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Exploring the Limitations and Possibilities of Researching Mathematical Dispositions of Learners with low Literacy Levels

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Abstract

In this paper we share the challenges we encountered while gathering data on young learner mathematical dispositions in the form of written responses to orally administered questionnaires in a context of poor literacy and proficiency in the language of learning and teaching. Drawing on data we gathered from questionnaires with 1208 Grade 3 and 4 learners across twelve schools in the Eastern Cape South Africa we explore what is visible in learner responses and raise issues of concern in relation to aspects of learner dispositions not visible through questionnaires. Differences in literacy levels and competence in the language of instruction affects learner responses in ways that make it difficult to interpret whether differences across schools are as a result of differing mathematical dispositions or rather due to differences in literacy and articulation levels. We open up for discussion both what is gained from the data gathered and explore the challenges of gathering richer data across large numbers of learners with low levels of articulation and literacy.

Key words: disposition, productive disposition, approach to mathematics.

Zkoumání omezení a možností výzkumu matematických schopností u žáků s nízkou úrovní gramotnosti

Abstrakt

V článku jsou představeny výzvy, kterým musíme čelit, když sbíráme data o matematických schopnostech mladších žáků s nízkou úrovní gramotnosti a zběhlosti v jazyce, v němž probíhá vyučování, formou písemných odpovědí na ústně zadávané dotazníky. Data byla získána od 1 208 žáků třetích a čtvrtých ročníků z dvanácti škol na východě Jihoafrické republiky. Na jejich základě je zkoumáno, co je možné z žákovských odpovědí odhalit, a jsou otevírány otázky, které jsou zajímavé ve vztahu k těm schopnostem žáků, které z dotazníků nejsou přímo patrné. Rozdíly v úrovni gramotnosti žáků a jejich zběhlosti ve vyučovacím jazyku ovlivňují jejich odpovědi a znesnadňují rozhodování, zda rozdíly mezi školami jsou výsledkem různých matematických schopností nebo spíše důsledkem rozdílů v gramotnosti a úrovni vyjadřování. Diskuse se zaměřuje na to, co lze odvodit ze získaných dat, a současně jsou zkoumány výzvy, které přináší nutnost získat množství dat od velkého počtu žáků s nízkou úrovní vyjadřování a gramotnosti.

Klíčová slova: schopnost, sklon k produktivní činnosti, postoj k matematice.

1 Introduction

South Africa's mathematics education is widely acknowledged as a cause for concern and more recently attention is shifting towards acknowledging and addressing the 'crisis' in the primary stages of schooling (e.g. Fleisch, 2008). A wide range of research (Bloch, 2009; Fleisch, 2008; Carnoy & Arends, 2012) highlights several factors influencing learner performance, including: social disadvantage; language issues, teachers' subject knowledge and opportunity to learn. Largely absent in this research is attention given to the nature of South African students learning dispositions as a factor impacting on our comparatively poor performance even with our African neighbours with less wealth (Graven, 2014). The following episode may illuminate why the notion of learning dispositions is so central to learners' performance.

The excerpt has been taken from one of the first author's after school mathematics clubs. The mathematics clubs run in varied contexts, including, a range of fee-paying and non-fee paying schools and an afternoon development centre. The clubs have between 6 and 12 participating learners. The centre caters for learners who require afternoon care, as their home situations do not enable this. The clubs aim to provide an after school informal learning space where facilitators can engage directly with learners and research in depth the nature of student numeracy learning and evolving proficiency. A focus of the clubs is on developing learner sense-making and shifting learner dispositions from passive learners to more engaging, confident and actively participating learners (see Graven, 2011).

The learners, seven children aged 9–10 years were each given a sheet of paper with the following activity on it (Fig. 1) and were asked to find the value of each of the shapes.

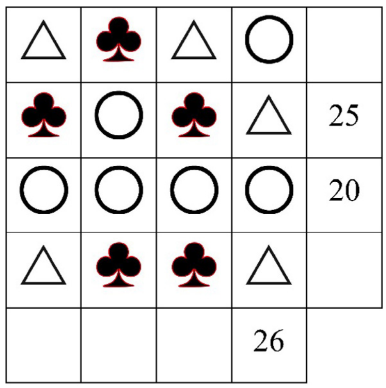


Fig. 1: Activity for children

Nandi, almost immediately noted (correctly) that the circle must be 5. Mellony (as facilitator) checked with the other learners in the club and asked if they agreed and whether they could say why the circle was 5. After this the learners were asked to find the value of the club and the triangle.

Of note here is the extent to which Nandi initially resisted thinking about the problem. Finding the circle was fine as she 'saw the solution' relatively quickly and perhaps such an activity was more familiar. However finding the value of the other shapes involved some calculation and carrying forward of her finding of the circle. Nandi however repeatedly resists using her time to think and instead presses Mellony (in short intervals of 36 seconds) to tell her what to do. Once she finally tries to solve the problem by spending more than just a few seconds on it she excitedly arrives at a solution (63 seconds).

