



Setting the Scene

The Maths and Science Community of Practice started the year with a bang, looking at key issues around ‘how maths is done’ in the early school years, what is missing in the way learners are being taught, and what learners need in order to successfully navigate maths (and science) curricula through to high school.

The central message from both speakers, Dr Nicky Roberts of the University of Johannesburg, and Andrew Barrett of OLICO Maths Education, is that mathematics is meant to make sense, that children’s engagements with maths must support sense-making, and that – with this approach in place – sustainable, scalable improvement in South Africa’s maths performance is achievable.

Nicky’s presentation focused on maths in the Foundation Phase, looking specifically at engaging with and strengthening the curriculum, developing number sense, and the teaching of maths in African languages. This was complemented by Andrew’s presentation on OLICO Maths Education’s work in the after-school or extra-curricular space to develop the maths competence of learners in the Intermediate, Senior and FET Phases.



Overview of Presentation 1

Click [here](#) to view the

Maths Education in South Africa: what is the missing link? A focus on the Foundation Phase – Dr Nicky Roberts

“The support we give to our teachers has to enable them to re-experience mathematics as something that makes sense, as something that coheres, and as something that has an underlying logic and structure.” Nicky Roberts



Dr Nicky Roberts

Nicky argues that the current approach of breaking down the curriculum into small units, giving teachers specific instructions to follow and then policing them, does far more than just de-professionalise teachers. In mathematics particularly, this approach has the effect of reducing the coherence and meaning of the subject for both teachers and learners.

This harmful consequence underscores the importance of supporting teachers with sound instructional material. Unfortunately, lesson plans, workbooks and worksheets are frequently developed at pace in order to meet short term deadlines, leading to insufficient consideration being given to the quality of the material and the kinds of support Foundation Phase teachers need.

Nicky describes her work in Foundation Phase maths as being about ‘illustrating and telling mathematical stories’ – from the perspectives of both teachers and learners. While story telling creates knowledge, language

This presentation was based on PhD-related work on improving Foundation Phase maths at a Western Cape school. It was conducted in English, with learners whose first language was not English, and resulted in a significant and sustained improvement in Grade 3 maths passes (*see slide 3*). The presentation also drew extensively on the work of Ingrid Mostert in the Eastern Cape, which was conducted in isiXhosa with first language isiXhosa speaking learners.

is required to tell the story (*slides 5 & 6*). In this respect, Nicky notes that although 75% of Foundation Phase learners learn maths in their mother tongue African languages, the potential for this to support their maths engagement is undermined because their teachers have not been equipped to communicate about maths in those languages. Added to this, the instructional practices that are dominant in the classroom make it very difficult to bridge the gaps that result.

For Nicky, the missing link in mathematics education is sense making. She describes South Africa as having inherited an instructional culture where maths is not expected to make sense, but instead is expected to be delivered 'like a parcel', by a teacher to a learner. This culture is further overlaid by a political lens that questions the ability of African people 'to do maths'.

"Our children have an incredible ability to tell stories, to imagine and express, but when their teachers have never experienced mathematics as something that makes sense – as something they can tell stories about – they can't ignite that interest in children." Nicky Roberts

Nicky emphasised the need to 'start systematically undoing this narrative'. Her presentation showed, in realistic and practical ways, how we can begin to do this.

➤ **Strengthen CAPS, and communicate it more effectively to teachers:**

Take into account our starting point – Many children lack experience of numbers when they start school. They must be allowed to move through all the intermediate steps needed to progress from counting reliably to calculating up to a 100. A learning trajectory from the Netherlands shows this process taking 7 years (*slide 28*).

Increase the 'bandwidth' per grade – Children do not all progress at the same pace. Within every lesson, teachers should be able to take a step back and a step forward – and should be supported with appropriate material to differentiate learning in this way.

Reduce the pace as this outstrips the pace of learning – "We teach children, not CAPS."

Reduce the number of topics by connecting across the 5 topics in the early grades – The work of Clements & Sarama (2009) shows how this could be done (*slides 13 – 15*). They identify the main areas to be developed in the early grades as (i) numeric and quantitative competence and (ii) spatial and geometric competence. These domains of learning support each other but are distinct, so it is important to develop both. The sub-themes of patterns and functions, data handling, and classifying, sorting and sequencing provide contexts in which the two main areas can be developed.

