Examples, explanations and learner engagement as a framework for research and professional development

1 January 2013

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Overview

- Set context
- Describe project: PD and research
- Describe artefact – boundary object
- Look at its use
  - In PD
  - In research
- Concluding comments

Professional development is a social practice located in time and place neither ahistorical nor decontextualised

- Socio-econom... ...earch
  political...

Circulating discourses

- lo... ...South Africa and a point in the co... educ... wit... re...
- ...ingful learning
- ...nal learning ...ities

Socio economic conditions

- global perform... intern... ass...

‘New’ technologies

University of the Witwatersrand, Johannesburg

wits maths connect
supporting secondary maths

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Wits Maths Connect (secondary)

- Research and development ‘Chairs’
- Located in the university and National Research Foundation
- Private-public funding
- Improve teaching and learning of mathematics in ten schools in one district

- Shifting the performance curve – negligible high performance, predominance of mathematics failure or very low ‘pass’

- *Strengthening the pipeline within the ten secondary schools and from school into tertiary education sector – working at the key transition points (Gr 9 to 10; Gr 12 into tertiary)*

- *Excellence – equity agenda (social fabric)*
- *Explicit agenda to work ‘on’ the boundary and between research and development*
- ***research led development led research***

A note:

In selecting to describe and inter-relate these two domains of practice in the project in this talk, will work to motivate and show the relation

As a result I might not do full justice to either

The project - WMCS

The professional development

(previous research and local evidence)

- Teachers' mathematical judgment
  - Examples
  - Explanations
  - Learner activity
    - Video records
- In third year – initiated 'professional courses'
- MKT with emphasis on SMK

The research

(base line data – learner diagnostic tests; teacher interviews, observations)

- Teachers' mathematical discourse in instruction
  - Examples
  - Explanations (accompanying narrative)
    - Common places in teaching
- Teacher biographies, identities, and smk
- Learning gains

Teacher’s mathematical discourse in instruction

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

- In our schools, learners’ access to a set of resources – the means through which they can participate in mathematical discourse (i.e. learn) - is largely through the teacher

- It matters deeply, how teachers’ mathematical **discourse** in instruction supports (or not) mathematical learning

- We want to be able to describe whether and how this shifts over time, in what ways, and how related to what is made available to learn

The emerging artefact

<table>
<tr><td colspan="3">Object of learning (teaching x to y)</td></tr>
<tr><td>Examples
(examples/representations)</td><td>Explanations
(questions, explanations)</td><td>Learner activity
(talking, writing, listening..)</td></tr>
<tr><td>What examples were used
• At the start of the lesson
• For questioning
• For further explanation?

How did these help build the key concepts and skills?</td><td>What kind of explanations (related questions) were used?
• What; How; Why; When?

How did these help ….</td><td>What work did the 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?

How did these help ….</td></tr>
<tr><td colspan="3">Are the object of learning, examples and explanations elements coherently connected?
What do you think about the sequencing of examples & explanations in relation to learner engagements?
Can you see instances where an explanation helps to move a learner’s thinking forward?</td></tr>
</table>

The artefact in professional development

Working on records of practice with discursive resources (tools to talk/think/reflect with)

- Lab lesson(s) e.g.
  - A function as relation between input and output
    - Two numbers multiplied give me 12 – what are the numbers?
    - Two numbers added give me 12?
- Teacher's own video
- Other selected video clips

And in research?

- Analysing teachers' mathematical discourse in instruction
- Operationalised through 'example space' and 'representations and legitimations'
- And the latter further using Sfard's elaboration of discourse (words, routines and endorsing narratives)

Research questions

- What examples does the teacher select and use? How do these (following Rowland) attend to variables, sequences, representations and the objective of the lesson
- What explanations (as observable, following Sfard, in words that provide elaborations and/or substantiation of narratives) accompany examples in use in school mathematics?

Examples and example spaces

Rowland – 2008 "Empirical paper" emerging from the knowledge quartet and the code – "choice of examples" – constructs "analytic" resources for engaging with choosing and using examples

- Examples of - particular cases of generality; to provoke or facilitate abstraction
- Examples for (exercises) practice-oriented

Taking account of variance and invariance in components
Taking account of sequencing
Taking account of representations
Taking account of learning objectives

Explanations accompanying examples

- Evidence in SA and (supported by our observations) that MDI largely procedural; AND poor pacing and progression (towards specialised content); but also disconnected

- Literature on instructional explanations – Leinhardt (e.g. 1997) pertinent ("… social … local in time and place … reflect rules of communication and the rules of the discipline … the colloquial and familiar, as well as … intermediate and abstract …)

- Not clearly operationalised

Sfard

Substantiations of mathematics in schools ‘much less exacting’ and ‘qualitatively different’

Narratives in school mathematics involve substantiations that move between more colloquial (often empirical) and literate (discourse specific substantiation procedures)

The work of the teacher is to ‘narrow the gap’ between the colloquial and the specialised.