Tab. 1: Discussion with Nandi

		What is said	What is done/Remarks
1	Mellony 20:28	So how are you going to figure out the club and triangle?	Nandi walks to a desk away from the group to work on it.
2	Nandi and Mellony 21:16–21:42	Nandi shows Mellony her answer of 3 for the triangle and Mellony engages her in why it doesn't work because the column will then give a total of 16 not 26.	
3	Nandi 21:42	I don't understand.	Mumbles as she walks away from Mellony.
4	Mellony 21:44	It isn't that you don't understand you need to keep trying...	A lot of children want Mellony's attention.
5	Nandi 22:18	Teacher teacher – I don't understand!	In a complaining, emphatic tone. Stands in front of Mellony and looks confused.
6	Mellony 22:20	No, it is not that you don't understand it is that you have to think. You do understand, because you found the circle. But, it's not so easy to find the club, and the triangle, you have to think. You have to problem solve. So stop thinking you don't understand and think.	
	Nandi 22:32	Shoo*	She turns her head away seemingly unimpressed by the instruction
	Mellony 22:33	You have to problem solve. So stop thinking you don't understand and think.	
	22:33–23:35		Mellony works with other learners individually. Nandi sitting looking at her problem solving sheet and doing some counting with her fingers against her cheek
	Nandi 23:36	Teacher, teacher, teacher, teacher.	Nandi comes running from her side of the table to show Mellony what she has got. She is very excited.
	Nandi 23:38	I found it. It is...	Nandi gives her card to Mellony and points to her answer of 8 for the triangle.
	Mellony 23:50	Shh. Ahhhh! Very good!!! Now who told me they didn't understand? And all she had to do was think.	Nandi goes out of the camera's sight but you can hear her excitement.

*This is a widely used expression in South Africa suggesting discomfort or a difficulty. So for example people may say 'Shoo – it is hot today' or 'Shoo that was a difficult exam'.

Quite clearly, the obstacle for Nandi in this episode was not the mathematical content involved in the problem. She had all the necessary skills to solve it. The problem lay somewhere else, somewhere that might be called a "helpless disposition". Importantly, we do not claim this to have been Nandi's 'individual' problem. Rather, we have observed such dependent 'ritual' behaviour (Sfard & Lavie, 2005; Heyd-Metzuyanim, 2013) in many students in the South African context. This ritual behaviour consists of blindly following rules, mainly for the sake of pleasing others and not for the sake of thinking for oneself and coming up with mathematical truths. Changing this behaviour is evident even from this short episode, where Mellony simply had to insist on not providing the answer to Nandi for her to engage in a more explorative type of participation. And yet, at a large scale, forms of learning and instruction are much more difficult to change. It is this change in forms of participation in mathematical learning that our South African Numeracy Chair Project (SANCP), led by the first author, was after. More generally, this project works with teachers, learners and parents in the broader Grahamstown area of the Eastern Cape and includes a teacher development, parent involvement, and an after school mathematics clubs program all aimed at improving learners' mathematical proficiency (MP).

MP is conceptualised in terms of Kilpatrick, Swafford and Findell's (2001) five interrelated strands, namely: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. These strands are taken to work together and are complexly intertwined. To supplement our assessments of project learners' evolving proficiency in the first four strands, drawing on instruments adapted from (Askew et al., 1997) and (Wright, Martland & Stafford, 2000), we developed an instrument to gather data on learner mathematical dispositions (see Graven, 2012). A mathematically productive learning disposition according to Kilpatrick, Swafford and Findell (2001: p. 131):

> refers to the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics. If students are to develop conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning abilities, they must believe that mathematics is understandable, not arbitrary; that with diligent effort, it can be learned and used; and that they are capable of figuring it out.

Recent work of Gresalfi and Cobb (2006) and Gresalfi (2009) highlights the importance of researching mathematical learning dispositions. Thus Gresalfi (2009: p. 329) drawing on her earlier work with Cobb writes that:

> learning is a process of developing dispositions; that is, ways of being in the world that involve ideas about, perspectives on, and engagement with information that can be seen both in moments of interaction and in more enduring patterns over time (Gresalfi & Cobb, 2006).

It is beyond the scope of this paper to conduct a thorough literature review of the emerging field of literature on learning dispositions. However it is useful to note similarities and differences between Kilpatrick et al.'s (2001) definition which emerges within research in mathematics education and that of Carr and Claxton (e.g. Carr & Claxton, 2002; Claxton & Carr, 2004) whose research emerges from the early childhood learning context and is not numeracy or mathematics specific. Carr and Claxton (2002: p. 10), drawing on Katz's (1988) notion of dispositions as habits of mind, note that the term disposition "is necessarily imprecise, it points very usefully at a domain of human attributes that are clearly different from 'knowledge, skill and understanding' ".

Arguing that 'not all dispositions are equally relevant to learning power' (p. 12), Carr and Claxton (2002) foreground three key learning dispositions, namely: playfulness (experimentation), resilience and reciprocity. The importance of developing resilience in learning dispositions of young learners can be related to the notion of steady effort although with the added caveat that steady effort continues even in the face of difficulties. The arguments of these authors on dispositions link with Kilpatrick et al.'s (2001) notion of habitual behaviours and similarly argue that dispositions should be a focus of both practitioners and researchers as a component of learning. In the context of South African numeracy education this is especially important because widespread research points to a crisis in early learning of number where the majority of learners fail to progress beyond inefficient one to one counting largely due to an absence of sense-making and exploring connections in lessons (Hoadley, 2012; Venkat & Naidoo, 2012). Research questions we thus ask in relation to our research into learners' mathematical proficiency levels and possible shifts over time are:

