SELF-DIRECTED LEARNING: LESSONS FROM INDIGENOUS KNOWLEDGE HOLDERS FOR SCHOOL SCIENCE EDUCATION

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ABSTRACT– In this paper we argue that the holders of indigenous knowledge were and are self-directed learners. The authors will discuss the construct of the Ethnobotanical Knowledge Index (EKI) and how this statistical construct suggests that indigenous knowledge holders' self-directedness could be traced back to survival needs (and solving problems in authentic contexts). One of the theoretical contributions of this paper is our unconventional use of third-generation cultural-historical activity theory (CHAT), namely using a process (self-directed learning) and a system (indigenous knowledge systems) as the 'subject' in two activity systems (in contrast to the conventional way, namely human subjects), that are juxtaposed by the authors to determine whether self-directed learning and indigenous knowledge systems share common ground. We then use CHAT also in the conventional way, focusing on the school learner as the subject, to determine which lessons indigenous knowledge systems hold for the science classroom, which is often characterised by teacher-centred transmission mode teaching and learning, and in general very little self-directed learning. In an era where school science education is often not promoting self-directed learning due to the decontextualized nature of it, this research provides insights that could assist in preparing learners better for the 21st Century.

Keywords: Indigenous knowledge; holders of IK; science education; self-directed learning; cultural-historical activity theory.

1. INTRODUCTION

Education in South African science classrooms is unfortunately mostly characterized by transmission-mode teaching (De Beer & Ramnarain, 2012). Although the Curriculum and Assessment Policy Statement (CAPS) requires problem-based (inquiry) learning, this often does not happen because of the examination-driven education that characterizes many school classrooms. Despite many advocates for cooperative learning and problem-based learning, 'chalk-and-talk' approaches with the focus on memorization and reproduction of knowledge continues to plague our education. This prompts us to question whether our school system effectively prepares young people for the demands and challenges that they will experience in the 21st Century workplace where they constantly need to acquire new skills and knowledge. Many learners will one day take up careers that do not exist today, and this necessitates that they are lifelong- and self-directed learners.

The purpose of this paper is to focus on the lessons that the holders of indigenous knowledge holds for science education in South Africa. We do it by using a tripartite approach: we firstly utilize examples from indigenous knowledge practice, which we then measure against the criteria for self-directed learning. Secondly, we use Cultural-Historical Activity Theory (CHAT) (Engeström, 1987) in a rather unusual way to compare self-directed learning as a process, to the nature of indigenous knowledge systems (Rogoff, 1990). Thirdly we then use CHAT in the conventional way, by comparing two activity systems where children are involved in: on the one hand, informal learning within an informal cultural context (indigenous knowledge), and secondly formal learning in the school classroom (the Curriculum and Assessment Policy Statement) (Department of Basic Education). We then compare these activity systems, to see what lessons could be learnt from the holders of indigenous knowledge.

In this paper we aim to show how the holders of indigenous knowledge were per definition self-directed learners. We'll do so by using three examples. In the first example, we'll show that the holders of indigenous knowledge were problem-based learners. The second example focuses on how they engaged in cooperative learning, which fosters self-directed learning. In the third example, we provide statistical evidence for their self-directedness, by exploring the notion of the Ethnobotanical Knowledge Index (EKI) (De Beer & Van Wyk, 2011). We need to demarcate this research as developing research, as the EKI is a relatively new construct, and limited data (mainly in the Northern Cape) is available. We then use third-generation Cultural-Historical Activity Theory to look at what lessons this holds for science education in South Africa.

2. SELF-DIRECTED LEARNING AND THE ROLE OF SOCIAL CONTEXT IN COGNITION

Knowles (1975:19), considered as the father of self-directed learning, define it as follows: "In its broadest meaning self-directed learning describes a process by which individuals take the initiative, with or without the assistance of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating outcomes". He highlights five key assumptions that underpins self-directed learning, according to Manning (2007): (a) An essential component for human being to grow in capacity, is to be a self-directed learner; (b) As a learner matures, the learner's experiences become a rich resource that should be exploited with the resources of experts; (c) A self-directed learner is always ready to learn what is required in order to deal more adequately with their life problems; (d) Self-directed learning assumes an orientation of being problem-centred; and (e) SDL dictates that learners are motivated by internal incentives such as self-esteem.

