RESEARCHING AND DOING PROFESSIONAL DEVELOPMENT USING A SHARED DISCURSIVE RESOURCE - A WMCS STORY

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The lead ‘actor’

Mathematical discourse in instruction (MDI): A socio-cultural framework for describing and studying/working on mathematics teaching

Object of learning

- Exemplification
  - Examples
- Explanatory Talk
  - Tasks
  - Naming
- Learner Participation
  - Legitimations

Mediational means
Cultural tools
Overview

- The South African mathematics education context and teachers’ work
- Learning from schools – initial research
- The overall framing of the WMCS project and emerging ‘shared’ discursive resource
- The project
  - Using the resource in and for PD
  - Operationalising this for research
- Some results and reflections
The context of WMCS

Wits Maths Connect Secondary (WMCS)
2010 – 2014 (5 years – phase 1)
Research and Development Chairs in Mathematics Education – 2009 – FRBank & DeptST, NRF

- To improve the quality of mathematics teaching at previously disadvantaged secondary schools
- To improve the mathematics results (pass rates and quality of passes) as a result of quality teaching
- To research sustainable and practical solutions to the mathematics crisis
- To develop research capacity in mathematics education
- To provide leadership and increase dialogue around solutions

Skovsmose – 2008
90% of the research in mathematics education is in service of 10% of the world’s children – typically in resourced environments
The South African education context - 2009

- High levels of poverty and enduring, deepening inequality
- The relationship between poverty and educational outcomes well known
- The OECD report (2013) argues that:

  Inequality in school performance in South Africa has been largely driven by the socioeconomic differences in parental background. Social Economic Status (SES) of parents is correlated with child test scores in all PISA countries, but the relationship appears to be stronger in South Africa. While parental SES explains about 13% of the variance in PISA test scores, it explains 22% when an index of school (rather than pupil) socio-economic composition is considered (p. 70).

Achievement gap
International phenomenon
(within and across countries)
Access for all - learning for some


Can a research informed professional development intervention

* Shift this curve?

* Thicken pipeline within the secondary school?
Socio-economic status is the strongest predictor of educational success in school (e.g. Coleman et al., 1966; Hoadley, 2010).

Recent studies ... argued that ‘achievement in countries with very low per capita incomes is more sensitive to the availability of school resources’ (e.g. Gamoran & Long, 2006, p. 1).

Social justice imperatives thus demand that we investigate what happens in schools and how practices might be changed in order to mediate greater education success of poor learners.
Teachers’ work depends on (assets):

- **Learners they teach**
  - academically prepared
  - physically healthy
  - homes a second site of acquisition

- **Curriculum**
  - well-specified

- **Resources in school**
  - Material
  - Academic

- **Functional management in the school**
  - Mediates bureaucratic demands
Dual economy of schooling in South Africa and teachers’ work

Three groups of teachers

- Teachers with access to all four in the top 20% schools
  - high achieving – predominantly middle class, urban, racially mixed

- Teacher with access to none – bottom 20%
  - Predominantly in poverty areas, rural, informal settlements, often dysfunctional

- Teachers with access to some – the 60% in the middle
  - Distributed across urban/rural; cities, townships, often underperforming, unstable

Dual economy – schools for the ‘rich’ and schools for the ‘poor’

WMCS schools
Working with schools and teachers

- Understanding that teachers were in the middle schools, unstable, with differing levels of low morale and poor “assets” and support in terms of conditions of work.

- Shalem & Hoadley … combination of demands make teachers’ work in schools for the poor “impossible”

- The professional development work with them must interact with this context.

- Increasing prescription, national testing, compliance.
The Project – what have we done?

