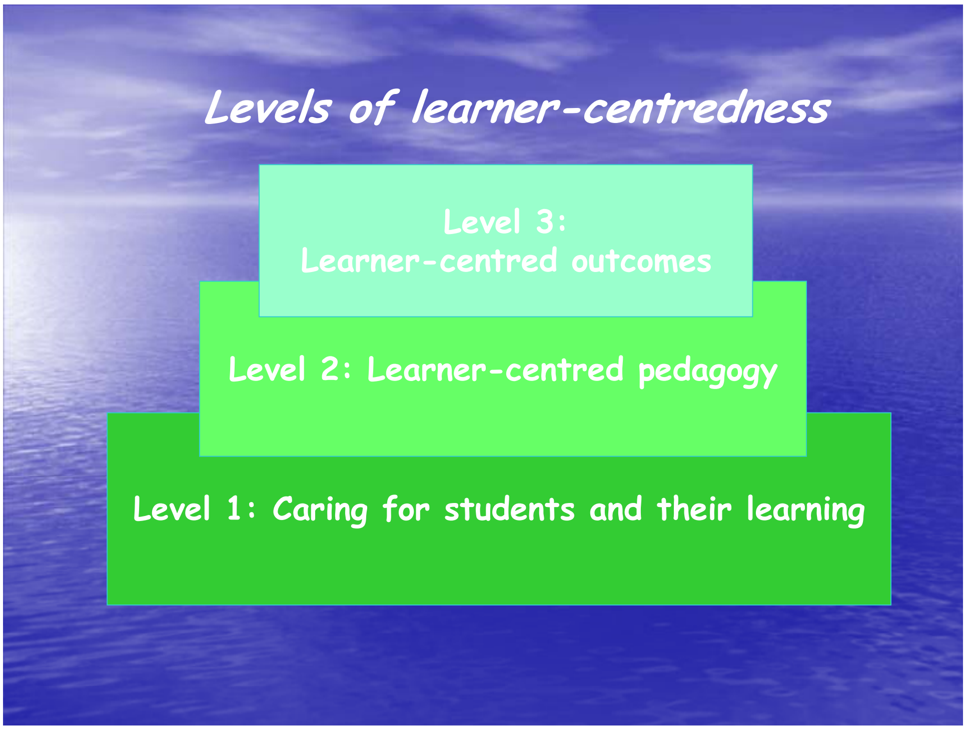
Learner-centredness

New education policy requires responsiveness to learners' needs and experiences (Department of Education, 1995). Curriculum development "…s*hould take account of the general characteristics … of different groups of learners"* (Department of Education, 1997:11).

Although often referred to in the context of our 'new and modern' system, learner-centredness has ancient roots going back to Socrates who demonstrated in a mathematics lesson how a student 'teaches himself'. Socrates' view was that knowledge is a matter of 'remembering', (*Meno 86*: in Jowett 1892:366) and that no-one can be 'taught'. He also maintained that 'values' are learnt "through love" (*Symposium*, in Jowett 1892:301). The concept of learner-centredness has been advanced through the work of Piaget and Dewey (Brodie, Lelliott & Davis, 2002) and is a key foundation of C2005. However, learner-centredness has been taken up in a largely symbolical way especially in rural primary schools (Brodie, Lelliott & Davis, 2002).

The premise of love being the foundation of the most basic level of learner-centredness is described in the model presented in Figure 3.1 (Malcolm & Keane, 2001), and is resonant of Socrates. This 1st level also embodies the more symbolic implementation of learner-centredness that has been noted in South African schools.

Figure 3.1 Levels of learner-centredness



Malcolm et al. (2000) in a study of successful (and ‘disadvantaged’) schools proposed that teaching and learning was strongly based in the first level of ‘caring’ and included aspects of ‘team-work’ in that students motivated each other in examination training, rather than ‘group-work’ in the co-operative sense of constructing meaning together.

Noddings’ vision of classrooms reaches to the third level: “…students should be involved in planning, challenging, negotiating, and evaluating the work that they do….” (Noddings 1993:150 in Burton:38, 1996).

Progression to higher levels of learner-centredness is premised on the trust that students can take responsibility for their own learning. Following on Lave’s (1993) assertion that children do not need to be coerced into learning, Roth in a radical study of learner-centredness in a French village, shows how, in the right conditions, children flourish and learn by themselves. Roth quotes a teacher in the research as explaining that his job is to: “make the group function as a community… and to have the responsibility for not preventing children from leaning how to read.” (Roth, 1998:xvi). Results showed such faith in the innate motivation and abilities in the children was well founded. Roth maintains that children learn where there is “a sense of community in which collective learning was celebrated over individual prowess.” (Roth, 1998:xvi).

The concept of learner-centredness in C2005 is intended to take into account students’ out-of-school experiences, cultures, languages and abilities (Department of Education, 1997). A common assumption in the Western world is that, by drawing curriculum topics from students’ interests, they will be more likely to choose science as a subject and be more inspired in their learning (Solomon & Thomas, 1999; Sjoberg, 2004). This may or may not fit with Level 3 learner-centredness in Fig 3.1. Learner-centredness needs to question whether ‘individual interests’ and ‘choosing science’ are teacher-centred and system-centred concepts.

Social Constructivism and Situated Cognition

Scientific knowledge is not the product of purely rational (or cognitive) processes (Hess, 1995). Rather it is shaped by social, political and cultural factors (Kuiper, 1998). Hence the theories of knowledge production that are appropriate to this study are social constructivism and situated cognition.

