Educational Implications of Applying the Complexity Approach to Indigenous Knowledge Systems (IKS)

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Abstract

Indigenous Knowledge (IK) is a body of valuable knowledge produced and owned by local people in their specific communities and found worldwide. Indigenous Knowledge Systems (IKS) comprises a complex and an often implicit educational system that is not easily recognisable. The paper focuses on complexity thinking to unravel IKS and proposes that using Capra's notion of meaning, Luhmann's concept of communication in social systems and metaphors like *autopoiesis* (self-organisation), emergence and holism from complexity may provide explicit educational value in critically examining IKS and education. Applying these metaphors to IKS implies curricula at universities and schools need to be re-focused and disciplines re-structured for cross-disciplinary teaching and learning in order to solve current and pressing societal problems.

Keywords: IKS; education; complexity theories; *autopoiesis*, emergence, holism

Introduction

Research scholars have provided multiple interpretations of the term Indigenous Knowledge (IK). Often, it is referred to as a body of knowledge produced and owned by local people in their specific communities and passed on from generation to generation, through practice and mainly oral channels. While IK refers to the kind of knowledge, IKS also refer to how IK is preserved and transmitted in different cultures and in various forms, such

as traditions, customs, myths, etc. Kincheloe and Steinberg (2008:136) refer to IKS as a 'multidimensional body of understandings', 'alternative ways of knowing'… and is often viewed by Euroculture as 'inferior and primitive'. Indigenous Knowledge Systems (IKS) and its epistemology can be overwhelming and challenging when viewed from an educational perspective as IKS spans several complex concepts and cuts across several disciplines and cultures. While certain areas like agriculture and the relationship between IKS and Western knowledge have been explicitly focused on in the literature, there are still many embedded connections that need to be unravelled that may provide valuable insights to education. Complexity offers new ways of understanding and thinking about organisational systems that are capable of responding to and influencing complex nonlinear relationships. Complexity can be simply defined as a situation where an 'increasing number of independent variables are interacting in interdependent and unpredictable ways' (Ilachinski 2001:xxvii). Examples of complex systems are traffic, the weather, the stock market etc. Understanding the local dynamics in a complex system can provide great insight into the behaviour of the overall system and help identify key leverage points of change and transformation. To be effective in its context, the emerging macro characteristics of a system must be understood in terms of the micro constituents – 'an organization must learn to think and act as one coherent yet flexible system with a high degree of communication, cooperation and collaboration among its networks' (Sanders & McCabe 2003:10). Thus Complexity as an approach to thinking, can provide information about the underlying structure and patterns of interaction and its on-going evolution of a system over time. How then should we approach the understanding of a complex system of IKS in education?

This paper, seeks, through using metaphors of *autopoiesis*, emergence and holism from complexity theories to examine communication networks in IKS and the educational implications of applying complexity thinking to IKS. It uses Capra's notion of meaning and Luhmann's concept of communication in social systems to critically examine complexity in IKS and education.

While IKS are still practiced and valuable for many indigenous communities worldwide, they are still neglected in Africa's formal education where Western education and its languages still dominate. IKS can be

perceived as the storehouse of human consciousness and experiences where knowledge acquired by the human-mind is inextricably linked to the environment, acquired through centuries of cultural practices, mediated by languages and established by customs. Claims of knowledge of indigenous practices in Africa 'were not just ways of working; they were ways of knowing and thinking' (Onwu & Mosimege 2004:1). Of significance are educational practices embedded in IKS that serve as a stimulus for promoting social interactions and dignity needed to create a cosmopolitan world of mutual engagement and sustenance.

IKS as 'ways of knowing' bring together multiple epistemologies that can be connected with science and technology in a creative, imaginative, and analytical way necessary for the current and future social and individual well-being. In the global knowledge arena, Africa's contribution via IKS is generally unknown, unrecognised or often regarded as traditional and archaic (Maathai 2010; Zulu 2006). Yet, Africa, and in particular Southern Africa is rich with a variety of archaeological sites such as the Cradle of Humankind in Sterkfontein and new fossil finds, tracing the origins and culture of the earliest humans to 3.5 million-years back, through the 2 million-year history of the Stone Age and the Khoi-San people (Hilton-Barber & Berger 2002), to the greatest storehouse of high quality rock paintings and engravings in the world; through the 2000-year history of agriculture, mining and settlement by Iron Age descendants in Africa (Rodney 1973) and much more. However, the historical and contemporary African knowledge contributions to the global education spectrum is largely absent, even though research has documented indigenous technology, astronomy, cosmologies and social systems in Africa in many areas (Chirikure 2010; Snedegar 2007; Sunal, Jones & Okebukola 1998; Van Sertima 1999). UNESCO best practices report (de Guchteneire, Krukkert, & von Liebenstein 2003) confirms that

> … indigenous knowledge systems are now being regarded as an invaluable national resource; and within the development community, where IK provides opportunities for designing development projects that emerge from priority problems identified within a community, and which build upon and strengthen community-level knowledge systems and organizations …. Recent research has given valuable insights into how people use their own

> locally generated knowledge to change and to improve, for example, natural resource management. Greater efforts therefore should be undertaken to strengthen the capacity of local people to develop their own knowledge base and to develop methodologies to promote activities at the interface of scientific disciplines and indigenous knowledge.

