

## DECOLONISATION OF THE SCIENCE CURRICULUM: A DIFFERENT PERSPECTIVE (#COOKBOOK-LABS-MUST-FALL)

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**ABSTRACT**– Issues about transformation in education is exponentially receiving more focus (just consider the #RhodesMustFall campaign). In this paper we argue for more Afrocentric approaches to curriculum development in science education from a learning psychology perspective [embodied, situated and distributed cognition], rather than from the predominant political perspective that characterizes such discourse. In the paper we share mixed-method research (with emphasis on the qualitative component) on how Gibbon’s concept of Mode 2 knowledge production, and context-sensitive science, could be the answer to a more Afrocentric science curriculum. We show how indigenous knowledge could provide an authentic context to many science inquiries currently included in the Curriculum and Assessment Policy Statement. Through this epistemological border-crossing between the (western) constructs in the science curriculum, and indigenous knowledge, we could create authentic learning opportunities that center-stage problem-based learning, cooperative learning and metacognition (and critical reflection), and we argue that this holds affordances for the affective development of a next generation of scientists. We also show how such an approach could address the problem of transmission mode teaching and “cookbook practicals” that do not reflect the tenets of the nature of science. We report here on short courses that were offered to teachers in Limpopo and North-West Province. The major themes that emerged from this research are that teachers need professional development to develop their pedagogical content knowledge to incorporate problem-based learning, cooperative learning and indigenous knowledge in their classrooms; and they need to be more exposed to the tenets of both the nature of science and indigenous knowledge in order to facilitate this epistemological border-crossing in their classrooms. By succeeding in this, we might move forward in decolonizing the curriculum.

**Keywords:** Indigenous knowledge; science inquiry; Mode 2 knowledge production; context sensitive science.

### INTRODUCTION

Issues regarding the decolonisation of the curriculum are currently a lively discourse in the world and in South Africa. It was placed on the foreground by the recent #RhodesMustFall campaign where students demanded that the Rhodes Memorial be removed because Rhodes, according to the students, symbolizes colonialism and the legacy thereof. According to Le Grange (2016) the real impetus for the unrest was for a movement of decolonising the university curriculum in SA and that campaigns like this are long overdue. According to Shay (2015) it is important to decolonize the universities resulting in a radically altered curriculum and diversified academia.

The #FeesMustFall campaign, followed by the #RhodesMustFall campaign, was in essence fueled by conditions of structural disenfranchisement experienced by deprived workers and university students who want access to opportunities to improve their lives (Dismelo, 2015). Some argued that these unrests are unnecessary because all qualifying South Africans have access to tertiary institutions as it is open to all. A counterargument in this regard, is that although our institutions give physical access it does not necessarily provide knowledge (epistemological) access to the diverse South African student population. Persons who advocate the latter argument use evidence such as the huge dropout rate of black school learners and university students. Le Grange (2016) point out that only 60 per cent of black

university students pass their first year and from them only 15 per cent complete their studies. It is therefore understandable that students believed that the legacies of colonialism and apartheid SA are still evident in the education system (primary, secondary and tertiary sectors) which is fundamentally built on Western perspectives. We can identify with the students' outcry for the decolonisation of the curriculum. However, we are of the opinion that such decolonization should be argued from a learning psychology perspective [to be more specific, embodied, situated and distributed cognition], rather than from the predominant political viewpoint that characterizes such discourse. By infusing the science school curriculum with indigenous knowledge, we would to a larger extent provide epistemological access to the national curriculum for the diverse South African school population.

