South African Journal of Education

Vol 22(4) 305 – 312

Indigenous Knowledge Systems: implications for natural science and technology teaching and learning

Jerome-Alexander van Wyk
CCD of Vista University, P.O. Box 156, Athlone, Cape Town, 7760 South Africa
javw@mweb.co.za

Given the growing multicultural composition of South African classrooms, educators of science and technology, like educators across the spectrum of all learning areas, are increasingly challenged to reflect how they and their learners conceive of and, as a result, construct knowledge. The reality is that in an expanding globalised world, learners can easily become alienated from what is taught in science and technology, as well as the way it is taught. Indigenous Knowledge Systems (IKS), as a broad framework of thinking about our local context, seeks to problematise the insufficient integration of the cultural-social and the canonical-academic dimensions of natural science and technology education. In this article I conceptualise and clarify IKS *vis-à-vis* knowledge production, particularly towards educational transformation in which educators may assume that all learners are the same in terms of identity and cultural dynamics. Natural science and technology, in particular, have assumed a definite culture of power, which has marginalized the majority of learners in the past. IKS strategically wishes to transform this view and therefore holds valuable implications for educators in the learning areas of natural science and technology.

Context

It would have been extremely useful if educators were able to grasp the detail and depth of how subjective meanings mediate the micro-social processes involved in everyday classroom interactions. In our 'global times', Yon (2000:1) observes the renewed interest among people to explore how cultural and other identity dynamics play out among learners in schools, and therefore argues:

> On the one hand the closing decade of the twentieth century is marked by openings and possibilities for reaching out across differences, by transnational and post-national identities that accompany aspiration toward global citizenship ... on the other hand these times are also marked by closures, identity politics, social aggression, and civic strife.

As in the rest of the world, South Africa is in the midst of global historical transformation, as Castells (1998:1) explains:

> As all major transformations in history, it is multidimensional: technological, economic, social, cultural, political, geopolitical. Yet, in the end, what is the real meaning of this extraordinary mutation for social development, for people's life, and well-being.

Notwithstanding the complexity of racial, ethnic, cultural as well as urban-rural poverty challenges we may face (Marx, 1996; Vale, 1994; Wentworth, 1994), South Africa's new political democracy, in addition to global transformation, seems to require even greater attempts to effect meaningful change and social cohesion. Moreover, given the increasingly multicultural and multilingual composition of South African classrooms, educators may have to address the complex challenges in terms of how they would give effect to, and are in fact affected by both the content and quality of interactions encountered in intercultural learning and teaching (Banks, 1991; Macpherson, 1983; Weil & Joyce, 1978). Effecting change may well require committed, albeit critical educators to rethink how they would strategically construct opportunities and spaces in which they will be able to recognise and build on learners' knowledge and experience (Elstgeest, 1992:14; Odora-Hoppers, 2001:2) and, as such, ensure that such learners are able to insert themselves into the democratic processes (Prakash & Esteva, 1998:23) in the curriculum. Learners act upon knowledge, even as it acts upon them. As a result, Schostak (2000:48) argues:

> There can be no grand narrative concerning what is 'good for all'. Standardisation ... to create the curriculum is patently absurd in a context of change that is so fast, so diverse and so technologically and culturally creative.

Standardisation of the curriculum generally tends to imply that schools exist "... in a vacuum hermetically sealed off from the outside" (Brighouse & Woods, 1999:99). Such a curriculum could prove to be rather alienating than invitational in that it primarily seeks to satisfy the state, curriculum developer or teacher, instead of converging with the needs of learners in their respective personal and social contexts (Odora-Hoppers, 2001:2). At best we may have considered the gloss teachers have painted over the social dimension of knowledge construction (Roth, 1998:11). After all, we all interpret behaviours, information, and situations through our own cultural lenses, below the level of conscious awareness, making it seem that our own view is simply "the way it is" (Delpit, 1995:151).

In a context of constant change, the learning and teaching of natural science and technology, therefore cannot unilaterally continue to operate as if knowledge can still be regarded as an objective mirroring or reality (Elliott, 2000:181). On the other hand, individuals participate in the process of culture, including knowledge production, not just in webs of culture and tradition, but also in ways that may exceed the culturally given or expected (Yon, 2000:5). Herein resides the gist of this article, i.e. how do educators expand and integrate a wider, in fact more flexible and a more authentic perspective of culture and identity in knowledge construction, particularly in the learning and teaching of natural science (henceforth we will just refer to 'science') and technology. Educators, in a collaborative way, may have to strategically rethink the curriculum challenges in terms of how scientific and technological knowledge will be constructed (Hawes, 1982; Russell, 1991; Scott, 1999).

A critical contributing factor, which impacts on the dynamics in science and technology knowledge construction, is that of globalisation and its diverse implications (Esland, 1996:13). One of the many key aspects of globalisation is the emergence of the knowledge or network society (Castells, 1998) in which all social organisation and knowledge production inevitably become increasingly interdependent activities, and which could hopefully lead to expanded levels of understanding and change in our society (Subotsky, 2001), as well as us becoming aware of the "cultural flows" and "deterritorialization of culture" (Appadurai, 1997:15). If it is generally accepted that the nature of knowledge production is constantly shifting, this would require a critical mindset towards paradigm shifts (Kuhn, 1962) on the part of all educators of science and technology, to shape and validate not only factual content of their disciplines but also to critically conceptualise and integrate personal and social skills, processes and information that learners may bring, and which may ultimately adjust, reconfigure or reconstruct knowledge content (Beetlestone, 1998; Harlen,1992b; Larochelle *et al.*, 1998; Newman, Griffin & Cole, 1989).

In many schools there may be the tacit or maybe expressed belief that standards, to reinforce the tendency towards an imitation and reproduction of the *status quo* (Gomez, 2000:126), may be compromised. Delpit (1995:141) argues that in mainstream educational thinking,

many teachers feel that they are losing control if learners do not fit in with their traditional teaching content and teaching methodology. Roth (1998:19) refers to the reality of mainstream understanding of science and technology, which is well-established and paradigmatic in nature and application of canonical knowledge. Elliott (2000:201) acknowledges this reality, but argues for a more critically-responsive curriculum:

> Standards-driven change is surface reform and largely reinforces the time-warped character of schooling at a time when schools need to become more responsive to social change in the wider society.

Greater responsiveness to social change would decidedly be a key challenge for science and technology in that educational change depends on what teachers do and think — it's as simple and complex as that (Fullan, 1991:117). Amidst the local and global complexities of educational change, educators would have to adopt a particularly cross-fertilising (Kraak, 2001:4) perspective in science and technology knowledge production in local contexts, i.e. being mindful of the fact whether or not the artefacts and activities of the setting allow students to engage in practices that bear resemblance with those in out-of-school communities (Roth, 1998:14).