Nicky observes that the ingredients for this approach are already in CAPS, the two main areas being (i) number operations and relationships, and (ii) measurement, combined with shape and space (geometry), and with the remaining areas as meaningful contexts for learning.

Abandon the 'clarification notes with teaching guidelines' in the CAPS document – This section can be published as one possible learning programme, which is not to be slavishly followed and policed.

Simplify the appearance of DBE workbooks – increase font size and space for writing and drawing.

Focus on the underlying big ideas to avoid each section, week or lesson being experienced as a new piece of content – Provide an overall framing of content organised by big ideas, rather than by increases in number range (*slides 18 - 20*). Show connectedness, which is currently lacking – numbers are dealt with in isolation, with questions and tasks tending to focus on a particular number (e.g. 11), with little to show how it relates to other numbers.

➤ **Focus on number work:**

Attend to the numerous intermediate steps/stages/levels through which children develop their number concept and quantitative reasoning – The material (NECT lesson plans and DBE workbooks) features extensive repetition of very similar tasks, with a focus on ever larger numbers, rather than conceptual development. The push towards higher numbers gets in the way of the intermediate steps that children need to go through in order to make sense of what they are doing when calculating.

Give far more time for developing numbers, operations and relationships in the 0 – 20 range – Nicky asserts that Grade 2 should focus on the number range 1 – 20, which should include firmly establishing place value. This would give learners time and the opportunity to move through the intermediate steps (*slide 28*) essential for developing number sense.

“If we can get 0 to 20 right, including place value, everything else will follow.” Nicky Roberts

Our learning as humans is closely linked to our bodily structure, which also gives us various anchor points in mathematics. Counting using a base of 10 is inherent in our body design, and 5 and 10 provide key markers for working with other numbers. However, this kind of structuring is almost completely absent from what teachers communicate to Foundation Phase learners. (In Germany, children focus on 0 – 20 until Grade 3.)

Attend specifically to structuring¹ – A comparison with the Netherlands learning trajectory shows the major missing steps to be (i) moving from counting to structuring, and (ii) learning to calculate by structuring, with the help of suitable models (*slide 29*). This explains why so many South African children are stuck at counting in ones. Nicky advises teachers to scaffold children’s counting to enable them to make the shift from ‘one-ness’ to ‘five-ness’ and ‘ten-ness’ – and to help them to use their fingers and hands in ways that show structure when working with numbers.

Select a few powerful and structured representations (e.g. number lines), then develop them consistently – The widely inconsistent representation of number lines in the learning material (*slides 30 - 34*) shows a lack of attention to detail and research in terms of how particular representations need to be developed.

Children have to make a substantive shift when moving from using a number track where each block has a number, to a number line which has intervals. Children find it very difficult to distinguish between ‘the fence and the poles’, so must be introduced to number lines in a very deliberate way, to avoid confusion. This shift takes 6 - 12 months to become secure.

Nicky recommends using a structured 1 - 10 number line in Grade 1, and 1 - 20 in Grade 2. Empty number lines can be used in Grade 3.

“If we are not going to have another 20 years of being disappointed in our maths performance, we have to invest in instructional design – and understand that a workbook takes a year to develop, then has to be trialled in the right context, and then improved.” Nicky Roberts

➤ **Focus on teaching and learning mathematics in African languages²:**

When developing materials in African languages we need to ‘trans-language’, not translate – *Slide 36* shows a key example of the translation not having the mathematics in mind. In isiXhosa, numbers used as adjectives must accord with the noun class, which changes the form of the number name. The activity is meant

¹ Being able to break down and build up numbers, seeing them as a whole and in various combinations, and doing this flexibly and fluently, without counting.

² Ingrid Mostert’s paper *Number Names: Do They Count?* delves into these and other issues. <https://www.tandfonline.com/doi/full/10.1080/18117295.2019.1589038>

to show that ‘four-ness’ is invariant – but the intended learning will be compromised because the word for 4 is inconsistent in the translated isiXhosa version. To make this activity meaningful, the isiXhosa material would need to (i) provide an explanation of the way the word for 4 depends on the noun class and (ii) make the objects being counted easily recognisable.