According to Hardey-Valle and Payette (2008) embodied, situated and distributed cognition [ESDC] views cognition as a process of mutually dependent neural, cognitive and social systems. From an ESDC perspective, learning cannot take place in isolation. The brain is embedded in the body and integrates all bodily actions (Holvikivi (2007) but is also embedded in the environment (dynamic social context) referring to the situatedness of cognition; and that learning take collaboratively place with other people and is therefore socially distributed (constructed) (Hardey-Valle & Payette, 2008). Teaching and learning from a ESDC theory perspective make (cultural) border crossing possible, a construct coined by Jegede and Aikenhead (1999) where students can daily "travel" between different cultures or environments (e.g. Western vs. African). This imply that teachers need to design teaching-learning experiences which take into account the contextual knowledge (own cultural knowledge; indigenous knowledge) of the learners in order to scaffold learning in such a way that science can make better sense to all of them. If applied as such, decolonisation of the curriculum does not mean throwing away all Western knowledge, but necessitates that we view the curriculum also as something that is lived and that accommodates and protects indigenous knowledge. This will provide knowledge access to the diverse student population and also points to a so called "Mode 2 knowledge production" a construct coined by Gibbons (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994). (This of course should also be emphasized in teacher education programmes. Indigenous knowledge does not seem to receive the emphasis it deserved in pre-service teacher education). The Council on Higher Education (CHE) identified indigenous knowledge systems (amongst others) as an emerging priority while the National Research Foundation are also inclined to fund projects like IKS in the creation of new knowledge (CHE, 2016).

Gibbon's concept of Mode 2 knowledge production could be realized through a more Afrocentric, context-sensitive approach to the natural sciences curriculum. In this regard indigenous knowledge, as contextual Afrocentric knowledge, could afford a genuine authentic context to implement the science inquiries currently included in the Curriculum and Assessment Policy Statement. Through epistemological border-crossing between the (western) constructs in the science curriculum, and indigenous knowledge, we designed appropriate and authentic learning opportunities that center-stage problem-based learning, cooperative learning and metacognition, and we argue that this holds affordances for the affective development of a next generation of scientists. An ESDC approach to science teaching could address the problem of the overwhelming use of teacher-centred teaching methods and so called "cookbook practicals" that do not reflect the tenets of the nature of science (Abd-El-Khalick, Bell & Lederman, 1998). So often, school laboratory work does not promote guided inquiries or investigations, and Herron (2009) reminds us that many of these laboratory "investigations" merely serve as cookbook or verification activities. Hailman (1975) argued more than three decades ago that the approach to the "scientific method" in schools was often just as detached from how an Einstein functions as the color-by-numbers sets are removed from Michelangelo's painting technique. We need to ask ourselves whether laboratory investigations today give students true insights into the nature of science and recent developments in science.

In this article we show how the life sciences teacher can plan an inquiry learning opportunity with such a mode 2 focus, and also utilizing active teaching-learning strategies like problem based learning and cooperative learning.

## **THE ROLE OF INDIGENOUS KNOWLEDGE, PROBLEM-BASED LEARNING AND COOPERATIVE LEARNING IN DEVELOPING CONTEXT-SENSITIVE INQUIRY ACTIVITIES**

### **Indigenous knowledge and the nature of science**

Cronje (2015) has shown that there is (despite several differences) many shared tenets when the nature of science and the nature of indigenous knowledge are compared. Both science and indigenous knowledge are empirical (although indigenous knowledge also has a metaphysical component), both are tentative (and subjected to change), both are inferential, both are creative, and both are socially and culturally based. Epistemological border-crossing in the Life Sciences classroom (between 'western science' and indigenous knowledge) could therefore be facilitated with ease, provided that the teacher has a sound pedagogical content knowledge. Although many teachers recognize the value of indigenous knowledge in science teaching (Cronje et al, 2015), the literature suggests several reasons why teachers do not integrate indigenous knowledge in their classrooms: teachers have not been exposed to indigenous knowledge in their pre-service teacher education (and it is also not a focus in in-service teacher education), teachers have an under-developed pedagogical content knowledge to do so (Mothwa, 2011), whereas some teachers fear that they will be teaching pseudo-science when incorporating IK (De Beer & Whitlock, 2009). The last reason points to a bigger problem: the lack of a good understanding of the nature of science and the nature of indigenous knowledge (Ogunniyi, 2007). Abd-El-Khalick, Bell & Lederman (1998) indicate that there is a correlation between teachers' views on the nature of science, and how they teach. The same applies to indigenous knowledge. How teachers view indigenous knowledge, will influence their classroom teaching (Cronje et al, 2015). It is therefore of crucial importance that teacher professional development programmes focus on this neglected aspect. This is the "gap" that this research addresses. This paper reports on in-service teacher education, where Life Sciences teachers were exposed to a problem-based, cooperative learning intervention with a focus on the incorporation of indigenous knowledge in the CAPS curriculum.