This article attempts to contextualise and develop the often complex ramifications of the concept of Indigenous Knowledge Systems (IKS) in terms of the general framework of knowledge production, and examine the shifting implications these perspectives may have for the teaching and learning of science and technology in a developing country such as South Africa.

Knowledge production

Traditionally knowledge construction in South African schooling has always assumed a space beyond the social position of the knower and, this problematic issue needs further unpacking.

Knowledge production and context

The epistemological crisis confronting education (Petraglia, 1998:7) focuses very much on how educators conceive of and define knowledge, and as a result view the purposes of schooling. For example, in examining the role of constructivism in knowledge construction, Phillips (1995) identifies the constructivist's good side as the need for active participation by the learner and the recognition of the social nature of learning, but the bad side seems to be:

> ... the tendency within many forms of constructivist epistemology ... towards relativism, or towards treating the justification of our knowledge as being entirely a matter of socio-political processes or consensus ... (Phillips, 1995:11).

Yon (2000:15) warns that the processes of globalisation have significantly changed perceptions of time and space and rendered problematic the notions of identity in learning as fixed in time and space. Central to the emerging processes in the global society of which South Africa is part, educators may have to engage with a conception of knowledge which would speak to their social context, particularly since changes in the curriculum can call into question the nature of knowledge itself as it has always been a powerful factor (Atkin, 2000:82). Generally-speaking, there are at least two approaches for our challenges to the sociological analysis of knowledge. The first derives from political economy and the other from political theory. On the one hand political economy views knowledge as a form of property or capital. Such knowledge as a form of cultural capital is subscribed to by Castells (1998) and Bourdieu (1986), and is usually, although not always, acquired through formal education. While Collins (1979) argues that the latter may be used as an instrument of closure and monopoly of meaning, Carnoy (2000) believes that while it can be used in an exploitative manner, formal education is a productive force for the development of self-knowledge, i.e. developing a sense of cultural identity, whether ethnic, racial, gender, local, regional or global.

On the other hand political theory views knowledge as intimately linked to interest and the domination of power (Badat, 1997:14-16). This form of knowledge is well-known to South Africans who, as a result of Apartheid, have regarded knowledge produced in the schooling system as hegemonic practice in that it gave rise through power domination to discrimination, inequality, poverty and social breakdown (Avis, 1996:6). Hence, the current emphasis on a social justice framework for education and training in terms of empowerment, investment in the people, lifelong learning and the necessity for responsive, yet equitable approaches should point towards social justice and the development of democratic participation (Avis 1996:9). As a result, knowledge towards what is referred to as situational understanding can be generated only within the situations and by those persons who through their action (or non-action) are elements of it (Posch, 2000:62). To give greater effect to Posch's argument it may be useful to examine two critical modes of knowledge production, i.e. Mode 1 and Mode 2, to contextualize Indigenous Knowledge Systems (IKS).

Mode 1 and Mode 2 knowledge production

In terms of knowledge production through the utilisation of the local, indigenous expertise and resources at hand (Posch, 200:63), it is helpful to refer to the Mode 1 and Mode 2 models of knowledge production, postulated by Gibbons (in Kraak, 2001). Gibbons argues that fundamental transformation of knowledge production is taking place outside of existing academic disciplines. The Mode 1 strategy refers to the core or base of disciplinary and specialised knowledge. With the dramatic changes occurring in virtually all disciplines in a rapidly globalised and shifting world order, there has been a radical shift towards Mode 2 knowledge production in which educators may begin to recognise and validate the context in which such knowledge is produced. For science and technology educators this would mean that new and appropriate knowledge could arise in the process of recognising the value of community involvement and the impact that the local context could have on knowledge construction in science and technology. Mode 2 knowledge production, according to Gibbons (in Kraak, 2001:2) is essentially collaborative in its intentions and proves by far to be more heterogeneous in terms of learner inputs which do not always necessarily represent the views of the experts as contained in the final product (Kraak, 2001:2).

Mode 1 knowledge production, within subject-specific disciplines, is however an essential prerequisite for Mode 2 knowledge production and they therefore ultimately cross-fertilise each other. These modes ought to become increasingly interdependent and reshape each other for enhanced understandings of the interconnectedness of science and technology with all relevant social phenomena (Kraak, 2001: 6). Instead of developing the traditional, hierarchical modes of knowledge production, Mode 1 and Mode 2 could be viewed as being relational and not one of sub- and super-ordination but as being relatively symmetrical (Posch, 2000:63).

For our purposes Mode 2 may be an extremely useful platform to contextualize the notion of Indigenous Knowledge Systems (IKS) because the latter is generated in the context of application and is not developed first and then applied to the context later, although elements of existing knowledge have entered Mode 2 (Kraak, 2001:1). In this sense the application of Indigenous Knowledge Systems in science and technology cannot be developed along pre-specified routes but are stimulated by the perception of shared interests (Posch, 2000:63). The application of this approach to a science and technology curriculum may be one, albeit crucial way of dealing with the rapid shifts in knowledge production, and at the same time, contextualize all learning in an authentic and non-standardised way. Our approach is thus a critique of the essentialism and assumptions about the fixed nature of knowledge construction, especially in science and technology. In order to encourage and foster qualitative change in the way science and technology are taught, it may be necessary for more clarification, to examine the self-correcting purpose of Indigenous Knowledge Systems.

Clarification of Indigenous Knowledge Systems

Landan (1996:183) argues that after several decades of benign neglect, the content of science has once again come under the scrutinous gaze of the sociologist of knowledge. It is in this context of a culture of silence (Prakash & Esteva, 1998:2) that IKS wants to address the teaching of science and technology. Any conceptualisation of IKS would suggest that the science curriculum must focus on the relational dimension of cultural life where dialogue, conflict and interaction are more significant than fixed characteristics (Montecinos, 1995:294). Therefore, rather than pursuing a single and definitive meaning, Indigenous Knowledge Systems (IKS) present a critical framework for thinking and knowledge construction which would be complementary and expansive to the mainstream understandings of all disciplines. Given the increasingly diverse multicultural composition of our classrooms, Odora-Hoppers (2000:4) offers a broad perspective of IKS that may be useful to assist educators get a grip on what could be a rather complex situation, no matter how simple they may think it is:

> IKS is characterised by its embeddedness in the cultural web and history of a people including their civilisation, and forms the backbone of the social, economic, scientific and technological identity of such a people. It is these knowledges that are referred to as indigenous knowledge.