South Africa's government has developed an Indigenous Knowledge Systems policy that can respond 'positively to a rapidly changing environment, and through which indigenous and local communities and individuals can share equitably in the social and economic opportunities' (Department of Science and Technology 2004:4). Proposing the integration of IKS into several disciplinary areas such as education, commerce, agriculture, sciences, etc., the document implies several challenges to the idea of knowledge at post-colonial universities in South Africa, and has significant implications for educational development. The policy explicitly highlights the affirmation of African cultural values. This implies, for example, the recognition of 'experience and wisdom' and the integration of services provided by indigenous knowledge practitioners into disciplinary areas. Indigenous knowledge scholarship seeks to not only promote a repository of heritage and history but to be also critical of education, its scholarship, its epistemology and methodologies etc., as evident in formal education. In doing so, one of the primary roles of IK education is to counter the insidious long-term effects of colonisation and for the re-establishment of indigenous identities cooperating on an equal footing in Western capitalistic societies. Kincheloe and Steinberg (2008:135) stress that IK scholarship does not involve 'saving' indigenous people but 'helping construct conditions that allow for indigenous self-sufficiency' while learning from the vast storehouse of IK that 'provide compelling insights into all domains of human endeavor'.

In this article, I propose that metaphors from complexity theories such as *autopoiesis*, emergence and holism can be pedagogically useful in understanding complex issues in social systems such as indigenous knowledge systems in education (cf. Davis & Sumara 2006). These are explored in this study side by side with the focus on the unravelling of the notion of complexity.

Complex Systems and Complexity Theories

The need for new ways of understanding is highlighted by Sanders and McCabe (2003:5) as follows:

> The challenges of the 21st century will require new ways of thinking about and understanding the complex, interconnected and rapidly changing world in which we live and work. And the new field of complexity science is providing the insights we need to push our thinking in new directions. …We now have the ability to move beyond the old reductionist paradigm; to look at whole systems; to study the interactions of many interdependent variables and to explore the underlying principles, structure and dynamics of complex physical, biological and social systems.

A very early paper published by Weaver (1948) suggests that the power of computers and cross-disciplinary collaboration through 'organized complexity' (539) might contribute to new learning and provide insights to problems of the day. In the past three decades, the Sante Fe Institute Consortium (SFIC) pioneered work in transdisciplinarity and regularly engages in complexity theories. Complexity theories, while originating from sciences, has grown rapidly in the last decade and has penetrated into educational (Davis & Sumara 2006; Morrison 2002) and social discourses (Byrne 1998) as well. There is no one theory of Complexity but a number have been put together as Complexity research or Complexity thinking (Manson 2001).

For a coherent understanding of Complexity thinking, common properties of complex systems include complex collective behaviour, signalling and information processing and adaptation (Mitchell 2009). Complexity thinking is a matter of 'perspective or framing' (which in our case relates to human intention, interests and action), 'level of detail' (fine or coarse graining), and the result of 'perceiving through observation' (Steward 2001:324). Weaver (2004:65) adds that Complexity theories are like 'pioneers in a new land, making new discoveries', are theories of change, evolution and adaptation, often in the the interests of survival, and often through a combination of cooperation and competition (Battram 1999; Morrison 2002).

As scientists began looking for connections among different types of complex systems, the boundaries between disciplines began to open. Complexity steers away from the straightforward cause-and-effect models, and a reductionist approach to understanding phenomena, replacing them with organic, non-linear and holistic approaches. Complex systems consist of a large number of elements that in themselves can be simple. The elements interact dynamically by exchanging energy or information. These interactions form a rich network structure. Even if specific elements only interact with a few others, the effects of these interactions are propagated throughout the network system. The interactions are 'nonlinear' (Cilliers 2000:24) and focus on *relations* within interconnected networks as significant communication devices (Wheatley 1999). Complex systems are often described as open, recursive, organic, nonlinear, autopoietic and emergent.