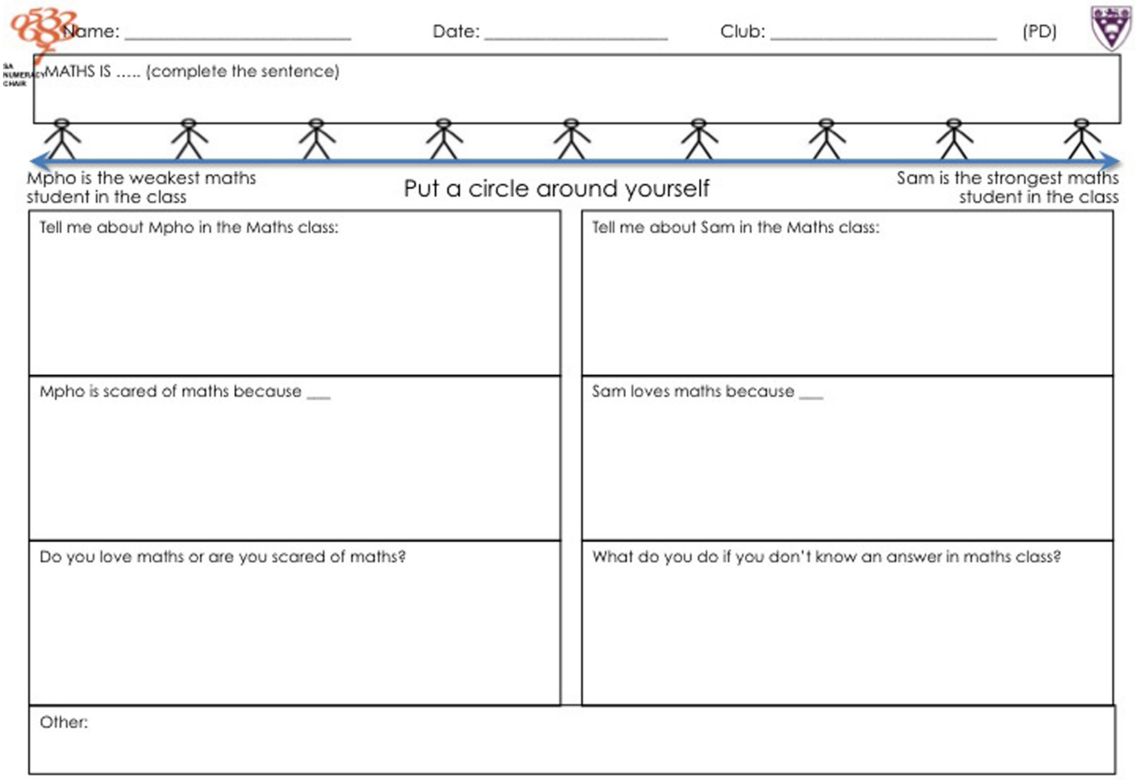
- What is the nature of Grade 3 and 4 learners' mathematical dispositions in the schools that we work with and in the after school mathematics clubs that we run?
- How might these dispositions evolve over time (if at all)?
- How might these dispositions be accessed across a large number of learners?

While we gather in depth case study research on learner evolving dispositions in our project clubs through a combination of methods, including observation and interviews, the focus of this paper is on our attempts to gather data from a large number of year 3–4 learners in orally administered but written response questionnaire form. As insightful as our qualitative analysis has been (see Hewana & Graven, 2014; Ndongeni, 2014), since this analysis is based on a limited number of case studies with only a few learners it does not provide us with a general view of learners dispositions towards mathematics across our schools (and especially not with a means to assess change in these dispositions that could be attributed to our interventional program). Therefore, we needed a tool that would enable us to efficiently collect data about learners' dispositions across all of the schools with which we were working (totalling more than 1 000 learners).

Though tools for assessing attitudes towards mathematics and beliefs about the subject have been around for a long time (e.g. Aiken, 1974; Fennema & Sherman, 1976), these tools were not sufficient for our work for two main reasons. Firstly they were constructed around mainly individual constructs (such as 'attitudes' or 'self-concept') that neglected the social dimension of dispositions and the cultural context in which they are formed. Secondly their Likert-scale style did not fit our population of learners who, we suspected, would not be able to reliably respond to propositions as those used in these questionnaires. We therefore set out to design a tool that would fit our population on the one hand, and would reflect our notion of 'productive dispositions' on the other hand.

Methodology

The methodology of the broader research combines qualitative and quantitative research methods. Qualitative methods include case study classroom observation, club observations (with transcriptions), individual learner mathematics interviews and dispositional interviews (also video recorded and transcribed). The data that forms the focus of this paper is quantitative in nature having been derived from use of the above instrument as an orally administered questionnaire given to 1208 Grade 3 and 4 classes in 38 classes across twelve schools (including fee paying and non-fee paying). An instrument containing several questions and complete-the-sentence items was designed with the goal of eliciting data on mathematics learning dispositions. The instrument was designed for use as both a questionnaire and interview and is included in Fig. 2.


Name: ____ Date: ____ Club: ____ (PD)

MATHS IS ..... (complete the sentence)

Mpho is the weakest maths student in the class

Put a circle around yourself

Sam is the strongest maths student in the class

Tell me about Mpho in the Maths class:

Tell me about Sam in the Maths class:

Mpho is scared of maths because ___

Sam loves maths because ___

Do you love maths or are you scared of maths?

What do you do if you don't know an answer in maths class?

