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ADAPTING NUMBER TALKS TO FOREGROUND MATHEMATICAL PROGRESSION IN SOUTH AFRICAN CLASSROOMS

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Abstract

In this paper we describe our use of design research processes to adapt and implement number talks as a key teacher development strategy focused on pushing for progression in our local project schools. Additionally we share data of teacher experiences of this initiative. Given the widely reported prevalence of one-to-one

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counting methods as the dominant calculation strategies across the four operations even in the intermediate phase grades (4-7) in South Africa our aim in introducing the talks was to simultaneously develop learners mathematical talk (verbal reasoning) and to push explicitly for the use of more efficient calculation strategies.

Keywords: Number talks, mathematical talk, verbal reasoning, calculation strategies, teacher development, South Africa

INTRODUCTION

Our work within the South African Numeracy Chair (SANC) project is located within the broader context of mathematics education in South Africa and more specifically within the development of mathematical proficiency in primary school learners in the Grahamstown area of the Eastern Cape. The aims of the SANC project rest on a dialectical relationship between development and research. In development terms the SANC project is expected to improve the quality of numeracy teaching at primary school level. In research terms we are tasked with providing possible pathways that address the 'crisis' in primary mathematics education (Fleisch, 2008). Our research and development work are both premised on a Vygotskian (1934; 1978) perspective of learning which emphasises the critical importance of both language and social interaction (including peer and adult mediation) in learning and individual progression. For Vygotsky, language is the primary cultural tool, with speech being the primary mediational means. Vygotsky (1978) emphasised the role of semiotic (systems of signs and symbols) mediation, in effecting the internalisation of activity. It is through mediation that a child is able to transform external activity into internal activity and therefore understanding. The child learns and develops concepts through internalisation, transferring from the social (interactional) plane to the individual (internal) plane.

A wide range of international and regional comparative research points to South African learners persistently performing below those of other countries despite our relative wealth in the African region and our comparatively high expenditure on education (HSRC, 2011; Spaull, 2011). A range of contributing factors are identified across large and small-scale studies including: language, classroom practices, poverty, teacher knowledge, teaching time, home resources and learner dispositions (Fleisch, 2008; Graven, 2014). In particular, and of relevance to this paper are the first two factors. In terms of language practices, from grade 4 onwards the majority of South African learners switch from mother tongue language of instruction to learning in a language which is not their mother tongue. Thus 79.1% of South African Grade 4 learners learn mathematics in English while only 6.9% of these learners speak English as a home language (DBE, 2010; Robertson, Graven, submitted). This has direct impact on access to mathematical meaning or what Setati (2008) refers to 'epistemological access'.

In terms of classroom practices, interaction patterns tend to foreground teacher talk and learner chorusing often at the expense of individual sense making, coherence and mathematical progression (Hoadley, 2012; Askew, Venkat, Mathews, 2012). Setati (2005) argues that in many South African mathematics classrooms the discourse is primarily procedural and lends itself to low cognitive demand tasks. In relation to this much research shows a predominance of one-to-one counting methods persisting in the intermediate phase (Schollar, 2008) meaning for example that even for a simple problem like 198 + 2 learners would use a tally representation and count all strategy. Ensor, Hoadley, Jacklin et al. (2009) argue that as a consequence

> learners' opportunities to grasp the symbolic system of mathematics are inhibited by classroom practices that privilege concrete modes of representation, which restrict access to more abstract ways of working with number, and by the inefficient use of class time (p. 8).

For the last four years our project has worked with twelve schools in the broader Grahamstown area in the Eastern Cape, South Africa. The Eastern Cape is one of the poorest provinces with the lowest performance in education. Our teacher development programme is called the Numeracy Inquiry Community of Leader Educators (NICLE) and focuses on the critical transition between the Foundation (Grades R-3) and Intermediate phase (Grades 4-6). Numeracy teachers participate in monthly workshop sessions focused on exploring ways forward to the challenges in numeracy teaching. Additionally we run learner focused activities such as after school maths clubs and family maths events.