This non-essentialist approach to IKS illustrates the plurality and inclusivity of its vision, which will build on learners' experiences and how they give value to the social and relational importance of identity (Yon, 2000:24). IKS seeks to embrace both the tangible and intangible aspects which have exchange value and which can be transformed into enterprises or industries to perpetuate social, cultural, scientific, philosophical and technological knowledge (Odora-Hoppers, 2000:4). Besides its complementary and expansive role in terms of how learners insert themselves into the curriculum which is often being pre-determined, IKS aims to be transformative, particularly in the way teachers in South Africa, across all subject areas, engage learners in a form of knowledge construction in which they will recognize themselves. The notion of indigenous implicit in IKS seeks to be transformative in that it strives to be inclusive, particularly of those views that have been historically excluded from knowledge construction, to encompass the diversity of cultural, racial, ethnic and religious practices of all people, and which will lead to a situational understanding (Posch, 2000:62) of the learners' social context.

The notion of *indigenous* in IKS

The notion *indigenous*, admittedly, could be a highly contested concept, for it could also be taken by some to be indicative of that which is primitive, naïve or unscientific (Stavenhagen, 1997:165). However, meanings and specifically the rendering of context-specific meaning can change, since it also only displays another world-view (Cuff & Payne, 1985:8; Landan, 1996:85;). When one explains one's indigenous status, the description can never satisfy the desire to be recognised as a complex subject, for identities change everyday, sometimes for better, sometimes for worse and in the end it is all up to us to try to be the person we want to be (Yon, 2000:25). In our attempts to develop an indigenous discourse, therefore, we may also encounter a very fragmented and factionalised indigenous movement (Stavenhagen, 1997:164).

Etymologically, however, the concept *indigenous* refers to a sense of belonging naturally to a place, i.e. that which is native. The same concept *ezemvelo* in the Xhosa and Zulu language derives from the root *mvelo*, meaning the original inhabitants of an area. Similarly, the concept *inheems* in the Afrikaans language refers to what naturally belongs to an area. The study therefore of *heemkunde* (*Heimatkunde* in German) is the study of an environment, the people's morals, habits, historical relics, legends, songs and stories. If the notion of *culture* refers to and in fact expresses the being and attributes of a particular native land and its people, we may link *culture* to the notion of *indigenous*, as not only a particular form of intellectual expression; e.g. in art and literature, but also to include the customs, arts, technologies and social institutions of a particular group of people as well. Culture, anyway, is constantly constructed, reconstructed, invented and reinvented by ever-changing subjects (Stavenhagen, 1997:155). This point is well argued by Yon (2000:6):

> Cultures are viewed as objects that can be set against each other, so that 'new cultures' and 'not having a culture' are set against 'old cultures' ... Elusive culture, made from the fragments and mingling of representations, is a critique of this dominant discourse of culture.

By considering the implications of mingling of culture and the indigenous element in science and technology, educators may create a platform for learners to construct knowledge in terms of that which speaks to them as learners.

The notion of *indigenous knowledge* in IKS

Roth (1998:11) points out that learning is not only the result of individual sense-making efforts but involves interactions between all living and what he calls "artifactual components of a community of participants". He challenges particularly science educators to reconsider the gloss which they may have painted over the social dimension of knowledge construction (see also Walshok in Kraak, 2001:1). The notion of *knowledge* in its social context would therefore embrace both declarative, i.e. the specific cultural, traditional and community facts, as well as the procedural, i.e. the peculiar or general processes in knowledge construction. In this sense IKS could be linked to the scientific literacy of learners which is not hermetically sealed off from the outside (Brighouse & Woods, 1999:99), but involves an understanding of the social organisation and practices of science whereby knowledge claims are transmitted into public knowledge, and of the influence of science or the wider culture, and *vice versa* (Driver, 1996:13). Science and technology educators can, and ought to expand and integrate the social and academic aspects of learning to contribute to an increasingly globalised world. Mode 2 knowledge which is generated in the context of local applications will undoubtedly be useful for science and technology educators (Kraak, 2001:2) if integrated in a sensitive manner into Mode 1 disciplinary knowledge.

The social versus academic dimensions of IKS

In seeking to understand the essence of IKS we may argue that there would be a constant meta-level of historical, ontological and epistemological creation and re-creation of individual and collective experiences which are at work within the context of a society's norms and ideologies (Martineau, 1997:391). Within all societies there are also entrenched codes or rules for participating in power, i.e. there is a definite culture of power (Delpit, 1995:24). This process may moreover be conscious or unconscious and may often be both orderly and unruly (Odora-Hoppers, 2000:4) in the way it unfolds. The essential dilemma however is captured by Roth (1998:11):

> The fundamental problem of schools is that the social context they [teachers] offer are different from everyday communities of practice, where newcomers enter existing communities; in most school classrooms there usually is one teacher who is responsible for a common learning curriculum ... students are grouped homogeneously [and] such homogeneity of learning is uncharacteristic of everyday out-of-school communities.

In the South African context Muller & Taylor (1993:315) speak of the need among learners to invent new knowledge precisely because the domain of everyday life stands in stark contrast to the academic domain. The school as a pivotal location (Cornbleth, 1990:110) seems to be best placed for the construction and reconstruction of knowledge in a formal sense (Van Wyk, 1997:540). With particular regard to science, Russell (1991:137) expounds the link between communities' perceptions of science and its impact on the content and processes involved in the curriculum:

> The perception of science by any particular society, the values and beliefs with or against which science must work, the preconditions, misconceptions and alternative frameworks which

> occupy the minds of the population, including children when first entering school, are some of the features of a culture which interact with the content, methods and attitudes of primary science.

IKS has a great deal of common ground with constructivism which tells us that there can be no grand narrative for teaching but rather that, in the case of science and technology, all knowledge must be understood as partial to the social position of the knower — the knower's race, gender, class, and so on will determine what is paid attention to and how things are interpreted (Montecinos, 1995:297). The learner's social knowledge therefore needs to be integrated with what is otherwise regarded as mainstream, academic knowledge.

The integrative function of IKS

Given the transformative attempts under way in South Africa, education and particularly the way teachers view learners' construction of knowledge, the social purposes of scientific and technological knowledge and their applicability in the learners' environment, have become more intertwined than ever before. The social dimension of Mode 2 knowledge could be socially useful and socially accountable knowledge and it will establish the unity of science (Kraak, 2001:2; see also Landan, 1996:210). Montecinos (1995:297) sees this as situated knowledge that stems from the social intersections from which various individuals participate.

IKS essentially problematizes the insufficient integration of "personal knowledge" and "public knowledge" (Watts, 1991:124). This is particularly applicable in the teaching of science and technology, which is emphasised by Atkinson and Fleer (1995:7), and which resonates with the integrative and interactive intentions of IKS strategies in the curriculum:

> Learning is viewed as a human construction — children try to make sense of their world through active exploration of their environment and social interchange with people around them.

