

WHEN SYSTEMIC INTERVENTIONS GET IN THE WAY OF LOCALIZED MATHEMATICS REFORM

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South Africa is a nation of extremes. We have among the highest levels of income inequity in the world (National Planning Commission, 2011) and TIMSS results from 1999 to 2011 show that we have among the highest performance gaps in mathematics and science education (Reddy *et al.*, 2015). Essentially, South Africa has two systems of education: one, a functional system for the wealthy (where performance in TIMSS compares favorably to international benchmarks); the other, a largely dysfunctional system in crisis serving the majority of learners living in poverty (where TIMSS performance is amongst the lowest of participating countries) (Reddy *et al.*, 2015; Fleisch, 2008). Money spent on education is comparatively high in relation to our African neighbors, and political will for redress is strong, at least in terms of rhetoric.

Three curriculum revisions since democratic elections were held in 1994 have aimed to address the crisis in education. A nationally commissioned review of our first post-apartheid curriculum concluded that policy cannot be considered “good” if it operates in a vacuum and ignores the vastly unequal contexts in which the implementation of curriculum change occurs (Christie, 1999). Yet subsequent curriculum revisions and accompanying systemic “support” continue to ignore inequality in the context of implementation. Furthermore, Chisholm *et al.* (2000) argue that a focus on integration across subjects created a particular problem for fields of knowledge such as mathematics, in which attention to progression is structurally important. Hence, in relation to mathematics, they argued that “the result is a weaker grasp of the central skills and concepts [...] which in turn jeopardise[s] higher skill acquisition” (p. 35).

The first post-apartheid curriculum foregrounded teacher autonomy and professionalism. Two decades on, however, the response to the continuing crisis in education has been an increase in managerial systems such as the recent Annual National Assessments and the Integrated Quality Management System for schools and teachers. This shift reflects wider international trends.

Day and Smethem (2009), in a discussion of international research on the effects of sustained, centrally initiated government reforms on teachers’ work, argue that:

Teachers in most countries across the world are experiencing a similar mix of government interventions in the form of national curricula, national tests, criteria for measuring the quality of schools and the publication of

these on the internet in order to raise standards. (p. 142)

They focus particularly on England as an “outlier” case study (p. 141) because of the intensive nature of government intervention there in recent decades and the way in which teacher professionalism became redefined in managerial terms. That is, target-setting and appraisal for teachers through annual performance management, national learner assessments of performance against curriculum expectations in English, mathematics and science, as well as external inspection, all became the norm in English schools.

In this article, South Africa provides an “outlier” case that illuminates the tensions that exist between locally responsive mathematics education interventions, aimed at tailoring initiatives to vastly unequal contexts of schooling, and the systemic “one size fits all” interventions of the state. I draw on the experiences of two teachers involved in an in-service teacher intervention project, to argue that our current curriculum and systemic “support” fail to accommodate the extreme backlogs in learner knowledge.

Systemic challenges

The backlog in learners’ mathematical knowledge is clearly evident in the Department of Basic Education’s systemic analysis of its own Annual National Assessments, which mirror the findings of regional and international comparison studies. Analysis indicates that by grade 4 (aged 9-10 years) most students are already two grades behind expected levels of mathematical competence (Spaull & Kotze, 2015). By grade 9 (ages 14-15 years) this gap has expanded, as indicated by a national average of only 11% for the national benchmark assessments for mathematics that assess expected learning outcomes for this grade (DBE, 2014).

A wide range of research (*e.g.*, Schollar, 2008) has found that learners fail to progress beyond one-to-one counting methods, even well into the intermediate phase (grades 4-6, ages 9-12 years) because of a predominance of concrete over abstract methods of calculating in most primary classrooms (Hoadley, 2012). Such practices inhibit coherent development of number sense and efficient arithmetic strategies resulting in the application of taught algorithms without consideration of the reasonableness of the answer or the underlying place value of the digits being manipulated (Graven, Venkat, Westaway & Tshesane, 2013). Schollar (2008), based on the findings of the Primary Mathematics Research Project, which began in 2004 with the examination

of over 7,000 Grade 5 and grade 7 learner test scripts from 154 schools across all 9 provinces, found that 79.5% of Grade 5 and 60.3% of Grade 7 children still rely on simple unit counting to solve problems. He argued that:

the fundamental cause of poor learner performance across our education system was a failure to extend the ability of learners from counting to true calculating in their primary schooling [...] Learners are routinely promoted from one Grade to the next without having mastered the content and foundational competences of preceding Grades, resulting in a large cognitive backlog that progressively inhibits the acquisition of more complex competencies. The consequence is that every class has become, in effect, a “multi-Grade” class. (p. 1)

