Highlights of Maths & Science Community of Practice Meeting

Rethinking Mathematics and Science Education

02 August 2018

Setting the scene

The August meeting of the Maths and Science CoP explored a variety of ideas and developments in maths and science education. Our two speakers, Dr Craig Pournara of the Wits School of Education and Philip Pare of the South African Nuclear Energy Corporation shared a collection of ideas and thoughts on issues that they have been concerned with over the years. They were also asked to survey some of the current thinking in the teaching of these subjects – and invited to be provocative.

Overview of the presentations

Rethinking Maths Education in SA: How are we thinking? Listening? Acting?

Dr Craig Pournara is the director of the *Marang Centre for Maths and Science Education* – a division of the Wits School of Education which researches and develops innovative pre-service and in-service teacher education programmes – as well as project manager for the *Wits Maths Connect Secondary Project* which aims to improve teacher competence and learner performance. Craig taught high school maths and computer science before becoming involved during the late 90's in maths teacher education as well as community Saturday schools over the northern part of the country. He is passionate about finding better ways to teach maths that will work in South Africa's diverse contexts.

A 20 year journey in maths teacher education

Craig opened with a brief overview of some of the mathematical tasks he has found effective over the years in different teacher education contexts, and how they can be used creatively to engage people in developing their understanding and professional competence. Click here to view the presentation and tasks.

The important question is whether these tasks are doable in a 'typical' South African school. The word *typical* is already problematic – what does it mean in South Africa's 'dual economy of schooling'? The reality is that it is unlikely that these tasks would get done. Aside from the challenges they would pose in the area of competence, many of them take time to do, which CAPS would not accommodate.

The financial literacy example illustrates the significance of language for maths education by showing that the demands of this kind of problem go well beyond simply knowing the terminology, and that the language used is crucial for meaning and relation. Unless the learner understands and pays attention to the words, the relationships between the items – and the maths requirements – cannot be understood.

60% - the key figure for matric maths

The NDP's goal of 450 000 young people eligible to study maths and science at university by 2030 was brought closer by the DBE, which aims to have 350 000 learners 'passing grade 12 mathematics' by 2024. With 8 years to go, we are at 25% of this target. We also know that fewer than 15% of those who pass maths achieve at least 60% – which is the minimum requirement for entry to maths and science related courses – and is required by many universities even for some non-maths degrees. The reality is that it is not a matter of the pass rate, or of 'passing', but of attaining 60% or more.

What is possible in our schools right now?

Data collected during 2017 from grade 9 learners at Q1 - 2 schools by the *Wits Maths Connect Secondary Project* provided another reality check in terms of maths basics. The process was then repeated in 2018 with Q5 schools, three of which are top Wits feeder schools. While the results were significantly better they are still not what one would expect, and show that – despite these schools' 100% matric pass rate – many of their grade 9 learners struggle with maths basics.

Grade 9 : Quintile 1 & 2 schools

Data collected Feb 2017
- 9 township schools
- 2350 learners

Integers	Correct (%)
$4-9=$	52
$-4+9=$	27
$-9-4=$	19

Algebraic expressions	Correct (%)
$3x+4x=$	60
$3x+4y+x=$	6
$2x-(y+x)=$	1

Equations	Correct (%)
$4x-10=2$	17
$4x-10=2+x$	6

Grade 9 : Quintile 5 schools

Data collected Feb 2018
- 5 schools
- Includes top feeder schools to Wits
- 800 learners

Integers	Correct (%)
$4-9=$	87
$-4+9=$	78
$-9-4=$	68

Algebraic expressions	Correct (%)
$3x+4x=$	86
$3x+4y+x=$	54
$2x-(y+x)=$	20

Equations	Correct (%)
$4x-10=2$	62
$4x-10=2+x$	36
$8-4x=2-x$	14

How relevant is international maths education research to our South African situation?

An important consideration – because it influences the thinking on maths education – is that 90% of the research in maths education concentrates on 10% of the most affluent classroom environments in the world, while 10% of the research addresses the remaining 90% of classrooms. While most local research does focus on the under-resourced school majority, to what extent do we think of the conditions and learnings described in our international reading as normal, and aspire to it?

Learner-centred pedagogy is failing

The argument has been made that learner-centred pedagogy is failing in the sub-Saharan context, partly owing to the ideology behind it and partly because it is a mismatch culturally. Richard Tabulawa, writing in the context of Botswana which fares better than South Africa does in international assessments, suggests that this is because teachers and students chose a pedagogy that fits their purposes – which in the sub-Saharan context is to produce good exam results – and so they are rejecting learner-centred pedagogy.