Guglielmino (1978) identified a number of factors that impact self-directed learning: openness for learning, initiative and independence in learning, informed acceptance of responsibility for own learning, the ability to see problems as challenges, the ability to evaluate own learning, and the ability to use basic learning skills and problem-solving skills. Candy (1991) has shown that self-directed learners look for deeper meanings, rather than being satisfied with superficial knowledge or memorization of facts. In essence, self-directed learning could be seen as a process (Knowles, 1975) which requires certain characteristics of a learner (Guglielmino, 1978), and that asks for a specific approach to learning (Cremers *et al*, 2014).

Social context is of essence in learning. Rogoff and Lave (1999:4) state: "People, usually in conjunction with others and always guided by social norms, set goals, negotiate appropriate means to reach the goals, and assist each other in implementing the means and resetting the goals as activities evolve". The holders of indigenous knowledge provide an excellent example of how learning takes place in a social context. This research therefore adopts social constructivism as theoretical foundation.

The affordances of indigenous knowledge

Battiste (2002:5) states that "As a concept, indigenous knowledge benchmarks the limitations of Eurocentric theory- its methodology, evidence and conclusions- and reconceptualizes the resilience and self-reliance of indigenous knowledge. Knowledge is not a commodity that can be possessed or controlled by educational institutions, but it is a living process to be absorbed and understood. Indigenous pedagogy values a person's ability to learn independently by observing, listening and participating with minimum intervention or instruction". This clearly points to self-directed learning. Before continuing with the three examples, it is important to first define what we mean by 'holders of indigenous knowledge'. This concept refers to people who, within a specific cultural-historical context and environment, possess indigenous knowledge. Jones and Hunter (2003) and Mitchie (2000) show

that indigenous knowledge is based on experience, and is subjected to verification through centuries of use. These authors further point out that indigenous knowledge is dynamic, it changes as times change, it is holistic, it emphasizes problem solving, and it is orally transferred to a next generation.

3. RESEARCH QUESTIONS AND METHODOLOGY

This paper claims that holders of indigenous knowledge are self-directed learners. The four research questions guiding this paper are:

How would an unconventional use of cultural-historical activity theory, where SDL and IKS form the subjects (and not people) in activity systems, result in a better understanding of these constructs?

What similarities and differences exist between self-directed learning and indigenous knowledge systems, when viewed from a cultural-historical activity theory lens?

What evidence exist that the holders of indigenous knowledge are self-directed learners?

What lessons can be learnt from the holders of indigenous knowledge in terms of science education?

This conceptual paper also utilizes qualitative data to support its central argument. Since the Ethnobotanical Knowledge Index (EKI) that was developed by De Beer & Van Wyk (2011) provides insight into the self-directedness of indigenous knowledge holders, we do provide some background on the methodology that was followed by these researchers. In the EKI research convenience sampling was used. People of Khoi-San descent and of different ages in the Agter-Hantam area in the Northern Cape were asked to participate in the study. The EKI is an index measuring the knowledge of people on the use of plants for various reasons (e.g. as source of food, medicinal use, or use for arts and crafts). This index is derived from completing a matrix. The EKI values were calculated by multiplying the number of plants with the score each person obtained on the matrix when answering the questions, 'do you know the plant?', 'do you have any names for the plant?', and 'can you recall any uses of this plant?' In our interpretation of the EKI calculated by De Beer (2012), we compared the EKI's of participants based on their age. Validity was ensured through the involvement of experts in ethnobotany, and all field notes were compared with the transcriptions of the interviews.