Think carefully about the language and the register and use it consistently across all materials and documents – ‘Trans-linguaging’ necessitates developing and agreeing on mathematics registers for communicating mathematically in each language. For e.g. there are two ways of naming fractions in isiXhosa, so one must be chosen as the dominant way and used throughout, with the other being referred to only by way of explanation.

Seek opportunities to leverage the linguistic features of the language for communicating the mathematics – An example of the way language could support maths learning comes from isiZulu, in which ‘more’ includes the notions of ‘higher’ and ‘up’. This suggests that it would be helpful in isiZulu materials to start with vertical number lines (with 0 at the bottom), rather than horizontal number lines. This example also calls attention to the cognitive conflict that children learning in isiZulu experience when working on the concept of ‘more’ using a 100 square (which typically has the smaller numbers at the top and the bigger numbers at the bottom).

Nicky noted the importance of understanding more about how mathematics is expressed in South Africa’s languages, and invited others to work on this in their own areas of competence.



Overview of Presentation 2

Click [here](#) to view the presentation

Building maths skills for a strong finish in High School – Andrew Barrett



Andrew Barrett

“Improving maths performance is a daunting challenge, but with the right kind of emphasis around sense making, and building a good number sense in learners, we can make massive strides.” Andrew Barrett

Andrew believes it is difficult to overstate ‘just how much mathematics’ learners are missing, particularly in terms of number structuring. Some learners in the Senior Phase still make tally marks and count in ones. Most learners in OLICO’s Senior Phase programme are building their maths skills for the first time. OLICO’s position in the after-school and extra-curricular space means that although its work is CAPS aligned, it is less constrained by the CAPS curriculum and so has greater freedom to go back as needed to build these missing skills.

Andrew speculates that the ‘counting in 1s method’ has become so stubbornly embedded across the country because it is rewarded and reinforced – learners often arrive at the correct answer (at least with smaller numbers), and teachers expect learners to use it. He notes that it is also ‘massively inefficient’, making the rest of maths more difficult, and leads to mistakes once larger numbers are involved.

The value of OLICO’s methods was confirmed when its first cohort wrote matric in 2019. Three quarters of the Diepsloot Grade 12 group matriculated with bachelor level passes in maths. Despite making up only 3% of Diepsloot’s matric population, the group accounted for over a third of the community’s bachelor level maths passes.

In terms of bridging across the Phases, Andrew also stresses how vital it is for learners to develop a full conceptual understanding of number lines in the Foundation Phase. This understanding underlies many aspects of maths in the later school years. If learners fail to develop a proper sense of number lines during their early years, the concept is difficult to introduce later when it is needed for other areas of maths.

The common threads running through all OLICO's interventions are (i) the **development of a strong, flexible number sense**, and (ii) an **emphasis on sense making**. The aim is for learners to be able to manipulate numbers and do mental arithmetic easily and efficiently – equipping them to work through whatever maths challenges they encounter and keeping their cognitive load low when they do more advanced maths in high school.

OLICO works with learners from Grades R - 12. Some of their programmes are:

Maths Clubs (for Foundation and Intermediate Phase learners)

These involve **small groups of learners in games and activities** designed to develop their number sense and fluency. The aim is to de-stigmatise maths, make it approachable and enjoyable, and embed the core number concepts needed for more advanced maths.

“Maths Clubs are a wonderful opportunity to engage differently with maths with young learners.”
Andrew Barrett

The games are open source, and available on the Maths Club website (mathsclubs.co.za), together with information on starting a maths club. Detailed handbooks/session plans are provided. An extensive Grade 4 focussed curriculum has been developed but is not yet on the website. Anyone interested in obtaining a copy is invited to contact Andrew on andrew@olico.org.

Tutoring and Technology (for Senior and FET Phase learners)

With older learners, OLICO uses a blend of tutoring and technology to build number sense, procedural fluency and conceptual understanding that will take them through to matric and beyond.

OLICO's 'maths tool' covering the Senior Phase CAPS curriculum is available online and is free to access. It includes interactive questions, tutorial videos and supporting material, and takes the learner through 'core and key concepts' which OLICO has identified as crucial to creating pathways into mathematics in Grades 10, 11 and 12. Although it is pitched for learners in Grades 7 - 9, the tool 'goes back' to the early grades where needed. In schools without technology, learners use pen and paper.