The paper begins from a premise that IKS display characteristics of complex systems and that IKS and its embedded educational system can be better understood through the complexity system perspective. Cilliers (1998) lists ten characteristics that a complex system can be described by and IKS has yet to be explored from within this framework. Even within education, there are several approaches to complexity. Urry (2004:58) explores whether complexity theories can generate 'productive metaphors' that could illuminate globalised social and political events. He adds that the science of complex systems provides a way of thinking about social orders by utilising a set of concepts for describing the social world, rather than deploying a scientific understanding of complexity as an inherent quality of material reality. We are mindful that the 'borrowing' of metaphors and ideas from different approaches and borrowing piecemeal can bring about internal contradictions in claims, assumptions, etc. Noel Gough's (2012) piece on methodological borrowing cautions us to the confusion that can arise when inappropriate ideas and metaphors are borrowed to analyse complex systems. Some of the key terms of reference and/or metaphors from Complexity applied to education and social systems can be equally valid for IKS such as: *self-organization, complex adaptive systems, non-linear change, emergence, diversity, differentiation and autopoiesis, networks, connectivity and relations, order without central control, feedback, open systems, collectivity, distributed knowledge, holism, and co-evolution* (Davis & Sumara 2006). In

considering the cautious borrowing of metaphors, I first address only three metaphors from the above list (due to space limitations and what I consider most appropriate), namely, *autopoiesis, emergence* and *holism* and elaborate on how these metaphors can generate understanding of IKS in education as a complex autopoietic system. I then examine the educational implications of using these metaphors in IKS. As an attempt towards a unified approach of Complexity, I draw on mainly the works of Capra and Luhmann and focus on *Complexity as communication - meanings arising through interactions of human consciousness and matter and embedded in non-linear network systems that have a history, a dynamic contextual structure with feedback loops that sustains and promotes autopoietic and emergent systems.*

Autopoiesis

Societies organise themselves structurally and often the interactions between levels of relationships are complex and not easily definable or traced. Complex systems can be understood in different approaches, for example, the Complexity theory proposed by scientists in trying to understand biological interactions in the field of neurobiology by Maturana and Varela. In their work together Maturana and Varela (1987) developed the idea of *autopoiesis* (self-production) as the primary feature that distinguishes living things from non-living things. *Autopoiesis* (from Greek *auto*, meaning 'self', and *poiesis*, meaning 'creation, production') literally means 'self-creation' and expresses a fundamental dialectic among structure, mechanism and function. An autopoietic system is autonomous and operationally closed, in the sense that there are sufficient processes within it to maintain the whole. Autopoietic systems are 'structurally coupled' with their medium, embedded in a dynamic of changes that can be recalled as sensory-motor coupling. From their theory of *autopoiesis* in biology, Maturana and Varela develop a naturalistic, non-transcendental and observer-dependent interpretation of cognition, language, and consciousness. They argue against any absolutely objective world; instead they claim that we bring forth a world with others through the process of our living in human created worlds that arise through language and the coordination of social interactions. Cognition is identified as the process of knowing, with the process of life, a mental activity including processes of perception, emotion and behavior. Cognition

according to Maturana and Varala (Capra 2004:34) is 'the activity involved in the self-generation and self-perpetuation of living networks'. The interactions of living entities with its environment are cognitive interactions. Insights from complexity theories and cognition studies have been applied to other fields such as media, ecology, sociology, education etc. An application to sociology can be found in Niklas Luhmann's Systems Theory of social communication which is elaborated on later. The intention in this paper is not to elaborate on social theories developed historically but to identify ideas or metaphors of what makes a social system like IKS autopoietic. Philosopher Fritjof Capra (2004:82) is of the view that applying our knowledge of living networks to social phenomena and to validate the concept of *autopoiesis* in the social domain is still far from clear. Luhmann holds that the notion of *autopoiesis* can be extended to the social domain and he developed a theory of 'social autopoiesis'. Luhmann (1990), however, takes the position that social systems while autopoietic are not living systems while Capra (2004:82-3) views social systems that involve human beings and cognitive systems such as language, consciousness and culture as alive to varying degrees. Luhmann's (1990) central point is to identify communications as the key element of social networks: 'Social systems are communication as their particular mode of autopoietic reproduction. Their elements are communications that are recursively produced and reproduced by a network of communications and that cannot exist outside of such a network; …' (3). These networks of communications are self-generating as each communication creates thoughts and meaning, which give rise to further communications, and thus the entire network generates itself - it is autopoietic. Capra (2004:83) emphasises that communication and feedback is the basis of autopoietic systems: 'As communications recur in multiple feedback loops, they produce a shared system of beliefs, explanations, and values - a common text of meaning that is continually sustained by further communications. Through this shared context of meaning individuals acquire identities as members of social network, and in this way the network generates its own boundary'. The notion of *autopoiesis* has implications of viewing social systems such as IKS as networks of communications perceived as the dual nature of human communication, that is, ideas and contexts of meaning and the rules of behaviour embedded in social IKS structures.