Research lens: Third generation Cultural-Historical Activity Theory

Rogoff (1995) first stated that three planes, namely the personal, the interpersonal, and the institutional or community plane, might be identified in sociocultural analysis. These three ways of utilising CHAT as a lens hold affordances in educational research. Conventionally CHAT is used as a research lens on the personal plane, where the subject is an individual for example a teacher or a student and the object is this individual's activity/ learning/ professional development. We utilise CHAT in this paper in this conventional way in paragraph 5.2. Authors such as Beatty and Feldman (2009) used CHAT on the interpersonal plane, looking at the interaction between the teacher (subject) and the students and their knowledge (object). Rogoff identifies a third way of using CHAT, namely where the subject is a system or a theory. In this research, we also use CHAT on this more systemic-theoretical plane, with the **subject** being either self-directed learning as a process, or indigenous knowledge systems as an epistemology. This is an approach seldom used, and is one of the contributions of this paper.

The CHAT lens makes provision for a specific 'gaze' into the activity system- looking for an acting subject, an object of activity, tools and signs used in mediating activity, rules for the system, the community in the system, and the division of labour in the system (see Figures 1 and 2).

4. THE HOLDERS OF INDIGENOUS KNOWLEDGE AS SELF-DIRECTED LEARNERS

We would like to test our claim that the holders of indigenous knowledge are self-directed learners, by studying three examples. After discussing the three examples, we will use third-generation Cultural-Historical Activity Theory (Engeström, 1987) to distill the lessons that the holders of indigenous knowledge have for school science education.

4.1. Holders of indigenous knowledge as self-directed learners: the example of zaï farming practices in Burkina Faso

Traditional farmers in the Mossi culture in Burkina Faso are faced with this problem: how can they plant and produce crops that are sustainable, cost-effective, and how can they find home-grown solutions to the problems that plague agriculture in this challenging environment. The annual rainfall in Burkina Faso is 599 mm per year, and most of the rain falls in July to September. Zaï is a home-grown solution to these challenging circumstances. At the beginning of the dry season the existence farmers make holes of 10 – 20 cm deep, and 20 – 40 cm in diameter. The soil that is digged out, is then placed next to the hole in the shape of a half-moon, so that any running water would be directed into the hole. Early in May, with the first rainfall, the farmers put organic materials (dung) in the holes. This attracts termites, and these insects start to delve deep funnels in the soil under the holes, stretching several meters deep (Boven & Morohashi, 2002). During the rainy season water then accumulates in these deep funnels, and it provides moisture to the crops. (The funnels are so deep that evaporation cannot take place). This zaï farming practice ensures that the crops are supplied with both nutrients and water. In the next planting season the process is repeated, but this time new holes are made between the old holes. This results in the benefit that soil can be rehabilitated within a period of five years (Boven & Morohashi, 2002:47).

If we would measure this practice against the definition of Knowles (1975) provided earlier, we can see that the Mossi people pass with distinction as self-directed learners:

They realized that they face a problem in a dry country with soil that is not very fertile. Being dependent on farming to survive, they realized that they had to find home-grown solutions for this problem.

They then identified learning goals for themselves, based on their needs. In a relatively poor environment, with restricted financial resources, conventional solutions like purchasing very expensive fertilizers, or investing in expensive irrigation, would not have worked. They realized that they will have to develop their own solutions, where they capitalize on what there is in the environment.

They identified human and material resources, and worked with members of the community in testing various solutions. They realized that organic nutrients for the poor soil could be obtained with the help of the abundant termites in this area.

Through a process of trial-and-error they developed effective farming practices that would support them. The complex zaï technique shows us that the Mossi people made careful observations, accurately captured their results, and constantly reflected in order to find viable, sustainable solutions. This indigenous knowledge is also passed on to a next generation.

The Mossi people evaluated the outcomes, and have also introduced other farmers in Burkina Faso to zaï. The World Bank has showed that zaï farming practices result in a 500% higher than expected yield.