NUMBER TALKS AS AN INTERVENTION STRATEGY

From a Vygotskian perspective, mediation is defined as a form of intervention that focuses on experiences during the process of thinking and learning. It refers to use of cultural tools (for example language and symbols) to bring about qualitative changes in thinking. Thus within our theoretical framework and within the context described above, a key on-going focus of our work is developing increasingly active learner participation, exploratory talk, sense-making and mathematical progression enabled through strategic use of teacher and peer mediation. In this respect we chose to investigate number talks, as conceptualised in a range of international literature, as a possible teaching intervention strategy.

In the introduction to their new book titled, *Making Number Talks Matter*, Humphreys and Parker (2015) point out that many teachers note their students' lack of mathematical understanding. They suggest that as this happens in so many classrooms around the USA (and in fact around the world) perhaps the failure is in how mathematics is taught, even with the best intentions. Research has shown that the mathematics classrooms in which students learn number facts and number sense through engaging activities that focus on mathematical

understanding are preferable to those that promote rote memorisation (Boaler, Williams, Confer, 2014) and that successful mathematics learners are those who can flexibly use numbers by decomposing and recomposing numbers (Gray, Tall, 1994). Boaler et al. (2014) believe that using 'number talks' as a teaching strategy is crucial for simultaneously developing number sense and mathematics facts.

Originally developed by Ruth Parker and Kathy Richardson in the early 1990s, they were conceptualised as short teaching activities that teachers can use as lesson starters. In the foreword entitled *The Wonder of Number Talks*, Boaler (2015a) indicates that a number talk involves posing a maths problem such as 18 x 5 and asking learners to solve the problem mentally, without pencils and paper and on their own. The teacher then asks the learners to share the different methods used to solve the problem and importantly discusses why they work. By using number talks, teachers can, in a short space of time, change learners' view of mathematics, teach them number sense, help them develop mental maths skills and engage them in creative, open mathematics.

The key aims and objectives of a number talk are to clarify thinking, to investigate and apply mathematical relationships, for learners to build a repertoire of efficient strategies, for learners to make decisions about choosing efficient strategies for specific problems and to consider and test other strategies to see if they are mathematically logical (Parrish, 2011). For Parrish number talks are "classroom conversations focused on making sense of mathematics" (p.203). Another advantage of number talks is that they can be used at all levels of difficulty for children and adults of all ages. So for example, '*how many do you see'* type of problems (using dot patterns and 10-frames) can be used for earlier grade learners (grades 1 to 3), whilst addition, subtraction, multiplication and division problems can be posed from grade 3 up to university students and beyond.

All of the above appealed to us and strongly cohered with both our research assumptions and the aims and vision of our teacher development project and we thus planned to trial number talks for use in the classrooms of our NICLE teachers. However, having watched the USA number talk videos (Parrish, 2010; Boaler, 2015b), we noted that the learners were used to talking about their mathematical thinking, the class / group sizes were small, there was a lot of space in the classrooms, the classrooms were well resourced and the teachers had a rich repertoire of mediatory prompts.

PILOTING AND RESEARCHING NUMBER TALKS IN OUR SCHOOLS

Given the key language and pedagogical challenges identified above as well as the issue of overcrowded classrooms, we were aware that our number talks were unlikely to unfold in the same way as the USA number talks we had watched. In this respect, design research was well suited to our needs as

> by grounding itself in the needs, constraints, and interactions of local practice, can provide a lens for understanding how theoretical claims about teaching and learning can be transformed into effective learning in educational settings (DBRC, 2003, p. 8).

Thus the methodological approach taken to the research and implementation of number talks in our project schools was based on a design research approach, which is a methodology for "understanding how, when, and why educational innovations work in practice" (DBRC, 2003 p. 5). One of the characteristics of design research is that research must account for how designs function in authentic settings so as to provide insight for teachers who wish to adapt such proven curricula / interventions for use in their own classrooms.

We began our pilot by collaborating with an opportunity sample of one NICLE teacher in a nearby school. All learners were isiXhosa speaking and only began learning mathematics in English in Grade 4. Furthermore this was a no-fee paying township school and thus shared features with many South African schools. We chose to pilot with one Grade 4 class of learners in order to experience the range of language challenges which might emerge in relation to the number talks. We emphasised that code switching by learners and teachers (Setati, 1998) should be used wherever it was deemed helpful. Additionally, following permission, the talks were video-recorded in order to enable reflection.