Two other activities which bridge across the Phases and significantly improve fluency and efficiency while reducing cognitive load in more advanced maths are (i) 'Two-minute tango', which is essentially about structuring, and (ii) a times-table competition. (Website: learn.olico.org)

“Many of the backlogs and problems that we see in Grades 8 and 9 essentially stem from Foundation Phase mathematics. It is not just a case of learners being a few years behind. Instead, the problems we are seeing in high school are fundamentally around the structure of numbers – for example, learners being unable to access any of the algebra because they are still struggling with the core structure of numbers.

Much of the 'remediation' that OLICO does involves taking high school learners back and developing their number sense. This means giving them some sense of the 10 structure of numbers, the ways of working flexibly with subtraction, and understanding multiplication and division.” Dr Lynn Bowie, OLICO Maths Education



@CoP

Panel and Group Discussions

This section highlights aspects of the CoP discussions, arranged by theme. Facilitator, Peter Glover, invited participants not to limit questions to the specifics of maths teaching and remediation, but also to look at how the new thinking about maths education might be embedded and systematised, and how currently practising teachers could be helped to change their approach.

Is there still a role for manipulatives and hands-on activities in the maths classroom?

- Hands-on activities are crucial for developing understanding – even in Grades 8 and 9, especially as many learners have never had the experience of manipulating physical objects in maths. Even when technology makes it possible to use online manipulatives, the physical, tactile experience is particularly useful.
- Instead of just ‘hands-on’, we should be looking at ‘minds-on’.
- There is a role for manipulatives, but they should not be complicated or expensive (e.g. plastic bottle tops in two sizes, ice cream tubs). Bead strings are essential and can be made simply using beads from plastics goods stores, structuring them by 5s in alternating colours. For Grade 1, strings should have 10 beads, and for Grade 2, 20 beads.
- It is important to be very deliberate about which manipulatives to use.
- Manipulatives are a necessary investment in sense making and should bring in the local context – as in the Primary Science Programme’s activity books for practical maths and science teaching using everyday household objects.

Disrupting Piaget:

“In mathematics, Piaget’s linear model – that we start with the concrete, move to the iconic, and then towards the abstract (e.g. 5 fingers, then a picture of 5 fingers, then the number 5) – is not helpful and can be destructive. In mathematics we move in a cycle, between the three. The process is not linear, with the abstract as the destination. For example, when learning calculus, one needs to look at the equation, to imagine the car accelerating away from the stop street and to picture that as a velocity/ time graph.” Dr Nicky Roberts



What are the implications for teacher preparation? It is important to prepare our teachers for the context they are going to teach in. Student teachers whose training is conducted in English, but who then teach maths in an African language face the additional burden during WIL programmes of constantly having to decode between their English language notes and training, their own African language, ‘maths language’ and back again.

Nicky provided details of activities across universities in relation to improving teacher preparedness:

- There has been progress, mainly through the EU-funded Primary Teacher Education Project (PrimTEd) in which 23 universities offering B.Ed. degrees are collaborating to improve primary school teacher education and equip graduates to teach maths and languages effectively. (Anyone working in this area, who would like to join the process, is welcome to contact Nicky.)
- The University of Fort Hare is trialling a B.Ed. in isiXhosa.
- There is greater interest in how the languages and maths can – and need – to support each other.
- The University of Johannesburg now includes hands-on/minds-on activities, games and use of an online app in the first 6 months of its B.Ed. FP and IP programmes. This material has recently been published in book form, and there are plans for universities to collaborate on developing this type of material across all 4 years of the B.Ed. programme.
- Wits University is using the OLICO materials with its ITE students and is looking proactively at how to change its B.Ed. programme.

“There is growing awareness that it is unrealistic to expect student teachers who are learning maths in English and were last exposed to mathematical language in their home language when they themselves were children, to just transform themselves into fluent African language teachers of mathematics.” Nicky Roberts

Why does the transition in Grade 4 from home language to English as the LOLT need to happen when it is so detrimental?