4.2. The emphasis on cooperative learning among the holders of indigenous knowledge: A case study of the Bakgatla Ba Kgafela people in the North-West Province, South Africa

It is generally acknowledged that cooperative learning could foster skills needed to become self-directed learners (Fischer, 2013). An example of such cooperative learning is found in the Bakgatla Ba

Kgafela culture in the North-West Province. Young men coming back from the initiation schools (*bogwera*) (or girls after attending the *bojale*) form a brotherhood called *mophato*, and this group then has a collective responsibility in society. During *bogwera* the boys would learn the responsibilities of a respectful and responsible adult. On their return they then are assigned by the *Khosi* with collective responsibility, which very much reminds of Johnson & Johnson's (2009) criterium of positive interdependence in cooperative learning. Johnson & Johnson (2009) state that positive interdependence exists when the outcomes of learning are affected by own and others' actions. This has traditionally been true of Bakgatla culture, where the *mophato* cooperatively learn from each other, mentored by the Kgosi and other traditional elders (Jautse, Thambe & De Beer, 2016). One example is a particular cohort of *mophato*, where the group was asked to build a school in the Moruleng environment. They had to not only develop the different funding models for consideration by the Khosi, but had to also find building material, do an environmental impact study and ensure that there is buy-in from the community (Jautse, Thambe & De Beer, 2016).

4.3. The ethnobotanical knowledge index of the Khoi-San, highlighting the importance of Mode 2 knowledge production and problem-based learning

Throughout the world people in rural environments make use of plants as sources of food, medicine, cosmetics and for arts and crafts. Such people make use of self-medication, making use of (as they call it) God's pharmacy- plants in the veld. This oral tradition of phyto-medicine is passed on from one generation to the next, but it is also continuously revised as circumstances change (De Beer, 2012). As new problems arise, or old solutions to problems do not work any longer, these holders of indigenous knowledge go back to the drawing board. One example is that the community had to find solutions to the HIV/ AIDS pandemic, and they soon realized that *Sutherlandia frutescens* (the so-called 'kankerbossie' or 'cancer bush') is helpful in building the patient's immune system. (It need to be stated here that *Sutherlandia* does not cure AIDS, but biochemical studies has shown that the triterpenoids in the plant have immune-boosting and corticomimetic effects (Van Wyk, Van Oudtshoorn & Gericke, 2009).

These holders of indigenous knowledge use a similar process to western scientists, namely they make careful observations, postulate hypotheses, decide upon an experimental design, and test the plant medicines *in vivo* (among human patients). This is of course one of the major differences between indigenous knowledge healing systems and western medicine, where drugs are tested *in vitro* in the laboratory.

The analysis of the EKI of people provides a very interesting insight into self-directed learning. It was firstly encouraging to note how excited all the people in this region (the Agter-Hantam) were about plants and its uses. (Nortjé reported a similar finding in her 2012 study in the Kamiesberg in Namaqualand, and Magwede and Van Wyk in a 2015 study on Vhavenda plant use). Very little attention is given to the use of plants in the Natural Sciences/ Life Sciences school curriculum, yet learners are eager to learn about plant uses from their elders. It is interesting to note that the young children in the survey (Gert Swarts and Andreas Thys), both with low EKI values (both of them 0.27) could mention all the edible plants in the region such as *Grielum humifusum* (snotwortel), *Hydnora africana* (jakkalskos), or *Microloma saggitatum* (bokhorinkie). These two boys also had a very good knowledge of where these plants occur, and how it can be harvested sustainably. The older boys in the study, Bertus Baadjies and Frans Swarts, respectively had EKI's of 0.37 and 0.38. In addition to the edible plants, they could also mention some of the plants used for medicinal reasons. Some of the plants that these boys could mention were *Aloe microstigma* (the aloe, which can be used as a wound dressing), *Artemisia afra* ('wildeals' or African wormwood, that is used for colds and headaches), and *Mentha longifolia* ('ballerja', or wild mint, used amongst others for colds, coughs, and for indigestion).

