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Assessing early number learning: How useful is the Annual National Assessment in Numeracy?

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Annual National Assessment (ANA) performance in Mathematics across the primary grades in South Africa indicates a decrease in mean performance across Grades 1–6. In this paper, we explore the apparently high performance in Grade 1 through a comparative investigation of learner responses on two assessments: the Grade 1 ANA taken in February 2011 by Grade 2 learners and a diagnostic oral interview test drawn from the work of Wright et al. (2006), administered at the same time. Our findings point to a predominant pattern of high performance on the ANA and low performance on Wright et al.'s tests. In-depth analysis of the responses of two learners in this group indicates that this discrepancy is due to acceptance in the ANA of correct answers produced through highly rudimentary counting strategies. The diagnostic test, in contrast, awards lower marks when correct answers are produced in inefficient ways. We conclude with concerns that acceptance of low-level counting strategies in the ANA may well work against persuading Grade 1 and 2 teachers to work towards more sophisticated strategies.

Keywords: ANA, early number learning, South Africa, numeracy, assessment

Introduction

While the 2012 Grade 3 Annual National Assessment (ANA) results showed a welcome increase to 41% in the national mean score (DBE, 2011, 2012), concerns remain about the levels and nature of early number learning in South African primary schools. Concerns relate also to the declining mean scores in Mathematics across the primary grades. In the national policy context, the ANA tests were part of a raft of measures aimed at supporting improvements in coverage, sequencing and pacing of the enacted curriculum. The ANA was explicitly focused on providing nationwide information on learner performance for purposes of both formative (providing class teachers with information on what learners were able to do) and summative

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(providing progress information to parents and allowing for comparisons between schools, districts and provinces) (DBE, 2011).

The research question driving this paper is: What information does the ANA provide for purposive follow up? We answer this question through analysing learner responses on number-related items in the February 2011 Grade 1 ANA paper taken by Grade 2 learners. We compare these responses and performance with the responses and strategies seen in an oral interview-based diagnostic test that is discussed later in the paper. The following sections detail the problem context leading to this focus, the literature and theory on progression in early number learning, the comparative methodology used to gather information on learners' responses, and the findings and analyses. We conclude with a discussion of possible ways to improve Foundation Phase assessment of early number learning.

The problem context

Several researchers have described the low performance of South African students in Mathematics as 'a crisis' (e.g. Fleisch, 2008; Schollar, 2008). Mathematics education literature points to early number learning as the 'bedrock' upon which later mathematical learning is built. In South Africa, specific problems have been identified within primary learners' work with number. Schollar's (2008) findings indicated that the majority of learners were performing well below grade-level expectations, with number problems often solved by unit counting in which learners reduced all numbers to single tallies. Almost 40% of Grade 5 and 11.5% of Grade 7 learners relied entirely on unit counting even with problems involving higher number ranges. Schollar also found that multiplication and division problems were reduced to repeated addition and subtraction.

Ensor, Hoadley, Jacklin, Kuhne, Schmitt, Lombard and van den Heuvel-Panhuizen (2009) Western Cape study provided confirmatory evidence for Schollar's findings. In tracking unit counting strategies back to pedagogy, the authors noted the 'permissibility' of concrete counting methods across Foundation Phase as part of the failure of many learners to work more abstractly with number. Hoadley (2007: 700) noted the 'inability to abstract, to work with mathematics in the symbolic as opposed to concrete form', describing unit count strategies as 'a very rudimentary form of counting'.

Overall, significant proportions of South African learners find difficulty with moving from highly concrete strategies relying on unit counting to more abstract strategies relying on reified notions of number, which are disassociated to varying degrees from counting processes. We thus began this study (drawn from the first author's master's study) with an interest in looking at what learner responses on different tests could tell us in relation to the use of more concrete/more abstract strategies. We focused on comparing learner responses on two tests – the February 2011 Grade 1 ANA and Wright, Martland and Stafford's (2006) oral interview diagnostic early number tests.