To understand *autopoiesis* further within complexity, we need to explore key interrelated concepts that define the complex system of living entities. Manson (2001:409) elaborates that exploring the 'relationship between entities, internal structure and surrounding environment, learning and emergent behavior; and how complex systems change and grow' can give rise to understanding the complexity of life. Capra makes a similar assumption that there is a fundamental unity to life, that different living systems exhibit similar patterns of organisation like non-living systems. Cudworth and Hobden (2012) argue that if we can gain an understanding of these patterns then this can allow us insights into the workings of human societies. Complexity theories suggest that there are limits to what the social sciences are capable of, but we can use concepts from material non-living systems in a productive and cautious manner. It is possible to study the processes of *autopoiesis*, emergence and holism and to track the developments of social systems, and to increase our awareness of them as embedded within other social systems. However, Cilliers (2005:257) cautions us that it does 'not provide us with exact tools to solve our complex problems, but shows us (in a rigorous way) exactly why those problems are so difficult'. In what follows, I examine IKS in education as an autopoietic system comprising of living and non-living entities in varying degrees of relationships to each other and highlight the inherent difficulties in education dominated by Western hegemony, power, research and curricula.

Metaphors of Complexity Applied to IKS

Autopoiesis in IKS

Indigenous knowledge is the historical, cultural and embodied knowledge of local communities acquired over centuries. While, customs, rituals, artifacts, paintings etc. of IK are explicit evidence of non-living components of IKS, IKS also contains *implicit* knowledge, links and connections that are often elusive to outsiders but accessible to the indigene consciousness. With growing cosmopolitanism, the recognition of one's own cultural knowledge and its integration in formal educational structures become paramount towards the realisation of one's own identity and community's aspirations and survival. While Western knowledge has resulted in material benefits but

with irreparable damage to the environment, there are still millions living in poverty, unemployment and lack of formal education. On the other hand, IKS is eco-friendly, sustainable, based on respect and humanistic and can enhance the learning endeavor towards cultural relevant education. Concepts of respect, morality and ethics – 'ubuntu' in Africa and wise ecological use of the resources, display *autopoiesis* in that both material and living things are construed in harmonious relation and preservation with each other. Ubuntu creates thoughts and meanings practiced through indigenous social and cultural activities. For example, an inyanga (herbalist) uses only one-tenth of his/her stock of plants ensuring the survival of valuable plant species. Human consciousness as meaning, communication, and survival through conservation has led to the self-organisation and permeation of IKS cultural practices via network structures. Steinberg and Kincheloe (2008:138-9) summarise the view of indigenous scholars and philosophers as follows:

> …we want to use indigenous knowledge to counter Western science's destruction of the earth. Indigenous knowledge can facilitate this ambitious twenty-first century project because of its tendency to focus on relationships of human beings to both one another and to their ecosystem. Such an emphasis on relationships has been notoriously absent in the knowledge produced in Western science over the last four centuries.

One way to explore IKS is to use the structure of scale-free networks (often used in science) as it can provide a framework of IKS links and then explore useful metaphors to extend the thinking in IKS epistemology. This approach allows for a deeper exploration of understanding phenomena, their links and dynamics at varying levels. Capra (2004) offers a similar model for understanding social systems. Capra's notion of social reality also stems from Maturana and Varela's postulations of biological life processes. Complexity theories explain how large-scale complex phenomena organise and adapt from interactions of a myriad of individuals parts in complex systems. In analysing social reality, Capra (2004) uses insights from theories of living systems including nonlinear dynamics or 'complexity theory' and uses the terms ' patterns of organization' – the relationships among system 'components' and 'structure' – the material embodiment of its pattern of

organisation. This he equates to 'form' and 'matter' and adds a third perspective to living systems called 'process' (Capra 2004:71). These form a pattern of organisation that can only be recognised if it is embodied in matter, and in living systems. Thus life and matter interacts through non-material forms - organisation, complexity, processes etc. Capra adds a fourth perspective when applying complexity thinking to social systems - that of meaning. In social systems we come across multitude phenomena such as values, ethics, social rules of behaviour, power relations, and designs of organisations. While these are non-material (matter) phenomena, they are essential to human social life. IKS can be considered as a complex human-environment system (Figure 1) as elucidated by Capra and consists of centuries of trial and error experiences, practical wisdom of the earth, applied knowledge and historically acquired cultures. It is embedded and shared locally through collective network structures and diverse learning modes (Sefa Dei 2008).

Varela and Maturana's, Capra's and Luhmann's ideas of complexity are also embodied in IKS –IKS are the basis of human consciousness, namely, *communications and meaning*. In IKS, these are mediated by communication links (nodes) at primary level of human-matter interactions that generate meanings (IK) that are localised and embedded in social and cultural practices. Numerous nodes are connected to form larger hierarchical decentralised structures (hubs) resulting in more complex associations to a network system. Thus IKS comprises of intricate networks of nodes and hubs, connected by links, with a wealth of meanings in context. IKS hubs that can be identified include the cosmology of IKS, agriculture, local to global connections, methods of practice, social justice such as morality and ethics as in ubuntu etc. The hub cosmology itself includes multiple links connected to nodes comprising of spirituality, morality, ethics, ubuntu, God, ancestral spirits, etc. The identification of decentralised networks of links, nodes and hubs in a phenomenon such as IKS (Figure 1) is often taken as a critical indication of complexity and *autopoiesis*.