Wits Maths Connect Secondary (WMCS)
2010 – 2014
The 10 project schools

- 5 no fee schools (township - large) and 5 low fee schools (‘suburban’ - smaller)
  - Shifting demography in post Apartheid South Africa

- All in the ‘middle band’ (National exams)
  - Unstable (with six ‘underperforming’ in 2010, ‘priority’ schools)
  - Mathematics (pass rates and averages low)

- Learners predominantly from townships

- Teachers (most qualified) diverse training and education backgrounds
NO FEE SCHOOLS
“Low” FEE PAYING SCHOOLS
Learning from/in the schools

- Diagnostic testing in schools – algebra
  - ‘Foundations’ unstable, even in later grades, absence of skill and meaning

- ‘Observation’ in schools/classrooms
  - ‘object’ out of focus – mathematics narrative incoherent
  - Dominant culture of ‘no learning without teaching’
  - Practices where learning only counts in the later grades
  - Underprepared teachers in some schools in early grades (8 and 9);

- Interactions with teachers over time
  - Discourses of “they can’t”

- Social, political, epistemological and psychological
PD in context
Our starting point on teaching

- Teaching has purpose – there is something to be learned … **object of learning** (concept, procedure or algorithm, metamathematical/practice)

- bringing that into focus is central to the work of teaching

- we privilege the development of scientific concepts – network, connected, systematically organised … generality and so enabling independent (re)production …
Socio-cultural framing: Mathematical discourse in instruction (MDI)

- Implicated in, but only a part of a set of practices and conditions that produce poor performance across our schools.

- Significance of talk in mathematics pedagogy.

- It matters deeply, how mathematical discourse in instruction supports (or not) mathematical learning.
Our intervention – the goal

- We set out to strengthen teachers’ relationship to mathematics, and through this shape their ‘discourse’, firstly in and for themselves, and then in their practice (PD)
  - Grade 9 – 10 critical transition point

- And then to be able describe whether and how this shifts over time, in what ways, and how this is related to what is made available to learn, and to learning gains (RESEARCH)
PD MODEL
Two ‘20 day courses’

- Critical transitions
  - Transition Maths 1: Gr 9 – 10
  - Transition Maths 2: Gr 11/12 – tertiary education)

- Focused on mathematics knowledge for teaching – (SMK/pck) – MDI – 75%

- Working on practice – maths teaching framework

Reversioned learning/ lesson study
In school learning/lesson study with a structuring discursive tool (MTF)

- Studying teaching together (plan, teach lessons …)
- Using a discursive resource
  - Maths Teaching Framework (MTF – MDI)
- Teachers teaching their own learners
- Other teachers observing
- 3-week block; 3 blocks in 2014; ‘curriculum’
- Clusters of schools

Boundary encounter
**Our discursive resource – Maths Teaching Framework**

## Object of learning: teaching x to y

<table>
<thead>
<tr>
<th>Examples and tasks</th>
<th>Explanation / talk</th>
<th>Learner participation</th>
</tr>
</thead>
</table>
| **What examples are used?**  
  - To start off the lesson  
  - To develop the lesson (these may be “examples of”)  
  - To introduce a concept  
  - To ask questions  
  - To explain further  
  - For learners to practise/consolidate (these are “examples for”)  | **What kinds of explanations are offered?**  
  - What (and why)  
  - How (and why)  | **What work do learners do?**  
  e.g. listening, answering questions, copying from the board, solving a problem, discussing their thinking with others, explaining their thinking to the class |
| **What are the associated tasks?**  
  - What are learners required to do with the example/s?  
  - How do these combine to build key concepts and skills?  | **What representations are used?**  
  - How do these help to build the key concepts and skills?  | **How does their activity help to build key concepts and skills?** |

**Coherence:** Are there coherent connections between the object of learning, examples, tasks and explanations?
Maths Teaching Framework – Focusing on explanations