It is interesting to note that children’s abilities in everyday situations are often very different from the abilities they display in school (Rogoff, 1984; Lave, 1988; Lave & Wenger, 1991). Is this a matter of content, interest or assessment? Whatever the reason the observation is an indication of the dissonance of activities within and outside the school. Driver et al. (1994) maintain that knowledge is socially constructed and negotiated: learning does not arise simply from encountering physical reality but through the interaction with symbols and beliefs. If we add to that the well-acknowledged statement of Ausubel that the most important input to learning is what a student already knows, then, logically, educators need to take into account the beliefs and worldviews of students. Mazrui (1978) cautions against the tendency in Western culture to elevate cognitive processes above other faculties. Thinking (only) can make people “inadequately sensitive” and “divorce them from the process of living.” (Mazrui, 1978:220). Students do not bring only concepts and knowledge to their new learning situation. They bring also cultural values and affective qualities.

Theories of pedagogy need to be considered within these larger philosophical, epistemological and ontological perspectives. The two learning theories that could contribute to an understanding of curriculum design and implementation in this context are constructivism - particularly social constructivism (e.g. Driver, et al. 1994; Taylor, 1998; Borko & Putman, 2000) and situated cognition (Cobb, 1994; Kirshner & Whitson, 1997b). Situated cognition ties in well with notions of relevant science (Lave, 1988; Kirshner & Whitson,1998a). Yet it is not a synonymous concept: students may learn in a community of practice that is arcane: working in a university department on string theory. Mlodinow (2003) describes his own situated cognition (not calling it such) in his book on Feynman. Much of Mlodinow's induction into the authentic world of Nobel prize-winning physicists was through lunchtime chats, walks with Feynman, incidental sharing of concerns - what Lave and Wenger (1991) call 'legitimate peripheral participation'.

Wenger (1998), states that cognition is 'distributed' over all aspects of life. A number of studies show that learning is greatly enhanced, and performance in complex science and mathematical tasks is higher, when conducted in an authentic situation (Kirshner & Whitson, 1997b; Watson, 1998; Cobb & Bowers, 1999; Lemke, 2001). An 'authentic' setting for a student could be supported through the interest of parents. For example by providing opportunities in the home for projects and sharing knowledge. The involvement of parents and communities can contribute to increased student performance (Hewson et al. 2001; Howie, 2001). Of course it is difficult for parents and communities to be involved when the curriculum is foreign and culturally inappropriate. There is also an irony in this arcane aspect of school science, as it is not what scientists actually 'do' (McGinn & Roth, 1999). McGinn and Roth recommend an 'authentic science' in which one is accountable to peers. In a rural setting this could mean being accountable to the community.

There are a number of 'authentic' possibilities in curriculum design: 'learning through work' provides a learning environment where products have their own value, power is shared among participants (the discourse community), and outcomes are not narrowly prescribed. The AFCLIST[2] Zanzibar science camps for primary children provided a non-threatening, fun environment, that nurtured creativity and learner-centredness (Savage, 1998). Both these examples are consistent with the recommendations of Osborne (2001), that a wide variety of teaching strategies be employed, and Savage (1998), that as many people as possible participate in curriculum change.

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[2] African Children's Literacy in Science and Technology project

Clay (1996) and Fox (1996) recommend that vernacular knowledge and outside-school contexts need to be bought into curricula so that school learning is ‘socially more real’. This is a two-way possibility in recommending that science come into the classroom and the classroom move out into the community. Cobb (1994) recommends that learning is about learning to participate in discourse communities -- which is to understand the particular genre (Rollnick, 2000), that purposive activity has its own register (Christie, 1997). For rural students this needs to include the genre of community knowledge.

These pedagogical frameworks inform my orientation to curriculum design. The following discussions on the nature of science, scientific literacy and multiculturalism provide arenas for explorations of relevant science in the rural setting.

The Nature of Science

There has been wide debate about the meaning of the ‘Nature of Science’ (NOS) (Rudolph, 2000). Its definition is not fixed in time or place (Lederman, 1992). Definitions of the NOS overlap with scientific inquiry, philosophy of science, history of science, and inherent in science epistemology are values and beliefs (Lederman, 1992; McComas, 1998). In spite of a lack of consensus on meaning there are agreed features which include (in summary)

Science knowledge:

- is tentative
- is empirically-based / derived from observation of the natural world
- is subjective: theory-laden (See also Chalmers, 1982)
- involves human inference, creativity, imagination: inventions and explanations
- is socially and culturally embedded: involves culture, power structures, politics, socioeconomics, philosophy and religion (Lederman, 1998).

There is strong support for including the NOS in the school curriculum (Solomon, 1993; Hodson, 2002; Matthews, 1994; Lederman, 1998) – if for no other reason than some view of the NOS is implicit, inevitably. Lederman (1998) however, is pessimistic and predicts that this new policy focus will have little effect. This, he maintains is partly due to the confusions in understanding <u>scientific process</u>: the collecting and analysing data (observing, classifying, measuring, questioning, predicting) and drawing conclusions; scientific inquiry, which is about knowledge, reasoning an algorithm (Jenkins, 1996). Lederman advocates an explicit approach to teaching and critical thinking – including descriptive, correlative and experimental processes; and scientific method which has been distorted at the classroom level to the NOS – which is in itself a 'context' for science learning (Lederman, 1998). Abd-El-Khalick and Lederman (2000) found that teaching the NOS through a historical approach is ineffective - although there are counter-claims (e.g. Matthews, 1994; Monk & Osborne, 1997). The explicit approach to teaching the NOS is likely to be beneficial in an African setting as it ties in with calls for discussion, debate and integration with African ways of knowing. If, as McGinn and Roth (1999:15) state: "scientific knowledge emerges from the nexus of interacting people, agencies, materials, instruments, individual and collective goals/interests, and the histories of all these factors", then scientific knowledge is likely to be particular *for* and *to* our rural context.