Below follows a literature review on shifts in early number learning towards the more abstract strategies described as necessary for flexible and efficient working with number.

Literature on progression in early number

Gelman and Gallistel (1986) propose five principles that underlie a mastery of counting. The first is internalisation of the one-to-one principle, which relies on two sub-processes: differentiating between items that have been counted and those still needing to be counted; and presenting separate items one at a time. Counting depends on connecting these processes with the number words. Secondly, they emphasise the stable order principle – that counting proceeds in an organised, repeatable and stable order. Third is the cardinal principle – understanding that the last 'tag' in a counting process stands for the sum of objects in a set. The fourth principle, the abstraction principle, indicates understanding that counting can be applied to any collection of objects. The last principle is the order irrelevance principle involving understanding that the order in which a set of objects is counted does not influence the result.

Cobb and Steffe (1983) note that counting relates to the coordination of a sequence of number words with the production of unit items. Their investigations show that the items that children are able to enact counts upon undergoes a 'developmental change' from motor unit items to abstract numbers that support a 'flexible, adaptive counting scheme that [can be used] to solve a variety of problems' (1983: 89, 91). Reified images of numbers support a flexibility and efficiency that cannot be provided when acting with concrete objects. Carpenter, Fennema, France, Levi and Empson (1999: 3) view children's progress in terms of an evolution from counting concrete objects in the context of direct problem-modeling strategies to doing mental calculation – a development from 'direct modeling strategies' to 'more sufficient counting strategies, which are generally more abstract'.

Gray (2008: 89) suggests that numerical symbols do not singularly signify either processes or concepts; rather, they embody both simultaneously as procepts: 'as a process and as a concept, both of which are represented by the same symbol'. Thus, 4 + 3 can be viewed in two ways: as an operation with the numbers shown (process) or as an expression of a holistic entity (object). The holistic entity is a mental object that emerges from the operational process over time. The emergence of this mental object requires the compression of operations into objects.

Askew and Brown (2003: 6) describe the sequence of development from counting into mental methods for addition and subtraction up to 20 in terms of: 'count all, count on from the first number, count on from the larger number, use known facts and derive number facts'. They argue that children should develop mental methods to work in this low number range to prepare for effective and efficient working with number in higher ranges.

With ‘counting-all’, this most basic strategy for 2 + 3 involves counting out two items, then three items, and then putting them together and recounting to get 5. This strategy involves three separate counts from 1. Counting-on involves proceeding from the first number presented in the sum. Here, the child acts on the 2 directly in concept rather than process terms, reducing the triple count to a single counting process, making it a more advanced strategy. Counting-on from the bigger number involves recognising that the counting-on process can be further compressed by starting from 3. Immediate recall of 5 as the answer to 2 + 3 lies at the most sophisticated level for early addition/subtraction. Here, no operational working is required. Both 2 + 3 and 5 have achieved the status of an object. Thompson (2008) adds detail relating to subtraction within this trajectory, incorporating a selection of the most appropriate strategy for use in problems such as 11–9 (counting down to nine, rather than taking away nine).

While many researchers have suggested progressions in strategies for working with early number problems, Wright et al. (2006) have devised a nuanced model of this progression that cuts across early counting, addition and subtraction. This model provides the analytical framework for this study.

Theorising the concrete to abstract shift in early number learning

Much of the work on early number learning rests on the seminal work of Piaget. Number concepts for Piaget (1964) rest on a combination of social knowledge, physical knowledge and logico-mathematical knowledge. Social knowledge is based on conventions of language and culture. Within number, the number words are key examples of social knowledge. Physical knowledge is knowledge based on an object’s external existence, coming into being through observation. In early number, this can refer to gaining understanding of quantity through concrete counting. Logico-mathematical knowledge is related to actions on objects without the physical presence of the objects.

