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Primary learner descriptions of a successful maths learner

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In this paper we present the findings of Grade 3 and 4 learners across twelve schools in the Eastern Cape area in relation to how they described a good, successful mathematics learner. An instrument containing several questions and 'complete-the-sentence' items was designed in order to elicit data on mathematics learning dispositions. Dispositions for our purposes are broadly taken to be a tendency to perceive and respond to mathematical situations in a certain way. The disposition instrument was orally administered to 1208 learners in 38 grade 3 and grade 4 classes across different types of schools including fee paying and non-fee paying, historically White, Coloured and township schools. Questions (or complete the sentence items) were explained to learners with translation into Afrikaans and isiXhosa where required and learners provided written responses on the instrument. Items investigated aspects of learner mathematical dispositions. This paper focuses on the findings in relation to one question on the instrument – describing a good strong mathematics learner. All responses were translated and coded and checked for inter-rater reliability. The paper interrogates the findings in relation to learner descriptions of an effective mathematics learner. The low percentage of responses indicating active participation, sense making or steady effort is argued to be a possible cause for concern.

Introduction

South Africa's mathematics education has been described by many to be 'in crisis' (e.g. Fleisch, 2008). Several years of mathematics intervention projects and curriculum change aimed at improving South Africa's poor performance in regional and international comparative studies have done little to shift learner levels of proficiency. Along with our recently implemented curriculum in the form of the Curriculum and Assessment Policy Statements (CAPS) (Department of Basic Education, 2011) Annual National Assessments (ANAs) in Grades 1-6 & 9 have been introduced (Department of Basic Education, 2012). While their introduction indicates increased monitoring of the 'crisis' in mathematics education it does little to support the improvement of learners' performance. The results show alarmingly poor mathematics skills across learners in the primary grades with average performance steadily declining by about 10% each year from 68% in Grade 1 to 27% in Grade 6 and then to 13% for Grade 9s (DBE, 2012).

A wide range of research (Fleisch, 2008; Spaull, 2011; Carnoy et al, 2011) highlights several factors as impacting on learner performance, including: social disadvantage; teachers' subject knowledge; teaching time; teacher absenteeism; lack of resources; poorly managed schools; and poverty effects, including malnutrition and HIV/AIDS. What is not explained in this research is why South Africa performs even worse in mathematics than our neighbours with much less wealth and why we perform lowest of all countries

participating in TIMSS which includes several developing countries (Reddy, 2006). Fleisch (2008) proposes that perhaps the dependency and profound disempowerment experienced by South Africa's poor needs consideration. In this respect as mathematics education researchers we need to begin to research the role of learning dispositions promoted and or developed within our mathematics classrooms in relation to this 'crisis'.

This paper emerges from a broader study aimed at researching learner mathematical dispositions and the evolvement of these dispositions within the South African Numeracy Chair Project work in the broader Grahamstown area. In this work the first author runs various development projects with twelve schools which include a teacher development program called the Numeracy Inquiry Community of Leader Educators (NICLE), after-school maths clubs (see Stott & Graven, 2013), and a range of community based events (see Graven & Stott, 2011) including family based activities. Across this work the aim is to support learners in developing mathematical proficiency.We consider this in terms of Kilpatrick, Swafford, & Findell's (2001)conceptualisation of five interrelated strandsof mathematical proficiency namely: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. For Kilpatrick, Swafford and Findell (2001, p.116) all strands are equally important as mathematical proficiency 'cannot be achieved by focusing on only one or two of these strands'. Across our projects we have used several instruments to annually monitor learner evolving levels of proficiency, in terms of the first four strands (e.g. instruments adapted from Askew, Rhodes, Brown, Wiliam, & Johnson, 1997; Wright, Ellemor-Collins, & Tabor, 2012; Wright, Martland, & Stafford, 2006). However,we realised after the first year that we did not have an instrument that specifically engaged with the fifth strand of proficiency, i.e. productive disposition.Productive disposition, as Kilpatrick, Swafford &Findell, 2001, p.131) define it:

> refers to the tendency to see sense in mathematics, to perceive it as both useful andworthwhile, 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.