A hub of social power in IKS consisting of law, politics and power which are embedded in traditional councils consisting of chiefs, elders, priesthood etc. operate with other intertwined hub structures. This decentralisation of power is often more robust, efficient and provide feedback loops than centralised networks and are not easily susceptible to

collapsing. For example, if one hub or node is broken then other links, nodes, and hubs ensure the survival of the network.

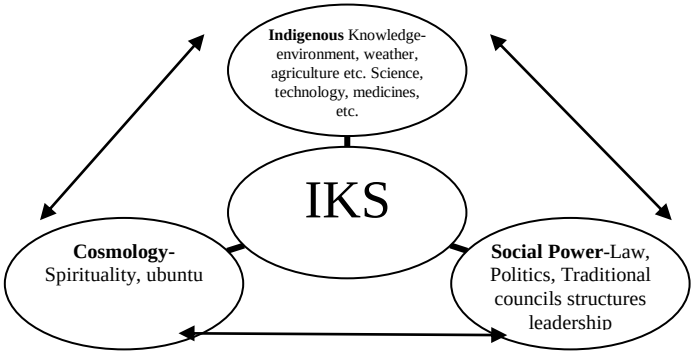

Figure 1: A simplified network for IKS

A network system is 'a more viable structure for any system that relies on the efficient exchange of information - a category that includes all living and learning systems' (Davis & Sumara 2006:88).

Autopoiesis as a model for self-creation/self-organisation of culture that includes IKS seeks through communication via the network structures (Figure 1) to produce, process, re-create through feedback loops that give shape to complex systems. Hubs also allow for external networks that allow for information to flow, in and out, re-creating IK in the process. Maintaining strong connections and linkages between hubs require processes of communications that link organisations of power to cognitive and social processes and to contexts linking systems of thought resulting in multiple 'ways of experiencing' the world. Thus, autopoiesis as imagery presents us with 'history and culture as a map' (Deleuze & Guattari 1980) that reveals

IKS arising from evolutionary processes involving dynamic, social and environmental interactions embedded in network structures.

Using Capra's idea of knowledge making-meaning and human consciousness, that is, the interaction of structure, form, process and meaning and Luhmann's social autopoiesis that embeds social networks, IKS can be viewed as encompassing individual cognition mediated and supported by sustained collective communication. Using Capra's framework for IKS, this comprises material structures and form (design or patterns of organisation) in the environment like homesteads, fields, villages, technologies conceived and built through generations by IKS communities and material goods generated and evolved from agricultural practice such as food including maize, yam, rice, fish, cattle etc. and artifacts such as curios, paintings, pottery, clothing, beadwork etc. These are exchanged between network nodes like villages and ports leading to networks of physical communication. Thus the structures in a social system are different from that of biological cellular structures and are created for a purpose, according to some design, and they embody, through processes, some meaning. For example, the colourful and 'grotesque' masks used in many African rituals display the status of the wearer as well. In African communities, the mask festival serves to empower creativity in art and sculpture as well as to display caricatures of power and status in society. These are now sold as curios to foreign visitors and museums. While extending the economic network of material goods (matter) to other parts of the world, these masks unless understood have little meaning on foreign walls except for the indigene community. Thus embedded in meaning-making are processes arising from the interaction of form and matter that embody human experiences and with the metaphysical leading to inseparable links to physical reality, emotions and spirituality. Capra (2004:84) elaborates on these multi-dimensional forms of communication as follows: 'The perspective of meaning includes a multitude of interrelated characteristics that are essential to understanding social reality'. As we have seen with the masks, meaning itself is embedded in the cultural context that gives a symbolic representation to rituals, customs, and power structures-revealing a systematic cultural phenomenon and where meaning is largely localised. When we interpret something we put it into a particular context of concepts, ideas, values and beliefs. We need to relate the phenomena to things in its environment, in its past or its future. Capra

(2004:84) stresses that 'Nothing is meaningful in itself'. Integrating both Capra's communication ideas and structural-network perspectives aid our understanding of social phenomena such as culture that are sustained by a network (form) of communications (process) embedded in material artifacts and written texts (matter) in which meaning is generated and passed on to the following generations. Our ability to hold mental images and project them into the future allows us to develop goals, purposes, design and strategies and also enables us to choose alternatives and hence formulate rules and social values of behaviour. All of these social phenomena are generated by networks of communications as a consequence of the dual role of human communication leading to an integrated system of values, beliefs, and rules of conduct producing culture.