Such recommendations which focus on the explicit teaching and debate of the NOS are not unproblematic for South African rural schools, as many teachers have inadequate understandings of the NOS (Singh, 1998; Chakane, 2001; Dekkers, 2002).

The debates on the NOS may be subsumed under the notion of 'scientific literacy'. In approaching community human rights and democracy advocacy from a science education perspective, the consideration of appropriate and empowering science is pertinent. This is explored through the literature on scientific literacy.

Scientific Literacy

The commonly held conviction that everyone needs some level of 'scientific literacy' is over 100 years old (Shamos, 1995). It is often supposed that 'scientific literacy' is as important a goal as language and mathematical literacy and is included in many countries' educational policy documents (Abd-El-Khalick & Lederman, 1998; McComas et al., 1998). The notion of 'scientific literacy' includes understanding of the Nature of Science (Jenkins, 1998), key terms, and concepts and awareness of the impact of science and technology (Miller, 1983).

Fensham (2003) defines scientific literacy as:

“The capacity to use scientific knowledge to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.”

‘Scientific literacy’ or ‘public understanding of science’, means: what citizens ‘need to know about science’ (Durant, 1993) to function in everyday life – and increasingly - to contribute to democracy. As the concept of science is potentially very broad and dependent on context, there are a number of variations of what scientific literacy might mean (DeBoer, 2000). DeBoer commends a broad definition as it allows for localised interpretation in the classroom and a variety of innovative responses.

Millar (1996) and Osborne (2001) conceive of scientific literacy in terms of purposes: it should include what the public needs in order to make moral and political decisions. Kemp (2000b) proposes a similar responsibility of ‘controlling science’. These purposes are not necessarily pressing in a rural area where strengthening democracy focuses on the right to food, services and employment. Roberts (1982) suggests ‘everyday coping’ as one of seven curriculum foci -- again in a rural setting this is more about ‘survival’ than ‘coping’. Rollnick (1996), writing in South Africa, reaches a more pragmatic conclusion in identifying (among others) extrinsic scientific literacy values such as awareness of science and technology careers and skills for industry.

Roberts (1982) proposes that the purposes that children have in learning school science are:

- Everyday application
- Structure of Science - how scientific ideas develop and change and the significance of evidence; scientific method
- Science-technology-decisions – including an appreciation of values, ethics, and the influence of economics and politics
- Scientific skill development
- Correct explanations
- The self as explainer
- Solid foundation - preparing students for further learning.

All of these could inform science curricula at a local level, as could the broader purposes identified by Symington and Tytler (2003), in Australia. Their examples of content however are applicable to Western developed countries. In rural communities, there may be more pressing interests than genetic engineering and a wide variety of high tech objects. Symington and Tytler identify the following purposes of science education:

- Democratic: members of society should be able to understand and be involved in scientific and technological issues that impact on society, e.g. global warming, genetic engineering.

- Economic: to produce the number and quality of scientists and technologists for the country's future.

- Personal development: students' benefit from the values and skills of science.

- Utilitarian: sufficient knowledge of science enables students to operate effectively and critically with technology.

These purposes can be restated using examples more relevant to a rural South African community. For example, the democratic purpose can relate also to participation in the local community and the economic purpose may relate to community survival.

Bregman, a leading educationalist at the World Bank, also claims that education is vital for economic development (SAIIA, 2004). However, the economic purpose of 'science education for development' has been widely criticised (e.g. Drori, 1998). Not only is it questionable that there is a causal relationship between science education and the national economy, but the assumption that economic development should mean development on a national scale requires interrogation. Economic development may mean - in a rural context – being able to farm more effectively for the immediate community's security. Irzik (1998) cautions against a closed view of science and points out its limitations for social development. Like Ogawa's (1998) 'multi-science' approach, Izrik recommends the use of eclectic epistemologies.

Although emphases differ in different countries, and over time, the 'basic content' or science knowledge and skills have remained much the same (Malcolm, 2004b). There have been many suggestions for change. Mayer (2002) in a study with six Eastern and Western countries proposes the theme 'Nature' as of common interest. He narrates the story of his farmer father as an applied scientist. This expansion of the notion of scientific competence and acknowledgement of non-academic science has implications for rural science education. Further, Lederman, (1998) argues that science literacy is not discipline specific but is about larger ideas such as cause-effect; equilibrium; structure and function; cycles.

Osborne's (2001:17) list of relevant science content includes "medical genetics and modern cosmology". Although I have suggested that such topics may not be of high priority to many South African students, a topic may indeed be 'interesting' on account of its exotic nature: defining 'relevance' is complex (Malcolm, 2004b; Stears, 2005).

Scientific literacy is also considered from the point of view of desirable qualities that students need to develop. Marton, Fensham and Chaiklin (1994) in a study interviewing Nobel Laureates in science conclude (to present one example) that scientific intuition is an important quality that scientists use as an alternative route to, or integral part of, problem solving. In an inquiry into what qualities scientists themselves considered important for their field (rather than an inventory of concepts) Fensham and Law (2003) elicited the following responses from scientists. The top qualities identified with remarkable consistency were: *creativity; personal interest in science; perseverance; willingness and desire to inquire; the ability to communicate;* s*ocial concern* and *team spirit.* This provides a new way of looking at the structure and content of science courses.

The assumption of a 'literacy' in science (equivalent to literacy in language) presents dilemmas in the levels of complexity and specialisation required to really understand current scientific issues. It is unrealistic to expect the general public to achieve this level of scientific competence (Giddens, 1990) that permits critical appraisal of leading-edge science and its applications. Hewson (2002) proposes that the scientific equivalent of 'reading and writing' in language literacy could be seen as 'explaining and predicting'. A move to a simpler definition could facilitate implementation.