We piloted three number talks with the selected Grade 4 class. The first talk led by the class teacher involved a *how many do you see* dot-type problem which encourages learners to see the dots in groups or patterns and explain how they see the dots. The second talk, led by Stott was a 10-frame based talk, which involved working with dots in 10-frames and adding further dots in another 10-frame. The third talk, led by Graven was centred on the multiplication problem of 7 x 12.

In our reflections with the teacher afterwards, we were excited with the piloting process as we were able to note some learners progressing through the talk both with efficiency of their methods and their ability to communicate these and their confidence to do so. We were convinced there was value in sharing the number talk strategy with the teachers in the broader NICLE community based on an adapted approach.

We noted some challenges from all three talks, which would need to be addressed. Asking learners to show their methods by writing on the board was time consuming and extended the talk beyond the anticipated 10 to 15 minutes. There was thus reduced opportunity for discussion. Large classes have organisational issues, which can make it difficult for all learners to participate and time consuming for learners to get to the board. Thus, we tried a number of different approaches in each of the three talks, to determine their value. For example, rather than writing their method on the board, learners were asked to

point to and use other gestures from their seats or at the board to support the recording of their method by the teacher. We found also that allowing the learners a few moments to work in smaller groups to discuss the problem before opening it up to the whole class, gave them opportunities to discuss and talk about their ideas first before sharing them in the broader group.

Two other key concerns raised in the literature also needed to be addressed. Teachers can often feel overwhelmed when making the shift toward teaching for understanding (Parrish, 2011) and learning how to do number talks. There are some important things to know when learning how to do number talks such as: what to say (how to mediate) when learners share an incorrect solution or make a mistake in their workings; what mediatory prompts / questions can be used if learners have no methods to share and where teachers can find rich problems to use for a number talk (Boaler, 2015a).

Adaptations from the pilot for broader implementation in NICLE

With these factors in mind and from our experiences in the three pilot talks, we developed two key resources for the teachers in our project: a 2-page number talk handout accompanied by a series of carefully selected stimulus problems that could be used in classrooms.

The first resource contained a number of key ideas and scaffolds for the number talks. An important part of this is what we called the 'talk plan', shown in Figure 1 below. This gives a step-by-step breakdown of a number talk session that teachers can follow to introduce number talks into their classrooms in a structured way. The talk plan refers to other sections of the handout, which provide further support for the teacher, for example mediatory questioning prompts. The handout also lays out the teacher's role and the classroom ethos required for a number talk.

Timing	*Section of talk*	*Comments and instructions*
30 SECONDS	Hand out cards to groups of learners	
30 SECONDS	Breathe and visualise	*Close eyes and visualise the pattern / sum on the card*
30 SECONDS	How many and how do you see them? **OR** Can you solve this problem? Think about how you will explain how you got your answer	*No touching (hands behind back)* *No writing (except for large multiplication problems)*
8 MINUTES	Whole class talk	*Use the **prompt** (see separate examples)* *Use **questions** (see overleaf)* *Teacher **records** visually (use coloured chalk if possible)* *Keep all records up so learners can see while watching / listening to others and see if their method is same / different* *Encourage use of **hand signals***
1 MINUTE	Discussion of strategies	*Discuss the strategies contributed* *Which are more **efficient**? **Accurate**?* *As a class agree on the **2 most efficient** strategies as key strategies* *Write final strategies on flip chart to hang on class wall*
30 SECONDS	Recap of efficient strategies	*Whole class to point and say the 2 most efficient strategies*
APPROX 11 MINUTES		

Figure 7: SANC project number talks - Talk Plan

We added two other aspects to the talk plan. Explicit discussion of strategies was important not only for providing access to strategies but also for comparing efficiency. In order to encourage learners in our schools to work beyond the *counting all* strategies, we wanted teachers to emphasise progression towards more efficient strategies. We also encouraged teachers to follow up the number talk with some kind of activity to stress the use of more efficient strategies. We provided them with these three examples: 1) create and post a class strategy chart after each talk, 2) give quick problems similar to the ones done in the week in which learners are required to solve each problem in at least two ways and 3) solve a 'homework problem' where learners solve a previously discussed problem using an efficient strategy used in a class strategy talk and then using any strategy they wish.