<table>
<thead>
<tr>
<th>Object of learning</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What is written?</strong></td>
<td><strong>What is said?</strong></td>
</tr>
<tr>
<td>What does the teacher write (publicly) regarding the mathematical object?</td>
<td>Colloquial language</td>
</tr>
<tr>
<td>Colloquial language</td>
<td>Colloquial language</td>
</tr>
<tr>
<td>Everyday language</td>
<td>Everyday language</td>
</tr>
<tr>
<td>e.g. “taking x to the other side”</td>
<td>e.g. “taking x to the other side”</td>
</tr>
<tr>
<td>Ambiguous referents for objects</td>
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</tr>
<tr>
<td>e.g. this, that, thing</td>
<td>e.g. this, that, thing</td>
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<tr>
<td>Learner activity</td>
<td>Non-mathematical cues</td>
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<tr>
<td></td>
<td>Colloquial language</td>
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<td></td>
<td>Everyday language</td>
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<tr>
<td></td>
<td>e.g. this, that, thing</td>
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<tr>
<td></td>
<td>Some mathematical language</td>
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<tr>
<td>to name object, component</td>
<td>Some mathematical language</td>
</tr>
<tr>
<td>e.g. factor, parabola, derivative</td>
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</tr>
<tr>
<td>Reading a string of symbols</td>
<td>Reading a string of symbols</td>
</tr>
<tr>
<td>e.g. “x into x plus 2”,</td>
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</tbody>
</table>

Examples and tasks:
- Words, phrases, sentences
- Terminology and expressions
- Graphs, illustrations, figures
- Definitions
- Procedures
- Solutions
- Proofs
Deepening teachers’ mathematical knowledge of functions
- domain, range, discontinuities, asymptotes

Preparing to teach the lab class: Gr 10 functions
- Selections of examples / tasks
- Anticipating learners’ responses
- Planning follow up prompts, examples, explanations

Key tasks
The product of 2 numbers is 12
The sum of 2 numbers is 12

Our maths teaching framework

Object of learning - teaching x to y

<table>
<thead>
<tr>
<th>Examples and representations</th>
<th>Explanations and questions</th>
<th>Learner activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>What examples and representations are used?</td>
<td>What kinds of explanations (and related questions) are used?</td>
<td>What work do learners do?</td>
</tr>
<tr>
<td>- At the start of the lesson</td>
<td>- What?</td>
<td>e.g., listening, answering questions, copying from the board, solving a problem, discussing their thinking with others, explaining their thinking to the class</td>
</tr>
<tr>
<td>- In the development of the lesson</td>
<td>- How?</td>
<td>How do these help to build the key conceptual skills?</td>
</tr>
<tr>
<td>- For introducing a concept</td>
<td>- Why?</td>
<td></td>
</tr>
<tr>
<td>- For questioning</td>
<td>- When?</td>
<td></td>
</tr>
<tr>
<td>- For further explanation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reflecting on the lab lesson
- Examples & representations
- Explanations & questions
- Learner activity

We teach lab class on campus, teachers observe
From PD and so working on mathematics and teaching (and discursive resource) to Researching teaching (and so analytic device)
Our framing

Mathematical discourse in instruction (MDI): A socio-cultural framework for describing and studying/working on mathematics teaching

- Exemplification
  - Examples
- Explanatory Talk
  - Tasks
  - Naming
- Learner Participation
  - Legitimations

Mediational means
Cultural tools
Research

Previous work on language and then on the constitution of mathematics (enacted) in mathematics teacher education

Analytic unit – evaluative event (Davis, 2005; Adler & Davis, 2006; 2011) – the centrality of signifiers, how these are ‘filled out’ i.e. named, and what comes to be legitimated as mathematics.

Practice

the educational ‘ground’ met in 2009 – 2010 in secondary mathematics classrooms in SA – social practices
Teaching/learning in time and over time

- Unit of analysis – mathematical event
- Analysis of the elements in each event and as these accumulate across events over time (temporal unfolding of the lesson)

Adler, J. and Venkat, H. (2014); Teachers’ mathematical discourse in instruction (MDI): Focus on examples and explanations. (Book chapter)


Adler & Ronda (forthcoming) Framework for MDI and describing shifts in practice
Data production