Baker, Clay and Fox (1996:2) in their discussion of 'literacy practices' take a less literal interpretation of literacy as 'a single psychological entity' and (the reverse notion) illiteracy as a 'state of being'. Clear definitions, especially encompassing oral and literate practices, are elusive (Heath, 1996; Street, 1996). The conventional definition of 'literacy' as a type of academic competence (in language, mathematics or science) excludes the concepts of 'communities of practice' that I described briefly in 'situated cognition'.

The theory of academic literacies advocated by Lea and Street (1998) provides science educators with a different awareness of text. In the academic literacies model, students are not merely made responsible for adapting to the institution (which defines the literacy through its practices), but texts are accepted as manifestations of social practices which are subject to contestation. Texts, through their being embedded in social practices, are part of 'identity' and strongly influence students' identities.

With this continuing call for scientific literacy comes deeper criticism of existing conceptions of science education. Rudolph (2000:404) claims that school science is ineffective in its range of conceptions "from the traditional five-step scientific method to the less algorithmic, yet still oversimplified, inductivist methods of generating new scientific knowledge". Further, in spite of widespread promotion of reform, efforts have been largely unsuccessful in advancing scientific literacy (Shamos, 1995). The broad purposes of science education which show strong similarities among theorists and across countries, are dependent on teachers' abandoning restricted and positivist notions of the Nature of Science which excludes much of the basis of these purposes (Linneman & Lynch, 2001).

Kemp (2000a) cautions that - as with the expanding of definitions – the expanding of rationales for scientific literacy means that few people question its desirability or feasibility. Kemp suggests empirical studies of scientific literacy's benefits would strengthen its case.

In spite of difficulties in definitions and in implementation there is general agreement that science has the potential to enrich personal, social and economic life through the appreciation of a particular way of knowing (Shamos, 1995). Atwater (1996) while championing multiculturalism, agrees that all students need to have access to Western science. Science is, after all, a part of culture (Horton, 1967; Hodson, 1993; Cobern, 1994), and the purpose of school 'general' science is to ensure that all members of society develop a critical appreciation of the culture of science. Scientific literacy or 'science for all' is "an equity issue rather than a relevance issue" (Rollnick, 1998b:85).

In summary, Scientific literacy I take to be an important goal as it offers a powerful way of knowing. How it may be implemented with due care for students' own contexts and existing ways of knowing is not clear.

Relevant science education

Notions of scientific literacy involve many interest groups (media, clubs, museums, etc.) whereas relevant science education is more the concern of educationalists, and possibly policy makers (Laugksch, 2000) – possibly also politicians.

Fensham and Law (2003) provide an overview of how the reforms of school science, starting in the 1960s led to upper secondary science classes mimicking the way science was being taught in universities. Science was thus clearly an ‘elite’ subject to be taken by those aspiring to science careers. Such content-based, decontextualised science was not necessarily a successful educational strategy – even on its own terms. In the 1980s the goal of Science for All led a number of countries in the 1990s to include science as a compulsory subject in primary school curriculum (Fensham & Law, 2003).

Even if science is compulsory at least at some level of schooling, there remains the problem of low enrolments into secondary or tertiary science courses. Science education is sometimes described as science’s worst enemy! There is some student resistance (Sjoberg, 2002) and a decrease in students choosing science as a career (Aikenhead, 1994). Part of the disenchantment may be the lack of course relevance to everyday life (Holbrook, 1992). Science curriculum often follows structures produced by scientists (Yager, 1992) - a quasi-replication of laboratory assistants’ courses with some reference to famous (white male) scientists. South African students in rural areas have described science as ‘too difficult’ (HSRC, 2005). This is one of the factors, in addition to lack of relevance, that Duggan and Gott (2002) identified as contributing to student resistance to science courses.

In South Africa the difficulties that students experience in science are compounded by language, cultural and socioeconomic issues. Many researchers (Aikenhead & Jegede, 1999; Manzini, 2000; Odora Hoppers, 2004; Chetty, 2002) have attributed this problem in part to methods of teaching in science subjects that often fail to link the sciences with students’ prior knowledge – the content and beliefs that the children have acquired from their different indigenous, scientific and mathematical cosmologies (Odora Hoppers, 2004). Rollnick (1998b) argues that for science education to live up to the hope of improving society the key factor for curriculum design is relevance.

Osborne and Collins (2001) recommend that teachers need to be given, and exercise, more flexibility in interpreting curricula. Recognition of different contexts, resources, issues, as well as student abilities and interests becomes a basis for science education. In Sub-Sahara Africa economic crises are a critical input into relevant context and purpose. Makhurane (2004) claims that in many African countries people are worse off now than 30 years ago. Ajeyalemi (2002) sees economic development in Africa as a necessary prerequisite before advances in more relevant science can be made. (Although this claim was made a few years ago, there is little reason to assume much has changed economically.) In particular rural school teachers say much the same thing claiming that implementing learner-centred science is impossible without better resources (HSRC, 2005). It is perhaps an indictment of science education that education researchers have to call for the obvious: ‘an education people can use’ (Nganunu, 1992).

Science curriculum reform in Southern Africa included projects such as Primary Science Project (PSP) and BOTSCI (in Botswana). In her work in Botswana Nganunu recommends that this needs to be directed particularly for self-employment and the inclusion of indigenous technology. The shortcoming of the BOTSCI and many other development projects in Africa has been the failure to involve the education department (Lewin, 1992 quoted in Rollnick, 1998:83). Thus, in our intervention we took care to always inform and invite officials.