### **Problem-based learning**

Problem-based learning (PBL) is an active teaching-learning instructional method where students learn while solving the problem. The problem should be complex and authentic and should not have a single correct answer (Hmelo-Silver, 2004). The focus in PBL is not on the answer to the problem per se, but rather on the process of solving the problem while the students develop their higher-order thinking skills such as problem-solving and creative thinking. PBL can also develop students' self-directed learning skills such as taking ownership of their own learning, intrinsic motivation and metacognitive skills. In particular, a good structured PBL lesson can develop students' ability to interrogate the learning outcomes, identify suitable resources and the choice and effective implementation of learning strategies. In addition to the above students' social skills such as working together effectively in a group and listening and respecting each other's views can also be developed in a problem-based teaching-learning activity. Unfortunately far too many science classrooms are characterized by transmission-mode teaching and learning (De Beer & Ramnarain, 2012), and "inquiries" are often framed as "cookbook labs" that does not promote problem-based learning.

### **Cooperative learning**

Cooperative learning is another active teaching-learning strategy where students work in small groups to complete a common goal. According to Johnson and Johnson (1994) the group size should be between two to four members for the students to learn optimally. These authors agree further that

group work can only be regarded as cooperative learning if the following five elements are present during the lesson: with **positive interdependence** students engage in cooperative learning with the view that they can only succeed if other students succeed as well, as the so-called “sink or swim together” principle. Every student’s work should benefit all the group members; in **individual accountability**, each member is held accountable for his/her share of the work and need to present it to other group members. Although they learn together, the ultimate goal is that each group member must be able to perform similar tasks by themselves. **Face-to-face promotive interaction** occur when individual members encourage and facilitate each other’s efforts to achieve, complete tasks, in order to reach the group’s common goals. Small groups enhance face-to-face interaction. **Interpersonal and small-group social skills** such as their leadership abilities, decision making, communication, listening, accepting and supporting each other and conflict management skills should be developed. During **group processing** the group members need to determine how well they achieved their goal(s) through self-reflection and group-reflection (Johnson & Johnson, 1994).

Our argument is that the Life Sciences teacher can create a Mode-2 inquiry-based learning activity (Gibbons, 2000), by contextualizing the scientific investigation in terms of indigenous knowledge, and utilizing cooperative learning and problem-based learning effectively.

## METHODOLOGY

In this mixed-methods research, utilizing a pragmatic paradigm, we focus on the affordances of a short course in indigenous knowledge that was presented to 70 Life Sciences teachers in Limpopo and 14 Life Sciences teachers in North-West Province. This decision was based on Johnson, Onwuegbuzie and Turner’s (2007) argument that such mixed-methods research is useful when the researcher believes that both qualitative and quantitative data sets will add insights to get answers on the research question. This paper specifically focuses on how the intervention provides teachers with a more nuanced understanding of how to incorporate indigenous knowledge in the classroom, as well as how the effective use of problem-based learning and cooperative learning could result in context-sensitive science that would promote the affective domain. Teachers were asked to complete questionnaires after the three-day course, and individual interviews were also conducted with a number of teachers. (Teachers also completed the Views of the Nature of Indigenous Knowledge questionnaire that was developed by Cronje, De Beer & Ankiewicz, 2015, but in this paper we only briefly refer to this in our findings). During the intervention teachers also designed posters, and we also analysed these posters, in which they planned learning activities for learners based on the different scenarios provided (see ‘The intervention’ below). In this mixed-methods research we therefore capture teachers’ views on the intervention that aimed to provide them with more nuanced views of indigenous knowledge, problem-based learning and cooperative learning. Data was analysed by using Saldana’s (2009) coding system: codes were identified, categories were formed, and eventually a number of emerging themes were identified. We describe the four major emerging themes in this paper. We also use qualitative data (comments by teachers in both questionnaires and during the interviews) to support the quantitative findings.

### Sampling

All 84 Life Sciences teachers agreed to complete the questionnaires, and the Likert-scale items responses were analysed, and form part of the quantitative data discussed in this paper. We randomly selected ten teachers to conduct interviews with.