While Piaget views gradual shifts to the abstract understandings underlying logico-mathematical knowledge as a stage, the writing in early number detailed above suggests much more fluid and partial shifts to abstract understandings of number. Sfard’s (1991; 2008) writings, in particular, view mathematics as produced through successive discursive layers of reification of processes into abstract objects. In Sfard’s (1991) earlier work, she notes ‘the dual nature of mathematics’ in which mathematical objects can be worked with as both operational processes and structural objects – as in the number example above. Sfard’s (1991) theory of reification describes the movement of operational processes into abstract objects. For Sfard, progression is worked into this reification, with operational processes necessarily preceding the possibilities for the creation of structural objects that encapsulate these processes. In her later work, Sfard (2008) describes reification processes in communicational terms, with nouns standing in for processes as though they signified objects. She views the compressions in the counting process noted by Gray (2008) as more broadly critical for communicative effectiveness.

Reification can be linked to the progression: count all, count on, and mentally calculate. A wholly operational understanding refers to 'count all' – unit counting a set of objects or triple counting in early addition and subtraction tasks. A partially structural number concept can be seen in count-on strategies where one number figures as a reified object. Recalled or derived facts usually involve structural number concepts across multiple quantities in a numerical expression.

The early number assessment framework devised by Wright et al. (2006) centres on a staged progression towards more reified number concepts across counting, addition and subtraction. Central to their model are the stages of early arithmetical learning (SEAL) summarised in table 1:

Table 1: Stages of early arithmetical learning

Stage	*Name of stage*	*Explanation*	*Stage*
Stage 0	Emergent counting	Cannot count visible items	0
Stage 1	Perceptual counting	Can count perceived items, either through seeing or feeling items	1
Stage 2	Figurative counting	Can count screened items, but when faced with combining sets, counts from one – does not count on	2
Stage 3	Initial number sequence	Count on to solve addition/count-down-from, but not count-down-to in order to solve relevant subtraction tasks	3
Stage 4	Intermediate number sequence	Count-down-to in order to solve subtraction/missing subtrahend problems; child can choose the more efficient count-down-to or count-down-from strategies	4
Stage 5	Facile number sequence	Use strategies that involve partitions of 5 or 10, combined with compensation and other non-count-by-ones methods	5
Possible score			5

The authors identify a range of further aspects – each subdivided into levels of sophistication – that feed into the SEAL in table 2:

Table 2: Additional features

Additional Features	Sub-levels and associated descriptions	Level range
Forward Number Word Sequence (FNWS)	0 – Cannot produce FNWS 1–10	0–5
	1 – Can produce FNWS 1–10 but cannot say number after	
	2 – Can produce FNWS 1–10 and say number after 1–10, but drops back to 1 when doing so. Cannot give number after beyond 10	
	3 – Can produce FNWS 1–10 and say number after 1–10 without dropping back to 1	
	4 – Can produce FNWS 1–30 and number after 1–30 without dropping back to 1	
	5 – Can produce FNWS 1–100 and number after 1–100 without dropping back to 1	
Backward Number Word Sequence (BNWS)	0 – Cannot produce BNWS for numbers 1–10	0–5
	1 – Can produce BNWS 1–10, but cannot say number before 1–10	
	2 – Can produce BNWS 1–10 and say number before 1–10, but drops back to 1. Difficulties producing number before beyond 10	
	3 – Can produce BNWS 1–10 and say number before 1–10 without dropping back to 1. Difficulties with number before beyond 10	
	4 – Can produce BNWS 1–30 and say number before 1–30 without dropping back	
	5 – Can produce BNWS 1–100 and say number before 1–100 without dropping back	
Numeral identification	0 – Cannot identify some or all the numerals in the range 1–10	0–4
	1 – Can identify numerals 1–10	
	2 – Can identify numerals 1–20	
	3 – Can identify numerals 1–100	
	4 – Can identify numerals 1–1 000	
Tens and ones knowledge	1 – One ten and ten ones do not exist for child simultaneously	1–3
	2 – Can see ten as a unit composed of ten ones	
	3 – Can solve addition/subtraction tasks involving tens and ones without using re-presentations of materials. Can solve written number sentences involving tens and ones by adding/subtracting units of tens and ones	
Total possible score including SEAL stages		22