These are the plants that are used to treat the ailments that young healthy adolescents would commonly experience.

The older people in the study, with higher EKI values (ranging from 0.43 to 0.93 in the case of Jan Baadjies, who is a *bossiedokter* or traditional healer) also know the plants that can treat the ailments and diseases that come with age: *Ballota africana* ('kattekruid', that stimulate lactation in pregnant women), *Dodonaea viscosa* ('basterolien' or sand olive, that is used for bladder and kidney problems), and *Melianthus comosus* ('kruidjie-roer-my-nie' that is used for swollen and painful legs and feet). It was particularly interesting to note how many plants are used for back pains, and this is understandable if one considers that the participants are farm laborers.

This finding is also supported by the data of Nortjé (2012) and Magwede & Van Wyk (2015), who showed that the EKI of participants in respectively the Kamiesberg in Namaqualand and in Venda show a similar pattern. In their study the children could also mention the edible plants.

From this data it is clear that self-directed learning takes place when a *need* is identified, that influence peoples' existence. For young children it is a need to identify edible plants (these are poor communities, and many people go to bed hungry). As children grow older, and they get colds, or fall and want to treat a painful wound, they start to become interested in medicinal plants as well. It is important to note that learning takes place within a social structure, with Jan Baadjies (with an EKI of 0.93) the mentor of the younger people.

5. LEARNING SHOULD BE ANCHORED IN AUTHENTIC TASKS IN A RELEVANT SOCIO-CULTURAL CONTEXT: INSIGHTS FROM CULTURAL-HISTORICAL ACTIVITY THEORY AS GAZE

5.1. Mode 2 knowledge production

Gibbons (2000:161) speaks of mode 2 knowledge production, which he describes as "context-sensitive" science. Rogoff & Lave (1999) point to the fact that many students who struggle to develop a particular skill in a laboratory situation, manage to do this much easier in their everyday lives. The above researchers show that, when learners investigate a problem, the background of the problem is of big importance. The student is also a social creature, and the socio-cultural background is of crucial importance in learning (Rogoff & Lave, 1999).

The above research on the EKI shows that learning should be problem-based, and that the learning task should be contextualized in terms of the social-cultural background of the learners. The role of cooperative learning should also be acknowledged. In the science classroom problems should be posed that the learners would experience as meaningful, and they should be motivated to learn more about the particular phenomenon. This new knowledge should have applications in the learners' daily lives. The learning material should be packaged in a way that would stimulate learners to identify own learning goals, to find the necessary resources to master this new content, and to evaluate whether the learning goals were actually achieved.

5.2. USING CHAT IN AN INCONVENTIONAL WAY, TO MEASURE INDIGENOUS KNOWLEDGE SYSTEMS AGAINST SELF-DIRECTED LEARNING THEORY

The root of CHAT goes back to Lev Vygotsky (1978) and his well-known construct of the zone of proximal development (ZPD).