When reforms of this kind fail, we tend to claim that the failure is the result of insufficient resources, high learner- teacher ratios or defective teacher education – and try to fix it by doing more of the same – but there is recent research showing that direct instruction works (there is more on this in the presentation).

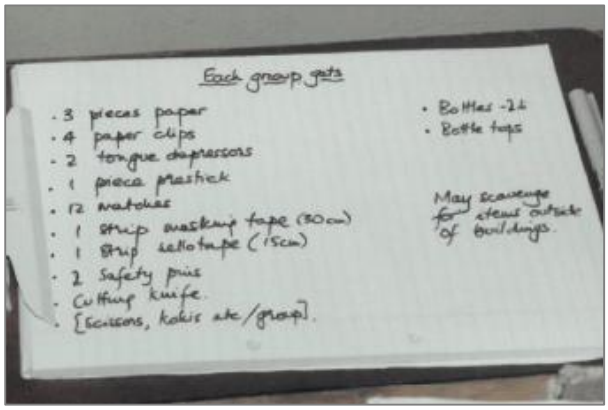
"We all need to ask ourselves – how are we acting, who are we listening to, and are we thinking about things that challenge our comfortable view that *if it's learner-centred it must be good and if it's direct instruction it must be bad*?" (Dr Craig Pournara)

Some thoughts on Science Education: Where are we going? Home, education, work…

Philip Pare's experience in science covers a broad spectrum. After obtaining a degree in electronics engineering he taught at St Mark's College in Jane Furse where he experienced some of the difficulties of teaching science, both as a subject and as a particular way of thinking, and developed an interest in teaching science in Sepedi. He spent some time working with the NGO sector and later joined the University of Pretoria where he tutored first year and pre-first year physical sciences students. After ten years in that role he returned to 'hard' science and now works in the Isotopes Division of the South African Nuclear Energy Corporation (NECSA) at Pelindaba.

Learning from the death of Curriculum 2005

Although much has been written about the failure of C2005, there are still many lessons to be learnt from it. C2005 was an honest effort to give South Africa a world-ranking educational system that moved away from Bantu education and tried to respect the values, knowledge and skills of good teachers – but it did not work because so many of our teachers lacked the ability to implement it.



This links to the questions in the previous presentation as to **how far learner-centred education should be taken**, and how much freedom learners should be given. Describing a 1999 primary science programme camp where children made telescopes from basic materials to look at the moon, Phillip reflected on whether this activity might now be criticised as being 'too directed'. Or whether, given that the children were learning from their environment, it could be described as *situated cognition.*

Science in everyday life

Ordinary **household products and activities** such as baking can be used to introduce learners to chemical reactions, naming conventions, symbols and chemical equations.

Click here to view the presentation.

The importance of developing scientific literacy

Citing the debate in the media about the use of renewables vs nuclear to generate electricity, Phillip showed examples of language being used to manipulate meaning and the need for people to be able to read this type of article with sufficient understanding to think critically about what is being said.

"If our students read this, are they going to be able to see the sly tricks that people use to try and pull the wool over our eyes as they push for either a nuclear solution or a renewable energy solution?"

Issues of language in science education

It has been argued that educational outcomes for the majority of learners would be significantly better were African languages to be used in a meaningful way to augment learning in the classroom. Despite his deep interest in using African languages for teaching and learning, Phillip does not believe that simply translating into local languages would necessarily be a panacea for low performance in science.

Phillip used the example of *speed, velocity and acceleration* to show the kinds of problems that can arise when attempting to translate these terms into African languages that do not have words that correspond with these terms. Science requires a precise use of language and using variations of the existing words to express these concepts might confuse learners more if the translations do not make the differences between them clear. Addressing these challenges would mean developing new terms for technical and scientific concepts.

Learners' ability to read for meaning in English and how this impacts their performance in science is another major consideration: "To what degree is science education dependent on learning to read English?"

Context resolves many of the ambiguities of language – which is another reason to provide **rich learning environments for science** where learners can see and experience the way that words are being used.

@CoP CoP questions and comments

- Several questions related to the **methodology and value of the maths tasks**. *Craig responded that the tasks were neither good nor bad (or learner-centred/not learner-centred) in and of themselves and that it was important to consider the purpose and context carefully when using them.*
- With reference to trying to solve problems by allocating more resources, it would be better to create a more balanced education system that would **nurture each child's creativity and talent** – this would eventually add to the system instead of draining from it. *Craig's thoughts on this were that while this described the ideal, the reality was that the dichotomy of our system was such that this was 'not doable' in most of the country – and that this was the fundamental issue to be addressed.*
- It is concerning that people are saying there is evidence that direct instruction works but learner-centredness does not. The important thing is not whether one method is better or worse, but **how we interpret and apply the methods** – both can be terrible or good.
- While it is wonderful to want our children to be the best they can be with whatever qualities they have, but when they leave the schooling system there are certain things they need in order to be employable.
- The problem of finding comparable terms for concepts in African languages also occurs in other subjects for e.g. in mathematical literacy where equivalents could not be found for an average of 30% of the terms across the different languages.