In earlier work we have elaborated on the evolution of an instrument for the purposes of researching learner dispositions (Graven, Hewana& Stott, 2013) and motivated for the importance of researching this key aspect of mathematical proficiency (Graven, 2012). In this paper we present the findings of Grade 3 and 4 learners across twelve schools in the Eastern Cape area in relation to how they described a good successful mathematics learner. An instrument containing several questions and complete-the-sentence items was designed in order to elicit data on mathematics learning dispositions. Dispositions for our purposes are broadly taken to be a tendency to perceive and respond to mathematical situations in a certain way. The instrument was designed for use as both a questionnaire and interview and is included in Figure 1 below:

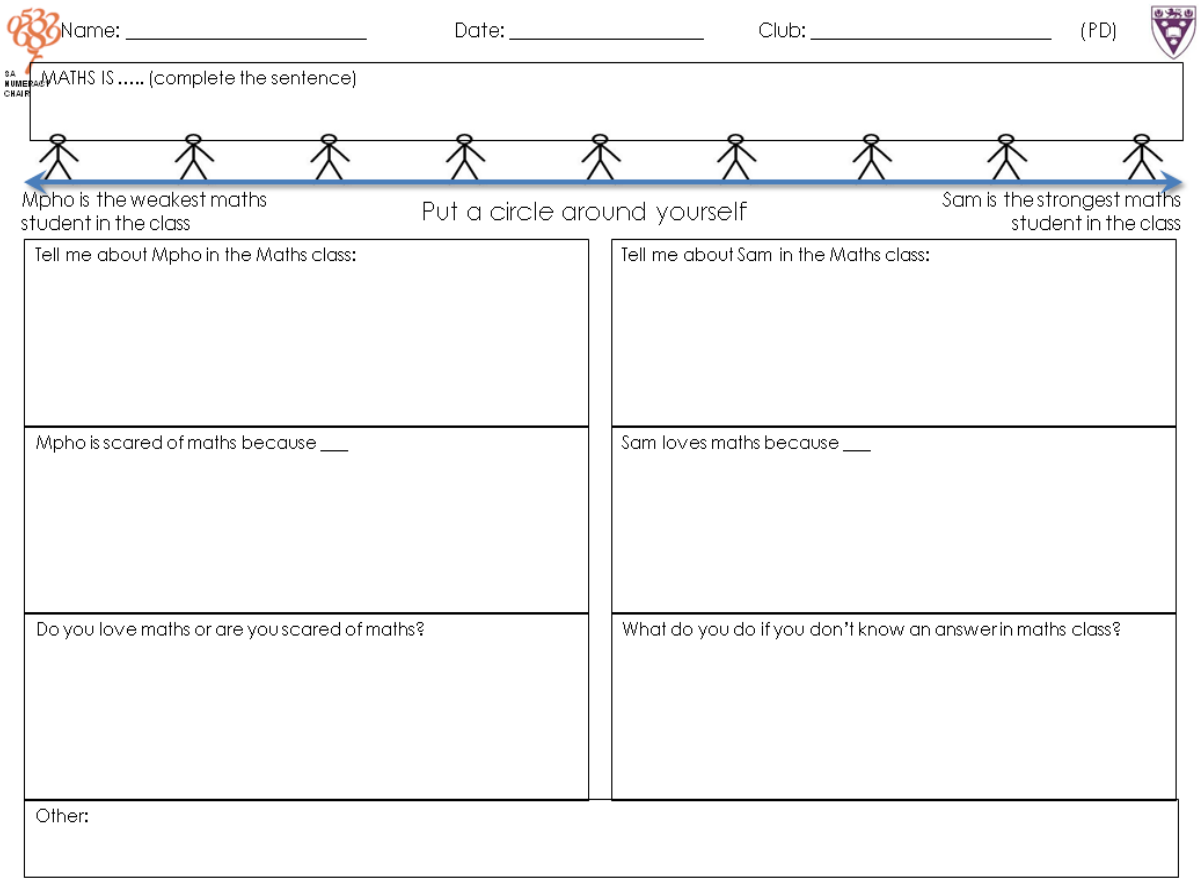

Figure 1: An instrument for accessing mathematical learning dispositions (Taken from: Graven, 2012, p.55)