Culture arises from a complex, highly nonlinear dynamic with multiple feedback loops and extends and limits actions of individuals through a re-enforced network of communications. IKS embodies culture. Viewed from Capra's notion of meaning, IKS is therefore an organised social system of knowledge and since the organisation of social systems is self-generating networks - they are autopoietic systems. The network structures from complexity theories are the nodes, links and hubs. These communication devices in IKS become sufficiently complex such that a large number of hubs control multiple nodes of activity resulting in a complex and 'self-organized' behaviour (Mitchell, 2009:286). At local levels, self-organisation of indigenous community and their collective activities are evident in their daily social activities. When self-organisation operates effectively, the community or its IKS is characterised by *adaptability, open systems, learning, feedback, and communication* (Cohen & Stewart 1995; Prigogine & Stengers 1985). These self-organisation characteristics identified in complex systems are evident in indigenous communities as in other social systems; there are on-going interactions with the self, others and the environment. Learning of one's role within IKS through social practices and apprenticeship are informal educational structures. Engagements with other localised communities are part of open-systems, sometimes exchange of material goods, intermarriages, cultural exchanges and ideas occur, strengthening and adding value to the network of IKS. Mitchell (2009:12) adds that complex collective behaviour is the 'collective actions of vast numbers of components that give rise to the complex, hard-to-predict, and changing patterns of

behaviour that fascinates us'. While some 'systems *need* disequilibrium in order to survive' (Stacey 1992), IKS generally deplore completely closed and individual systems as those in long-term stable equilibrium often become isolated and when challenged with new ideas, possibly face extinction. In the process of self-organisation, the organism (the local indigenous community), and the system of which it is a part of the larger regional community (IKS), demonstrate *autopoiesis*, that is, they have their own identity and nature and they self-create these. Hence, in the case of indigenous communities, they become diverse, adaptable in their cultures, environment and knowledge systems. The nature of adaptation depends on the stress and current influences on the system and solutions are immediately sought to address the problem. The creation of a unique and collective identity gives the local community knowledge and its constituent elements a capability for survival, through increasing differentiation - they become unlike other systems, and, thereby, their uniqueness provides their niche in the world, and that unique situation contributes to their survival. For example, in indigenous communities, the shortage of food and labour in one locality is supported by another local community until stability is reached whereas we have seen is Western communities access to food and labour is left to individual resources and wealth leading to poverty in poor communities.

Emergence in IKS

Another useful metaphor in complexity is *emergence.* Cilliers (2010:40) adds that complex systems have emergent properties, that is, 'properties that cannot be simply reduced to properties of components in the system'. Complexity offers us a way to think about relationships between inputs and outcomes that do not impel us to seek evidence of causal relationships between them. Complexity suggests that educational processes like IKS ought to be characterised by gaps between 'inputs' (policy, practices) and 'outputs' (learning). In Biesta's (2009) terms, these are not gaps to be 'filled' but sites of emergence. As Goldstein (1999:49) writes, emergence 'refers to the arising of novel and coherent structures, patterns, and properties during the process of self-organisation in complex systems'. In other words, what we have previously imagined to be 'outcomes' or 'products' - knowledge, understandings, individual subjectivities, etc. emerge in and through

indigenous educational processes in unique and unpredictable ways. As Biesta (2009:40) argues, education - and I add also indigenous education - contributes not only to 'qualification (the transmission of knowledge and skills) and socialization (the insertion of individuals into existing social, cultural and political orders)', but also to processes of subjectification - of becoming a subject. In IKS, the emergence of 'socialised' individuals occurs through the process of years of apprenticeship and experiences gained from a collective educational system.

Creative emergence in systems requires a process of change, determined in part by the need for survival, and is itself a 'process characterized by increasing connectivity, networking and feedback' (Stacey, Griffin & Shaw 2000:146). Most IKS worldwide through forceful colonisation and decimation of their own cultures (like the First Nations of America) have integrated their way of life in various degrees to accommodate Western culture, education and economies. However, their worldview, for most, is still rooted in their cultures and when cultural barriers are crossed, new challenges in education emerges. For example, theories of cultural crossing like collateral learning theory (Jegede & Aikenhead 1999) describes how people cope with disparate worldviews mediated by transcending cultural borders between their everyday culture and the culture of the scientific world. Emergence as a metaphor is thus useful in probing how changes and new links and hubs are formed when IKS are integrated with other knowledge systems. The implication of this holds pedagogic value when students from indigenous backgrounds enter foreign learning environments and requires greater research.