The Mode 1 knowledge production within specific science and technology content will be a requirement for Mode 2 local knowledge production, and they would ultimately cross-fertilise each other (Kraak, 2001:6) to stimulate shared interests (Posch, 2000:63). This focus on shared interests, however, also requires an attitudinal change on the part of the educator. Delpit (1995:177) refers to a well-intentional teacher who says she does not see colour, she only sees children. Delpit (1995:177) asks: "What message does this statement send? That there is something wrong with being black or brown, that it should not be noticed? I would like to suggest that if one does not see colour, then one does not really see children". It is clear that IKS also has an explicit political message, particularly in the South African context.

The political-cum-transformative function of IKS

The need to integrate IKS in South Africa across curricula of the various learning areas has, among others, a very definite socio-political and socio-historical context, particularly in the teaching of science and technology (Bigelow, 1985; Harlen, 1992a; Hawes, 1982; Mehl & Rhodes, 1989; Odora-Hoppers, 2000). Odora-Hoppers (2000: 9) argues that to engage in IKS, the political implications of colonialism would need to be examined by educators as well as policymakers to realise how and why colonialism spawned the development of:

> ... hierarchies of knowledge and power by inventing discourses of Otherness which involves the recreation of people's history by those 'outside' of it. But at the same time creates within its own ranks, as it happened during apartheid, a separate category of 'Others'. In both instances of this 'colonialism', there is an implicit and explicit reinforcement of the myth and purported superiority of those with control over the process of representation, whether as tertiary institutions *vis-à-vis* the rest of society, or in groupings within the camp.

The debilitating legacy of colonialism, particularly the way it has shaped the mindsets and general behaviour of both the colonised and the coloniser, is admittedly extremely complex (Nicholas & Cooper, 1990). For clarification, Hernández, a Nahua Indian living in Mexico, speaks of his experience of prejudice which is not just what he calls a one-sided syndrome. The whites and mestizo (mixed-blood) population have prejudices about Indians, but Indians in turn also have prejudices about whites and mestizos:

> I became more aware of the fact that I was different from the rest of society in 1965 when I took up my post as bilingual teacher in the Nahua region in the northern mountains of Puebla. They called dogs bilingual to degrade and humiliate us as teachers. As a reaction, I came to deny my culture, my language, my origin, and my identity. Fortunately, years later I had access to reading that helped me understand that I belonged to a historically oppressed social group: the indigenous peoples. Fanon's 'Wretched of the earth', Memmi's 'The coloniser and the colonised', Freire's 'Pedagogy of the oppressed' and Amilcar Cabral's 'Culture as a foundation for the liberation movement', are some of the books that helped me form a broader vision of my reality as a member of the indigenous community (Hernández, 1997:182).

Our concerns regarding IKS *vis-à-vis* science and technology in the context of the indigenous element and the emphasis on the local, or the lack thereof, seek to go much further than experiencing a sense of timidity in the face of colonial exploiting, occupying, recording flora, fauna and ethnographic peculiarities. There is a deeper level of personal and collective experiences than these observable exploits (Hernández, 1997:182-184). In fact, the act of colonisation as a form of alienation is often likened to symbolic castration or the process of cutting off in which the colonised achieves a genealogical death of the defeated local lineage, whilst at the same, allowing him or her to continue to live which, as a result gives rise to a split or schizophrenic condition. Miller (1991) argues how the cultural emasculation of colonialism and slavery has resulted in institutionalised marginalisation on the one hand, and institutionalised reintegration of all those alienated colonised into the system where they were regarded as strange and exotic and minors who need protection (Hernández, 1997:185). This discourse of schizophrenia or separateness has been systematically entrenched into all conceptualisations and explanations of western cosmology (Stavenhagen, 1997:158-163). In coming to terms with the trans-oceanic slave trade where black people were the dispossessed and victimised, as well as reflecting on the race-based ideology of apartheid in South Africa, we need to differentiate between real oppression and the use of oppressive methods in a society (Mellet, 2000: 19). Being socialised into oppression and powerlessness has a very complex impact even on educators' lives, which makes the desocialization process from powerlessness very difficult, especially for the definition and enjoyment of cultural rights (Stavenhagen, 1997:160). Among all societies there is still the strong assumption that culturally different children are mismatched to the school setting and therefore cannot be expected to achieve as well as white, middle-class children. They are told that children of poverty backgrounds are developmentally slower than other children (Delpit, 1995:178). Nicholas and Cooper (1990:25) refer to Althusser's (1971) theory when they discuss the pre-1994 political dispensation in South Africa:

> In seeking to naturalise and reproduce the existing social and power relations, the ruling class employs the ideological state apparatus (ISA) which includes schools, the media and professional associations. So conformist psychological journals, in the interests of maintaining the coalition, must reproduce its existing notions of science and neutrality.

In the face of the arduous task to conscientise and desocialise both the colonised and the coloniser from their respective limiting mindsets and behaviour, poses a huge but not insurmountable challenge for IKS. Against the backdrop where Castells (1998) and Bourdieu (1986) view knowledge as a form of property and capital, Dias (1993:230) sketches the history of Africa in which its status is always referred to as pre-capitalist, pre-democratic and irrational capital and therefore stuck in time and space with regard to rapid developments in the rest of the

developed world. Given this huge challenge, Roth (1998:19) questions how teachers in developing countries would engage the mainstream understandings as social capital of science, design and technology which is well-established in its paradigmatic nature and application of canonical knowledge — it is more or less linear, logical processes of applying well-established knowledge to existing problems. Local knowledge production in science and technology, however, ought not be sub- and super-ordination, but rather symmetrical (Posch, 2000:63). In this context the notion of colonial knowledge needs to be clarified *vis-à-vis* the value of local knowledge.

The canon and the local in IKS

The canon in the traditional curriculum represents the grand narrative and usually privileges the Western-European perspective and silences the other non-Western (Montecinos, 1995:300). In contrast to canonical and mainstream scientific and technological practices, Odora-Hoppers (2000:2) is convinced that the strategic attempts in Western scholarship gave a negative cognitive and ontological status to everything African and more particularly to explain everything in terms of concepts and understandings belonging to western cosmology which is directly part of a monopolising and conformist-driven strategy:

> This had the consequence that the defeated ones (the colonised) not only lost their life space, but also their word. Monopolisation of the parameters for interpretation was further ensured by marginalising whatever has not been determined by western conquest ... (own emphases).

At issue here is whether or not the artefacts and activities of the local setting would allow learners in science and technology to engage in practices that bear resemblance with those in out-of-school communities. Muller and Taylor (1993:319) argue that curricula in highly abstract subjects such as mathematics tend to mirror the theoretical concerns of the educators. Gestures towards making school mathematics relevant to the world of work and other daily activities are most often simply a contrivance, however well meant. By drawing upon the everyday local and often taken for granted experiences of learners, each successive experience can be exploited towards enquiry and understanding in order to develop higher levels of scientific and technological literacy in an integrative manner (Macleod & Mills, 1990:4; Pluckhouse, 1989:5). Bruffee (in Petraglia, 1998:76) argues that educators should help learners renegotiate their membership in the knowledge communities they come from while helping them reacculturate themselves into the academic communities they have chosen to join.