Wright et al. (2006) have used this combined framework to devise a series of diagnostic oral interview-based tests, administered individually, to qualitatively assess the sophistication of learners' early number strategies. Our aims in this study were to understand similarities and differences in the overviews of performance drawn from the Grade 1 ANA responses and the videotaped interviews using Wright et al.'s tests. The SEAL framework with its sub-aspects viewed through Sfard's theory of reification provided an analytical framework for this study.

The sub-aspects were combined with the SEAL framework to produce an overall score for each of the learners tested with Wright et al.'s tests in the focal school. This score was then compared with the scores gained by the same learners on the Grade 1 ANA – with both tests taken within three weeks of each other in February 2011. While the broader study (Weitz, 2013) focused on overviews of performance across key groups based on overlaps and contrasts in their test scores, our focus in this paper is on the single largest group that emerged from this analysis – those with 'high' scores on the ANA contrasting with 'low' scores on Wright et al.'s tests. Specifically, we used learner response data from both tests to understand the different ways in which learner strategies moving from the concrete to the abstract were assessed.

Methodology

We begin with a brief description of the school that the data were drawn from, followed by a discussion on the two assessment instruments. We then outline the scoring methodology that allowed us to identify the sub-sample of two learners whose strategies on early number were analysed, forming the basis for the arguments in this paper.

ANA – background

The ANA tests are standard national tests that are distributed to all government schools. There is an annual test for Grades 1–6, with Grade 9 included in the 2012 ANA administration. Teachers mark the tests internally using a rubric provided by the National Department, and aggregate summaries are sent to district and provincial levels. On the Grade 1 tests – which are the focus of this paper – the national mean scores in 2011 and 2012 were 63% and 68% respectively (DBE, 2012: 3). The declining mean scores across Grades 1–6 (Grade 6 mean scores were 30% and 27% across the two years) indicate decreasing proportions of learners meeting grade-appropriate curriculum requirements through primary school. In Grades 1 and 2, the ANA tests are orally administered, with learners writing answers down on their scripts. In 2011, following rescheduling of the school year around the 2010 Soccer World Cup, the Grade 1 ANA was administered to Grade 2 learners in February.

The focal school

The school from which the data was drawn is a township/informal settlement school with six Grade 2 classes. The school is part of the broader Wits Maths Connect – Primary (WMC-P) project that has been working over five years (2011–2015) to improve primary mathematics teaching and learning. As part of baseline data collected in the project, Wright et al.'s tests were administered to six learners drawn from across the attainment range based on teacher reports in each of the Grade 2 classes in all ten schools in the WMC-P early in 2011. ANA results were also collected, and photocopies of the ANA scripts of the learners in the test sample were re-marked by the WMC-P project team. Learners in this school were allocated to classes based on the LOLT coinciding with their Home Language (one Tsonga class, two Zulu, two Sepedi and one Xhosa) and wrote the ANA in this language. Due to learner absence, we ended up with matched data across both assessments for 29 of the 36 learners drawn from the six Grade 2 classes.

The 2011 ANA Grade 1 assessment

In the 2011 Grade 1 Numeracy ANA, there were 19 questions on the paper with a total allocation of 20 marks. A total of 17 from 19 questions (carrying 18/20 marks) related to number. Given our focus on number strategies, we restricted our analysis to these 17 questions (see table 3):