Holism in IKS

Complexity in the social world recognises that, and in much of reality including biological reality, 'causation is complex' (Byrne 1998:20). The outcomes are determined by multiple causes and the resulting effect is not usually the sum of separate effects. In IKS there exists a dynamic relationship between the 'being' and its environment; they change each other (Battram 1999). One is a member of a web of life, relations and networks (Capra 2004). Further, one cannot consider the 'being' without considering its environment; thus the emphasis is on collective, relational behaviour and

holism rather than on isolationism and individualism. The whole is greater than the sum of its parts, and these parts interact in dynamical, multifarious ways, thereby producing new realities, new collectivities and new relations. Educational activities of teaching and learning are deeply ingrained and embedded in IKS that it is often taken as 'normal daily activities of learning and interacting with the environment'. For example, story-telling in oral traditions has blended learning outcomes to develop significant educational and social outcomes such as historical and cultural information, listening skills, group participation, knowledge of and relationships in the environment, moral and social values. The characteristics of holism are often embedded at a collective level in IKS where sophisticated but unraveled thinking processes are deeply embedded in socio-cultural activities and philosophies. Another example is knowledge of the cosmos, sky and natural phenomena that are linked to spirituality, customs and traditions. Lightning as a natural phenomenon in indigenous communities is holistically connected to the cosmos, diviners (sangomas), ancestors, safety and the environment.

Educational Implications of Viewing IKS as Complexity Phenomenon

Complexity Affords a Perspective of Viewing the Impact of Global Knowledge Systems on IKS

The influence and effects of globalisation on knowledge systems mean that there is a greater need to critically challenge and cooperate with mainstream ways to create a platform to integrate IKS with other knowledge systems especially Western science (Wallner 2005). IKS is a culturally-rooted relevant point for the interface with other knowledge systems for the promotion of sustainable development. In addition, challenges faced by the global community provide an opportunity to explore IKS and other related knowledge systems as a central point of reference in pursuit of sustainable solutions with a potential to contribute to economic and social discourses. Emeagwali (2003) argues that IKS have implications for sustainable development, capacity building and intellectual development in Africa in the 21st century and hence has outcomes for education. The role of local ecological and cultural knowledge in resource management and sustainable

yield production is momentous now in seeking imperative solutions to climatic change, poverty alleviation, environmental sustainability and global warming (Maila 2007). Nobel peace laureate Maathai adds that the environment needs to be the centre of all challenges and decision making and that 'Development practices must be conceived and implemented holistically' (20). There is also a growing intellectual awareness of the environmental impacts on the Earth by (human) social interactions and if African countries are to achieve the desired level of economic and agricultural production, then metaphors of *autopoiesis, emergence* and *holism* in IKS have a greater role to play in understanding how natural resources are to be managed.

Complexity Provides Avenues to Integrate IKS with Science and Education

The metaphors in Complexity invite us to understand our physical and social worlds as open, recursive and organic and to be cautious of complying with models and trends in education that assume linear thinking, control and predictability. William Doll (1986) was one of the first education scholars to explore the theoretical and practical implications of reconceiving curriculum, teaching and learning by reference to concepts associated with chaos and complexity theorising in the natural sciences. Doll (1993:12), using the concepts of 'self-organization, dissipative structures, ecological balance, punctuated evolution, and complexity theory', suggests the major strength of post-modernism is the creation of new knowledge and the transformation of learning. Re-conceptualising the curriculum to incorporate metaphors of *autopoiesis, holism* and *emergence* in IKS teaching and learning in complexivist terms 'foregrounds the unpredictable and generative qualities of educational processes', and invites educators and students to value that which is unexpected and/or beyond their control (Gough 2012:41). Thus, IKS becomes both a catalyst for transformation and itself is transformed through feedback loops by interacting with other knowledge systems. Breidlid (2009) points to the significance and impact of classroom and community learning and teaching of IKS as pivotal for meaningful education and relevant community development. The mismatch between indigenous

learning patterns at home and formal Western education can be narrowed if IKS is integrated into the curricula. This step will affirm its values and traditional knowledge as integral to the academy. Education and training in IKS then implies several purposes such as promoting synergy, creating awareness, understanding and helping to reduce the gap between home and school, promoting cooperation between educational institutions and local communities and affirming cultural values. In addition, integrating IKS into the formal educational system requires knowledge of interfacing with other knowledge systems and how to enhance cross-cultural understanding. Kincheloe and Steinberg (2008:143) emphasise that 'any study of indigenous knowledge in the academy must allow for its evolution and ever changing relationship to Eurocentric scientific and educational practice'. The metaphors of autopoiesis, emergence and holism can provide conceptual access to analyse and follow transformation pathways in IKS.