An additional factor in this backlog is that the vast majority (94%) of learners learn mathematics in either English or Afrikaans from grade 4 onwards even while only 17.2% of learners are native speakers of these languages (DBE, 2010). There is research evidence for a strong correlation between “mother tongue education and scholastic achievement” (DBE, 2010, p. 5). The 1997 Language in Education Policy advocates mother tongue instruction, most especially for the early years of schooling (Robertson & Graven, 2015). A preference for English in particular tends to be motivated by perceptions that access to learning in English provides access to social and economic power, rather than considerations of what will be most beneficial for learning mathematics (Setati, 2008).

Two interventions in the Eastern Cape

The Eastern Cape is one of the poorest provinces in South Africa with amongst the lowest Annual National Assessment results. My recent work with schools in the province [1] includes two intervention projects: a teacher development program, the Numeracy Inquiry Community of Leader Educators (NICLE); and a program of after school mathematics clubs. These two projects began in 2011 and focus on supporting the development of mathematical progression and proficiency through encouraging active, independent, conceptual and exploratory participation. NICLE functions as a “community of practice” of primarily grades 3 and 4 mathematics teachers from 12 schools, as well as university researchers and a district advisor, whose role was to support teachers of children in their first four years of schooling (ages 5-9 years) across the district. The after school mathematics clubs consist of groups of 8-15 learners working with a mentor (a university researcher, NICLE teacher or community volunteer), to explore mathematics through active participation and discussion, free from the demands of curriculum, grade-specific expectations and the constraints of large, whole class teaching.

These projects have led to increased teacher confidence and commitment to practices that foreground sense-making and conceptual understanding (see, for example, Pausigere & Graven, 2014), as well as overall improved learner performance on a range of assessments from 2011 to 2014 [2]. There are, however, several systemic obstacles to the success of such programs and, in particular, to possibilities for expansion. A primary challenge for NICLE has been con-

fronting the way in which grade-specific curriculum demands ignore large learning gaps arising from earlier grades. In the context of a systemic focus on monitoring curriculum coverage, rather than on supporting teachers’ localized needs, these grade-specific demands push teachers to focus on providing evidence of teaching, as opposed to meeting the specific needs of their learners. An advantage of projects like NICLE is that they can be tailored to the specific needs of mathematics teachers teaching in vastly different contexts. A disadvantage is that such localized tailoring makes scaling up the projects difficult. The attraction of systemic interventions is that they can be nationally implemented but such interventions are not then tailored to the varying needs of the different contexts in which they are implemented by district officials and teachers.

To illustrate the above challenges, I first draw on the experiences of two participating NICLE teachers.

Two teachers’ experiences

Zandi and Rose teach mathematics in grades 4-7 and grades 4-6 respectively and both have participated in the NICLE project since 2011. Their experiences, as captured in interviews and questionnaires, illuminate the tension of both tailoring one’s teaching and learning materials to the specific needs and levels of learners (as promoted by NICLE) and meeting the Department of Basic Education’s push for curriculum coverage and systematic assessment.

Their comments arise in the context of the introduction of Annual National Assessments in 2011. These assessments were intended to assess the mathematics and literacy/language proficiency of all learners in Grades 1-6 and 9 to provide “credible monitoring” in these areas “to know what action needs to be taken” (DBE, 2012, p. 3). Unfortunately, when the national average score for Grade 9 mathematics is just 11% (2014 ANAs), they tell teachers very little, about what learners know, or about where to begin remediation. They simply tell us what we already know: there is a crisis and the vast majority of learners are several grades behind. If Annual National Assessments are to show “what action needs to be taken” then surely the system should find ways to remediate gaps in learners’ foundational mathematics concepts. Yet, based on feedback from several NICLE teachers, including Zandi, this does not appear to be the case:

They (the Annual National Assessments) were not very useful because they cover the whole year’s work in September [3]. I can’t rush to finish everything in September, because in that way I will be teaching the syllabus, not the learners.