In earlier work Graven(2012) argued that accessing learner mathematical dispositions can be difficult, especially with young learners who struggle to articulate their stories. Graven, Hewana & Stott (2013)describe the evolution of the above instrument and explain how following the piloting of an earlier instrument it was noted that some learners answered questions about their relationship to mathematics largely in terms of what they perceived to be a correct or positive expected response.

The complete-the-sentence items about Mpho and Sam were thus introduced to provide learners with the opportunity to describe how they envisioned a successful or unsuccessful learner of mathematics without having to consider their own dispositions or what they thought they should write about themselves so as to cast themselves in a positive light.

Perspectives on dispositions

Aside from Kilpatrick, Swafford and Findell's(2001) inclusion of a productive disposition as a key aspect of mathematical proficiency, other work that foregrounds the importance of learning dispositions more generally than within mathematics education includes for example that of Carr and Claxton (e.g. Carr & Claxton, 2002; Claxton & Carr, 2004). More recent work within mathematics education that highlights the importance of researching learning dispositions is that of Gresalfi & Cobb(2006) and Gresalfi (2009). While it is beyond the scope of this paper to conduct a thorough literature review of the emerging field of literature on learning dispositions

we briefly note the importance of the above works and their relationship to the earlier definition of a 'productive disposition'.

Carr and Claxton (2002), drawing on Wenger's (1998) perspective of learning and the centrality of identity as 'ways of being' in the world define learning dispositions as a tendency to respond or learn in a certain way. In this respect they emphasise that:

> not all dispositions are equally relevant to learning power. The inclination to bebossy, for example, is probably less crucial to learning in general than the tendency to persist with learning in the face of confusion or frustration (p. 12).

They identify three key learning dispositions, namely: resilience, playfulness and reciprocity in their work that draws on research with early learners. The aspect of resilience connects well with Kilpatrick, Swafford and Findell's indicator of seeing steady effort as paying off. Carr and Claxton (2002:14) explain resilience as:

> the inclination to take on (at least some) learning challenges where the outcomeis uncertain, to persist with learning despite temporary confusion or frustrationand to recover from setbacks or failures and rededicate oneself to the learning task.

Similarly Gresalfiand Cobb (2006) and Gresalfi (2009) note that learning involves a process of developing dispositions.Thus Gresalfi (2009: 329) drawing on her earlier work with Cobb writes:

> Thus, learning is a process of developing dispositions; that is, ways of beingin 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).

These perspectives on dispositions link with Kilpatrick et al.'s (2001) notion of habitual behaviours or dispositions that should be attended to, both by practitioners and researchers as a component of learning. Our research questions thus ask: 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 be accessed across a large number of learners? While we gather in depth case study research on learner evolving dispositions of learners in our club through a combination of methods including observation and interviews the focus of this paper is on data emerging from our gathering dispositional data from a large number of learners in written questionnaire form.

Methodology

The methodology of the broader research combines qualitative and quantitative research methods. In our work with learners in clubs we gather data via interviews and transcribed club sessions in order to analyse the nature of learner dispositions and the possible evolution of these dispositions within our clubs. 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 Grade 3 and 4 classes in twelve schools. The disposition instrument was orally administered to 1208 grade 3 and grade 4 learners in 38

classes across twelve schools including fee paying and non-fee paying, historically White, Coloured and township schools. Questions (or complete-the-sentence items) were explained to learners with translation into Afrikaans and isiXhosa where required and learners provided written responses on the instrument. Learners were encouraged to write in whichever language they were most comfortable with. Permission for research was obtained from the department of education, parents, teachers and principals.