@CoP

Group Discussion

CoP participants were invited to consider any aspect of the maths and science curricula. The group's diversity would contribute to a wider range of ideas. *This section highlights some of the topics discussed.*

Science

Language use, reading ability and learners' understanding

- ✓ Learners' inability to read for meaning is a serious obstacle for science education. PROTEC addresses this by allocating time for reading during Saturday sessions. Learners read books and magazines – which builds reading skills and encourages reading for enjoyment – and learn to interpret exam questions.
- ✓ Science has a language of its own – the words themselves 'have no meaning' and it is the concepts behind the words that are important. We have to assist learners to understand by simplifying and explaining with care.
- ✓ Textbooks often use calculations to explain the meaning of words, but this does not help learners to understand the concepts. It is more effective to leave the calculations aside initially and to use other methods such as pictures to convey the meaning.
- ✓ Even though African languages may lack technical words, is there a place for language access from both mother tongue and English? Discussions in the learners' mother tongue can help to build their understanding, which they can then communicate using English.

The importance of giving learners the experience of science

- ✓ Children learn science more effectively when they can visualise and experience it. For e.g. use pictures and other visual aids to give them the concepts and a feel for what is happening, use analogies for comparison and get them to converse with each other about it. Show them how science features in their lives so they do not just see science as something that is done in isolation at school.
- ✓ Help learners develop a feel for numbers – if they cannot 'feel the number' they are unable to develop a 'feel for the concept'. For e.g. use metre-rules to demonstrate the size of a cubic metre.
- ✓ Give learners the experience of chemistry at a simple level, using what is commonly available. For e.g. have them put a bit of Enos on their tongues and talk to them about what is happening and what this means. Often teachers have not been exposed to this kind of experience, so don't think about doing it. It is important to support teachers with these quick and inexpensive ways to trigger interest so their learners will want to continue with science.

Need for influencing, developing and supporting teachers

- ✓ Many teachers of science have themselves not been exposed to stimulating teaching. Teacher education has to do more to awaken a teacher's passion for the subject. Too often teachers' main concern is with finishing the curriculum – instead they need to know that 'less is more' and that they can trigger far more interest and enthusiasm by giving learners the experience of science.
- ✓ The emphasis on results leads many teachers to focus on the equation and getting the answers right, rather than on developing a deep understanding – and each year the lack of understanding gets worse. The focus on results also lead to teachers spending less time teaching the material and more on teaching learners how to write the paper.
- ✓ Teacher accountability is another important issue – learners' uneven performance in exams shows that large sections of the curriculum are omitted. Do teachers need help on those sections?

Thoughts on assessing Science Expo projects

Expo projects usually focus on proving a hypothesis true – but it can also be extremely useful to prove a hypothesis wrong. Teachers usually give low marks when this happens as they do not see the value in it – which points to their limited understanding of the purpose of such projects and need for support.

Mathematics

The quality of maths textbooks and teachers' competence to use them effectively

- ✓ More research is needed to ensure the quality of textbooks and workbooks. Good textbooks are useful for building teachers' content knowledge. Teachers need to know how to use textbooks effectively (which one? which exercises? which questions?).
- ✓ Textbooks should (but often don't) provide good summaries of each section and of the curriculum as a whole. There would be value in having access to the whole curriculum in 4 pages (summary sheets) as a tool for teaching. Who would create this? How would the quality be ensured?
- ✓ Can South Africa learn from Singapore which has one national textbook per subject per grade?

Teacher education and teacher competence

Teachers seem to have lost the key elements of passion and purpose. Many lack the ability to effectively 'check where their learners are' and whether they are coping, to teach concepts, to deal with definitions, to choose good quality tasks and textbook activities to use in the classroom, or to assess. Student teachers should be taught these explicitly and practising teachers who are unsure in these areas should be upskilled.

Consequences of the inflexible, overfull curriculum

"The biggest frustration for a teacher is to know that by the end of each week you are expected to have taught such-and-such – and if you have not, you are required to account. Yet you are dealing with children who have large gaps in conceptual understanding. You can say you have taught everything – but what did the children learn? What is the point?" (CoP participant)

- ✓ Teachers need flexibility to do what is needed to fill the gaps and to make sure learners do not lag behind, but this is not allowed. This affects massive numbers of learners – it is immoral to treat children in this way. If children constantly fail to understand, the impact on their confidence is immense.
- ✓ In the lower grades many children are able to do calculations although they have only a very limited comprehension of what they are doing and what it means. When they get to the higher grades and have to do, for e.g. differentiation and integration, they have nothing to build on. Building comprehension should be an integral part of doing maths and science, but it is not possible with our full curriculum.