IKS moreover problematizes the need and role of the local reality versus the global which often encompasses decontextualized, canonical, mainstream understandings of science and technology (see especially Rowlands & Holland, 1991). The traditional guidelines for local school practice, i.e. the values, attitudes and knowledges of particular localities, have often been replaced by more removed and globalised substitutes (Giddens, 1990:21-29). This leads to the child-deficit and invisibility assumptions teachers hold about children (Delpit, 1995: 172-176). In fact, what is included and excluded in the curriculum and school practice, including in the case of science and technology, directly or indirectly contributes to the escalation or de-escalation of learner invisibility and marginalisation (Martusewicz & Reynolds, 1997:5). This form of marginalisation or alienation of learners from the 'high and elite culture' (Stavenhagen, 1997:154), has given rise to the tremendous difficulties which, for example, mathematics teachers have experienced in assessing learners in particular multicultural contexts. In this regard Cooper and Dunne (2000:43-44) raise the difficulties around what they call "relational sociologies of education and culture" in that assessment techniques tend to favour some social groups over others, making them to rethink the boundaries between "esoteric mathematical knowledge", the IKS type, and "everyday knowledge", the mainstream type. Cooper and Dunne's work focuses on US learners, while Nunes, Schliemann and Garraher (1993) focus their work on UK learners. Nunes, Schliemann and Garraher (1993: 10) argue that street mathematics and school mathematics often lead to a trade-off in order to solve educators' problems. To correct the historic power imbalances in the teaching and learning of science and technology, IKS offers a valuable paradigm for eliminating personal and systemic dysfunctional consequences in our schooling.

The new space for IKS

IKS opens the creative space for science and technology educators to reflect on their learners' concepts of identification, which raises critical questions about complex insidious classroom and more specifically teacher-learner relationships. While it is true that learners may construct and reconstruct their identity over the passage of time, the present reality in science and technology classrooms is articulated through codes (language, behaviour, knowledge constructions) that may still belong to those who are made other (Yon, 2000:12). Looking to the future and accommodating diversity, science and technology (and other) educators will begin to grasp the difficulties inherent in talking across cultures, ethnicities, and power differentials (Delpit, 1995:144).

Implications of Indigenous Knowledge Systems for science and technology teaching and learning

In the preceding sections we addressed the rationale as well as the conceptualisation framework of IKS in terms of the construction of situated knowledge (Montecinos, 1995:297). It has become clear that a learner's social and cultural life cannot be subsumed into a master narrative. As such, the wider implications of IKS, in terms of its political, interpersonal, policy, institutional, linguistic and cognitive, methodology and ethical principles, hold tremendous value for science and technology educators in grasping and changing their long-held personal and systemic dysfunctional practices.

Political

Historically science and technology have been the preserve and monopoly of an ethnic minority in South Africa (Mehl & Rhodes, 1989: 220). The legalised political exclusion of the majority of South Africans gave rise to skewed perceptions that Blacks are not "naturally" inclined to science and technology understanding and manipulation. As all South Africans are hopefully seeking to transcend the "economy of stereotypes" (Morrison, 1992:11), where we recognize and validate difference, rather than using difference to separate cultures, communities and social formations. Science and technology learning is one way, albeit an important way, through which people make sense of their worlds and those of others. Learners of all cultures and backgrounds build "webs of significance" (Geertz, 1973:19) by bringing to the learning situation their representations of ideas which can be received and passed on (Banks, 1991; Bigelow, 1985; Russell, 1991). Amidst the mainstream notion of science and technology as the exclusive site of western scientific knowledge construction, educators may appreciate the rich value of integrating all knowledges, i.e. as Prakash & Esteva (1998:46) acknowledge: "Learning to listen, then listening". In terms of IKS, educators will be required to develop the political will and continually engage in change so that their identification of science and technology needs and opportunities will lead to relevant, yet constantly changing planning and evaluation to include all learners (Clare & Sisson, 1990:3-15).

Interpersonal

Historically the scientific fraternity in South Africa has always been a narrow if not almost exclusive white male network representing a culture of power. Delpit (1995: 25) speaks of the rules of the culture of power which are a reflection of the rules of the culture of those who have power. With our post 1994 democracy hopefully there will be an increased culture of sharing, even among institutions, so that science and technology educators will strategically want to ensure that the school provides their children with discourse patterns, interactional styles, and spoken and written language codes that will allow them contentment and success in the larger society (Delpit, 1995:29).

The science and technology curriculum cannot successfully operate without celebrating and acknowledging learners' social needs and their self-esteem (Dunn & Larson, 1990:14). In terms of IKS the school will always be the pivotal location (Cornbleth, 1990:110) to facilitate greater communication between and among the diverse learners, educators and institutions within communities. Science and technology educators can thus "avoid the standard didacticism of mathematics and science teaching" (Hawkins, 1990:121) by facilitating interactive, exciting and exploratory approaches which will include learners from all backgrounds. In acknowledging the role of IKS, educators will soon learn that learners are no longer margins and centres but all centres (Prakash & Esteva, 1998:114-115).

Policy

Historically the political ruling class institutionalised an effective policy framework on every level of schooling, and which particularly marginalized the majority of Black learners in science and technology. Indigenous perspectives were often regarded as other, primitive and unscientific (Odora-Hoppers, 2000:2). Often there has been little, if any integration of personal and public knowledge in the domain of science and technology policy and teaching (Watts, 1991:124). For science and technology teaching to be both relevant and authentic (Petraglia, 1998:14-19), it has to be enshrined in and driven from a policy perspective that is not only inclusive, but also enabling. This is particularly requisite for mathematics and science, as pointed out by Delpit (1995:63-64). IKS policy implications for science and technology educators must be supportive to avoid them being

> ... criticized and caricatured as 'politically correct' or 'caught up in their own mission' by those who are indifferent or supposed to what they believed these policies required from them. In these ways competing discourses shape relations among teachers as they also produce tensions within individual teachers" (Yon, 2000:31).

Policy initiatives in science and technology teaching ought to facilitate the integration of knowledge systems of all learners (Odora-Hoppers, 2000:6) in an enabling environment which will build confidence and self-esteem (Benson, 1992:14).