### The intervention

Teachers were instructed to work in small groups of four members. Several scenarios were provided to the teachers, and they were requested to research these different scenarios, and to develop learning activities for their learners, for these scenarios. They were asked to design posters, in which they

indicate how they would guide learners to investigate these phenomena. In all three scenarios, indigenous knowledge was used as the starting point, prompting a scientific investigation. We hoped that this would show teachers how smoothly the border-crossing between indigenous knowledge and ‘western science’ could be facilitated in the classroom.

### **Scenario 1: Investigating the influence of karrikins on seed germination**

In the more Mediterranean biomes (e.g. the fynbos vegetation in South Africa), fire is essential for some plant species’ seeds to germinate. Research has shown that chemicals in the smoke are the cause of such seed germination. Smoke is a complex mixture of thousands of different compounds, but Flematti and his coworkers (2004) discovered the chemical responsible for this effect. Butenolide derivatives known as *karrikins* are plant growth regulators found in the smoke of burning plant material. These karrikins are formed from burning cellulose, the molecule that makes up the cell walls in plants. Recently, a highly active butenolide, 3-methyl-2H-furo[2,3-c]pyran-2-one, also known as KAR<sub>1</sub>, was isolated from smoke as a stable and volatile growth stimulant (Van Staden, 2010). Research indicates that karrikins make seeds more sensitive to sunlight, so that plants emerge with less exposure. Studies also seem to suggest that exposure to karrikins accelerates seedling growth and resistance to stresses (such as drought) in a large number of plants.

The term *karrikin* is derived from *karrik*, which means “smoke” in the language of the Noongar people, the native inhabitants of Western Australia. They were the first people to acknowledge this role of smoke on seed germination. This provides the opportunity to introduce indigenous knowledge in the life sciences classroom. Prior to the arrival of Europeans in Australia, tens of thousands of Noongar people lived in southwestern Australia. Colonization by the British resulted in violence, which took a heavy toll on the population, which today is estimated to number 21,000–28,000. The Noongar were environmentally literate people who divided the year into six distinct seasons that determined their migration, hunting, and agricultural activities (Green, 1984; <http://noongar.org.au/>).

Based on the case study (as a type of PBL), teachers were asked to develop an experimental design, for their learners to investigate the influence of karrikin (in smoke) on the germination of seeds. Teachers were scaffolded in their group discussions to consider experimental designs where the experimental seeds are exposed to smoke.

### **Scenario 2: An indigenous knowledge perspective on the plant hormone ethylene**

There is an ancient Chinese practice of burning incense in closed rooms with stored pears. Burning incense releases (amongst others) ethylene gas (Yang *et al*, 2007), which results in the ripening of the fruit. Another indigenous knowledge practice that learners could investigate is the ancient Egyptian practice of wounding figs to enhance ripening responses. The ethylene produced by the injured fruit tissue triggers a broader ripening response.

Recent research has shown that ethylene has an important role in many plant development processes, such as that this plant hormone can stimulate seed germination (Nascimento, 2003; Cervantes, 2006), fruit ripening (Burg & Burg, 1961), leaf abscission and senescence (biological ageing) in plants (Rudman & Whitehead, 2015). In this activity we wanted the teachers to focus specifically on the role of ethylene in seed germination.

Teachers were asked to develop an experimental design, for their learners to investigate the influence of the plant hormone ethylene on the germination of seeds. Teachers were assisted in designing experimental set-ups where the influence of ethylene on seed germination- through burning incense and scarred plant tissue- can be investigated.

### **Scenario 3: The post-harvest physiology of cut flowers**

The Dutch has more than 400 years of experience as leaders in the cut flower industry. A few suggestions to prolong the shelf life of cut flowers can be found in literature and on the internet.

The Royal FloraHolland flower market in Aalsmeer, The Netherlands, is the largest flower auction in the world. On average 20 million flowers are sold every day in Aalsmeer. The problem is that millions of flowers need to be distributed all over the world in the shortest time possible, in order to ensure that the end consumer can still enjoy fresh flowers for at least a week. From Aalsmeer flowers are transported to Schiphol airport in Amsterdam, and from there it goes to Europe, Africa, South America and the USA. Flowers are transported from Aalsmeer to New York on an 8 hour flight. When flowers arrive in New York, it goes to the New York flower market and from there to retailers. The flower industry strives to get flowers from the grower to the consumer in less than 48 hours. However, the moment the flower is cut, it starts to deteriorate. Teachers were asked to do desktop research on the role of ethylene in the ageing process of cut flowers. Ethylene reduces the postharvest life of flowers (Reid & Wu, 1992), as it results in flower senescence. Senescence can be described as the events that lead to the death of cells, tissues and organs.