Learner performance

- ✓ Teachers often say that learners do not participate enough in maths classes – a major reason for this is the delays and gaps in earlier phases, so it is important to solidify the foundation phase. (It was noted that problems in maths can start really early, even before grade 1. Brain development is most active from 0-3 years, after which it builds on the foundation laid during those years.)
- ✓ As a country we need to see the reality of where we are – and to dig deeper to understand properly what the issues and problems are. It is frustrating that teachers are not heard and have so little influence. We have hands-on experience and see things going wrong – and we need to be able to get that across to government and teacher education faculties.

Multiple intelligences and different learning styles

To what extent do teachers use different approaches when presenting information, to help children make as many connections as possible – graphs, tables, drawings, diagrams, physical models? This enables children to pick up the learning where they most relate. Are student teachers given this kind of information?

Techniques for dealing with large classes

Large classes in township schools mean that many learners don't benefit fully from the teaching. There are ways of getting interaction going in large classes (e.g. think, pair, share; cooperative learning techniques), that give the teacher quick pictures of where the learners are and allow the teacher to have some contact at least with all the learners in the class. Schools could also learn from ECD where children are formed into groups doing different learning activities, and rotated. Teachers could focus on one or two groups each lesson – while managing the others – and over the course of a week would make direct contact with each learner. These techniques do require adequate physical space and a strong school culture that allows the teacher to create discipline in the classroom. "We should share the things we have tried that actually work."

"A lot of what we heard in this session put the problem 'out there'… we heard that the problem lies with the curriculum, the government, the textbooks, the teachers, the teacher educators. I am not saying it does not – but we are not able to change much of that … so I would like us to change this to: "What can I do that is different, that can make a difference in my area within the next 30 days?"
(Dr Craig Pournara)

Facilitator's summing up

So many issues have been raised by just this group. Are there actions that we can take while waiting for government to address the problems? We look forward to hearing what people have done to make a difference within their own areas at the next CoP in October.

Attendees

Name	Organisation	Name	Organisation
Adel Hartley	Lebone 2	Mogodu Maake	eThuta
Andrew Barrett Barrett	OLICO	Molantoa Mokoena	Mafube intermediate
Anne Kariuki	Afrika Tikkun	Molapo Thocha	Tomorrow Trust
Benter Okelo	BRIDGE	Molatoli Tsotetsi	Mafube intermediate
Bev Johnson	Thandulwazi Maths & Science Academy	Motlalentoa Nthoba	Mafube intermediate
Bongiwe Radebe	Mafube intermediate	Omashani Naidoo	SchoolNet SA
Bronia Vollebregt	Lasec	Pamela	OLICO
Bulelani Ntuli	Nedbank	Pamela Mkitimi	Mafube intermediate
Carol Wyeth	Alexandra Education Committee	Peter Glover	Facilitator
Christiaan Visser (PhD)	Independent	Philip Pare	
Craig Pournara	Wits University	Piet Maseting	Mafube intermediate
Duduzile Ngoepe	PROTEC	Randy Mremi	funda afrika
Duduziwe Irene Miya	Izibuko Primary School	Salome Posthumus	VastraTech
Frank Longwitz	3P Learning	Sam Rametse	Zenex Foundation
Hazel Ncube	Funda Afrika	Shadrack Mahapa	Sci-Bono
Henricah Ncube	Ikamva Youth	Simangaliso Twala	COUNT Educational Institute
Irene Fricke	Ithuta Books	Simon Hartley	Royal Bafokeng Institute
Jade Pieterse	BRIDGE	Siyabonga Maleka	Mafube intermediate
Jenny Dry	Institute for Balanced Living	Teketsi N.C	Mafube intermediate
Lehlohonolo Sekobolo	Mafube intermediate	Thabile Zulu	Nedbank
Lerato Mathenjwa	TEACH SA	Thando Moeng	BRIDGE
Lisa Ann Catano	Bullying Specialist	Thoko Mbense	Hey Neniya Consulting Enterprise
Lynn Bowie	OLICO	Tshegofatso Bokaba	Nedbank Foundation
Mabatho Mosia	Mafube intermediate	Virginia Sibanda	Ikamva Youth
Mabeleng Vanrooi	Mafube intermediate	Yvonne Pennington	Independent
Margie Vorwerk	BRIDGE	Yvonne Sanders	WITS UNIVERSITY
Masiteng Motiisetsi	Mafube intermediate		