In an interview in February 2015, Zandi was asked how she managed the tension of revisiting work from earlier grades and keeping up with the grade 4-7 departmental schemes of work. She responded as follows:

We tell the subject advisor that I am actually at grade 2, CAPS [Curriculum and Assessment Policy Standards] says I must teach this [grade 4]. But my learners are not yet on that level. That means I have to go to grade 3 work. They [district subject advisors] said no it is wrong they know that some learners struggle or

whatever but we are wrong to go back to grade 2, or grade 3. We always argue about that and then they will say it is from the top not from them and then what do you do?

When asked if she felt she should hide the recovery work promoted in NICLE from district officials she explained that she showed them her books and argued:

What do you do to this kind of a learner? Do you expect me to teach them and what does the learner still struggle with? [...] Then how do I do that cause I am frustrating that learner more, not only that learner but myself because I am going to go nowhere with that learner.

Zandi's remarks capture both the resistance of the district official to depart from national imperatives, while simultaneously indicating some acknowledgement of the local reality. The tension articulated by Zandi highlights the tricky position district officials are in: they must comply with the demands of their employer, by implementing national systems in local contexts. This compliance involves communicating with teachers who might not see the value of what they are being told to implement. In this respect, district officials must manage localized forms of resistance, such as some schools simply not writing the Annual National Assessments, or teachers from certain schools not attending "compulsory" district meetings, and so forth.

For example, Zandi explained that for a 2014 mathematics subject meeting, in which teachers' files were "moderated", only a few teachers attended, indicating widespread resistance by teachers in most schools despite such a meeting "not (being) optional":

If you are expecting 15 schools, 3 schools will be there you see that is it [...] It is supposed to be a valuable process but it is not [...] They (other teachers) will bring a file this thick but inside that file there is nothing with the details you are supposed to have, it is some other things. Some other things, what happens, nothing happens whether you have or you don't have [...] Nothing, no follow up or nothing, nothing happens, moderation is just a, maybe they want to have proof.

Rose wrote similarly about her experience of the 2014 district subject "meetings" aimed at gathering evidence of curriculum compliance and coverage:

When the Department subject meetings came around, I went along with my Life Skills file as requested. The purpose of the meeting, I discovered on arrival, was to evaluate our files. Colleagues sitting next to each other were asked to swap files and evaluate each other's files against a given checklist. As long as proof of certain documents and forms were there, the block could be ticked. Interest in the quality of activities was not evident. Evidence of the documentation was all-important.

Such a scenario suggests the focus of such meetings is on checking teacher compliance and gathering "evidence" that can be cross-checked against a list that confirms compliance. Thus, while what is in a teacher's "lesson preparation file" in no way speaks to the quality of teaching (nor to what was

actually taught), such file checking is nevertheless deemed valid practice. Within this system, the focus on "teaching plans" appears to take precedence over support for the quality of teaching for learning. Additionally, such file checking does not take account of the appropriateness of the content for the mathematical level of learners being taught. A "one-size-fits-all" approach is promoted. Other NICLE teachers complained of time taken away from teaching to prepare such files.

Zandi's and Rose's comments illustrate the way in which Department of Basic Education systems tend to focus on monitoring teacher compliance and curriculum coverage, rather than supporting teachers to enable high quality learning in their classrooms. Ironically rather than enabling teaching and learning, these systemic interventions seem to get in the way of the very quality that they are intended to produce. In the next part of the article, I highlight some of the tensions that arise from this situation.