<table>
<thead>
<tr>
<th>Events</th>
<th>Exs</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Meaning of a Term</td>
<td>S, C, U</td>
<td>K</td>
</tr>
<tr>
<td>2 – Meaning of common factor</td>
<td>NA</td>
<td>K</td>
</tr>
<tr>
<td>3 – Simplify algebraic fraction</td>
<td>S, C, U</td>
<td>A - K</td>
</tr>
<tr>
<td>4 - Divide algebraic fractions (+)</td>
<td>S, U</td>
<td>A - K</td>
</tr>
<tr>
<td>5 – Extension to (-) coefficients</td>
<td>S, U</td>
<td>A - K</td>
</tr>
<tr>
<td>Cumulative Code</td>
<td>L3</td>
<td>L2- L1</td>
</tr>
</tbody>
</table>

Teacher A: Lesson X, Year Y

Codes – language of description – derived through interaction between theoretical and empirical fields
<table>
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<tr>
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<td><strong>Examples</strong></td>
<td><strong>Tasks</strong></td>
<td><strong>Naming</strong></td>
<td><strong>Legitimating criteria</strong></td>
</tr>
<tr>
<td>Examples provide opportunities within an event or across events in a lesson for learners to experience variation in terms of similarity (S), contrast (C), simultaneity (U)</td>
<td>Across the lesson, learners are required to: <em>Carry out known operations and procedures (K) e.g. multiply, factorise, solve; Apply known skills, and/or decide on operation and/or procedure to use (A)</em> e.g. Compare/ classify/ match representations; <em>Use multiple concepts and make multiple connections. (C/PS)</em> e.g. Solve problems in different ways; use multiple representations; pose problems; prove; reason etc</td>
<td>Within and across events word use is: <em>Colloquial (NM) e.g. everyday language and/or ambiguous referents such as this, that, thing, to refer to signifiers Math words used as name only (Ms) e.g. to read string of symbols Mathematical language used appropriately (Ma) to refer to signifiers and procedures</em></td>
<td>Legitimating criteria: <em>Non mathematical (NM) Visual (V) – e.g. cues are iconic or mnemonic Positional (P) – e.g. a statement or assertion, typically by the teacher, as if ‘fact’. Everyday (E)</em></td>
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Examples provide opportunities within an event or across events in a lesson for learners to experience variation in terms of *similarity (S)*, *contrast (C)*, and *simultaneity (U)*.

### Table: Exemplification

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<td>Examples</td>
<td></td>
<td>Naming</td>
<td>Legitimating criteria</td>
</tr>
<tr>
<td>Examples provide opportunities within an event or across events in a lesson for learners to experience variation in terms of <em>similarity (S)</em>, <em>contrast (C)</em>, <em>simultaneity (U)</em></td>
<td>Analyse, interpret, represent; pose problems; prove; reason etc</td>
<td>signifiers and procedures; generalization; principles, structures, properties; and these can be partial (GP) or ‘full’ (GF)</td>
<td>Building generality (connections)</td>
</tr>
</tbody>
</table>
### Object of learning

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**Movement between colloquial, informal and formal word use**

- **Colloquial (NM)** e.g. everyday language and/or ambiguous referents such as this, that, thing, to refer to signifiers
- **Math words used as name only (Ms)** e.g. to read string of symbols
- **Mathematical language used appropriately (Ma)** to refer to signifiers and procedures

Within and across events word use is:
Within and across events legitimating criteria are:

**Non mathematical (NM)**
Visual (V) – e.g. cues are iconic or mnemonic
Positional (P) – e.g. a statement or assertion, typically by the teacher, as if ‘fact’.
Everyday (E)

**Mathematical criteria:**
Local (L) e.g. a specific or single case (real-life or math), established shortcut, or convention
General (G) equivalent representation, definition, previously established generalization;
principles, structures, properties; and these can be partial (GP) or ‘full’ (GF)