In multilingual classrooms in ‘poor’ schooling contexts, demands on the teacher are considerable.

Mathematical discourse

- Word use, mediators, endorsed narratives

Combine in any discourse with

- Routines
  – repetitive patterns, regularities

- ***Rituals*** (talk about actions on symbols and their features, highly situated) and ***explorations*** (talk about objects)

- ***Our question: If opportunity to learn maths a function of teachers' MDI, then how ritualised?***

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A lesson

Selected because

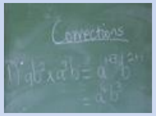
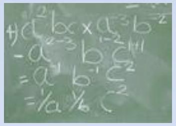
- More interactive than most, well qualified teacher, more ‘functional’ school (30+ in class)
- Gr 9 – ***product of algebraic expressions*** **-** transition point

Selected to

- Illustrate analytic frame in use
- Illuminate our interest in ‘bringing the object of learning into focus’

<table>
<tr><th colspan="2">Lesson overview: Homework, new work, exercises</th></tr>
<tr><td colspan="2">Unit of analysis: representation and its discursive elaboration
Episodes: marked by ‘next example’ or another represention</td></tr>
<tr><td>Episodes (example set)</td><td>Interactional pattern</td></tr>
<tr><td>Episodes 1 – 4, all under the heading “corrections”

Each focused on one example for homework
1. $ab^2 \times a^3b$ =
2. $ab^2 \times ac \times 2a^3b$ =
3. $ab \times ab \times ab$ =
4. $a^2bc \times a^{-3}b^{-2} \times c$ =</td><td>Checking homework proceeds with a learner writing a solution to Example 1 on the board while the teacher circulates in the class checking homework. She then comes to the board and together with the class considers/ratifies/corrects the learner solution. This routine is repeated across the four examples.

“Exponents – Laws” (on the board)

</td></tr>
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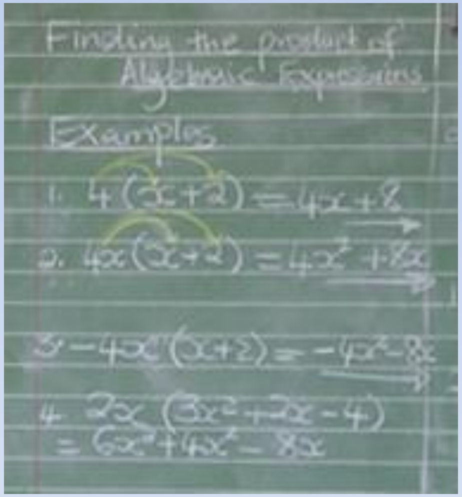
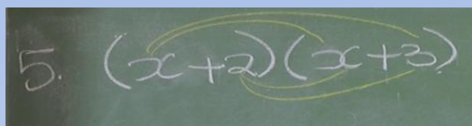
Episodes (example set)	Learner Interactional patterns
Episodes 5 – 8 **under the heading above, sub-heading “Examples”.** *5.* $4\,(x + 2) =$ *6.* $4x\,(x + 2) =$ $sub - episodes$: $6.1\ \ 4x \times x = 4x^2$ 6.2 Compares 5 and 6 *7.* $-4x\,(x + 2) =$ *8.* $2x\,(3x^2 + 2x - 4) =$ *9.* $(x+2)(x+3) =$	Finding the product of algebraic expressions started as ‘New’ topic - whole class instruction IRF format, some chorusing AND learners agreeing and disagreeing with each other, with an expectation that they explain ‘why’ they disagree 

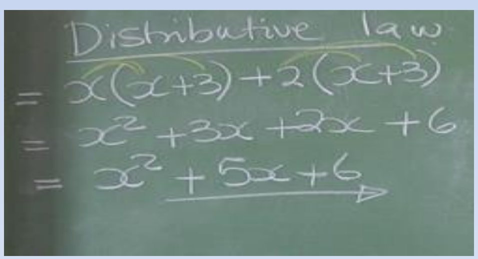
<table>
<tr><th>Episodes (example set)</th><th>Learner Interactional patterns</th></tr>
<tr><td>