The Science Technology and Society (STS) movement advocates that science education should be issues-based and not specialised for later tertiary study. Shymansky and Kyle (1992) emphasise the social and cultural importance of science. Yager (1992:2) gives the NSTA[3] definition of STS as “teaching and learning of science in context of human experience”. This includes 11 features (in summary):

- Students identify problems
- Local resources are used
- Active involvement of students
- Extends out of lesson time
- Focus on impact on individual
- Involves more than concepts
- Process skills
- Career awareness
- Opportunity to act in community

[3] National Science Teachers’ Association

- Identify ways will impact on future
- Autonomy of learner

Although this definition is dated, all of these features are still applicable and possible for rural science curriculum development. There is some irony in the institution of schooling: many education researchers call for more links to 'out of school' learning (e.g. Holbrook, 1992; Yoloye, 1998).

In response to the declining quality of science education in Africa in the late 90s, AFCLIST[4] was launched in 1998. Yoloye outlines a wide range of varied experiences that constitute good science curriculum in Africa. These include:

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- Funding but with a move to independence
- Long-term approach
- "the range of actors needs to be broad, including NGOs, the private sector, teachers' associations and institutions of higher learning." (Yoloye, 1998:21)

Rollnick (1998b) adds a critical point that relevance needs to be supported by appropriate assessment. These directives and recommendations inform the approach used in the research intervention reported on here. Having asserted the importance of science education and highlighted the difficulties of providing meaningful science especially for African students, a consideration of literature on Multiculturalism is pertinent.

Multicultural science

In the promotion of 'Science for All' the question of the potential conflict of science with other ways of knowing is highlighted. Taylor and Cobern (1998) make the point that the culture of science is insidiously invisible to those within the discourse and that this restricts curriculum development possibilities. To reflect on the characteristics, effects, and limitations of Western science and science education requires both willingness and awareness on the part of policy makers, curriculum designers and educationalists.

Issues of taken-for-granted terms, values, purposes and framing in science education need examination. Lemke (2001:303) states: "I should not be using terms … especially

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[4] African Forum for Children's Literacy in Science and Technology

race, or …*culture* and *language,* without problematising them.” Ramose (2004) too states that key terms such as *Africa, philosophy*… may be taken for granted. We often talk as though these terms are unambiguous. Even in lay terms, journalists in South Africa present interesting debates on these definitions. On the issue of ‘race’ Tom Eaton, a newspaper columnist, writes:

> *“I still don’t know if I’m allowed to call myself an African. I’d very much like to, but only if it doesn’t piss anyone off. … If I am an African, that is super. If I’m not, but could be under certain circumstances, would somebody please tell me so I can find out what I need to do to apply? And if I’m not and never could be, then break it to me gently …*” (Eaton. 2005:33)

This contrasts with the notions in especially American understandings, for example Atwater (1994), in focussing on ‘multiculturalism’ places emphasis on acknowledging ‘other’: gay, Hispanic, female and African-American, without interrogating the complexities inherent in such terms. Such signifiers in post-structural thinking may be considered ‘nodal points’. Torfing (1999:98-99) explains that nodal points “sustain the identity of a certain discourse by constructing a knot of definite meanings” and thus conceal ambiguities.

Ambiguities and subtleties require frank and rigorous debate, (preferably with humour and trust) that goes beyond slogans and platitudes of the politically correct. Kumashiro (2001) notes the tokenism inherent in less-than-rigorous framing of ‘inclusive agendas’. Proclaiming that Other is as normal as the norm, does not necessarily change the status quo. The Other is still perceived in relation to self.

Atwater (1994:1) states: “…all students can be successful in science and mathematics classrooms.” but does not question the norm of ‘science’ and indeed ‘classrooms’.

In the theoretical framework (Chapter 2), I draw on mindful inquiry which critiques “…existing values, social and personal illusions, and harmful practices and institutions.” (Bentz & Shapiro (1998:7). If this principle does not apply to all participants then the research framework becomes patronizing in its efforts to be ‘politically correct’. It becomes a ‘commodification of difference’. Kumashiro (2001) points out that adding more voices to the same story does not bring us closer to ‘truth’. “It is easy to add difference to curriculum in a way that complies with hegemony.” Kumashiro (2001:6). This is a helpful caution in exploring curriculum relevance in rural communities.

Although I have drawn on ‘multiculturalism’ – which is certainly a feature of the South African ‘rainbow nation’ – it is not, in a sense, a feature of rural communities. Such communities are strongly homogenous. However, the issues of concern with respect to worldview and the hegemony of Western science are pertinent.

The concept of multiculturalism in South Africa is complex and centres on acceptance and respect for diversity of culture, language and religion. What this may mean is not clear and is often debated with disagreements within groups and confusions of who belongs in which group.

Indigenous Knowledge

> *“In the face of scientism, local cultures, particularly those in less industrialized countries which import ready-to-use science curricula, are in danger of suffering erosion and loss of integrity as a powerful culture-insensitive science education …displaces traditional ways of knowing, being and valuing.”* (Taylor & Cobern, 1998:204)

Gado and Verma (2001:3) look at the effects of culture from a different perspective:

> *“In Africa, for example, the sociocultural influences, the superstitions, and the science misconceptions that the child brings in class constitute the barriers to children’s understanding of science concepts.”*

One wonders why this happens only in Africa. It is interesting to note too that sociocultural influences and misconceptions are in one category. The conception of some ‘purity’ – if not superiority of science over other ways of knowing is often tacitly assumed. Under the heading of ‘devaluation of science as knowledge’, Lelliott and Pendelbury (2005: 6/7) state that “equating the cultural beliefs with other assessment statements (in the South African science curriculum) will encourage a devaluation of ‘real science’.” They go on to criticize class discussion on current issues such as ‘causes of AIDS’ partly on grounds that such issues are “science in the making …rather than established facts of science”. This ‘factual’ notion of science is contested: although ‘belief’ is not countenanced in a science classroom educators seldom reflect on how students are overtly required to ‘believe’ the science they are taught - and with little question (Gauld, 2001). Further,

"…scientific knowledge is far more complex and tenuous than implied by myths of the scientific method and heroic scientists." (McGinn & Roth, 1999:17).