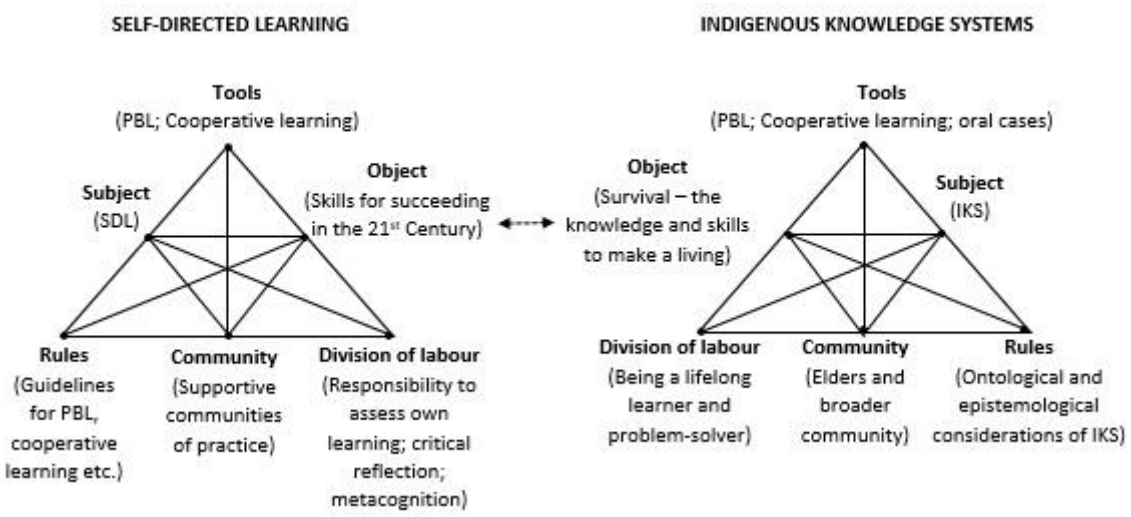

Figure 1: Using CHAT in an unconventional way: Comparing SDL process to IKS as epistemology

As mentioned earlier, Rogoff (1995) suggests that CHAT can also be used on an institutional plane, where the subject is 'dehumanized', and a systemic approach is followed. For our argument here, we consider the activity system on the left as a gaze on self-directed learning as a process (Knowles, 1975) and that is underpinned by theories. The activity system on the right considers indigenous knowledge systems as an epistemology or knowledge system. Such a specific gaze on both self-directed learning and indigenous knowledge systems would highlight both similarities and differences (tensions) in philosophy and approaches.

Activity system 1: Self-directed learning

We mentioned earlier that SDL could be seen as a process (Knowles, 1975), which requires certain characteristics of a learner (Guglielmino, 2001), and that asks for specific approaches to learning (Cremers et al, 2014). In the CHAT triangle on the left, Self-Directed Learning could therefore be seen as the subject, and the object is to prepare people for the demands of a challenging 21st century, where they will need specialized skills for the workplace (object 1). The tools or mediating artefacts would include approaches to teaching and learning that would foster self-directed learning, such as problem-based learning, case-based teaching and cooperative learning. Rules would refer to criteria that would foster dimensions of self-directed learning. For example: Johnson & Johnson (2009) have identified five elements necessary for effective cooperative learning. In similar fashion, there are criteria to ensure effective problem-based learning, such as authentic problem setting. The community would refer to all stakeholders supporting a learner in his/her self-directed learning. This could for example include an on-line community of practice. Division of labour would refer to the roles and responsibilities that a self-directed learner would have. This would include, amongst others, agency and creativity, a love for learning, and a disposition as a problem-solver.

Activity system 2: Indigenous knowledge systems

In the right-hand triangle we show a CHAT gaze on indigenous knowledge systems. The subject in this activity system is indigenous knowledge systems. The tools or mediating artefacts refer to how indigenous knowledge is utilized to achieve the object (which is providing a sustainable livelihood to the holders of indigenous knowledge). The tools used by the holders of indigenous knowledge include problem-solving (the example of zaï farming in paragraph 4.1), learning cooperatively (the example of the Bakgatla Ba Kgafela in paragraph 4.2), story-telling (that shows similarity to case-based teaching in

western context), and skills such as careful observation, and experimenting through trial-and-error. We acknowledge that indigenous knowledge is orally transmitted to new generations, but problem-solving is needed to cater for new challenges in an ever-changing society. The rules in such an indigenous knowledge system could be best viewed from an ontological and epistemic perspective. Ontologically indigenous knowledge is both empirical and metaphysical (in contrast with natural science, which is only empirical), it is socially and culturally based, and approach holistically (in contrast with the reductionist nature of natural science). Epistemologically the ways of knowing nature is transmitted orally, through observation, songs, dance and rituals. The community consists of the elders which scaffold learning, but also the community at large. Division of labour in this activity entails taking responsibility for both oneself and others, and putting on a problem-solving cap to ensure one's own existence.