Other:

Fig. 2: An instrument for accessing mathematical learning dispositions (Graven, 2012: p. 55)

Elsewhere the project team have elaborated on the evolution of this instrument for the purposes of researching learner dispositions (Graven, Hewana & Stott, 2013). We noted that searching for instruments that gather information about learner mathematical dispositions with young learners tended to involve ticking or circling pre-given options; for example, the Fennema and Sherman's Mathematics Attitude Scales (1976). However, attitudinal items such as 'I see mathematics as a subject that I will rarely use in daily life as an adult' (Mulhern & Rae, 1998: p. 302) completed on a 1–7 Likert scale, did not seem appropriate for young learners who are not familiar with such instruments. It was hypothesized that an instrument with simple graphics and limited language would be appropriate for young learners with limited language proficiency. Consequently an instrument involving circling pictures was trialed. However we were disappointed with the outcome as learners seemed to respond by ticking the picture they liked without relating these pictures to what was being asked. Thus some learners circled all the smiley faces with thumbs up no matter the question. Similarly our piloting of a learning tree to engage learners about their progress in mathematics learning yielded little data that provided insight into learning dispositions.

We thus designed our own instrument that included questions that were purposefully open ended. These were aimed at generating learner utterances that could be related to key aspects of dispositions. Open ended complete the sentence items were seen to be particularly useful in this respect such as, 'Maths[1] is. . . '. Additionally we chose to ask learners to describe strong and weak mathematics learners as we hoped that this would enable learners to tell us what they thought led to these strengths and weaknesses without the complication of evaluating their own performance. Our earlier experiences with visual tools seemed to suggest that learners tended to answer in ways that they thought you wanted them to be. Thus our questions such as 'Complete the sentence 'Sam is. . . ' where they are told Sam is one of the strongest learners in maths class aimed to see whether learners saw strength in mathematics as an innate ability, as teacher dependent or dependent on their own actions or 'steady effort'. Mpho and Sam were deliberately chosen as not gendered names, that is, in the South Africa context these names are widely used for both boys and girls.

When piloting the instrument as an interview in a club with ten learners the dominant descriptor of learners for Sam was that s/he was someone who: listens to the teacher (6/10 learners); behaves or doesn't play (2/10), or as someone who likes maths or an aspect of maths (3/10). [One learner gave more than one description for Sam]. From the piloting we felt confident that the instrument would generate at least some useful data on learner dispositions even while we expected that further adaptations would likely follow from subsequent data gathering processes.

Questions (or complete the sentence items) were explained to learners with translation into Afrikaans and isi-Xhosa[2] (where required) and learners provided written responses on the instrument. Learners were encouraged to write in whichever language they were most comfortable. Permission for research was obtained from the department of education, parents, teachers and principals.

Responses were transcribed (without changes to spelling or grammar), translated where necessary and coded. Developing a rigorous coding system was important in order to be able to identify which responses were most prevalent and to capture the wide range of responses that occurred. We developed a coding system for each item and numerous revisions of coding occurred before the coding system was finalised.

Our coding system for the three items that are discussed in this paper emerged as indicated in Tab. 2. For each code we have given one or more exemplar responses chosen mostly for their prevalence. These are given in the brackets below each category.

This coding system was checked for consistency on 40 learner responses across the authors. Following this a 'coder' was trained to code all responses. While the vast majority of learners only provided single code responses to items some responses

[1]In South Africa Mathematics as a subject is commonly referred to as Maths rather than Math.

[2]The Eastern Cape is one of the poorest provinces in South Africa. The vast majority of learners in this province speak one of three languages at home: English, isi-Xhosa or Afrikaans. The medium of instruction of schools in the area is one of these languages. In line with national policy in the isi-Xhosa medium schools the language of instruction shifts to English in Grade 4 (the start of the intermediate phase). Thus for the majority of home language isi-Xhosa speaking learners they will learn mathematics in isi-Xhosa for Grades 1-3 but in English from Grade 4 onwards.

Tab. 2: Coding system

Maths is…	**Sam is…**	**What do you do when you don't know an answer…?**
1. Positive evaluation (e.g. 'good' 'fun')	1. A label of innate quality (e.g. is 'clever', 'intelligent' 'gifted')	1. Indicating seeking teacher assistance (e.g. 'Ask the teacher' 'put up hand')
2. Negative evaluation (e.g. 'boring')	2. A label of general behavioral disposition (e.g. 'well behaved' 'a good child')	2. Indicating seeking assistance from someone other than the teacher (e.g. 'Ask a friend')
3. Positive evaluation of my performance in it (e.g. 'Easy') Note: if both 3 and 4 are noted then choose the one learner implies has greater weight e.g. hard but sometimes easy points to usually hard, if equal record both 3 and 4	3. Repeats description given of Sam's strength in maths (e.g. 'is strong at maths')	3. Indicating seeking assistance from someone outside of school (e.g. 'ask my mother/sister')
4. Negative evaluation of my performance in it (e.g. 'Difficult' 'Hard')	4. Indicates speed or fast pace (e.g. 'is fast'.	4. Indicates guessing (e.g. 'I guess')
5. Numbers (if only say numbers) – choose category 6 for 'counting numbers' or doing something with numbers. (i.e. 'numbers' or a response suggesting this e.g. 'nbers').	5. Indicates not being silent (e.g. 'Isn't Shy' 'Isn't too quiet')	5. Indicates opting out from it (e.g. 'I leave it out' 'I play' 'I sit quietly')
6. Doing something with numbers (e.g. 'Sums' 'counting' 'breaking up numbers')	6. Indicates the maths Sam can do (E.g. 'can count' 'can add')	6. Indicates general effort (e.g. 'I try')
7. Relates to non routine aspects (e.g. 'Thinking' 'solving problems')	7. Indicates behavior learner sees as 'good' (except listening – e.g. 'behaves good' 'sits still in class')	7. Indicates specific effort (e.g. 'I count' 'I use my fingers' I use a counting card')
8. Relates to assessments (e.g. 'Tests')	8. Indicates listening (e.g. 'listens')	8. Indicates some form of sense making (e.g. 'I think' 'I figure it out')
9. Other (e.g. phonics')	9. Indicates working actions (e.g. 'finishes work' 'answers questions')	9. Other (e.g., listen)
10. Illegible/incomprehensible (e.g. 'Mishhnoeiekk')	10. Indicates work outside of class (e.g. 'Does his homework' 'practices maths at home')	10. Illegible/ Incomprehensible
11. Blank Many learners simply rewrote the question 'Maths is…' or simply wrote Maths. We thus added category 12 below:	11. Relates to thinking or making sense of work (e.g. Thinks)	11. Blank Added category 12 below after inter rater meeting as negative emotions came up repeatedly in some classes.
12. Answers 'Maths is' or 'Maths'	12. Indicates does not find maths difficult (e.g. 'Doesn't struggle')	12. Feel a negative emotion (e.g. 'will be sad' 'be scared').
	13. Indicates does not behave in ways student sees as 'bad' behavior (e.g. 'Doesn't play' 'doesn't fight' 'doesn't talk')	
	14. Indicates resilience (e.g. 'Doesn't give up')	
	15. Doesn't guess (possibly empty category)*	
	16. Indicates a positive affective relationships to maths (e.g. 'likes/ loves math' 'is interested in math')	
	17. Doesn't have a negative affective relationship with mathematics (e.g. 'doesn't hate math')	
	18. Other	
	19. Illegible/incomprehensible	
	20. Blank	