In contrast to the view that discussing cultural beliefs in science 'devalues science', Aikenhead (2002a), in the 'Rekindling Tradition Project' advocates the inclusion of Aboriginal knowledge in science classrooms (from the learner-centred perspective) in order to learn about students' lives, as well as to nurture cultural identity.

Indigenous knowledge discussions in science education often focus on indigenous technology and medicine. In this study I have focused on philosophical influences, but there is also the aspect of indigenous education systems. For example Adeyemi and Adeyinka (2003) advocate the use of the five principles of indigenous education to contribute to current education in Africa:

- preparationism: gender-specific role training
- functionalism: utilitarian goals learned through imitation, work, play, stories
- communalism: ownership and responsibility is communal
- perennialism: education needs to preserve culture (what may be called 'traditional')
- holisticism: variety of tasks for future occupations

It is interesting to note that the majority of these principles draw on what Lave (1993) describes as legitimate peripheral participation in a relevant social practice, as well as Borko and Putnam's (2000) recommendation that learning needs to be embedded in authentic activities, that is in practices that people *actually* engage in in daily life. For similar rationales Service Learning is advocated as a means of both providing work experience and leading eventually to increase in productivity (Smith, 2003).

Gaps in this African Education system according to Adeyemi and Adeyinka (2003), are the lack of written literacy, and lack of reflective or critical thinking. Other aspects may be questioned (and are by Enslin & Horsthemke, 2004; Achebe, 2003; Armah, 2005). Perennialism and Preparationalism may not include gender fairness.

Indigenous knowledge may include philosophy, technology, as well as social, economic, educational and governance systems (Odora Hoppers, 2004). Kyle (1999) argues that Western science itself is an indigenous knowledge system, rooted in Western philosophies and cultures. This is closely aligned to worldview which Cobern (1996:585) describes as: "…non-rational presuppositions on which conceptions of reality are grounded…".

Alternative world-views have been excluded from the science classrooms in South Africa. The traditional didactic teaching styles have usually ignored the inner frameworks, ideas and experiences that a child brings to class. For those students in an urban–Western community, the assumptions of the science curricula are at least premised on familiar frames of reference. Recent researchers have focused on *barriers* to learning rather than on the ways existing knowledge and world-views *contribute* to learning - as in the quote of Gado and Verma, (2001) given earlier.

If school science curricula could be designed to ensure that socio-cultural influences are a resource rather than a hindrance this problem could be largely resolved. Aikenhead (2001b) for example recommends (for a child who is not from a Western cultural background) that teaching draws on both cultures. He points out that Aboriginal children are advantaged by having more than the world-view and language – unlike Euro-Canadian students.

This is the position I have taken in the curriculum design in this project. I have further assumed that an analysis of these cultural differences has the potential to enrich the scientific way of viewing the world. Some of these differences in worldview are presented by Biakolo (2002), Ogunniyi (2000), Ogawa (1998), and Irzik (1998).

Barton and Osborne (1995) advocate that other 'ways of knowing' should be included in science classrooms. Different world views need to be integrated so that students from an African culture can draw strategically on different kinds of knowledge when appropriate without threat to identity: what Jegede (1995) calls 'collateral learning'. Oginniyi (2000) refers to successful accommodation of different worldviews in his "contiguity theory". Boarder-crossing between different ways of knowing (Aikenhead & Jegede, 1999) focuses on individual students' cognitive dissonances with potentially conflicting types of knowledge. Because knowledge in traditional communities is carried by the elders (Jegede, 1998), and interdependence is emphasised in *ubuntu,* it may be useful to consider, instead of individual processes, 'secured *communal* collateral learning'. This would mean having community forums while generating and analysing research knowledge.

What is clear from the various perspectives is that the African student is faced with problems of dissonance between home experiences and the science classroom. Aikenhead and Jegede (1999) proposed a synthesis between collateral learning and border-crossing. It is possible that if discussions of world views, traditional beliefs and ways of knowing are brought into the classroom and community, new perspectives on the discussion may arise. The affective advantages of these discussions have already been noted by Manzini (2000b). From the perspective of social justice, not only do resources and access need redress but curriculum needs to be made equitable (Naidoo, Savage, & Taole, 1998).

Ogunniyi (2000) proposes that ways of knowing in traditional cultures differ fundamentally from a Western scientific paradigm in a number of ways. The assumptions we make based on interactions with nature constitute an important aspect of world-view. The Western science world-view is essentially mechanistic while the Indigenous world-view is anthropomorphic. While it is true that new physics and chaos theory goes beyond this mechanistic model, it is the positivist scientific paradigm that frames science learning at school level.

In ‘Islam and the Philosophy of science’: Irzik (1998:167) claims:

> *“…the modernist system of values behind modern science and technology are… dualist, mechanist and reductionist philosophy of being… rationalism, progressivism, materialism and indivi-dualism.”* (Sic.)

To guard against these tendencies in Japanese science education Ogawa, (1998) advocates a ‘multi-science’ which combines modern Western science and the tradition of *Shizen* (nature). Steven and Hillary Rose criticize science for its claim of neutrality which supposedly exempts it from responsibility for creating “many of the world’s major problems.” (Rose & Rose, 1980:18). Arditti, Brennan and Cavrak (1980), agree that ‘science’ is not neutral and maintain that the prevalent ideology underpinning science and science education is geared towards preserving a bourgeois class of scientists and funders.

Such tirades against science would lack credibility if at the same time it were not acknowledged that science is a powerful way of creating knowledge and transforming lives. The above authors concede that “Industrial advancement and social progress would be impossible without scientific research and development.” (Arditti, Brennan & Cavrak, 1980: 288).