The following questions were posed to the teachers:

Develop an experimental design, for your learners to investigate the influence of the plant hormone ethylene on the post-harvest physiology of cut flowers.

What advice will you give to people to make their flower arrangements last longer? If possible try to make your suggestions part of the experimental design.

### **FINDINGS**

In Figure 1 we show one of the posters that the teachers produced (For primary school learners).

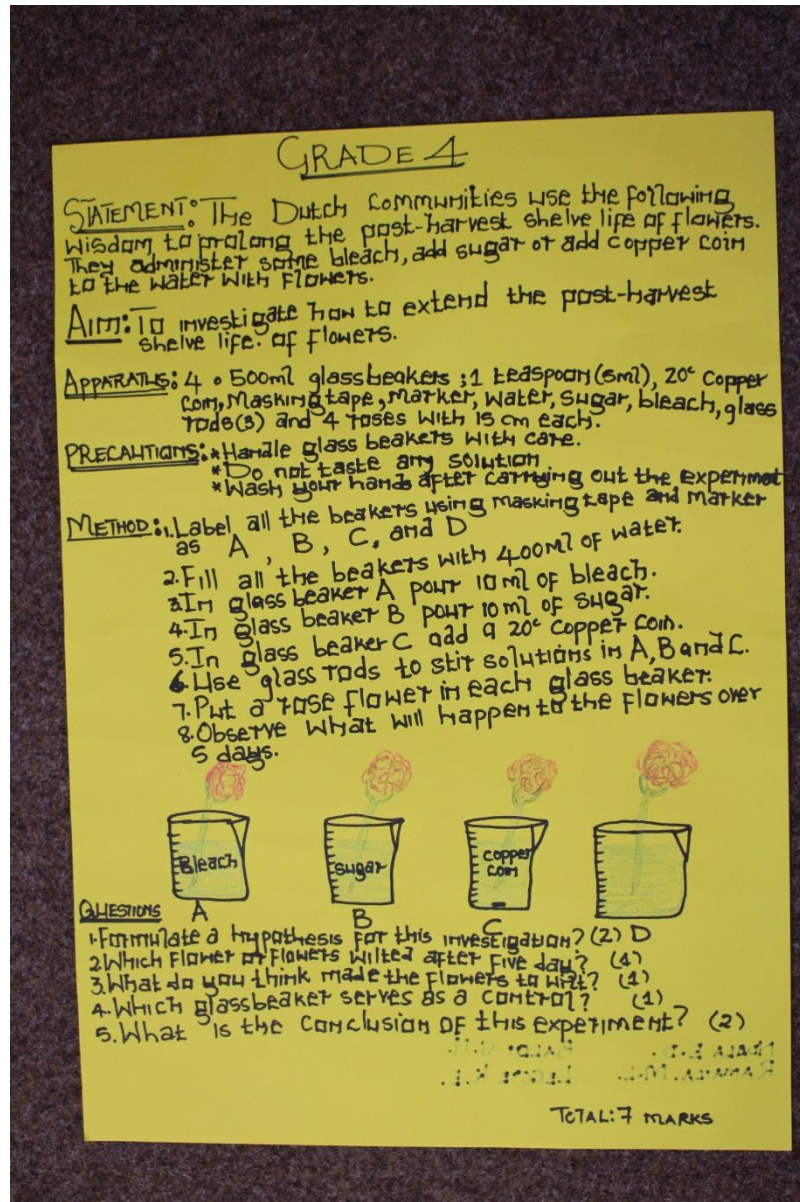


Figure 1: Poster produced by teachers on an activity to extend the post-harvest physiology of flowers

**Quantitative findings, supported by qualitative data**

After the intervention, the majority of teachers indicated that they agree that there is a place for the teaching of indigenous knowledge in the Life Sciences classroom- see Table 1.