Table 3: Grade 1 Numeracy ANA number questions

<table>
<tr><th></th><th>Topic</th><th>Question</th><th>Score</th></tr>
<tr><td>1.1 & 1.2</td><td>Forward counting</td><td>Fill in the missing numbers.
1.1. Table shows 3–11 in unit increments with 5, 8 and 10 missing;
1.2. Table shows 20–100 in increments of 10, with 30, 70, 80, and 100 missing</td><td>2</td></tr>
<tr><td>2</td><td>Identify/ produce number words</td><td>Complete this table by filling in the blank spaces
<table><tr><td>'Shapes'</td><td>'Total number'</td><td>'Number in words'</td></tr><tr><td>Δ Δ Δ Δ Δ Δ Δ</td><td>9</td><td></td></tr><tr><td></td><td>7</td><td>seven</td></tr></table></td><td>2</td></tr>
<tr><td>3</td><td>Ordinality of number</td><td>'What is the position of these pictures on the number line?'
A number line is given with shapes drawn at different positions.
There are 3 boxes: with a heart, an Aids sign and scissors. Box with heart is in the 6th position.
3.1 The scissors are in position ______________
3.2 Tick the box below the picture that is in position 6 on the number line.</td><td>2</td></tr>
</table>

5.1 & 5.2	Addition/ subtraction	5.1 20 + 3 = ? 5.2 18 – 4 = ?	2
6.1 & 6.2	Doubling/ halving	6.1 Double of 5 6.2 Half of 20	2
7.1 & 7.2	Addition/ subtraction	7.1 10 + 10 + 10 = ? 7.2 10 – 2 – 2 = ?	2
9.1 & 9.2	Coinage and Quantity	*Two 5c coins and two 10c coins shown* 9.1 The total amount of money is _______________ *Five 10c coins and five 5c coins shown* 9.2 I have 4 coins in my pocket. Tick the 4 coins that I have in my pocket.	2
10	Division	*Twelve sweets are presented in two rows* 10. Busi and her two friends ate 12 sweets. They each ate an equal number of sweets. How many sweets did each one eat?	2
11	Cardinality of number	*One row with seven apples, another row with five bananas* 11. Thabo bought apples and bananas at the shop. Write the correct number of each kind of fruit Thabo bought. 11.1 _____________ apples 11.2 _____________ bananas	2
Total possible score for number-related items			18

Wright *et al.'s* assessment instrument

Wright et al.'s (2006) suite of tests focuses on the early number topics discussed above and the relative sophistication of learner strategies. Of the six tests available, we used the two assessments focused on early counting, addition and subtraction. The tests took approximately an hour to administer with each learner. All test administrations included the presence of an interpreter who translated questions into the child's home language. These tests were conducted in the form of videotaped oral interviews in order to see children's counting strategies, with consent granted from schools, teachers, learners and parents. An explicit feature of Wright et al.'s tests is their concern with not only the answers themselves but also how answers are produced. The questions on the two sub-tests are detailed in table 4:

Table 4: Wright et al.'s (2006) early number items used

Question number/task focus	Specific sub-questions
Test 1.1	
Q1 – FNWS	Start to count from: 1-32, 48-61, 76-84, and 93-112 I will tell you when to stop
Q2 – Number Word After (NWA)	Say the NWA: Entry task- 14, 11, 19, 12, 23, 29, 20. Less advanced task: 5, 9, 7, 3, 6. More advanced task: 59, 65, 32, 70, 99
Q3 – Numeral identification	What numbers are these: Entry task: 10, 15, 47, 13, 21, 80, 12, 17, 99, 20, 66. More advanced task: 100, 123, 206, 341, 820. Less advanced task that is 8, 3, 5, 7, 9, 6, 2, 4, and 1
Q4 – Numeral recognition	1–10 cards placed randomly Which number is: 6, 4, 7, 9, 8?
Q5 – BNWS	Count backwards from: 10–1, 15–10, 23–16, 34–27, and 72–67
Q6 – Number Word Before (NWB)	Say the NWB: Entry task: 24, 17, 20, 11, 13, 21, 14, 30 More advanced task: 67, 50, 38, 100, 83, 41, 99 Less advanced task: 7, 10 4, 8, 3
Q7 – Sequencing numerals	Cards 46–55 placed on table in mixed order. Child asked to state each number as card is placed, then order from smallest to biggest Less advanced task: 1–10
Q8 (a-e) – Additive tasks	Introductory task: 3 + 1 screened: red (3), yellow (1). How many altogether? Entry task: 5 + 4 and 9 + 6 (all counters screened) Supplementary additive tasks: 8 + 5, 9 + 3 (all counters screened). If successful, interviewer moves to Q8f Less advanced task, one group of counters is screened: 5 + 4, 7 + 3, 9 + 4 Further less advanced task: both groups of counters unscreened: 5 + 2, 7 + 3, 9 + 4 Further less advanced task: 13 counters placed. How many? Then 18 counters