All 1208 learner responses were transcribed (without changes to spelling or grammar), translated where necessary and coded. We developed a coding system for each item on the questionnaire that was informed by examining a portion of responses. Numerous revisions of our coding system took place before the final coding system was agreed upon. This coding system was checked for consistency on 40 learner responses across the authors. Following this the first author trained a 'coder' to code all responses. While the vast majority of learners only provided single code responses 76 learners provided responses that required two codes. For example 'Sam is a good girl. She does her homework' received two codes, one for each part of the response. Thus the total number of codes derived from the 1208 learner responses was 1284. No learner provided a response requiring more than two codes for this item. 290 learner responses (24% of all learner responses), across a range of classes and languages, were coded by the first author in order to assess the level of inter-rater reliability with the trained coder. Across all items coding was more than 90% in agreement. For the item under discussion in this paper,(i.e. Sam is…), coding differed on only 19/290 learner responses (i.e. 93.4% reliability). Additionally more than half of these 19 responses included two coded responses per learner of which only one response differed across coders.

The complete-the-sentence items 'Mpho is…' and 'Sam is…' were introduced to provide learners the opportunity to describe how they viewed an unsuccessful and a successful mathematics learner respectively. These items were introduced since our earlier experiences of other instruments we piloted seemed to indicate that if learners were asked about their own mathematical participation they tended to answer what they thought we wanted to hear (Graven, Hewana & Stott, 2013). These items thus allowed them to describe an unsuccessful or successful mathematics learner without referring to themselves. The 'Sam is…' item provides particularly rich information in relation to learner dispositions as it elicits a description of imagined participation that learners perceive would lead to successful mathematics learning. We thus have chosen to focus on this item for the purposes of this paper.

Findings

A finding revealed by the instrument was the weak literacy levels of learners across grade 3 and grade 4. For the 'Sam is…' item only 770 out of the 1284 codes provide data relevant to the question. 19% of responses were illegible or incomprehensible (for example a learner wrote: 'msts is mtseay') and another 2 % did not respond to the item (i.e. they did not write anything). These percentages are similar to the proportion of 'illegible/ incomprehensible' and 'unanswered' responses on other items on the instrument. This

finding concurs with wider research that points to a crisis in literacy levels of South African learners beginning in the foundation phase (e.g. Fleisch, 2008). The recent National Education Evaluation and Development Unit's 2012 National Summary report notes that foundation phase learners receive insufficient opportunity for writing and practice in the writing of 'original consequential thinking' (NEEDU, 2013, p.12). The instrument used in its written form requires the writing of such 'original thinking'.

Another 19% of coded responses indicated a repeat of what they were told by the facilitator administering the instrument. That is during the oral administration of the instrument facilitators tell learners that Sam is good/strong at maths and point to the figure to the right of the spectrum of learners and to where it says Sam is the strongest learner in the class. Learners were then asked to 'describe *how* Sam is in the maths class'. This sentence is repeated and or translated into isiXhosa for learners. This 19% of learners responded with either Sam is… 'good at maths' or 'strong at maths' which while being perhaps an appropriate answer provided little in terms of how learners perceived a successful or strong mathematical learner to be or what dispositions they thought such a learner had. The pie chart in Figure 2 below shows the breakdown of answers in terms of those that provided us with relevant dispositional data and those that did not.