Institutional

In the past schools and institutions of higher learning pursued their scientific and technological efforts in exclusive, mainstream scientific paradigms, without really taking into account the value and realities of African perspectives (Odora-Hoppers, 2000:3). Many African children often could not recognize themselves in the science and technology curriculum and, like the Nahua Indians in Mexico, they felt that institutions tend to communicate on a formal level without managing to enter into a true dialogue with the community (Hernández, 1997:181). IKS seeks to humanize schooling by institutionalising a culture of democracy and to dispense with "cut throat, crass competition, or softens the competitive edge so that no one bleeds" (Prakash & Esteva, 1998:12). Changing institutional and cultural practices involves a commitment by all within the organisation/school to examine norms, values and policies that favour inclusion.

IKS moreover seeks to establish social justice, particularly in the South African context where funding for previously exclusively white schools and other institutions for resources (e.g. laboratories, equipment) has been grossly in excess of other groupings. In the pursuit of opening spaces and opportunities for science and technology careers, IKS ought to support educators to create win-win situations for all, including the right to equality and excellence (Prakash & Esteva, 1998:12). To achieve this in terms of IKS, science and technology educators must be rendered institutional support for capacity development (Van Wyk, 1997:542) to deal with the complex and contradictory discourses that structure conversations and students' decisions about what is appropriate (Yon, 2000:81). At the same time educators will be working to forge genuine partnerships and informed alliances for development (Odora-Hoppers, 2000:7).

Language and cognition

The western epistemological notions of what is scientific, reliable and valid have been squarely constructed in terms of western codes and rules of the culture of power (Delpit, 1995:24). Science and technology educators are keenly aware of what key role language plays in the cognitive processes of knowledge construction (Beetlestone, 1998; Driver, Leach, Millar & Scott, 1996; Newman, Griffin & Cole, 1989). Given the complexity of language-related difficulties surrounding the teaching of science and technology in South African schools where English is exclusively used, Delpit (1995:99) shares her experience of a Native Alaskan teacher:

> Another example of the decontextualizing ritual often enacted in schools is our insistence that children verbally mediate any action. The action ... must be put into words. Native teachers often told me that one of their greatest frustrations was to have one of the instructors ... insist that they explain how they solved the problem. Doing it was not sufficient; unless it was accompanied by words; it didn't count. How many times do we insist that children talk through some problem they have already solved? We think we are 'checking for understanding', but could we merely be helping them to ignore context?

Science and technology educators may well become aware of valuing learners' social and language context and, at the same time, become aware how language may have the potential to decontextualize what either they or the learner may say. IKS seeks to support educators not to decontextualize the learning and teaching of science and technology but, rather than being language-blind or deaf to mask educators' discomfort with differences, assist all learners, particularly those whose mother tongue is not English and achieve how to make the transition (Delpit, 1995:103).

Methodology

Odora-Hoppers (2000:5) elaborates on the methodological implications of IKS in that they will assist educators to become sensitive and empowering of themselves as well as their learners. Hawkins (1990: 97-139) urges educators particularly in science to become sensitive to what they regard as cultural or other gaps in their learners' experience and how to bridge that gap. With the introduction of outcomes-based approaches to the teaching of science and technology, the assumption has been that these approaches will foster critical thinking and independent decision-making, by giving greater recognition to the learner's prior, homegrown and local knowledge. In this regard Macleod and Mills (1990:2) emphasize that the teaching of science and technology constantly has to highlight features of local environment and any local supportive facilities and in so doing validate learner inputs. Kelly (1999:5) speaks of both the planned and the received curriculum. The former entails the official guidelines laid down, while the latter becomes the actual or received curriculum. Kelly (1995:5) focuses on the foolishness of educators who ignore the learner's homegrown and local experiences and who emphasize the theoretical concerns of the well-intentioned educators (Muller & Taylor, 1993:319). IKS alerts science and technology educators to the inescapable influence that other indigenous, yet inclusive perspectives hold for the knowledge-generating potential of all learners, i.e. "... its ability to create a place in an already accepted paradigm for a new particular" (Petraglia, 1998:124). More than this, educators may realize their ability through IKS approaches for "... establishing consensus to create a social knowledge that complements personal knowledge" (Petraglia, 1998:124). In this way educators will have succeeded in what is regarded as enlarging epistemic cognition, not only for previously subjugated groups, but for all (Odora-Hoppers, 2000:6).

Ethical

If the explicit attempts of IKS are to humanize and affirm learners (Odora-Hoppers, 2000:7), educators need, on a moral level, to reckon with the disparities of the South African past, particularly with regard

to the supposed neutrality of science and technology. In discussing ethics in pluralistic societies Colesante & Biggs (1999:186) argue that although tolerance is required in a democratic society that respects people, it does not necessarily follow that citizens should be tolerant of actions or ideas that negatively affect the rights and welfare of others — as enshrined in our constitution.

IKS is significant for science and technology educators, from an ethical perspective to help themselves refocus on "... the classroom site for suppressing the savage inequalities that leave some individuals more equal than others; and some cultures more excellent than others" (Prakash & Esteva, 1998:13). The ethical imperative for educators and curriculum developers is learning how to incorporate an appreciation of cultural diversity and IKS strategies in their science and technology teaching.

IKS draws attention to the fact that science and technology educators will want to become morally obliged to "... desire to know the different cultures, and conversely, the resentment toward having to know and adjust to them 'in order to teach', as one teacher puts it" (Yon, 2000:44). There is another dimension to this, i.e. that in the globalising scenario in schools, learners produce forms of culture, as well as race, and new cultural practices that facilitate and enhance their everyday social relations (Yon, 2000:44). Educators would thus become honest to acknowledge that the meaning of culture may also be constantly changing and their assumptions of learners' identity, culture, etc. will be increasingly displayed in the gap between learners and themselves in cultural and identity conceptualisations and the knowledge they produce (Peacock, 1991; Peacock & Smith, 1995).

Conclusion

We have sought to examine perspectives that underpin IKS in order to develop clearer understandings of how science and technology educators may challenge a "self-contained monovocal view" (Montecinos, 1995:293) of culture, ethnicity and identity, particularly in terms of how diverse learners may construct knowledge from these multiple perspectives. In terms of outcomes-based education (OBE) policies, educators have to facilitate all learning through processes which are designed to increase learners' ability to recognise, understand and appreciate differences as well as similarities. IKS therefore posits a critical choice of frameworks (Odora-Hoppers, 2000:8) to assist educators to become aware of the cultural space (Prakash & Esteva, 1998: 30) of learners and how they may be able to bridge the distance that separates them from their learners. Science and technology educators could develop a new consciousness or awareness of the value of integrating their learners' way of seeing and way of being (Odora-Hoppers, 2000:6) with existing paradigms and epistemologies used in science and technology. In this way IKS becomes "a pedagogy that listens to what Others have to say — in favour of a reciprocal interaction model" (Montecinos' 1995:301). IKS embodies ultimately a pedagogy that fosters cultural, social and identity criticism to validate the centrality of learners' experiences and how educators could support them to understand that their realities are socially constructed, and inevitably will be reconstructed as time goes on and exposure to different contexts are enhanced.