**Table 13. Would you say that there is a place for the teaching of indigenous knowledge in the Life Sciences classroom? Motivate your answer. (n = 62)**

No- IK is pseudoscience and devoid of any substance	Maybe some aspects of indigenous knowledge could be introduced in the classroom	Where applicable, indigenous knowledge should be brought in as a different perspective to the purely western view	Definitely. Indigenous knowledge can make the learning of Life Sciences much more meaningful.
1.6%	8.0%	38.7%	51.7%

The majority of the teachers therefore were of the opinion that indigenous knowledge could be introduced in a highly scientific way in the teaching of Life Sciences. Some of their comments were:

“Learners relate more to things they know and will definitely learn more if they can relate to the things the teacher is talking about”; “Most of IK go hand-in-hand with our curriculum”; “I was so surprised to see with this activity how indigenous knowledge and CAPS can join hands. It was brilliant!” However, there were also teachers still skeptical about the incorporation of IK in the teaching of Life Sciences: “It has myths and is unpredictable, where science is pure”.

Since this task was given in a cooperative learning setting, teachers were also asked if this intervention changed their views on the use of cooperative learning methods in the Life Sciences classroom- see Table 2.

**Table 2. Did this short course change your views on the use of cooperative learning methods in Life Sciences? Motivate your answer. (n = 62)**

No, not at all	Very little	Yes, it did	Absolutely! I will definitely use cooperative learning strategies more in future.
0	3.2 %	37.0%	59.8%

The majority of the teachers commented positively on the use of cooperative learning: “I learned new strategies that I saw are effective and I will use”; “With cooperative learning the learners can share ideas, clear misconceptions, and understand the content better”; “Cooperative learning methods are very useful if used carefully. Learners learn best from one another”.

We also asked teachers to reflect on the use of problem-based learning in the questionnaire. Their responses to the question “Did this intervention change your views on the use of problem-based learning methods in the Life Sciences classroom” are reflected in Table 3.

**Table 3. Did this intervention change your views on the use of problem-based learning methods in Life Sciences? Motivate your answer. (n = 62)**

No, not at all	Very little	Yes, it did	Absolutely! I will definitely use PBL more in future.
0	4.8 %	54.9 %	40.3 %

The majority of teachers reflected positively on the use of problem-based learning after the intervention: “I have learned that problems from learner’s environment may enhance learning”; “I’m definitely going to apply PBL in my classroom in future”; “The PBL is a very interesting method where you can better engage your learners”; “Learners are more involved. They solve the problem on their own with the teacher facilitating”.

### Themes emerging from the qualitative data

From the research, a number of themes were distilled:

#### **Theme 1: Teachers indicate that they need professional development in terms of implementing problem-based and cooperative learning methods**

In the questionnaire teachers were asked to formulate professional development goals for themselves (after the three-day intervention). It became clear that many teachers view their own pedagogical content knowledge as insufficient to facilitate inquiry teaching in the classroom, utilizing cooperative learning and problem-based learning approaches. A particular problem is teachers’ lack of confidence in facilitating laboratory work. Several teachers have indicated that they do not have the laboratory skills to assist learners effectively: “I need so much assistance in moving forward. I lack laboratory skills. In our lab session I could not even use the pipette well”; “Conducting experiments is problematic for me. I was never trained in doing this”.



## **Theme 2: Teachers need professional development support to develop a more nuanced understanding of indigenous knowledge, and its affordances in the Life Sciences classroom, as well as of the nature of science**

Although the intervention definitely provided the teachers with a better understanding of indigenous knowledge and the role that it could play in the classroom, the teachers' responses to the Views of the Nature of Indigenous Knowledge (VNOIK) questionnaire (Cronje *et al*, 2015) showed us that teachers still need support. In developing the VNOIK questionnaire the above authors were informed by the framework developed by Lederman, Abd-El-Khalick, Bell and Schwartz (2002) for the nature of science, and in analyzing the data it became clear that some teachers also have a naïve understanding of the tenets of science. This lack of understanding of the tenets of science makes it difficult for some teachers to look for similarities with the tenets of indigenous knowledge. This makes the epistemological border crossing problematic.