Q8 (f) – Missing addend	Four red counters screened. Two blue counters added without child seeing. 'Now there are 6 counters, how many more did I put under the paper?' Then 7 + ? = 10 and 12 + ? = 15
Q9 (a) – Subtractive sentences	Entry task: Card with 16 – 12. Child asked to read sum, work out answer Supplementary task: 17 – 14
Q9 (b) – Missing subtrahend	Introductory task: Interviewer shows child 5 counters beneath a screen, removes 2 without child seeing. 'There are 3 now, how many did I take away?' Entry task: 10 – ? = 6; 12 – ? = 9 More advanced task: 15 – ? = 11
Q9 (c) – Removed items	Introductory task: Interviewer shows child 3 counters, takes away 1 counter. The total left is screened. How many are left? Entry task: 6 – 2, 9 – 4, 15 – 3 Advanced task: 27 – 4
Test 2.1	
Q1 – Subsitizing and spatial patterns	Dot cards with random and patterned dot arrangements. How many dots can you see as cards are flashed? Random and patterned arrangements: 4, 3, 2, 5, 6, 7, 8 dots Domino cards with patterned dot arrangements flashed. How many altogether? 5 + 3, 6 + 4, 4 + 4, 5 + 4
Q2 – Finger patterns 1–5	Show 3, 2, 5, 1 4 on fingers Show 3, 2, 5, 4 fingers with two hands
Q3 – Finger patterns 6–10	Show 6 on their fingers: show 6 on your fingers in a different way Show 9 and 10 on fingers. Show 8 on fingers; show 8 in a different way
Q4 – Five-frame pattern	Five-frame cards with different numbers of dots flashed. How many dots do you see? 3, 2, 5, 1, 4
Q5 – Five-wise patterns on a ten frame	Ten-frame card with different numbers of dots flashed. How many dots do you see? 7, 10, 8, 6, 9
Q6 – Pair patterns on a ten frame	Pair-based patterns on a ten-frame flashed. How many dots do you see? 4, 2, 5, 1, 3, 7, 10, 8, 6, 9
Q7 – Combining to make five	I'll say a number. You tell me what goes with this number to make 5: 4, 2, 1, 3, 5
Q8 – Combining to make ten	Give me pairs of numbers that give 10 I have 8 apples, how many do I need to get 10 apples? Repeated with 4 apples, 7 apples

Sample

Our quantitative score on these assessments for each child, based on the SEAL and sub-aspect scores, was derived from looking across learner responses and assessing the predominant strategy used. Scores were then converted to percentages allowing for comparison with the child's ANA score on number-related items. Comparisons indicated that, in general, ANA scores were higher than scores gained on Wright et al.'s tests. Using 60% as a cut-off point to distinguish between 'high' and 'low' performance in these tests and 65% as the cut-off in the ANA test, we created the following summary:

Groups	*No. in each group*
High ANA/High Wright tests	2
Low ANA/High Wright tests	1
High ANA/Low Wright tests	14
Low ANA/Low Wright tests	12

This summary confirmed that most learners (26/29) performed at low levels on Wright et al.'s tests – where high scores depended on the use of more sophisticated strategies. The single biggest group in this categorisation was the High ANA/Low Wright tests group (14 learners).