Contrary to the rigid and prescriptive curriculum demands of the past, the OBE policy framework for all learning areas allows educators ample space to be creative and innovative. The learning outcomes and the assessment thereof, particularly in this instance, science and technology, favour the learner's voice and social identity. Therefore, the particular kind of *transformative* OBE policy envisaged for a new South Africa seeks to create an enabling teaching platform for every science and technology educator to validate and enhance the learning of all learners, in *their* context.

References

Althusser L 1971. *Essays on ideology*. London: Verso.

Anderson B 1991. *Imagined communities: reflections on the origin and spread of nationalism*. London: Verso.

Appadurai A 1997. *Modernity at large: cultural dimensions of globalisation*. Minneapolis: University of Minnesota Press.

Apple M 1979. *Ideology and curriculum*. Boston: Routledge.

Atkin J 2000. Social change, subject matter — and the teacher. In: H Altrichter & J Elliott (eds). *Images of educational change*. Philadelphia: Open University Press.

Atkinson S & Fleer M 1995. *Science with reason*. London: Hodder & Stoughton.

Avis J *et al.* 1996. *Knowledge and nationhood: education, politics and work*. London: Cassell.

Badat S 1997. Educational politics in the transition period. In: P Kallaway, G Kruss, G Donn & A Fataar (eds). *Education after apartheid: South African education in transition*. Cape Town: UCT Press.

Banks J 1991. *Teaching strategies for ethnic studies*, 5th edn. Boston: Allyn & Bacon.

Beetlestone F 1998. *Creative children, imaginative teaching*. Philadelphia: Open University Press.

Benson C 1992. *Design and technology at key stages 1 and 2: a practical guide to planning and implementation*. London: Longman.

Bigelow W 1985. *Strangers in their own country: a curriculum guide on South Africa*. Trenton NJ: Africa World Press.

Bird M 1991. *Mathematics for young children: an active thinking approach*. London: Routledge.

Bledstein B 1976. *The culture of professionalism: the middle class and the development of higher education in America*. New York: W Horton & Co.

Bourdieu P 1986. The forms of capital. In: J Richardson (ed.). *Handbook of theory and research for the sociology of education*. New York: Greenwood Press.

Brighouse T & Woods D 1991. *How to improve your school*. London: Routledge.

Carl A 1995. *Teacher empowerment through curriculum development: theory into practice*. Cape Town: Juta.

Carnoy M 2000. *Sustaining flexibility: work, family and community in the information age*. Cambridge, MA: Harvard University Press.

Castells M 1996. The net and the self. Working notes for a critical theory of the informational society, University of California Berkeley.

Castells M 1998. *The information age: economy, society and culture. Vol. 3: End of millennium*. Oxford: Blackwell.

Castells M 2000. *Possibilities for development in the information age: information technology, globalisation and social development*. Johannesburg: Centre for Higher Education Transformation (CHET).

Chambers B 1995. *Awareness into action: environmental education in the primary curriculum*. The Geographical Association. London: Watkiss.

Clare D & Sisson J 1990. *Technology in the national curriculum*. Department of Education and Science of the Welsh Office, HMSO.

Cloete N 2001. Different meanings of globalisation in higher education. Bellville: University of the Western Cape. Paper presented at the *Conference on Globalisation and Higher Education*.

Colesante R & Biggs D 1999. Teaching about tolerance. *The Journal of Moral Education*, 28:185-200.

Collins R 1979. *The credential society*. New York: Academic Press.

Cooper B & Dunne M 2000. *Assessing children's mathematical knowledge: social class, sex and problem-solving*. Philadelphia: Open University Press.

Cornbleth C 1990. *Curriculum in context*. London: The Falmer Press.

Cuff E & Payne G eds 1984. *Perspectives in sociology*. London: George Allen & Unwin.

Delpit L 1995. *Other people's children: cultural conflict in the classroom*. New York: The New Press.

Dias P 1993. Democratisation and education as political challenge to social authoritarianism in India. *Nord Sud Aktuelle*, Themen 2.

Driver R, Leach J, Millar R & Scott P 1996. *Young people's images of science*. Buckingham: Open University Press.

Duckworth E, Easley J, Hawkins D & Henriques A (eds) 1990. *Science education: a minds-on approach for the elementary years*. Hillsdale NJ: Lawrence Erlbaum Associates.

Dunn S & Larson R 1990. *Design technology: children's engineering*. New York: The Falmer Press.

Elliott J 2000. Towards a synoptic vision of educational change in advanced industrial societies. In: H Altrichter & J Elliott (eds). *Images of educational change*. Philadelphia: Open University Press.

Elstgeest J 1992. Engaging children in active science. In: W Harlen & J Elstgeest (eds). *UNESCO sourcebook for science in the primary school: a workshop approach to teacher education*. Paris: UNESCO Publishing.

Esland G 1996. Education, training and nation-state capitalism. In: J Avis *et al.*(ed.). *Knowledge and nationhood: education, politics and work*. London: Cassell.

Fullan M 1991. *The new meaning of educational change*. London: Cassell.

Geertz C 1973. *The interpretation of cultures: selected essay*. New York: Basic Books.

Giddens A 1990. *The consequences of modernity*. Stanford: Stanford University Press.

Giroux H 1988. *Teachers as intellectuals: toward a critical pedagogy of learning*. New York: Bergin & Garvey.

Gomez A 2000. Reflective education and school culture: the socialization of student teachers. In: H Altrichter & J Elliott (eds). *Images of educational change*. Philadelphia: Open University Press.

Harlen W 1992a. Developing understanding and skills for teaching primary school science. In: W Harlen & J Elstgeest (eds). *UNESCO sourcebook for science in the primary school: a workshop approach to teacher education*. Paris: UNESCO Publishing.

Harlen W 1992b. *The teaching of science*. London: David Fulton Publishers.

Hawes H 1982. *Curriculum and reality in African primary schools*. Essex: Longman.