*The Sam is categories aimed to enable comparison with categories generated from the complete the sentence 'Mpho is…' item. Since many students described Mpho as someone who guesses (category 15) we inserted this category for Sam even while it did not arise in our initial coding (similarly for category 17).

received more than one code. 24 % of learner responses were coded by the first author to assess the level of inter-rater reliability with the trained coder. Across all items coding was more than 90 % in agreement.

For the purposes of this paper we report on the findings of three items to illuminate our concerns. These include two 'complete-the-sentence' items and one question about their practice in the mathematics class:

- Maths is...
- Sam is good at maths in class, describe how Sam is in class. Complete the sentence: Sam is...
- What do you do if you don't know an answer in maths class?

These items are chosen as a focus for this paper because learner responses on these generated categories that can be related to several indicators of dispositions as suggested by the literature reviewed. Thus for example indicators of sense making, steady effort, view of its usefulness (Kilpatrick et al., 2001) and resilience, playfulness/resourcefulness and reciprocity – a willingness to engage (Carr & Claxton, 2002).

Data description and analysis

While articulation of mathematical ideas and literacy levels are likely to be in their infancy stages for all 8–10 year old students, the problem is exacerbated in the context of our study as learners are predominantly from poor socio-economic backgrounds with few literacy resources in the homes. Furthermore many learners chose to respond to the instrument in the language of instruction, which in many cases is not their home language, even when given the opportunity to respond in their home language. Tables 3, 4 and 5 show the percentage of learners who provided 'relevant responses' to the questionnaire for each of the three items above respectively. We have taken 'relevant responses' as those responses that answered the question, were legible and the response did not simply repeat what they were told in the question (e.g. 'Sam is good at maths').

Tab. 3: Percentages of relevant versus other responses for 'Maths is...' item

Response Category	**Percentage of responses in category**
Blank (no response)	14
Illegible/incomprehensible	15
"Maths"	9
Relevant responses	62

Tab. 4: Percentages of relevant versus other responses for 'Sam is...' item

Response Category	**Percentage of responses in category**
Blank (no response)	2
Illegible/incomprehensible	19
Repeats description "good at maths"	19
Relevant responses	60

Tab. 5: Percentages of relevant versus other responses for the 'What do you do if you don't know an answer?' item

Response Category	**Percentage of responses in category**
Blank (no response)	5
Illegible/incomprehensible	23
Relevant responses	72

Across all three questions we see a very similar picture emerging. Across the 3 questions:

- Only a small percentage of learners (14 %, 2 % and 5 % respectively) leave the question blank (i.e. provide no response) indicating a general compliance or willingness to participate in the questionnaire;
- Between one sixth and a quarter of the responses (15 %, 19 % and 23 %) were incomprehensible (either the letters could not be made out or letters did not form a recognizable word e.g. 'mfq'). Alternatively in a few cases the response did not relate at all to the question and seemed a result of copying a word from the board (e.g. Maths is 'phonics');
- The majority of responses (62 %, 60 % and 72 %) were legible and could be coded into categories;
- For the Maths is… and Sam is… items about one tenth (9 %) and one fifth (19 %) of learners respectively answered the items by repeating the information given in the question (i.e. Maths is 'Maths' or Sam is 'good at maths').

While on all three questions at least three of the learners provided codeable answers it is of course of concern that these answers are now likely skewed as they are not from a random majority of the general population but from the more literate, willing to respond and more articulate learners. It is thus of concern that possibly the dispositions of the less literate learners (and thus likely weaker performing learners) are not represented in the data we obtained. That said some interesting clustering of responses can be seen in the responses of this likely more literate percentage of learners. Tables 6, 7 and 8 indicate the relative percentage of responses in each of the categories we identified for each question.