Taylor and Cobern acknowledge the value in both Western science and in the combination of “dialectical interplay between: self and other; tradition and innovation; … East and West; consciousness and dreaming; materialism and spirituality.” (Taylor & Cobern, 1998:204). They recommend the acculturation of students into the culture of science. Mboya extends the argument:

> *“Education must not be simply an assimilation of Western values, but must also be directed towards strengthening of indigenous culture.”* (1999:1x)

Similarly Mwamwenda and Mwamwenda, (1986, cited in Mboya, 1999) recommend (alongside cultural development) the acknowledgement of the essential value of Western science in its contribution to a child’s intellectual development, and also to the development of Africa. So not only has Western science a valuable contribution to make cognitively, individually, in the community, and nationally, this needs to be done in conjunction and harmony with traditional practice.

Taylor and Vinjevold (1999) while pointing out the unrealized potential of local resources, extend the positive inclusion of traditional knowledge to other aspects of traditional life such as skills and crafts and recommend that these be brought into the school. As with well-intentioned policies, such recommendations are easier to proclaim than implement. Biakolo (2002) cautions that oral cultures tend to be conservative and traditional and used to acquiring knowledge and skills in participative practice. This has consequences for curriculum reform and innovation in research and development projects.

There is some disagreement too with the assertion that African Indigenous Knowledge is oral-based, (for example, Ellen & Harris, 1996; Obenga, 2004). Armah (2005) too asserts that Africa has a rich and ancient recorded literacy. Of course, if we include (in addition to ancient texts) paintings as recorded knowledge, this too supports the argument that Indigenous Knowledge is more than oral.

The question remains as to what knowledge is best included in school curricula and how this may be done. George (1999) has proposed a general scheme for categorizing cultural knowledge for using it in the science classroom. She has suggested four categories:

Category 1: The cultural knowledge can be explained in Western science terms. For example, the practice of using a mixture of lime juice and salt to remove rust stains from clothes can be explained in conventional science in terms of acid/oxide reactions.

Category 2: A conventional science explanation for the cultural knowledge seems likely but it is not yet available. For example, traditional medicines may have recognised pharmacological properties.

Category 3: A conventional science link can be established but the underlying principles are different. The cultural knowledge states that sugars cause diabetes, whereas Western science claims sugars can worsen the condition.

Category 4: The cultural knowledge cannot be explained in conventional science terms. For example, there is no conventional science explanation for the claim that spells cause lightning.

In our exploration of relevant science and interest in indigenous knowledge I hope that these categories may prove helpful in identifying aspects of knowledge in the community. I return to this in the Theme: 'Indigenous Knowledge' in Part 2A.

<u>Important conclusions from the above arguments are:</u>

- Indigenous knowledge and scientific knowledge, although often in conflict in science classrooms, need not be in competition. Even when unacknowledged, indigenous knowledge is present in the students: it should be openly brought to the classroom for discussion.

- Some aspects of different ways of knowing may overlap. Some ways of knowing and some 'facts' may be contradictory. This too needs open discussion.

- Science is a powerful way of understanding the world but is not infallible.

- Indigenous knowledge offers legitimate and valuable contributions to ways of being, acting and understanding and is also not infallible.

The role of Language

The specific role of language in this study was not a key area of inquiry. However, it is impossible for (mostly) English-only speaking researchers to work with (mostly) Zulu-speaking participants and not take some cognizance of language dynamics. Also, students in the study have had very little opportunity to converse in English and yet their textbooks and assessments are all in English. Further, scientific language is a particular variety of language that presents dilemmas for all students. Hence language issues cannot be ignored. Literature on language in science, briefly mentioned here, has formed a background for considering these difficulties.

At a fundamental level, language is clearly related to considerations of multiculturalism and indigenous knowledge. African Indigenous Knowledge and language are linked (Brand, 2004). Experience of the world is not only shaped by social and personal traits but is strongly dependent on the particular language through which one knows 'reality' (Sapir, 2000; Whorf, 1978). No two languages are equivalent in this respect (Brand, 2004) hence one's experience of the world is dependent on one's use of language. This is similar to the Kantian distinction between 'reality' and interpreted experiences through language which lead to a personalised experience of phenomenon.

Dombey (1996) argues that to prevent English being alienating and dominating, (in our case for Zulu-speaking students) students' mother tongue needs to be brought into classroom discourse. The attention to language as a means of developing voice and agency in the science classroom contributes to English second language learners' participation and empowerment (Rollnick, 1998).

In Manzini's (2000b) study on culturally relevant curriculum, learners were able to provide comprehensive explanations, ask keen questions and participate well in the lessons when they were given the freedom to learn in their mother tongue. Following these recommendations, in this study we encouraged students to use Zulu in speaking and writing whenever they wished.

On the other hand, Mayer and Tokuyama (2002:1) propose that "the scientific process can provide a model for achieving dialogue among peoples with different languages and from diverse cultures". This extends the notion of science being a culture to be assimilated or crossed into, to a language that may serve as a bridge to understanding. It is usually the negative or alienating aspects of scientific language that are highlighted, whereas scientific language may serve as an additional communication tool. There are also broader cultural aspects of language that come into play in the research setting. To take but one example, Kann and Quarmby (1990) in their work in schools in Botswana note that: 'Yes' can mean 'No, I don't want to talk.' Educators and researchers need to be aware of such conventions. Such culturally confusing communications become even more fraught when looked at from the perspective of ethics.