The need for remediation

The insistence on teaching mathematics according to national grade specifications and provided schemes of work and workbooks pushes teachers to teach as if learners have mastered the knowledge of previous grades. The Annual National Assessments clearly communicate that mastery has not been achieved. NICLE is based on a socio-constructivist premise, that mathematics requires teaching and learning to progressively build increasingly abstract and complex concepts on established foundational mathematical knowledge. We have focused on supporting teachers to revisit work from earlier grades to establish solid number sense. We have thus encouraged teachers to deviate, if necessary, from grade-specific schemes of work provided by the district. Thus, for example, our four operations assessment administered to over 1,200 grade 3 and 4 learners in 2011 showed a predominance of one-to-one calculation methods, irrespective of the size of the numbers. Many learners would draw tally lines even for problems such as $55 + 67$ and 25×6 or, alternatively, would attempt to use taught algorithms, mostly without success. To address the lack of arithmetical reasoning, we focused on developing teacher knowledge of the progressive stages of mathematics learning, drawing on Wright *et al.*'s (2006) Learning Framework in Number (LFIN) and Mathematics Recovery (MR) program. Activities focused on supporting learners to develop early arithmetic strategies and conceptual place value (Wright *et al.*, 2006), as these concepts are considered essential for mastering algorithms for calculations with multi-digit numbers. Schollar (2008) has similarly argued for a focus on foundational concepts of place value and calculation to support progress.

Ignoring gaps in learners' foundational mathematics knowledge is like insisting that builders lay subsequent layers of bricks on a structurally unsound substratum. When, by the ninth layer of bricks the entire structure has completely collapsed (as indicated by the grade 9 average of 11%), fingers are pointed at teachers, teacher content knowledge and teacher absenteeism (among other things). While I do not wish to imply that teacher content knowledge or teacher absenteeism are not factors in the crisis in education,

it seems to me that the system avoids the remediation of learning gaps which the vast majority of learners in low SES schools need. Addressing such gaps should not be seen as “dumbing down” the curriculum, but rather an acknowledgement that such focused work is necessary to enable successful mathematics attainment.

Learners’ workbooks

Without a shift in focus from monitoring implementation of curriculum to supporting the localized needs of diverse classrooms of learners, and planning for teaching based on where these learners are, progression of learners in low SES contexts is likely to be hampered, rather than supported by, the system. As an example of how teacher monitoring could in unintended ways transform (or perhaps corrupt) practice is the “policy” that all learners’ work must be marked. This policy resulted in what Aarnout Brombacher, in a 2011 NICLE workshop, referred to as the practice of “exactly 4 written sums per day”. He joked with our teachers that, since 4 sums times 40 learners in a class meant 160 sums to mark, 4 sums a day was “the doable” amount of marking to enable policy compliance.

Indeed our initial sampling of learners’ workbooks indicated little learners’ written work (also noted by Hoadley, 2012), and little homework. In response, we introduced a workbook for learners that would address some of the foundational learning of previous grades, that would be done by learners after school, and that would be free from inspection by subject advisors. Since such books were free from inspection, learners and their teachers had more freedom in the way they worked with them. The books provided learners with opportunities to work independently and at their own pace in order to develop fluency and number sense, as well as to develop habits of learning mathematics out of school. Sets of books were provided for every learner in grades 2-4 in participating schools. We emphasised that learners should develop a sense of ownership of the workbooks, free from fear of inspection, and that consistent work must be prioritized above neatness and cleanliness [4]. The books focused on the development and practice of basic facts (drawing on Askew, 2012) and the “fundamental development” of place value and calculation strategies (Schollar, 2008). A key challenge remained, however: namely the lack of spaces in which learners (living in poverty conditions) could do their homework. This issue raises a different kind of systemic challenge relating to many low SES schools being closed in the afternoons. I discuss this challenge in the following section.

Space to work

While the average day in wealthier schools in South Africa frequently ends after 4pm, with afternoons filled with supervised homework sessions, educational clubs and sports activities, the majority of the schools we work with end their school day between 1pm and 2pm, at which time school gates are locked. The lack of a culture of using school spaces for after school activities doubly disadvantages learners from low SES backgrounds. These are the learners who have few educational resources at home (such as books) and little space to do homework (both physically, and in terms of time available relative to the expectation that they contribute

to household chores).

These circumstances are consistent with the findings of Tsanwani *et al.* (2014), who conducted focus group interviews with learners in low performing schools. The learners identified lack of proper learning facilities at home, and challenges of time management within their contexts, to be key factors in their low performance. Learners in such contexts thus particularly need some form of after school care, supervision and opportunities to participate in activities such as reading, homework, clubs and so on. However, due to high levels of crime, the vast majority of schools are fenced and locked once the official school day ends. This situation means that even though most of our after school mathematics clubs run immediately after school, many can only run for less than an hour.