Tab. 6: Percentages of responses in categories within 'relevant responses' to 'Maths is…'

Response Category	**Percentage of responses in category**
Positive evaluation ('good/pleasant/fun')	40
Positive evaluation of own performance ('easy')	5
Negative evaluation of own performance ('difficult/hard')	4
'Numbers'	4
'Sums/counting/breaking up numbers'	31
'Tests'	4
'Thinking/solving problems/ making sense'	1
Other	11

Tab. 7: Percentages of responses in categories within 'relevant responses' to 'Sam is. . . '

Response Category	Percentage of responses in category
Innate label ('clever/intelligent/gifted')	22
'Can count/can add/can do maths'	13
Actions ('does work/concentrates/answers questions')	12
Label of good behaviour ('well behaved/good child) describes 'good' behaviour ('sits still/quiet in class')	12
Listens	15
Doesn't behave badly ('doesn't play/doesn't fight/doesn't be silly)	5
Likes/loves maths	13
Makes an effort ('does homework/practices/doesn't give up')	1
Thinks/Makes sense	2
Other	5

Tab. 8: Percentages of responses in categories within 'relevant responses' to 'What do you do if you don't know an answer?'

Response Category	Percentage of responses in category
Does something mathematical ('I count/use fingers/draw/break up numbers')	30
Thinks ('I think/work it out/figure it out')	15
Effort ('I try/reread question')	2
Opts out ('I leave it out/sit quietly')	6
Guesses	1
Ask the teacher	33
Ask friend or ask at home	2
Feel negative emotion ('I feel sad/I'm scared')	2
Other	9

The largest category (40 % of learners) relates to mathematics being of value "e.g. good" or being enjoyable "e.g. fun". The extent to which learners indicate it is fun is interesting given the relatively poor performance in general across learners in these schools. The second largest category indicates counting and sums or breaking up numbers as the second most prevalent description of maths. This is to some extent expected as this is what many of the learners do in class and would be activities in mathematics classes of this level around the globe. However the almost absence (only 1 % of learners) of explanations of maths as involving thinking, sense making, or problem solving (as is foregrounded in the curriculum documents) perhaps points to learners having more procedural views of mathematics. Such a view of mathematics would then connect with the importance of listening to the procedures given by the teacher in order to perform well at mathematics. We see this in the graph below.

The data in this table is reported and further elaborated on in (Graven & Heyd-Metzuyanim, 2014). The largest category as a description of Sam, who was said to be good at maths, related to innate qualities such as 'cleverness'. A range of research points to this view as being problematic (Bishop, 2011; Blackwell, Trzesniewski & Dweck, 2007) particularly for learners who do not then view themselves as innately clever. If being good at maths is about innate qualities that one perhaps sadly doesn't have rather than being dependent on hard work, engagement, participation and steady effort then learners have little agency over their performance and progress. In both Kilpatrick et al's. (2001) and Carr and Claxton's (2002) terms believing that steady effort pays off, or having a resilient disposition, is important for effective learning. This category however was only noted by 1 % of learners with another 2 % noting that thinking and making sense was why Sam was good at Maths. Thus in terms of this aspect of a productive or key learning disposition the absence perhaps points to a cause for concern.

The second largest category is that of 'listens' which 15 % of learners noted as important. This also connects with the compliant and good behavior categories which make up another 17 % of learner responses. The noting of a well behaved, listening and compliant disposition (sitting quietly for example) for Sam is likely connected to the view of maths noted above that tends to overlook the importance of individual sense making, contributions, thinking and engagement.

The largest category of responses to what learners do it they do not know an answer in class relates to asking the teacher. Almost one third of learners (33 %) suggest they would use this response. While asking the teacher is a useful learning strategy in some situations it can be equally problematic in others where learners might use this as a strategy to avoid thinking for themselves or trying a problem again and developing resilience. Some learner responses here said for example: 'I put my hand up and have to wait.' In some observed lessons indeed we saw learners put their hand up and wait for several minutes (not working on anything while waiting) before asking the teacher the question.

The second largest emerging code involves 'counting, using fingers to calculate or breaking up numbers'. The former two were most prevalent and were noted in several learner assessments conducted in the broader project. Thus for example many learners would either draw lines or use their fingers to calculate $55+67$ in our four operations assessments in both Grade 3 and 4. This tendency is reflected in several studies (e.g. Hoadley, 2012b; Schollar, 2008) that express concern for a lack of progression towards more efficient methods away from concrete counting in South African Schools. While such counting habits point to a certain level of steady effort, in the absence of sense making and thinking such strategies are unlikely to progress. Indeed the Grade 3 and 4 assessment standards in the Curriculum and Assessment Policy documents (CAPS) (Department of Basic Education, 2011a, 2011b) expect learners to use a much wider range of efficient strategies than counting. Breaking up numbers could be one of those strategies.

Discussion

From the above tables we note few responses that indicate aspects of sense-making, steady effort or resilience, resourcefulness ('playfulness') or experimentation, or reciprocity in terms of a willingness to engage with others about mathematics. It is of course possible that these aspects are difficult to articulate. However, the evidence of some learners providing simple responses to Maths is... such as 'problem solving', 'about thinking' or responses describing Sam as someone who 'doesn't give up' indicate that some articulation of such aspects is possible. The high percentage of learners who describe both Maths as counting and Sam as good at maths because he can count connects with the high percentage of learners who use counting if they do not know an answer. While counting all for a sum like $2 + 98$ is inefficient and one would expect Grade 4 learners to have moved to more efficient methods the problem indicated by our data is not with the prevalence of 'counting' per se but rather with the limited range of answers generated by the 'Maths is. . . ' item. It seems reasonable to expect that if mathematics was seen as an exploratory activity, we would expect at least some variation in the responses (both within individual learner responses and between learners). The fact that this item elicited such restricted and repetitive answers (where answers were provided that were legible and comprehensible) suggest to us that as a whole, mathematics is treated as a very ritualized activity (consisting of a set of very limited activities).