In this paper, we analyse the counting and early addition/subtraction strategies seen in the ANA and Wright et al.'s test responses of two learners in this group – Happy and James (pseudonyms). These learners were selected on the basis of rich evidence of their methods – methods that were not 'visible' on most ANA scripts, we believe, due to the use of fingers or tally counting on other working paper. This belief is based on widespread evidence of these strategies seen in our administration of Wright et al.'s tests.

Findings and analysis

We deal with each learner in turn, and structure our analysis according to the information gained from assessing each child's counting strategies in relation to SEAL and the other sub-aspects.

Happy

Happy scored 72,2% in the ANA number items but 18,2% on Wright et al.'s tests. In terms of awareness of the number sequence, Happy was able to state the number sequence to 30, but struggled to do so beyond this. When asked to count from 48, his response was: 'forty-nine, forty-ten, forty-eleven ...'. A lack of fluency with ordering of number was also apparent in his inability to state the number word after a given number beyond the 1–10 range, without reverting to counting from 1. With counting backwards, Happy was able to produce this sequence in the 1–10 range, but not beyond this. Within the 1–10 range, he was not always able to state what number came before a given number. Correct answers were produced through forward counting from 1. Happy was able to state the number of dots seen in dice and five-based arrangements, and to show these quantities on his fingers, although in some instances, he counted out the number of fingers rather than immediately opening the number asked for. He was unable to state the number of dots in paired and five-based pattern arrangements in the 1–10 range, and was also unable to say how many more were needed to make 5 given between 0–5 items.

Happy's working on the early addition and subtraction items in Wright et al.'s tests suggested that, while he could count perceived items, he was unable to proceed when one quantity was screened, or when the sum was presented in symbolic form (e.g. 16 – 12). He was able to attempt this question and other similar questions once counters were given to him, but sometimes made mistakes during the count (e.g. he gave 14 as the answer for 9 + 6). Overall, Happy showed a weak understanding of the relationship between parts and the whole in the context of addition and subtraction problems because he was unable to solve anything other than 'join'- or 'separate'-type tasks (Carpenter et al., 1999) even with counters available. This placed him at a relatively low SEAL Stage (1) due to his inability to handle the abstraction of number implied within count on strategies. Predictably, on the remaining aspects feeding into SEAL, lower levels were attained due to his inability to give the number word after a given number, etc., with scores attained as follows: FNWS (2), BNWS (1), numeral identification (1), and tens and ones knowledge (0).

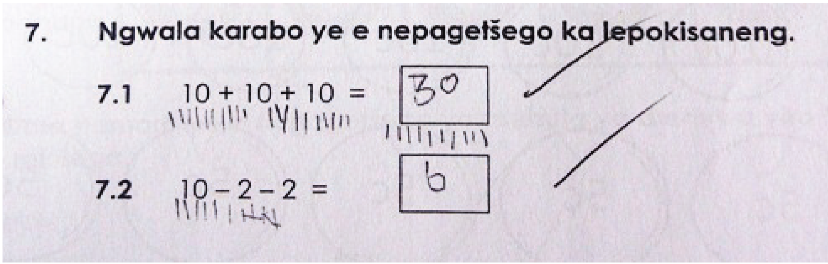
Happy's ANA responses largely aligned with his interview responses, but the written response format meant that we frequently only saw his answers, rather than the strategies used to produce the answers. Fourteen of the nineteen number-related questions on the ANA required identification and counting in the 1–10 range and, as seen in Wright et al.'s tests, Happy was able to answer these correctly. Correct answers on ANA Q1.2 and 7.1 suggest that Happy was able to count in tens, but does not seem aware of how the structuring of numbers in the decimal system might support, e.g. calculating 16 – 12 using the answer to 6 – 2. Addition and subtraction problems with lower number ranges were usually answered correctly on the ANA (Q7.1 and 7.2), but addition/subtraction tasks in higher number ranges (Q5.1 and 5.2) were answered incorrectly.