<table>
<thead>
<tr>
<th>Exemplification</th>
<th>Explanatory talk</th>
<th>Legitimating criteria</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Learners answer: yes/no questions or offer single words to the teacher’s unfinished sentence Y/N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Legitimating criteria: Non mathematical (NM) Visual (V) – e.g. cues are iconic or mnemonic Positional (P) – e.g. a statement or assertion, typically by the teacher, as if ‘fact’. Everyday (E)</td>
<td>Learners answer (what/ how) questions in phrases/ sentences (P/S)</td>
</tr>
<tr>
<td>Movement between, and towards mathematical principled criteria</td>
<td></td>
<td></td>
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Movement between, and towards mathematical principled criteria
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</tr>
<tr>
<td><strong>Examples</strong></td>
<td><strong>Tasks</strong></td>
</tr>
<tr>
<td>Level 1 - S OR C</td>
<td>Level 1 – K only</td>
</tr>
<tr>
<td>Level 2 - S AND C</td>
<td>Level 2 – K and/or some application A</td>
</tr>
<tr>
<td>Level 3 - U</td>
<td>Level 3 – K and/or A and C/PS</td>
</tr>
<tr>
<td>Level 0 - simultaneous variation with no attention to similarity and/or contrast with respect to aspects of the concept/procedure, and thus limits to bringing generality into focus,</td>
<td>Level 2 – A – K or C/PS – K is assigned to tasks set up at level 2 or 3 but then reduced to 1 when it unfolds.</td>
</tr>
<tr>
<td>Exemplification</td>
<td>Explanatory talk</td>
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<tr>
<td><strong>Examples</strong></td>
<td></td>
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<td>Level 1- S OR C</td>
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<td>Level 3- U</td>
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<tr>
<td>Level 0 -</td>
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<td></td>
</tr>
</tbody>
</table>
Lead actor - ‘boundary object’

- artifacts based on a range of larger and more localized research findings, and designed specifically for trialing in the overlapping ‘boundary’ region of the communities of research and classroom practice

- ‘objects that are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual site use.’ (Star & Griesemer, 1989, p.393)
Why view this as a boundary object?

- Interpretation, rather than ‘adoption’ of tools viewed as the norm
- Need to take contextual affordances and constraints into account
- Gain insights into the range of ways in which interventions come to being in practice
SOME IMPORTANT RESULTS
More learners are obtaining A, B and C-symbols in Grade 12 Mathematics. More careful selection of learners for Mathematics has substantially reduced the numbers scoring below 30%.
Learning gains

Investigating learning gains in relation to teachers’ participation in professional development courses

Intervention group and control group of teachers

Pre- and post-test with 800 Grade 10 learners in 5 project schools over 1 year

Learners taught by teachers who had completed a TM course made **bigger gains** than those taught by teachers who had not participated in a TM course. These learners had a **lower average pre-test score** than the control group but a **higher average post-test score**.
Teachers’ learning - mathematics

### Improvement
- Selection and sequencing of examples
- Naming of signifiers

### Less change
- Nature of the tasks
- Reasoning by principle

<table>
<thead>
<tr>
<th>Course, year</th>
<th>Registered</th>
<th>Completion</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM 1 2012</td>
<td>21</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>TM 1 2013</td>
<td>15</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>TM 2 2012-13</td>
<td>15</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>TM 2 2014</td>
<td>21</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>

Teachers’ MDI - pre and post video data TM1

- 60% TM1
- 65% TM2
Content illumination through exemplification in general and example sets in particular is productive across pedagogies and so across varying contexts and practices.

With explanatory talk, MDI framework allows for an attenuated description of practice, prising apart parts of a lesson that in practice are inextricably interconnected, and how each of these contribute overall to what is made available to learn.

It provides for comprehensive, yet responsive and responsible description.
Limitations — as with any framework

- Learner participation and tasks – combine?
- ‘Naming’ restrictive pointing to word use — a function of how language is at work in multilingual classrooms. This too could be developed further (e.g. positioning).
- Our concern has been to build an analytic concepts with practical appeal, operationalized so as to improve description of practice and relevant elements towards progress.
- Generality in our field... proliferation of frameworks?
Research and development

Shared discursive resource

in the margins?
THANK YOU!

KE A LEOGA!
NGIYABONGA!

DANKIE!

!