## **Theme 3: A lack of resources, and a full curriculum (and too little time) are reasons given by teachers for not implementing such problem-based and cooperative learning approaches in the classroom**

When we asked teachers what problems they foresee in implementing such approaches, teachers mentioned that they do not have the resources to facilitate such inquiry approaches, and that the full CAPS curriculum makes very little time available for such approaches. A few comments by teachers were: "I would love for my learners to do the experiment we devised on ethylene, but I do not have the resources, and parents cannot afford to pay for it either"; "The pace setters leave us with little time to follow such approaches. It is a pity, because I really enjoyed today's activity, and can see its value".

Although these teachers availed themselves for attending the short courses during the school holidays, which is evident of their positive attitude towards their career, our research highlights their lack of agency of making use of active learning and shoestring-science methods. Some teachers do not realise the affordances of such approaches and semiotic tools in scaffolding learning across the Vygotskian (1966 & 1978) zone of proximal development. Some of the educational benefits of active learning strategies such as PBL and cooperative learning aim to promote students' higher order thinking abilities such as planning, problem-solving and creative thinking. Although students might forget most of the content knowledge learned during PBL and cooperative learning experiences their higher order thinking skills are more of a lasting nature which could be applied in other similar situations, example studying subject matter of similar content. Although it is true that these type teaching strategies does take more time, it is also true that the more time spent ("wasted") in one such a learning opportunity can just as well be saved in another similar lesson. However many teachers have not yet made a paradigm shift from where they have to tell (teach) the students everything to where students can master subject matter on their own, of course with adequate support. The purpose of this type of intervention (short course) precisely aims to stimulate this kind of paradigm shift in teachers, helping them to become agents of change to enhance their teaching.

## **Theme 4: Short-term interventions can play a valuable role in teacher professional development**

In literature it is acknowledged that teacher professional development is best facilitated within well-established communities of practice, over an extended period of time. We concur with this sentiment, but also need to point out that the data from this research clearly shows that short courses could make a positive contribution to teachers' pedagogical content knowledge development.

## **CONCLUSION**

In a time where the 'decolonisation of the curriculum' is an important discourse, it would make sense to look at strategies of incorporating indigenous knowledge in the Life Sciences curriculum. To do this in such a way that the epistemological border-crossing between 'western' science and indigenous knowledge is smooth and supportive of learners' conceptual change, it is important to focus in both pre-service and in-service teacher education on the tenets of the nature of science, and of indigenous knowledge.

It is clear from this study that a more contextualized mode 2 type knowledge production can be used by teachers to design learning experiences that appear more authentic to learners. Another benefit of including IKS in the classroom is that it can assist in demystifying IKS and decrease the marginalization of IKS. One of the misconceptions that we should also highlight (as we have done so with the three scenarios mentioned earlier) is the tendency that IKS is associated with poor and developing countries like South Africa. In SA this tendency indicates that IKS refer particularly to the black population. (In the scenarios we also focus on Chinese and Dutch indigenous knowledge). Short courses like this should be commended as it aims to make IKS part of the mainstream of knowledge and in the process, contributes to decolonising the curriculum from a learning psychology (EDSC) perspective.

## ACKNOWLEDGEMENT

We would like to acknowledge financial support from both the National Research Foundation, and the Fuchs Foundation.