While working methods were not shown on the ANA, the video data suggest that unit counting based strategies (on fingers or on paper) may have been used to work out answers in the lower number ranges, with these becoming more error-prone in increased number range problems. Happy shows that he can group count in some contexts, e.g. in tens and in the context of coins, but video data indicate that this skill may be localised to particular counting contexts, rather than being used as a tool in calculation tasks. While in Wright et al.'s tests more concrete counting based strategies are 'penalised' with lower scores, this is not the case in the ANA where the right answer, however derived, is 'awarded'.

James

James scored 66,7% on the ANA test number items and 18,2% on Wright et al.'s tests. As with Happy's responses, there was overlap between the responses on the two tests. James' video data indicated that, while he was able to identify most numbers in the 1–100 range, he was unable to say the number word sequence beyond 29 and unable to state the number word after a given number beyond the 1–10 range, reverting to 1 to solve all problems. He also struggled with counting backwards and saying the number word before a given number within and beyond this range. Wright et al. (2006) note this reverting to 1 as prevalent among low attainers. In reverting to counting from 1, the absence of an objectified sense of subsequent numbers is revealed (Sfard, 2008).

While able to show 1–10 fingers on his hands, James was unable to show partitions of either 5 or 10 on his fingers. On addition and subtraction tasks, James was able to answer questions such as 5 + 4 and 9 + 6 when counters were available with unit counting used. On missing addend/subtrahend questions, James could not give the correct answer without using counters. James' response on the ANA items mirrored these responses, with additional evidence on the script of unit-counting strategies using tally marks, as shown below in his response to Q7:


7. Ngwala karabo ye e nepagetšego ka lepokisaneng.

7.1 10 + 10 + 10 = $\boxed{30}$

7.2 10 – 2 – 2 = $\boxed{6}$

Thus, in James' case, too, while concrete counting strategies resulted in low scores on Wright et al.'s tests (SEAL stage – 1, FNWS – 2, BNWS – 0, numeral identification – 1, tens and ones knowledge – 0), the rudimentary nature of these strategies remained invisible in the ANA's awarding of marks for correct answers rather than for sophistication of strategies.

Conclusion

While 16/29 children in our sample attained over 65% on the 2011 Grade 1 ANA, our data suggest the need for caution in interpreting these scores. Two features of the Grade 1 ANA may tend to work against the development of the more abstract number concepts needed for success with higher number range problems – the low number range that is a feature of the Grade 1 ANA (less than 25 for operation and less than 100 for counting), combined with the focus wholly on answers rather than how these are produced. These two features in combination make it perfectly possible for learners to use highly concrete strategies for answering questions successfully in low number ranges. In turn, the high scores that can be attained through use of these strategies may well work against persuading Grade 1 and Grade 2 teachers to work towards more sophisticated strategies.

As noted already, national ANA performance in Grades 1 and 2 is relatively high. Our data suggest that this high performance is predominately linked to concrete counting strategies, which starts to explain the drop-offs in mean performance seen in Grade 3 and beyond. Given widespread evidence of high-stakes assessment driving teaching (Resnick & Resnick, 1992), we believe it is imperative to incorporate features into the ANA that focus attention towards the need for more abstract conceptions of number in the early grades. We recognise that large-scale assessment cannot be performed in the interview format of Wright et al.'s tests, but suggest examples of task formats and questions that can be incorporated into the ANA written answer format that direct attention towards the progressions in number concepts that we believe are desirable. We conclude this paper with two examples of these:

- Encouraging visibility of strategy as well as answers, and awarding scaled marks for the relative sophistication of strategy used. This might be done through formatting answer scripts thus:

19 + 3 = ?	
Working out	Answer

- Inclusion of questions that require more abstract understanding of number. In this example, we direct attention to the efficiency of working 'through 10', and the usefulness of knowing these partitions:

Add these three numbers. Put a circle round the two numbers you would add first.	
7 6 3	Total = _________

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