Complexity Allows for Examining Power Relationships in IKS and Western Knowledge Systems in the Academy

Sefa Dei *et al.* (2008:xi-xii) recall their students asking them why 'certain experiences and histories count more than others when 'valid' academic knowledge is being produced and validated' and their lamentations of why educators do not recognise the linkages to their 'identity, schooling and knowledge production'. While IKS and its philosophy have made inroads into critical pedagogy theory, IKS and its epistemology still need greater elucidation. In this regard, Kincheloe and Steinberg (2008:136) lament that 'We find it pedagogically tragic that various indigenous knowledges of how action affects reality in particular locales have been dismissed from the academic curricula'. Thus, indigenous scholars see the 'production and validation of indigenous knowledge and the centering of them in the academy, as an important task for educational and social change' (Sefa Dei 2008:70). Van Wyk (2002:305) suggests that IKS, as a framework of thinking about our local context, 'seeks to problematize the insufficient integration of the cultural-social and the canonical-academic dimensions of natural science and technology education'. In social systems and in IKS, the driving force of *autopoiesis* is power reflected in social hierarchical status,

material and military resources and spiritual beliefs. When different cultures come into contact, struggles of power ensue and IKS do not 'sit in pristine fashion' outside of the effects of other knowledges but transform as well. In particular, autopoiesis reveals that 'Indigenous' implies maintaining that different bodies of knowledge continually influence each other to show the dynamism of all knowledge systems (Dei 2000: 111). Thus the metaphor *autopoiesis* leads to a critical examination of sites of power in systems and to view IKS as equally contributing to understanding and contributing to a sustainable world. Academic programmes in tertiary institutions are now seeking to address this challenge through research, mainstreaming and integrating of courses to incorporate IKS (Makgoba 1999; Sefa Dei *et al.* 2008; Sillitoe, Dixon, & Barr 2005). Governments are becoming proactive and states have afforded funding to IKS research programs to address both decolonial and development programmes relevant to the renaissance of African societies (Makgoba 1999). To promote research and development within an African context implies including IKS that encompasse maritime studies, agriculture, food security, cultural astronomy (Govender 2009 2011; Selin 2000), education (Naidoo 2010) etc. At present the compartment-alisation of knowledge is entrenched as isolated disciplines at universities but cross-disciplinary studies are now being facilitated, albeit slowly.

I argue that IKS epistemology viewed through the lens of metaphors such as autopoiesis, emergence and holism in Complexity thinking makes it incumbent for university curricula to be re-structured. This can proceed through seeking platforms for interdisciplinary connections, integration of science and IKS, and exploring culturally appropriate research methodological trends. This approach can contribute to a deeper exploration and understanding of the 'autopoietic' nature of IKS. Thus an autopoiesis process can reveal the workings in IKS and this has implications for the promotion of multidisciplinary research at universities as well as to counter and challenge historical effects of colonial hegemony (Sefa Dei *et al.* 2008). Applying Complexity thinking to IKS implies integration with Western education in a holistic and critical manner (Van Schalkwyk 2007). Klos's (2006) study in tertiary education confirms that the inclusion of indigenous knowledge in a scientific academic language support programme proves to be helpful to students and provide a model for student access to scientific content and academic language knowledge, skills, and democratic attitudes

and values. The valuing of IKS in humanities also has an important role in affirming the identity of the colonised and subjugated societies (Department of Science and Technology 2004; Sefa Dei *et al.* 2008). Therefore, in this respect, Battiste (2000:183) indicates that 'there is a shared body of understanding among many Indigenous people: these teachings are really about helping an individual find his or her face (identity)'. This implies finding out your cultural identity, your community link and your unique character and contribution to society. Elders hold a fount of traditional knowledge, moral values and ethics and these have led to a sustainable way of life over centuries. The lack of many of these 'identity' qualities in the lives and practices of the young today indicates a moving away from these treasured teachings. How we distil and blend these repositories of knowledges is now the serious task for educators. McDermott and Varenne (2005:x) add that with an increase in the cultural variation of students, 'Non-Western, indigenous and traditional world views are brought into the schooling process, creating classrooms in which cultural brokering becomes even more essential part of the teaching job than it has always been'. Hence, the rationale behind the academic advancement of IKS and the inclusion of it in tertiary education is not only to fulfill a critical, cultural and sustainable need but also to counteract the negativities of hegemonic societies in attaining equality.

Conclusion

Indigenous knowledge and why IKS education are still relevant in seeking resolutions to current challenges are discussed in this article. It argues that IKS and its epistemology perceived through the metaphors of autopoiesis, emergence and holism from complexity theories hold relevance for the outcomes of education. The educational implications of applying the metaphors to IKS and education are also discussed. The paper suggests that these metaphors provide a critical pedagogical stance to begin exploring network structures in not only achieving a holistic but organic perception of IKS but to critically view the power relations of knowledge domains. These metaphors in complexity begin a way to redefine new and emergent boundaries of knowledge taking into account historical and current indigenous knowledge and culture. The study of IKS as complexity implies

that curricula at universities should be creatively re-written with disciplines re-structured and knowledge integrated with cross-disciplinary teaching and learning to solve current problems in society.

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