Our second resource provided teachers with rich problems to use for a number talk. The resource consisted of a number of stimulus problems ranging from dot patterns, 10-frames through to addition, subtraction, multiplication, division and pre-algebra problems. Some examples are shown in **Error! Reference source not found.** and Figure 9.

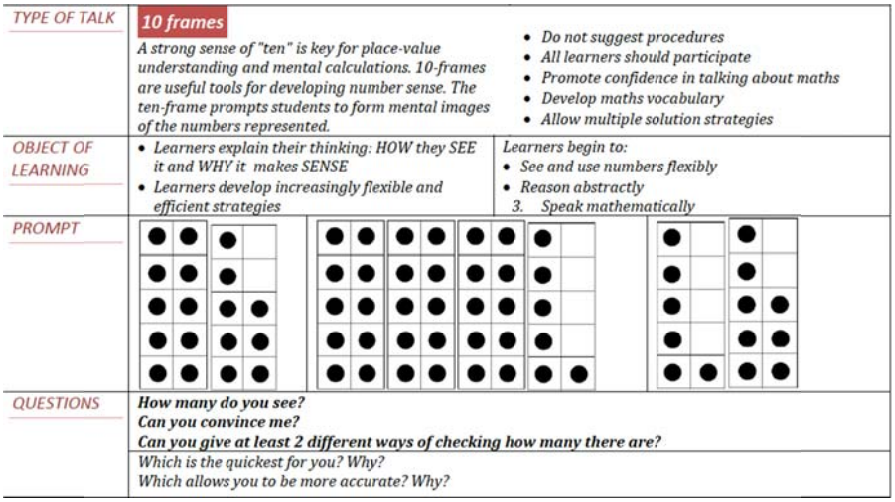

Figure 8: SANC project number talks – 10-frame number talk stimuli

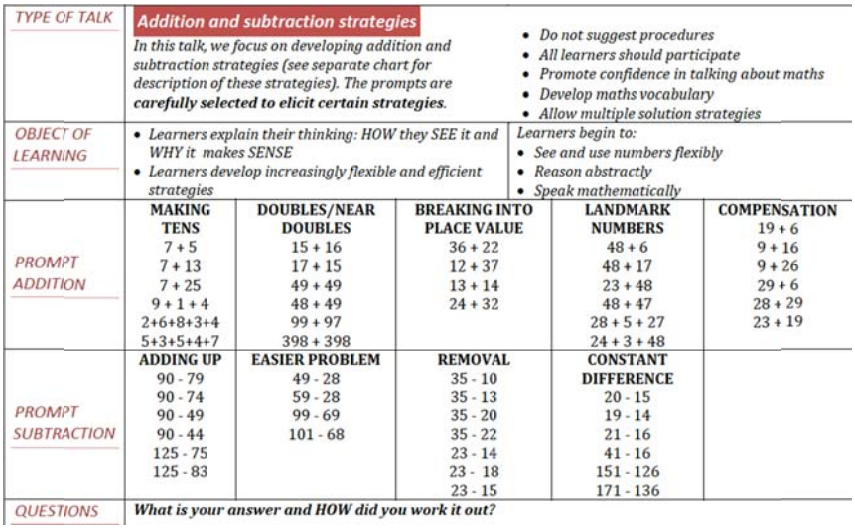

Figure 9: SANC project number talks - Addition and subtraction number talk stimuli

The intention was that as teachers became more familiar and confident with the types of problems that work well for a number talk, they would begin to devise their own. Indeed, this began to happen with the teachers in our schools. One for example reported "I try to do number talks whenever I detect a problem that seems common to a number of learners, or when areas in test papers are badly done".

Following the piloting we (the authors and the participating teacher) introduced number talks to all our NICLE teachers during a workshop. We shared our pilot videos, our experiences and encouraged teacher reflection on these. Teachers then practiced conducting number talks with each other in small groups. A key aim in introducing the talks into our project schools was to shift *one-to-one counting* strategies towards more flexible fluency. The talks provided rich opportunities for focusing on efficiency and explicitly promoting more efficient methods, for developing learner talk, fluency and mental flexibility. Following the workshop we (the authors) visited each of the teachers' classrooms in our project over the course of 6 weeks and demonstrated a number talk session, using the resources we had developed for the teachers. By the time we visited some classrooms, several teachers had already conducted number talks and provided us with positive feedback and examples of learner work from these.