## REFERENCES

- Abd-El-Khalick, F., Bell, R.L. & Lederman, N.G. (1998). *The nature of science and instructional practice*. Science Education 82, pp. 417 – 437.
- Burg, S.P. & Burg, E.A. (1961). Role of ethylene in fruit ripening. *Plant Physiology*, 179 – 189.
- Cervantes, E. (2006). Ethylene in seed germination and early root development. *Floriculture, Ornamental and Plant Biotechnology* Vol 1, Chapter 46. Global Science Books.
- Council on Higher Education. (2016). South African Higher Education Reviewed: Two decades of democracy. Pretoria.
- Cronje, A. (2015). Epistemological border-crossing between western science and indigenous knowledge and its implications for teacher professional development. University of Johannesburg: Unpublished PhD thesis.
- Cronje, A., De Beer, J. & Ankiewicz, P. (2015). The development and use of an instrument to investigate science teachers' views on indigenous knowledge. *African Journal of Research in Mathematics, Science and Technology Education*, 19(3), 319 – 332.
- De Beer, J. & Ramnarain, U. (2012). The implementation of the FET Physical- and Life Sciences curricula: opportunities and challenges. Research Report prepared for the Gauteng Department of Education.
- De Beer, J. & Whitlock, C. (2009). Indigenous knowledge in the life sciences classroom: Put on your De Bono hats! *The American Biology Teacher* 71(4), 209 – 216.
- Disemelo, K. 2015. Student protests are about much more than just #FeesMustFall. Mail&Guardian. <http://mg.co.za/author/katlego-disemelo> (accessed 28 April 2016).
- Flematti, G.R., Goddard-Borger, E.D., Merritt, D.J., Ghisalberti, E.K., Dixon, K.W. & Trengove, R.D. (2007). Preparation of 2H-furo[2,3-c]pyran-2-one derivatives and evaluation of their germination-promoting activity. *Journal of Agricultural and Food Chemistry* 55, 2189 – 2194.
- Gibbons, M. (2000). Mode 2 society and the emergence of context-sensitive science. *Science and Public Policy* 27(3), pp. 159 – 163.
- Green, N. (1984). *Broken Spears: Aborigines and Europeans in the Southwest of Australia*. Perth: Focus Education Services.
- Hardey-Vallee, B & Payette, N. (2008). *Beyond the Brain. Embodied, Situated and Distributed Cognition*. Newcastle: Cambridge Scholars Publishing.
- Herron, S.S. (2009). From cookbook to collaborative: transforming a university biology laboratory course. *American Biology Teacher*, 71, 548–552.
- Hmelo-Silver, C.E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, 16(3), 235-266.

- Holvikivi, J. (2007). Culture and cognition in information technology education. *European Journal of Engineering Education*, 32 (1), 2007:73–82.
- Jegede, O.J. & Aikenhead, G.S. (1999). Transcending Cultural Borders: implications for science teaching. *Research in Science and Technological Education*, 17 (1):45–66.
- Johnson, D.W. & Johnson, R.T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational researcher* 38(5), pp. 365 – 379.
- Johnson, R.B., Onwuegbuzie, A.J. & Turner, L.A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, 1(2):112-133.
- Lederman, N.G., Abd-Ek-Khalick, F., Bell, R.L., & Schwartz, R.S. (2002). Views of the nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching* 39(6), pp. 497 – 521.
- Le Grange, L. (2016). Decolonising the university curriculum. *South African Journal of Higher Education* 30 (2), pp. 1 – 12.
- Mothwa, M.M. (2011). Teachers' experiences of incorporating indigenous knowledge in the life sciences classroom. University of Johannesburg: Unpublished Med dissertation.
- Nascimento, W.M. (2003). Ethylene and lettuce seed germination. *Scientia Agricola* 60(3), 601 – 606.
- Ogunniyi, M.B. (2007). Teachers' stances and practical arguments regarding a science indigenous knowledge curriculum. *International Journal of Science Education* 29(8), 963 – 986.
- Reid, M.S. & Wu, M.J. (1992). Ethylene and flower senescence. *Plant Growth Regulation*, 11, pp. 37 – 43.
- Rudman, L. & Whitehead, C.S. (2015). The effect of short-chain saturated fatty acids and 1-methylcyclopropene on ethylene sensitivity in cut carnation flowers. Paper read at the Postgraduate Symposium, Department of Botany and Plant Biotechnology, University of Johannesburg, 27 October 2015.
- Shay, S. (2015, July 13). Don't just decolonise SA universities' curriculum- change the structure, too. *Times Live*. Retrieved from <http://www.timeslive.co.za/local/2015/07/13/Dont-just-decolonise-SA-universities-curriculum-%E2%80%93-change-the-structure-too>.
- Vygotsky, L.S. (1966). Igra i ee rol psikhicheskomo razvitti rebenka [The game and its role in the mental development of the child]. *Voprosy Psikhologii* 6, pp. 62 – 76.
- Vygotsky, L.S. (1978). *Mind in society*. London: Harvard University Press.
- Yang, T-T., Kuo, Y.M., Hung, H.F., Shie, R.H. & Chang, P. (2007). Gas pollutant emissions from smoldering incense using FTIR. *Aerosol and Air Quality Research* 7(3), 417 – 431.