Words describing emotion and enjoyment of mathematics are a strong feature both in the ways math is described (e.g. maths is 'fun') and in descriptions of an ideal math student (Sam 'loves maths'). In addition, they feature negatively in 2 % of learners when they indicate that they would be scared or sad if they did not know an answer. Yet these affective aspects of learners' relationships with mathematics are not included within Kilpatrick et al.'s (2001) or Carr and Claxton's (2002) indicators. Learners who write math is 'fun' are not telling us much about their emotional reactions towards math. We have not fully conceptualized (and neither did those who we cited) what emotions have to do with all of this. So I'm not sure we want to get into this murky area. If we do, all we probably can say is that the issue of emotions (or the ways emotion-words are used to describe dispositions towards mathematics) is still not fully understood or is under-researched. Of course 'fun' and a love of mathematics does not of itself lead to 'success' however nor do several of the other indicators such as belief in ones own ability. Thus our case study research shows several learners indicating that they see themselves as good at mathematics and as one of the top performing learners and yet their performance does not match this.

While the limitations of the instrument are clear, especially given that they are based on what learners say rather than based on observations of their habitual inclination to respond in a certain way, our sense is that the absence of responses indicating a sense of learner agency or the importance of active learner sense-making reflects many of the practices observed and noted in South African classrooms (Hoadley, 2012; Schollar, 2008; Graven et al., 2013).

Across the items we are concerned by the largely absent utterances relating to problem solving, sense making and resilience in the face of something unfamiliar, 'to persist with learning despite temporary confusion or frustration' (Carr & Claxton, 2002: p. 14). It is not only the absence of these ideas in what learners are able to say about mathematics but our concern is coupled with what we have observed when working directly with learners in various after school clubs (as illuminated in the excerpt of Nandi shared at the start of this paper).

Concluding remarks

Graven (2014) draws on a range of studies (including cross border comparative studies with Botswana) to argue that perhaps South African learning dispositions need special attention. She argues that Fleisch's (2008) notion of 'dependent poverty' is a useful opportunity to historicise South African poverty and poor performance and that Carnoy et al.'s (2012: p. 3) noting the "South African effect' – that is, the years of apartheid may still weigh on teachers' and students' perceptions of how successful both can be academically' needs redress. Our apartheid education differs from the colonial education of our neighbours as captured by Chisholm and Chilisa's (2012: p. 385) emphasis that under apartheid 'Bantu education … was accompanied by the violence of repression of opposition and the violence of the subordination of aspiration and possibilities through the limited (and limiting) education made available'.

The South African research noted above, in conjunction with some of the data presented in this paper, points to the effects of apartheid's repression on the dispositions and mind-sets of learners as a possible particular South African problem that needs to be further interrogated in relation to its impact on under performance and ways to counter it. However there is an absence of large-scale national evidence of the role student learning dispositions play in South Africa's particularly poor performance across both international and regional comparative studies. This paper opens up for further exploration the need for research into the way in which mathematics learning dispositions of South African learners is affecting teaching and learning in SA. In this respect given the fact that self-reports are highly questionable tools for gaining insight into students' behavior (at least in these grades, in these contexts of low levels of articulation and literacy), we need to ask how do we study learners' dispositions at scale? Our current research is thus looking into observational tools that would enable us to do that. A continuing challenge however will be finding ways to balance the reporting on possible negative learning dispositions so that we do not contribute to perpetuation of the dominant deficit discourse of South African mathematics learners. Such a deficit discourse can further contribute to the low expectations reported in a range of reports such as Carnoy et al. (2012). We believe that a focus on how to develop positive mathematical dispositions could usefully inform mathematics teacher education programs and bring this key aspect of learning into focus.

References

Aiken, L. (1974). Two scales of attitudes towards mathematics. *Journal for Research in Mathematics Education*, 5, 67–71.

Askew, M., Rhodes, V., Brown, M., Wiliam, D. & Johnson, D. (1997). *Effective Teachers of Numeracy: Report of a study carried out for the Teacher Training Agency*. London.

Bishop, J. P. (2011). 'She's always been the smart one, I've always been the dumb one': Identities in the mathematics classroom. *Journal for Research in Mathematics Education*, 43(1), 34–74.

Blackwell, L. S., Trzesniewski, K. H. & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: a longitudinal study and an intervention. *Child Development*, 78(1), 246–263. doi:10.1111/j.1467-8624.2007.00995.x

Bloch, G. (2009). *The Toxic Mix: What's wrong with South Africa's schools and how to fix it.* Cape Town: Tafelberg.

Carnoy, M. & Arends, F. (2012). Explaining mathematics achievement gains in Botswana and South Africa. *Prospects*, 42(4), 453–468. doi:10.1007/s11125-012-9246-6

Carnoy, M., Chisholm, L., Addy, N., Arends, F., Baloyi, H., Irving, M., …, Sorto, A. (2012). *The process of learning in South Africa. The quality of mathematics teaching in the North West Province. Technical report.* Pretoria.

Carr, M. & Claxton, G. (2002). Tracking the Development of Learning Dispositions. *Assessment in Education: Principles, Policy & Practice*, 9(1), 9–37.