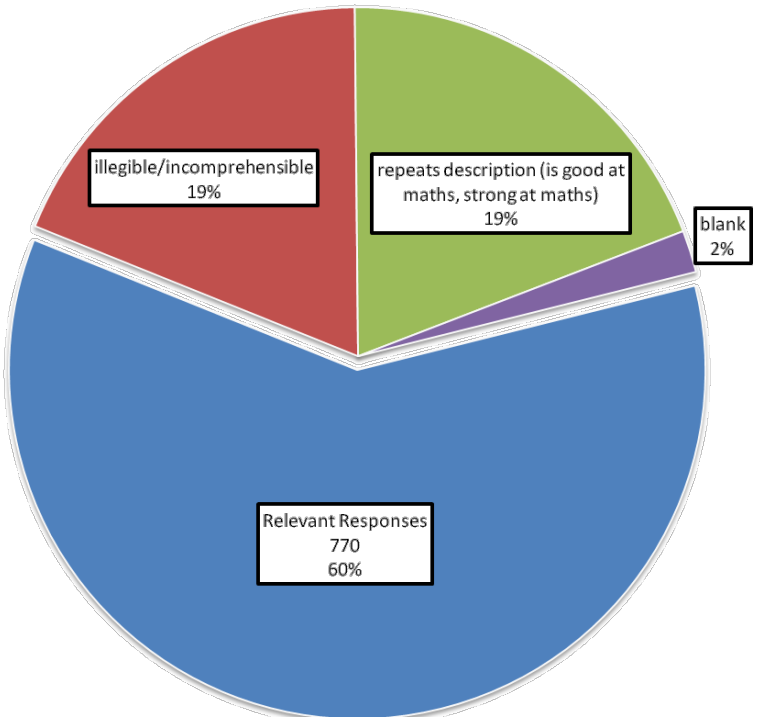

Figure 2: Learner responses to the 'Sam is…' item

Despite the limitation of only 60% of coded responses providing data in relation to our disposition related research questions, and that these responses are likely to be from a more literate portion of learners, the responses provide interesting results. We discuss this in the following section.

Learner descriptions of a strong maths learner

The pie chart in Figure 3 below shows the proportional distribution of the 770 codes derived from learner responses.

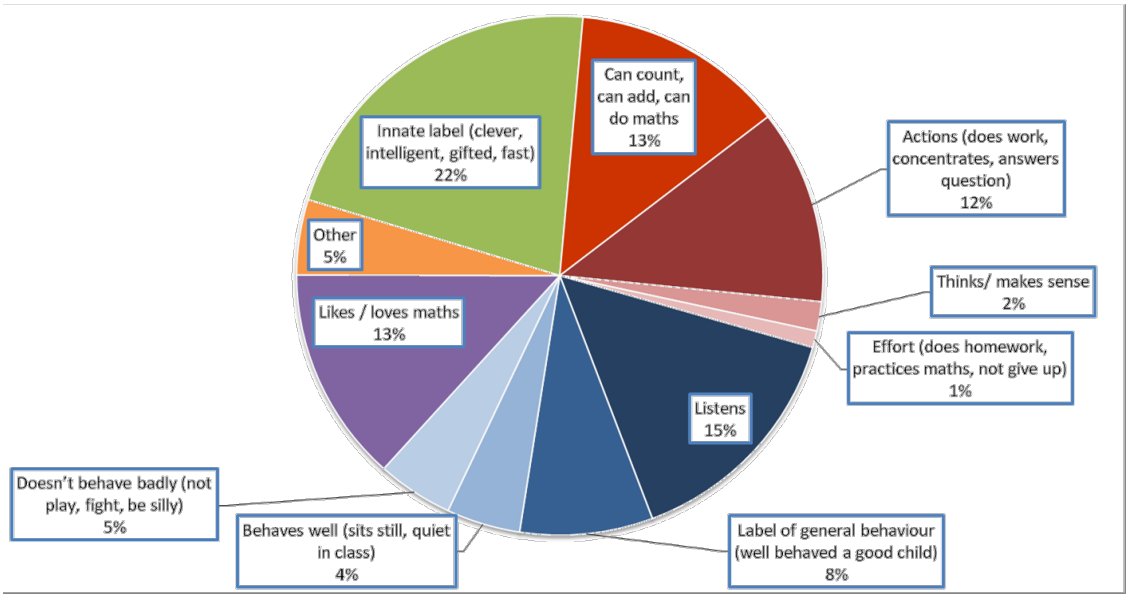

Figure 3: Learner descriptions of a strong maths learner

The high percentage (22%) of descriptions of Sam as being innately clever, gifted or bright contrasts with the low percentage (1%) of learners who indicated that Sam worked/ practiced or tried hard at maths and did homework (engaged in steady effort). Some examples of learner responses in these categories are given below. Responses have been provided as learners wrote them and thus no grammatical or spelling corrections have been made.Translations are given in italics.