By comparing the two systems, it is surprising to note the similarities. Both in indigenous knowledge systems, and in self-directed learning there is a focus on problem-based and cooperative learning: approaches to learning that foster self-directedness. In both systems there is a strong drive (division of labour) for the learners to acquire the necessary knowledge and skills to lead productive lives/ sustainable livelihoods, thus to prepare learners to be productive citizens in an ever-increasing complex society.

5.3. COMPARING INFORMAL CULTURAL LEARNING (FROM HOLDERS OF INDIGENOUS KNOWLEDGE) WITH FORMAL SCIENCE EDUCATION, USING CHAT

In this section we utilize CHAT in the conventional way, by looking at the learner (school pupil) operating in two activity systems: the triangle on the left illustrates contextualized learning in the local environment, where children learn about plants and its uses. The triangle on the right demonstrates the science classroom. However, it is important to note that the children in activity system 1 in Figure 2 (on the left-hand) initiate the learning process, based on their identified needs. In the right-hand scenario in Figure 1 (the science classroom) the needs of the learners are not always adequately considered. The activity system on the left (indigenous knowledge learning) conforms to what Gibbons calls mode 2 knowledge production (contextualized science), whereas the right-hand activity system (the science classroom) is often characterized by mode 1 knowledge production (disciplinary knowledge that is not sensitive to learners cultural contexts).

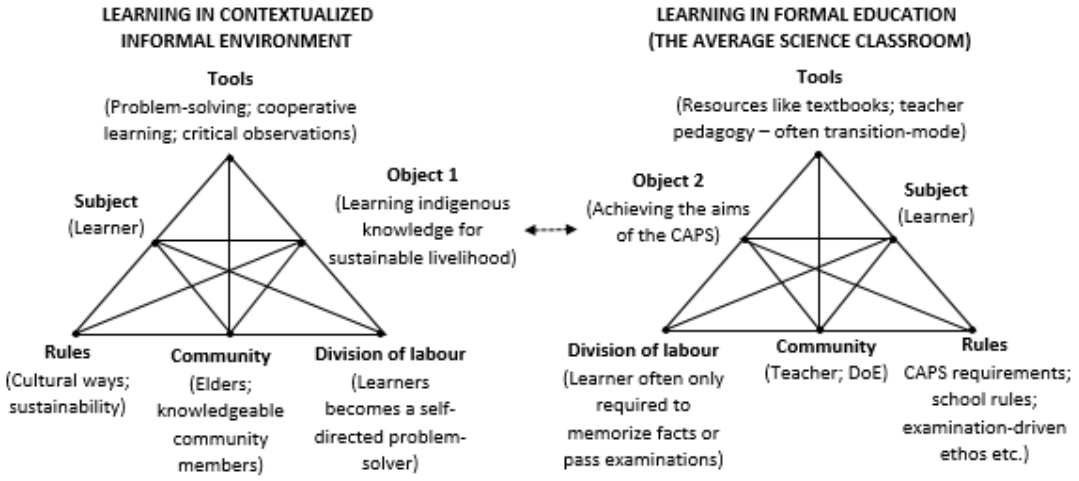

Figure 2: Looking at the lessons that the holders of indigenous knowledge hold for science education from a Cultural-Historical Activity Theory perspective

The subject in both the activity systems is the child (learner), and the object is to become a self-directed learner who will be successful in a most challenging 21st Century. This also means that the child should be a scientific literate person. The tools (or mediating artefacts) refer to the semiotic tool mediation- language, pedagogies, and learning resources that would assist in achieving the object. Rules refer to both explicit and implicit rules or protocols that may impact on the achievement of the object. The community refers to all the stakeholders that will influence learning, and lastly the division of labor refers to the different roles of all the stakeholders.