A systemic expansion of after school activities, coupled with keeping schools open in the afternoons to provide learners with a safe space for homework or other activities, could substantially add value to the educational opportunities of low SES learners. Systemic support for schools to remain open in the afternoons would greatly support locally organized initiatives, such as after school mathematics, science and reading clubs, as well as enabling learners’ opportunities to work on activities tailored to remediating foundational knowledge from earlier grades after school. Negotiating ways to keep schools staffed in the afternoons and utilized as spaces where volunteers can support student learning could be both cost effective and have a positive impact on learning.

Systemic vs. local interventions

I have highlighted some of the tensions that exist between national systemic interventions and localized non-government interventions that address the learning gaps of specific classes of learners. Since revisiting foundational concepts may be at the expense of grade-specific curriculum coverage (monitored by district officials), both teachers and district officials are faced with the difficult task of meeting the needs of learners and simultaneously the demands of the Department of Basic Education, which pays their salaries.

The socio-constructivist perspective adopted in NICLE foregrounds the progressive nature of mathematics learning and suggests that without addressing foundational concepts, subsequent learning will be severely constrained and performance gaps will continue to increase as learners move through the grades. From local experiences and research of NICLE, and the coherence between this research and broader national research, I have argued that the system must focus on ways to enable mathematical recovery of foundations based on the local needs of diverse classrooms of learners. A key problem is that the system focuses on checking that what is taught aligns with grade-specific “assessment standards”, with little consideration of the unequal context in which curriculum is implemented. Furthermore, this external monitoring shifts the focus of teachers away from their core business. As Rose argues:

The focus of teaching should prioritize the preparation of interesting lessons and promote an enthusiasm for learning and finding out about the world around you. Although record keeping is vital, it should not swal-

low up the majority of time and energy.

The experiences of Zandi and Rose are not specific to South African teachers (see Day & Smethem, 2009). What is, however, particular to South Africa is that the majority of learners have already fallen almost two grades behind expected levels of mathematics performance by grade 4. Systems of annual national assessments, provision of weekly work schedules and grade-specific workbooks continue to ignore this gap. Thus teachers must, for example, teach 3-digit by 2-digit multiplication to learners who might not know the meaning of 3×4 or who can only solve it using concrete representations. Thus learning, in terms of progression from where learners are, is neglected or at least “out of focus” in the systemic intervention process, which foregrounds bureaucratic form filling. Yet, as Zandi explained in her interview, the district subject advisor explained his practice in terms of his own need for compliance. A vicious cycle continues. Top-down management of teachers gives little attention to what might enable and support learning. Time-consuming “compliance” activities add no value to the overall quality of teaching and learning in mathematics classrooms. Instead, practices that obscure the very purpose of education are promoted. However, both local and systemic teacher support practices have the common goal of improving mathematics teaching and learning and so ways must be found to navigate the tension between local and national interventions more productively.

Possible ways forward

From my experiences working with NICLE teachers, national Department of Basic Education representatives, district foundation phase advisors and provincial curriculum specialists, I argue that creating more spaces for dialogue between local intervention projects, national Department of Basic Education officials, district officials and teachers is a logical and productive way forward. National education systems must find ways to be more locally responsive to the needs of the different schooling contexts, while privately funded interventions often face pressure to scale up their interventions and exert more influence on the national system. Currently, there are few forums for dialogue between the national and the local, and the discourses of government interventions and local research-based interventions like NICLE are very different. Funders of local initiatives often refer to the need for scalability and replicability of localized interventions in which research has shown positive results. Replication, however, is a complex process requiring interrogation of the capacity of others, in other contexts, to reproduce the interventions. The nature of intervention projects will inevitably change when implemented elsewhere. While there is much to be learnt from local projects, national replication of research-based interventions, premised on partnerships between universities (or NGOs) and schools, is likely to be compromised by both geographical and capacity constraints. The inevitable transformation of discourse and “recontextualisation” (Bernstein, 1996) of local interventions when scaled up must be confronted.