Table 1: Examples of indicators ['Innate' and 'Effort']

Indicators of innate characteristics	Indicators of effort
* Sam is gifted * Usemngovenomfundiubalaseleyo (*Sam is the gifted learner*) * Sam ukleva (*Sam is clever*)	* always practice maths and listen to the teacher * he is good because he does his homework * Sam is a good girl she does her homework

The instrument deliberately chose the names Mpho and Sam as these could be interpreted to be either male or female. The examples given in the right hand column of the table above show that, as intended, some learners assumed Sam to be male while others assumed Sam to be female.

Some examples of learner responses in these categories are given in the table below. The responses are written exactly as learners wrote them and thus have not been edited for spelling errors.

Table 2: Examples of indicators ['Active participation' and 'good behaviour' (including listening)]

Active participation and/or thinking/ sense making	**'good' behaviour or 'listens'**
* I'm thinking	* Sam is boy behave wele
* uyablalaisamu (*write sums*)	* uyamamelakhakhuleeclass(*listening carefully in the class)*
* uyabalaimathsmameleimithetho (*he counts maths and listen to the instructions*)	* uyabalaimathsmameleimithetho (*he counts maths and listen to the instructions*)

Similarly, interviews with a smaller number of learners indicated views that passive listening and compliance are the reason for Sam's mathematical competence (see Graven, 2012; Graven, Hewana, Stott, 2013). Tirosh, Tsamir, Levenson, Tabach, & Barkai(2012)cite a range of research where young learners incorrectly associate effort with competency. Within the data of this study it seems that rather than associating competence with steady effort many learners associate it with passive listening and teacher compliance.

Discussion

If we are to consider steady effort and resilience to be a key mathematics learning dispositions as argued by Kilpatrick, Swafford and Findell (2001) and Carr and Claxton (2002) then the above data suggests perhaps restricted learning dispositions for these learners. The large contrast between the high percentage of learners who identify innate characteristics as a descriptor for Sam and the low percentage of learners who identify steady effort as a descriptor is perhaps cause for concern.

Additionally if only 15% of our learners indicate some level of active mathematical participation, thinking/sense making and effort then this could indicate a problematic in relation to our assumptions about learning that foreground participation and sense making. This contrasts with the 32% of learner responses which foreground 'good' and mostly passive behaviour as a key descriptor of Sam.

While, as researchers with teaching experience, we do not wish to underestimate the advantage of respectfully behaved learners who listen when the teacher is talking, we are aware that within our perspective on learning such behaviours do not in and of themselves result in mathematical learning. Thus, we consider that 'the development of individual's reasoning and sense-making processes cannot be separated from their participation in the

interactive constitution of taken-as-shared mathematical meanings' (Yackel & Cobb, 2013, p.460). The extent to which learners' foregrounding of listening, behaving well and complying with teacher instructions indicates an absence of learner independence and agency for these learners would require further investigation. Earlier research based on interview responses of six learners at the start of their participation in a Grade 3 mathematics clubs of the South African numeracy Chair Project provided some interesting insights relevant to the findings discussed above. We share this briefly as it supports our sense that our findings on this item point to a concern for learner dispositions being not as productive as one would hope. In this club learners perceived Sam to be a compliant worker who did what he was told. So for example, Graven (2012, p.56) writes:

> the learners viewed Sam in terms of doing the work he was told to do and writing what was required. For example one learner explained: "He takes everything he needs when the teacher tells him to and he writes all the things she writes and he finishes it.