In considering the more science-based language issues, it is clear that communication in English is difficult for most South African students. In the TIMSS-R the fact that only 20% of the pupils answered the free response questions probably means that most pupils, in addition to lacking the basic science knowledge, do not have adequate communication skills in the language of the test (English) to articulate their scientific answers and findings in writing (Howie, 2001). According to Aikenhead and Jegede, (1999) the language used in science performance assessment can be very significant. Understanding of concepts cannot be separated from language. For example, in Zulu, the one word *amandla* means force, strength, power, energy, momentum and pressure. At this basic level of vocabulary ESL[5] students are faced with a bewildering web of meanings in science and English.

Kenyon and Kenyon, (1996:24) recommend that because science involves a range of symbolic systems it is important "that learners practice and develop a facility in translating across symbolic systems, moving between different literacy forms, and different language conventions". This is more than code-switching. Strategies we used to encourage a variety of 'symbolic systems' were use of video, play, drawing, photographs, songs, computers as well as translators. However, use of primary language is also important for identity, cognitive development, participation, affirmation and understanding. These aspects need recognition before the technical aspects of scientific language are attended to.

In sub-themes in Part 2A, I report on some of the issues arising in relation to language.

[5] English Second Language

Participative Action Research and related research paradigms

Edgar Jenkins (1996) advocates that qualitative studies of scientific literacy need to place context, and the dignity of respondents, at the centre of the research design. Participative research in a human rights and democracy framework is a research methodology that promotes this. However, Participative Action Research (PAR) is not the only influence on the methodology we used. The personal perspective: my own and also those of other participants are included through narratives, photographs, drawings and stories. Following the notion that mathematics and science are 'socio-cultural artefacts', they therefore need to be construed through narratives (Burton, 1996). While attempting to draw on this in curriculum design – I have also drawn on this for the research design. Brice Heath (2000) points out that narrative structuring is a familiar and powerful mental device. It is less commonly acknowledged as such in science education and science education research, with some notable exceptions, for example, Reason, (2001). I have explored Brice Heaths' contention that divisions in subject areas are both artificial and confining.

The following claim by Roth (2002) about education may well be applied to research: education is not only *preparation for* but *engagement in* responsible action. The goal of education is not only to interpret the world but to change it. The methodology of community involvement in planning, identifying key issues and curriculum development is both an end in itself and an input into the research findings. This approach and implementation is formed out of ideals of democracy, power-sharing and *Tirisano* (working together). In this intention the research has everything to do with 'action'.

Traditionally 'Action Research' is defined as "teachers researching their own practice of teaching. It is an inquiry into *their* teaching in *their* classrooms." (Feldman & Minstrell 2000:432). In contrast, "Large scale programmes tend to emphasise adoption and neglect implementation" (Verspoor, 1989:133 in Rogan & Grayson, 2002:2). Large scale studies would also preclude experimentation and exploration which the greater flexibility in a smaller study makes possible. Kaim (1997) defines Participatory Action Research (PAR) as:

> *"…a growing family of approaches and methods to enable local people to share, enhance and analyze their knowledge of life and conditions to plan and to act".*

PAR propels researchers t*o* know *with* others, rather than *about* them, and thus encourages democratic processes (Whyte, Greenwood & Lazes, 1989). When participates in research they are not objects of study but full partners in the process, they are likely to be committed to the project's success (Terra Blanche & Durrheim, 2002). PAR accentuates concern for the well being of individuals and communities, and the removal of oppression (Kieffer, 1984). PAR is also designed to promote a sense of community and raise people's awareness of their own abilities and resources. It seeks to privilege the everyday world over scientific discourse; the interests of research participants over those of the researcher; and the needs of disempowered groups over those of elites (Malcolm et al., 2005).

This requires a different notion of knowledge and its creation from traditional scientific enquiry. Tarnas (1996) points out that science seldom questions its own paradigms: this study attempts to do this through a combination of participation, mindful inquiry and reflection. It also does this in the approach to answering the question of relevant science: how does the community stretch the boundaries of science education in defining for itself 'relevant science'?

Participatory research potentially offers emancipation and empowerment not only to participants in the context community but in the community of researchers. Personal disenchantment with restrictive, competitive and disembodied research, that is often the norm in science, is beginning to be heard. In a pure science study Thimann states: "Scientific research hinders our growth and development as scientists and people." (Thimann Laboratory Group, 1980:320). As a counter-initiative, this group sought to discover: "What kind of working relationships and environment will nurture our intelligence, creativity, and sense of cooperation?" (Thimann Laboratory Group, 1980:321).

Such an aim fits well with participative research and *ubuntu.* Reason (1993:2) in focussing on these dilemmas proposes "Co-operative experiential inquiry". The key human quality of self-determination needs to be bought into the research process. This paradigm takes the 'action' aspect into a more 'inner action'. How these different perspectives unfold depends on the process: methodology itself requires investigation.

What *can* be directed is our intention. In order to ensure that information and perspectives are not deliberately excluded or favoured, I take care to have on-going negotiations of processes and information. I have also taken into account a variety of individual, cultural, social and moral factors.

My anticipation is that science education, defined through participation, will contribute to rural communities, not only practically, but in strengthening democracy and promoting equity. Democracy could be promoted by increasing the community's access to (global) information as well as through modelling democratic research processes. Equity could be promoted by ensuring that everyone has opportunities to participate and to provide a space to interrogate unfair processes. Scientific knowledge and ways of working thus have the potential to link rural, national and global (Mamon & Blanton, 1997) and to serve as a foil, as well as partner to African worldviews (Maharaj, 2004). This potential requires that the science and science education offered in rural schools are 'relevant', that is, that they 'lift up' the community they serve (Hawes, 1979).

Participative Action Research, while promising this range of advantages and opportunities is not without difficulties. These can be anticipated as not only validity concerns, theoretical framework complexities and research design, but practical difficulties. How participation may play out in a particular community cannot be predicted: what is sure is that flexibility is key, and investments of time, money and commitments will be great.