Nicky believes we should stop thinking in terms of whether there has to be a language transition in Grade 4, and how it should happen, and instead focus on using bilingual learning effectively. In this we can learn from what other countries are doing to develop bilingualism:

- Research by Harvard suggests that the best model consists of conducting a lesson (on maths or science) in the dominant or home language, and then repeating that lesson in fluent English. This introduces the concepts in the home language and consolidates them in English. The FP provides some opportunity for

this approach because the same teacher works across all three learning areas. The themes chosen for English FAL lessons would also relate to what children are learning in maths and science.

English is a world language and it is understandable that parents want their children to learn it. At the same time, we need to invest in our African languages for a wide range of reasons, not least of which is their role in children's cognitive and linguistic development:

- A key Harvard research finding is that children's progress in English is likely to stall if they do not continue their home language development (i.e. speaking, writing and reading in a range of discourses). Children in this situation need both their home language and English to move through the South African system.

Another important issue is that many classes in urban areas have a multilingual, rather than a bilingual, set up.

How can we take this thinking back to the schools and districts, and get everyone on board? How can practising teachers become aware of the research and new thinking on teaching maths? How can we change the focus from compliance to achieving learner understanding?

- Various government departments have begun implementing systematic interventions. For e.g. the WCED has had good results supporting Grade R teachers in maths, by orienting them to learning through play and using language in bilingual contexts, as well as building their mathematical knowledge. Novice teachers are also given a year of support, mainly through PLCs and their subject advisors. Nicky noted that ongoing professional development of this kind has to be embedded into the provincial structures.
- At school level, the weekly grade meetings and monthly phase meetings can be given a maths focus (rather than an admin focus). Discussions would typically cover what will be taught, how it will be taught, the actual planning, and a reflection on the previous week's performance.

Encourage experimentation:

We need to move the conversation on from negatives and problems, and instead start experimenting to find out what we can do. Start on a small scale with a small group – slowly, carefully, deliberately, with whatever context you are in. The more groups of people there are doing this, in different contexts, with different challenges, and feeding back, can only benefit the broader collective. There is not only one approach – we need to find the ways that work. Andrew Barrett

- There is growing understanding that workshops are not effective, and that teachers need good instructional materials, training and a coach/influencer (e.g. the HoD) who understands the issues (cf Braam Fleisch's 'triple cocktail'). At the same time, it is important for teachers to be active in their own development.

"It is important to develop capacity for our own change, in our own space. Try something different, reflect on it, improve it ..."

Organisations offering support:

- The Association of Mathematics Educators of SA (AMESA) stimulates and gives guidance through their 'how I teach' component, which provides a space for teachers to share what they are doing with others. <http://www.amesa.org.za/>
- Another option in terms of professional development for FP and IP maths teachers is the African Institute for Mathematical Sciences Schools Enrichment Centre (AIMSSEC). A 10-day programme in January immerses teachers in maths, enabling them to re-experience maths in ways that use the new methods. <https://www.aimssec.ac.za/>

"A combination of deep learning for yourself and reflecting on how things are going in your class is what we have to try to scale."
Nicky Roberts

Several participants recommended a more integrated approach to learning in the early years

“We need to look into what meanings we hold, and what we convey to learners – is it what we intend them to learn?” CoP participant

- If language, life skills and handwriting were to be integrated, with integrated materials, there would be more time to get the children’s number sense properly set in real life. There should be only two subjects in the Foundation Phase – language and maths.
- We need people to create stories in the home languages that go hand in hand with what children are learning in maths. This would reinforce the learning and create synergy between the different subjects.

Summing Up

It was agreed to continue exploring the topic at the next CoP meeting in May. This would feature a bigger emphasis on practical input from individuals who had tried different approaches in their maths teaching.

- Picking up on what has been said, could we choose one thing to try in a practical way for the next 6 weeks, and perhaps hold ourselves accountable to someone sitting nearby, and then reflect on it the next time see each other?
- The focus should be on what people have tried, and the insights they gained. This is not only about successes. It is also important to hear what people have tried, if the attempt was unsuccessful, as this could lead to suggestions for taking it forward.

“The power of change happens when we share. We need to look at how we can continue this conversation.” CoP participant

Anyone interested in making an input at the next CoP is asked to contact Benter on benter@bridge.org.za. Inputs should be short, lasting a few minutes.

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