Local projects, such as NICLE, are built on a set of principles, ways of working with teachers, and philosophical

assumptions about quality teaching and learning. “Replication” of such projects by a largely bureaucratically driven education department will likely lose the qualitative substance or intended function of the original locally responsive and non-hierarchical participatory intervention, and, as such, lead to different outcomes. Even without the challenges of “take up” by a bureaucratically driven department there is the challenge, as Thompson & Wiliam (2007, p. 3) identify, that unless “developers understand their own theory of action and the empirical basis on which it rests” and “the end users [teachers and learners too] [...] have a reasonably good idea of the why as well [...] quality at scale” is extraordinarily difficult to institute and maintain. Rather than scaling up, we should consider ways to expand the sphere of influence of our intervention projects, through partnering with provincial education officials, in ways that proactively communicate the theory of action underpinning our interventions and that identify and address the systemic and contextual impediments that will inevitably occur. In this respect, developing strong relationships and forums for communication between local intervention projects, teachers, district mathematics subject and phase specialist advisors, as well as provincial department of education officials, such as curriculum specialists, is a necessary step in enabling national interventions and localized interventions to both adapt to one another and to be transformed in ways that are responsive to the changing local and national landscape.

In the case of NICLE, we have developed increasingly productive working relationships with the two foundation phase district advisors (Eve and Thandi) and the provincial mathematics curriculum specialist (Lesedi, all pseudonyms). All three have participated actively in NICLE for several years. Eve participated from 2011 to 2013 and Thandi (who replaced Eve when she moved provinces) has been participating since 2013. Both Eve and Thandi have used a range of NICLE workshop resources for broader district work and both have developed collegial relationships with teachers through their joint engagement in NICLE workshops [2]. Such co-learning opportunities for teachers and district officials is important in enabling open communication. Lesedi, on the other hand, has been involved as a master’s research student and conducted her research on supporting grade 4 learners in an after school mathematics club. Her research participation led to her being approached to apply for the position of provincial mathematics curriculum specialist to which she was appointed in 2013. Lesedi has participated in several NICLE sessions (when departmental permission was granted for attendance and travel). She also presented two 2-hour NICLE sessions on her research on multiplicative reasoning and how teachers might implement “mathematics recovery” of multiplicative foundations in their teaching.

NICLE’s internet-based resources and the after school mathematics club resources are freely available online [5], enabling easy access for districts elsewhere. In 2014, Lesedi arranged an Eastern Cape workshop for district officials from 23 districts on how to run mathematics clubs based on our model and resources. This year, the Provincial directorate for General Education and Training Programs distributed some of our resources to 5,000 schools and

15,000 teachers. There is, therefore, much to be gained from expanding such clubs, and sharing our research-informed and trialed resources such as our mathematical games booklet and our take-home workbooks. Acknowledging that the nature of take-up will differ across contexts, I prefer to talk of the “share-ability” rather than scalability of the resources and projects.

Finding spaces in which teachers and district officials can engage and participate outside of the bureaucratic mandates of monitoring is, I believe, an essential first step in enabling the system to find better ways to respond to mathematics teachers’ needs and to enable transformation of the system informed by the grounded experiences of teachers. As Rose noted in her 2015 response on how the NICLE program could improve in future: “Education Department managers and subject heads could benefit from the same inspiration and support.”

Notes

[1] The projects form part of the South African Numeracy Chair Project (SANCP), based at Rhodes University in Grahamstown, Eastern Cape. The SANCP consists of me (the Chair) and a group of post-graduate primary school mathematics researchers working to improve primary school mathematics learning in partnership with schools in the area that cater for learners from predominantly low socio-economic status (SES) backgrounds.

[2] As reported in the End Term Evaluation Report for the South African Numeracy Chair Project, Rhodes University 2011-2015, conducted by Khulisa Management Services.

[3] The school year begins in January.

[4] The latter suggestion emerged when some club learners indicated fear at bringing their homework books to the club because they had a dirty mark or because a page had got slightly torn in their bag.

[5] www.ru.ac.za/sanc/

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The nice thing about numbers, from my point of view, is simply that it is very hard to think of them as having intrinsic natures, as having an essential core surrounded by a penumbra of accidental relationships. Numbers are an admirable example of something which it is difficult to describe in essentialist language.

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