Activity system 1: Learning about plant uses at home

In the case of children (the subject) learning about plants that could be used as sources of food and medicine, the tools used are cultural artefacts such as stories, as well as careful observation and experimentation. Important is that the learners themselves formulate learning goals- they first experience the need to learn about the edible plants, and only later about medicinal plants. The community encompasses holders of indigenous knowledge, but also other learners: this is a cooperative learning situation. In this informal learning situation there are only a few rules. There are a few highly poisonous plants which- although it also has medicinal properties- is lethal when consumed. These are pointed out to the children at an early age. Holders of indigenous knowledge are very sensitive towards the environment, and children are taught how to sustainably harvest plants. Under division of labour, the child puts on many hats: (s)he becomes a taxonomist (who needs to identify plants), an ecologist (who needs to take care of the environment), a dietician (who must identify edible plants), and a homeopath (who needs to know which plants have medicinal uses). It is important to note that learning is driven by a real need (e.g. to learn about edible plants), and learning is highly contextual.

Activity system 2: The science classroom

We upfront need to state that we do not want to generalize, and we acknowledge that there are many classrooms where self-directed learning is promoted. However, there are also many classrooms that are characterized by transmission-mode teaching and learning (De Beer & Ramnarain, 2012). In the second activity system, the learner (subject) needs to meet the specific aims of the Curriculum and Assessment Policy Statement (CAPS) (the object). The tools refer to the textbook, teachers' pedagogies and the 'language of science' (which is often difficult for learners). There are plenty of rules governing learning: from the principles stated in the CAPS (and the pace setters that do not always make provision for the so needed affective aims in science education), to school rules and classroom rules. The community includes the teacher, parents, school management and the Department of Education. Under the division of labour we often find a one-dimensional picture: the learner should pass his/her examinations.

In the science classroom the focus often falls on preparing the learners for the examination, and teachers do not always spend sufficient time to contextualize the learning content that it makes sense to the learners. The tools often include teacher-centred lessons, where there is hardly the opportunity for problem-based learning. Learners often fail to see the relevance of the learning content in their daily lives- they are provided with answers to questions that they did not ask.

It is clear that there are 'tensions' in the second activity system. The teacher's pedagogy often fosters rote learning, at the expense of self-directed learning skills.

6. CONCLUSION

In this paper we tried to answer four research questions. The first question related to the unconventional use of cultural historical activity theory in studying the link between indigenous knowledge systems and self-directed learning. We have showed that learning in contextualized informal environments is often characterized by self-directed learning. This paper therefore makes a theoretical contribution by using CHAT as a research lens in an unconventional way, namely taking self-directed learning or indigenous knowledge systems as the subject. This approach proves to hold affordances in qualitative research.

The second research question focused on similarities and differences between self-directed learning and indigenous knowledge systems, and the use of CHAT provided a unique gaze on two activity systems, in order to answer this question. Both SDL and IK place a high premium on problem-based and cooperative learning.

The third question focused on evidence that the holders of indigenous knowledge are often self-directed learners, and this was answered by three examples in the paper: zaï farming practices in Burkina Faso, cooperative learning practices among the Bakgatla Ba Kgafela people, and lastly the ethnobotanical knowledge of Khoi-San communities in the Northern Cape.

The last research question focused on the lessons that could be learnt from the holders of indigenous knowledge in terms of science education.
They demonstrate an important principle that we often seem to forget in formal science education. The object of science education should be to empower learners to be self-directed learners, who can see the relevance of science in their everyday lives. In the school science classroom the teacher should create learning opportunities where the learners will experience the content in terms of an authentic problem that they can relate with. They should be provided with the opportunity to develop problem-based and cooperative learning skills where authentic real-world problems can be solved. We should focus on the lessons that we can learn from the holders of indigenous knowledge, in terms of self-directed learning.

We need to demarcate this research in terms of the fact that the EKI is a relatively new concept, and few studies have been done, targeting a few regions that show relatively sophisticated indigenous knowledge systems. More research is therefore needed, to see if self-directed learning is evident among holders of indigenous knowledge on a more national scale.

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