Hawkins D 1990. Defining and bridging the gap. In: E Duckworth *et al.* (eds). *Science*

education: a minds-on approach for the elementary years. Hillsdale NJ: Lawrence Erlbaum Associates.
Hernández N 1997. Indigenous images: assumptions and prejudices. Adult education and development. *Institute for International Cooperation of the German Adult Education Association*, 48:179-191.
Howson G 1991. *National curricula in mathematics*. London: University of Southampton Press.
Jarvis T 1993. *Teaching design and technology in the primary school*. London: Routledge.
Kelly A 1999. *The curriculum: theory and practice,* 4th edn. London: Paul Chapman Publishing Ltd.
Kraak A 2001. Globalisation, the learning society and the case for a unified national system of higher education in South Africa. Bellville: University of Western Cape. Paper presented at the *Conference on Globalisation and Higher Education*.
Kuhn T 1962. *The structure of scientific revolutions*. Chicago: University of Chicago.
Landan L 1996. *Beyond positivism and relativism: theory, method and science*. Oxford: Westview Press.
Larochelle M, Bednarz N & Garrison J (eds) 1998. *Constructivism and education*. Cambridge: Cambridge University Press.
Levin J & Allen V (eds) 1976. *Cognitive learning in children: theories and strategies*. New York: Academic Press.
Lund T 2000. Racism without frontiers. *Cape Argus*, May 31:6.
Macleod S & Mills G 1990. The teaching of science and technology in an interdisciplinary context: approaches for the primary school. *Science and Technology Education Document Series No. 19*. UNESCO: Division of Science, Technical and Environmental Education.
Macpherson J 1983. *The feral classroom*. London: Routledge & Kegan Paul.
Malone J, Burkhardt H & Keitel C (eds) 1989. *The mathematics curriculum towards the year 2000: technology and teacher dynamics*. Perth: Curtin University of Technology.
Martineau R 1997. Women and education in South Africa: factors influencing women's educational progress and their entry into traditionally male-dominated fields. *The Journal of Negro Education*, 66:383-395.
Martusewicz R & Reynolds W (eds) 1997. *Inside-out contemporary critical perspectives in education*. New York: St Martins Press.
Marx M 1996. Societal transformation: the basic programmes. In: A Burger, F Theron & A van Rooyen (eds). *Challenges in change*. School of Public Management, University of Stellenbosch.
Mazrui A & Alamin M 1998. *The power of Babel. Language and governance in the African experience*. Cape Town: David Phillips Publishers.
Mehl M & Rhodes J 1989. Peoples education in mathematics: a developing South African Revolution. In: J Malone *et al.* (eds). *The mathematics curriculum towards the year 2000: technology and teacher dynamics*. Perth: Curtin University of Technology.
Mellet C 2000. Victims can also be neo-fascists. *Cape Argus,* May 31:19
Miller E 1991. *Men at risk*. Kingston: Jamaica Publishing House Ltd.
Montecinos C 1995. Culture as an ongoing dialogue: implications for multicultural teacher education. In: C Slecter & P McLaren. *Multicultural education, critical pedagogy and the politics of difference*. New York: New York State University.
Morrison T 1992. *Playing in the dark: whiteness and the literary imagination*. Cambridge: Harvard University Press.
Muller J & Taylor N 1993. Into other wor(l)ds: curricular knowledge in the making. In: N Taylor (ed.). *Inventing knowledge: contests in curriculum construction*. Cape Town: Maskew Miller Longman.
Newton C & Tarrant T 1992. *Managing change in schools: a practical handbook*. London: Routledge.
Newman D, Griffin P & Cole M 1989. *The construction zone: working for cognitive change in schools*. Cambridge: Cambridge University Press.
Nicholas L & Cooper S 1990. *Psychology and apartheid*. Johannesburg: Madiba Publication.
Nunes T, Schliemann & Garraher D 1993. *Street mathematics and school mathematics*. Cambridge: Cambridge University Press.
Odora-Hoppers C 1998. Knowledge, socialization and learning in Africa: the challenge of authenticity in teaching. Pretoria: HSRC Unpublished paper.
Odora-Hoppers C 2000. Indigenous knowledge systems and the transformation of academic institutions in South Africa. Pretoria: HSRC Unpublished paper.
Odora-Hoppers C 2001. Decolonizing the curriculum, indigenous knowledge systems and globalization. Pretoria: HSRC unpublished paper.
Peacock A (ed.) 1991. *Science in primary schools: the multicultural dimension*. London: Routledge.
Peacock G & Smith R 1995. *Teaching and understanding science*, 2nd edn. London: Hodder & Stoughton.
Petraglia J 1998. *Reality by design: the rhetoric and technology of authenticity in education*. London: Lawrence Erlbaum Associates Publishers.
Phillips D 1995. The good, the bad and the ugly: the many faces of constructivism. *Educational Researcher*, 24:5-12.
Pluckhouse H 1989. *Seen locally*. London: Routledge.
Posch P 2000. Community, school change and strategic networking. In: H Altrichter & J Elliott (eds). *Images of educational change*. Philadelphia: Open University Press.
Prakash M & Esteva G 1998. *Escaping education: living as learning within grassroots cultures*. Boston: Peter Lang.
Robitaile D 1993. *Curriculum frameworks for mathematics and science*. Vancouver: Pacific Educational Press.
Roth W 1998. *Designing communities*. Dordrecht: Kluwer Academic Publishers. Science and Technology.
Rowlands D & Holland C 1991. *Problem-solving in primary science and technology*. Cheltenham: Stanley Thornes Publishing.
Russell T 1991. Primary science and the clash of cultures in a developing country. In: A Peacock (ed.). *Science in primary schools: the multicultural dimension*. London: Routledge.
Schostak J 2000. Developing under developing circumstances: the personal and social development of students and the process of schooling. In: H Altrichter & J Elliott (eds). *Images of educational change*. Philadelphia: Open University Press.
Scott G 1999. *Change matters: making a difference in education and training*. Sydney: Allen & Unwin.
Stavenhagen R 1997. Cultural rights and the rights of indigenous people in Adult education and development. *Institut für internationale Zusammenarbeit*, 48:151-178.
Subotzky G 2001. The contribution of higher education to development: what modes of knowledge production and research capacity-building are most appropriate. Bellville: University of the Western Cape. Paper presented at the *Conference on Globalisation and Higher Education*.
Taylor N (ed.) 1993. *Inventing knowledge: contests in curriculum construction*. Cape Town: Maskew Miller Longman.
Vale P 1994. Fashioning choice in Southern Africa. In: M Venter (ed.). *Prospects for progress: critical choices for Southern Africa*. Cape Town: Maskew Miller Longman.
Van Wyk J 1997. The intercultural culture of schools: problems and challenges for a post-apartheid South Africa. *The Journal of Negro Education*, 66:539-544.
Watts M 1991. Questions of policy: some lost opportunities in the making of primary science. In: A Peacock (ed.). *Science in primary schools: the multicultural dimension*. London: Routledge.
Weil M & Joyce B 1975. *Social models of teaching: expanding your teaching repertoire*. Englewoods Cliffs NJ: Prentice-Hall.
Wentworth B 1994. Cultural identity and equity in educational development in Southern Africa. Education for democracy, social development and reconstruction: challenges for Africa. *World University Service Conference,* Cape Town, 55-59.
Yon D 2000. *Elusive culture: schooling, race and identity in global times*. New York: State University of New York Press.