Chisholm, L. & Chilisa, B. (2012). Contexts of educational policy change in Botswana and South Africa. *Prospects*, 42(4), 371–388. doi:10.1007/s11125-012-9247-5

Claxton, G. & Carr, M. (2004). A framework for teaching learning: the dynamics of disposition. *Early Years*, 24(1), 87–97. doi:10.1080/09575140320001790898

Department of Basic Education. (2011a). *Curriculum and Assessment Policy Statement Grades 1–3: Mathematics. Policy* (0–102). Pretoria: Department of Basic Education, South Africa.

Department of Basic Education. (2011b). *Curriculum and Assessment Policy Statement Grades 4–6: Mathematics* (1–306). Pretoria: Department of Basic Education, South Africa. doi:10.1787/9789264030206-4-en

Fennema, E. & Sherman, J. A. (1976). Fennema-Sherman Attitude Scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education*, 7(5), 324–326.

Fleisch, B. (2008). *Primary education in crisis: Why South African schoolchildren underachieve in reading and mathematics.* Johannesburg: Juta.

Graven, M. (2011). Creating new mathematical stories: exploring opportunities within Maths Clubs. In *Proceedings of 17th National Congress of the Association for Mathematical Education of South Africa (AMESA)* (161–170). Johannesburg: University of the Witwatersrand.

Graven, M. (2012). Accessing and assessing young learner's mathematical dispositions. *South African Journal of Childhood Education*, 2(1), 49–62.

Graven, M. H. (2014). Poverty, inequality and mathematics performance: the case of South Africa's post-apartheid context. *The International Journal of Mathematics Education ZDM.* doi:10.1007/s11858-013-0566-7

Graven, M., Hewana, D. & Stott, D. (2013). The evolution of an instrument for researching young mathematical dispositions. *African Journal of Research in Mathematics, Science and Technology Education*, 1791–20, 26–37.

Graven, M. & Heyd-Metzuyanim, E. (2014). Primary learner descriptions of a successful maths learner. In P. Webb, M. G. Villanueva & L. Webb (Eds.), *New avenues to transform Mathematics, Science and Technology Education in Africa: Proceedings of the 22nd Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education* (39–50). Port Elizabeth: Nelson Mandela Metropolitan University.

Graven, M., Venkat, H., Westaway, L. & Tshesane, H. (2013). Place value without number sense: Exploring the need for mental mathematical skills assessment within the Annual National Assessments. *South African Journal of Childhood Education*, 3(2), 131–143.

Gresalfi, M. S. (2009). Taking up opportunities to learn: Constructing dispositions in mathematics classrooms. *Journal of the Learning Sciences*, 18(3), 327–369.

Gresalfi, M. S. & Cobb, P. (2006). Cultivating students' discipline-specific dispositions as a critical goal for pedagogy and equity. *Pedagogies: An International journal*, 1(1), 49–57.

Hewana, D. & Graven, M. (2014). Grade 4 learners mathematical dispositions: a case study of three learners participating in an after school club. In C. Stevenson-Miln (Ed.), *New avenues to transform Mathematics, Science and Technology Education in Africa: Abstracts of the 22nd Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education* (49–50). Port Elizabeth: Routledge: Taylor & Francis.

Heyd-Metzuyanim, E. (2013). The co-construction of learning difficulties in mathematics-teacher-student interactions and their role in the development of a disabled mathematical identity. *Educational Studies in Mathematics*, 83(3), 341–368.

Hoadley, U. (2012a). What do we know about teaching and learning in South African primary schools? *Education as Change*, 16(2), 187–202. doi:10.1080/16823206.2012.745725

Hoadley, U. (2012b). What do we know about teaching and learning in South African primary schools? *Education as Change*, 16(2), 187–202. doi:10.1080/16823206.2012.745725

Kilpatrick, J., Swafford, J. & Findell, B. (2001). *Adding It Up: Helping Children Learn Mathematics*. Washington DC: National Academy Press.

Mulhern, F. & Rae, G. (1998). Development of a shortened form of the Fennema-Sherman Mathematics Attitudes Scales. *Educational and Psychological Measurement*, 58(2), 295–306. doi:10.1177/0013164498058002012

Ndongeni, S. (2014). *Examining the nature of the relationship between learners' conceptual understanding and their mathematical dispositions in the context of multiplication. Unpublished Masters thesis.* Rhodes University: Grahamstown.

Schollar, E. (2008). *The primary mathematics research project 2004–2007: Towards evidence-based educational development in South Africa. Primary Mathematics*. Jhb.

Sfard, A. & Lavie, I. (2005). Why cannot children see as the same what grown-ups cannot see as different? — Early numerical thinking revisited. *Cognition and Instruction*, 23(2), 237–309. doi:10.1207/s1532690xci2302_3

Sfard, A. & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational Researcher*, 34(4), 14–22.

Venkat, H. & Naidoo, D. (2012). Analyzing coherence for conceptual learning in a Grade 2 numeracy lesson. *Education as Change*, 16(1), 21–33. doi:10.1080/16823206.2012.691686

Wright, R. J., Ellemor-Collins, D. & Tabor, P. D. (2012). *Developing Number Knowledge: Assessment, Teaching & Intervention with 7–11 year olds.* Los Angeles: Sage Publications.

Wright, R. J., Martland, J. & Stafford, A. K. (2000). *Early numeracy: assessment for teaching and intervention*. London: Paul Chapman Publishing.

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