TEACHER EXPERIENCES OF NUMBER TALKS: DATA

Three sets of data sources were used to gather information on teacher experiences and use of number talks in their own classrooms. The first related to a set of questionnaires given to eight NICLE teachers following the demonstration of number talks in their classrooms. The second source of data came from a question included in our annual end of year NICLE teacher questionnaire that asked teachers to provide critical feedback on the nature of their experiences of participating in various NICLE activities throughout the year. The third involved the video recording of teacher delivered number talks in those cases where NICLE teachers elected to do a number talk as their key practice reflection activity. It is beyond the scope of this paper to share data from the latter source and we thus focus on the first two data sources.

Following the number talk demonstrations across eight teachers' Grade 3 and 4 classrooms, teachers completed a questionnaire on the following questions:

1. Recently Mellony and/or Debbie visited your classroom to do a number talk. What was your experience of these visits?
2. Will you use number talks in your classroom? If yes, please say why and how.

In relation to teacher experiences of the number talks, all the teachers indicated that it was a good or positive experience because of either the factor of learner

excitement / fun (3 of 8), active learner participation (4 of 8) and/ or access to different strategies (5 of 8).

To the second question all eight teachers replied 'Yes' with reasons ranging from because they are: useful for progressing slow learners (3 of 8); emphasise strategies and concepts (3 of 8); make it fun/interesting (2 of 8); pushes for efficiency (quicker ways) learning from others (2 of 8); supports oral/mental maths contributions (2 of 8); allows for individual attention (1 of 8). So for example two teachers wrote:

> Yes. Love implementing number talks because these different strategies make maths so much fun and interesting.
>
> Yes, as I said before, the slow learners will also learn at the same time from the fast ones who understand. Learners also learn a quicker way. I like that!

26 NICLE teachers (Grades 2-5) completed the end of year questionnaire. Question 10 of this questionnaire enquired about teacher experiences of the introduction of number talks as a strategy shared with and practiced by the teachers in a NICLE workshop session. The session included video of number talk sessions and resources were provided to support the use of number talks in teacher classrooms. Question 10 thus asked:

- What was your experience of the number talks initiative this year? Explain. Would you continue to use the number talks in future? If so why.

All 26 teachers indicated that yes they would continue using them with several expressing that they love using them and use them regularly. Of interest, while many responses pointed to the way number talks enable learners: to develop mathematical talk (3) and listening skills (2), to participate actively (3), to develop learner confidence (3) and for learner enjoyment (8); the highest frequency of responses related to the conceptual development and progression we had built into our number talk approach. Thus eleven teachers noted that the number talks enable conceptual development and/or progression for efficiency which was the focus of our adapted version of number talks and were built into the teacher resources we developed.

So for example, teachers commented:

> Quite amazing. Number talks shows how many things one can do and figure out with numbers. To broaden one's sense about it.
>
> Learners are encouraged to talk and their confidence is built and also their thinking and reasoning skills are developed.

The focus on the mathematical function of number talks in addition to the pedagogical function of stimulating learner participation, talk, listening and enjoyment is important as there is much evidence in the South African context that suggests that the mathematical focus of curriculum interventions often become backgrounded to pedagogical issues focused on the form of an activity rather than the function of it. So for example the first post apartheid curriculum,

known as Curriculum 2005, was heavily criticised for the way in which mathematical progression and key concepts were backgrounded to broader pedagogical and political rhetoric (Chisholm et al., 2000).

CONCLUSION

Drawing on our experiences of working with teachers in NICLE as well as from the range of data gathered we have argued that number talks, in their adapted form, hold the potential to support teachers in shifting learners from the inefficient one-to-one counting strategies towards to more flexible and efficient strategies for calculations involving the four operations. The adapted format and explicit teacher mediatory prompts provided enabled teachers to focus the talks on concepts and progression (comparison of methods) enabling stronger mathematical conceptual development. An absence of such conceptual development, coherence and progression in lessons has been identified as a key contributing factor to South Africa's extremely poor performance across regional and international comparative studies. Hence many teachers commented that number talks are particularly useful for their so-called 'slower learners' who tend to persist with concrete one-to-one counting methods as through participating in the talks and the follow up activities they are able to learn from fellow learners' more efficient ways of working and be more motivated.

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