Similarly teacher dependent comments emerged from interview responses with these club learners on the final question on the instrument: 'What do you do if you don't know an answer?':

> In this club all of the six learners suggested asking someone. For example, five of the six learners suggested drawing on the teacher: "Ask your teacher", "put up your hand and the teacher will explain", "stick up my hand. Have to wait", while one learner said "I must ask someone – I'll ask my friend". While one might of course expect such answers, and of course in many cases I have given this advice to learners that I have helped with mathematics, the absence of utterances that indicate that one might find a way forward by drawing on one's own resources is significant (Graven, 2012, p.57).

Graven contrasts these responses with some interview responses of a few learners in another club where responses suggested a greater degree of independence and sense making. The Maths Clubs are conceptualized as 'informal, extra curricula clubs focused on developing a supportive learning community where learners active mathematical participation, engagement and sense making are the focus. Individual, pair and small group interactions with mentors are the dominant practices with few whole class interactions (Graven & Stott, 2012). Learners in this club said for example: "I thought in my mind", "I work it out", "I take scrap paper or counters or my brain" (Graven, 2012, p.57).

Concluding remarks and implications

In the paper we presented the findings of how 1208 Grade 3 and 4 learners across twelve schools in the Eastern Cape area describe a good successful mathematics learner. These descriptions provided us with insight into an aspect of learner dispositions. Our broader research provides further data on other aspects of learner dispositions. Our notion of a productive disposition drew on Kilpatrick et al (2001) and Carr and Claxton's (2002) indicators which include, seeing mathematics as sensible and useful, believing in steady effort, belief in one's own ability to do maths, resilience, resourcefulness and willingness to engage with others. Particularly the almost absent (only 1% of learners) description of a strong learner as someone who puts in steady effort (a Kilpatrick et al (2001) indicator) and/or doesn't give up (a Carr & Claxton (2002) indicator) raises cause for concern.

Similarly the low frequency of descriptions that indicate thinking and/or sense making (2% of learners) is worrying. Instead the most common descriptor (22%) was that a good learner had innate talent for mathematics – a view that is unhelpful if one is considered not to have that talent.

Thus we have argued from our data that the low percentage of responses indicating active participation, sense making, resilience or steady effort is a cause for concern in relation to these Eastern Cape learners' mathematical learning dispositions. Our data leads us to consider that perhaps a key aspect of South Africa's problematic in relation to our comparatively weak mathematics performance across assessments is related to an absence of productive mathematics learning dispositions. This might be as a result of our legacy of restricted, passive and compliant learning dispositions promoted under apartheid education. Perhaps we need to take seriously what Mamphele Ramphele said (Ramphele, 2013) in her speech *Rekindling the South African Dream*. She argued that we must shift our mind-sets from 'compliant subjects' to actively participating dignified citizens if we are to rekindle the South African dream. This call particularly resonates in relation to the discussion of the findings from our data on Grade 3 and 4 learning dispositions discussed above.

Our concern for possibly restricted learning dispositions resonates with our experiences and observations of working with learners in our maths clubs. Our observations and preliminary analysis of transcripts of learner interactions in clubs point to learners being confused, compliant and 'facilitator pleasing' behaviour as synonymous with mathematical competence and success.

Finding ways to support the development of more effective learning dispositions across the South African landscape will require further research. We need to find ways to shift classroom practices in order to shift learners' dispositions in positive ways that enable and support mathematical learning and the development of all five strands of proficiency. Kilpatrick, Swafford and Findell (2001, p.131) note in this respect that:

> Developing a productive disposition requires frequent opportunities to make sense of mathematics, to recognize the benefits of perseverance, andto experience the rewards of sense making in mathematics.

Indeed across the work of the various projects that we run providing these opportunities for learners is a key focus. Our broader research will continue to explore learner dispositions and the possible evolution of these dispositions given access to the above learning opportunities.

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