Episode 9

$$(x+2)(x+3) =$$



This example is now marked as requiring a new method – the distributive law



</td><td>

Learners guess how “to do” this “different” example ….
One learner offers: you multiple x with x and x with 3 and then 2 with x and 2 with 3 …. …; lesson continues with teacher describing the steps for the new method, which some learners can be heard saying “its too long”, and class activity follows:

</td></tr>
</table>

The example space

Range of example and pace marks lesson out

- 9 examples in whole class setting (examples of …) + 7 class activity (examples for …)
- attention to variance and sequencing
- all representations are symbolic
- Objective of lesson? products presented discretely as "exponents", "multiplying expressions" and the "distributive law".

Thus, while the example set has some variance, and is sequenced with progression in the terms being multiplied, the narrative is disconnected – presenting products of expressions as associated with three different rules of operation.

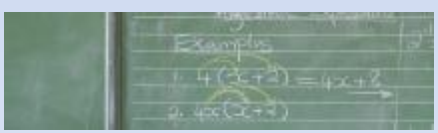
Discursive analysis

Episode 5 $4(x+2)$

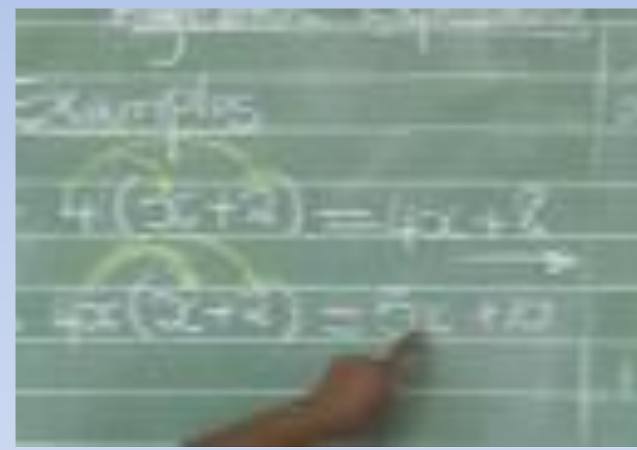
“we multiply each and every term inside the bracket by 4”

“we can’t add 4x and 8 because 8 does not have the variable of x”

“not like terms”



Episode 6 $4x(x+2)$



We pick up the episode after one learner offers *"it will be four x to the power of 2 … (revoiced) plus eight x …", and T asks if the class agrees …*

T	**Ok L5, why do you disagree**	
L5	Coz the two doesn't have a variable	
Ls	No, no	The teacher restates L4's idea and points to the 2 (in (x + 2) and the 8x in the line below on the board.
T	That's a very good point. He is saying the 2 does not have a variable, but suddenly 8x has a variable	
L6	I think it's because 4x, 4 has a variable of x so when we multiplied 4x we got our answer which is 8x	
T	Ok, that's very good. …because remember <u>we are multiplying each and every term inside the brackets by?</u> (chorus '4x')	She explains and points to the terms in the bracket (x + 2)
T	And x, 4x carries a? (chorus 'variable)	Points to the 4x
T explains again that $4x \times x = 4x^2$, reminding learners again of their homework tasks		
T	<u>That is why we did the exponents. So when you multiply the variable you know what to do with the exponents</u>. Ok any other question on this one? Can we go further?	she underlines $4x^2 + 8x$, and again asks if "we can go further"
Ls	Yes/No	Again there is disagreement
L8	Yes we can. Madam 4 plus 8 which is gonna be twelve, twelve x to the power two plus one.	L7 also tries to answer, gestures with her fingers, other learners talking
T	You are saying this will be?	
L8+ T	$12x^{2+1}$	[teacher writes on the board $12x^{2+1}$ as the learner talks]
T	Ok what is the class saying?	
Ls	Disagree	
T	You cannot just disagree we, you have to explain what you disagree with... L9?	
Following some interaction to finalise the product, L11 articulates $8x^2 + 4x$, as follows		
L11	Madam, if we have 4x to the power of 2 we can't add it with 8x because 8x doesn't have x^2	

Recurring narratives …

- We multiply each and every term inside the bracket by … some generality
- Accompanying visual illustration
- Numbers ‘have’ or ‘carry variables’ – confusion …. rule has to change as term ‘outside’ changes

- All cues visual, perceptual, how things ‘look’, and actions on objects ….
- Co-produced and revoiced by teacher

- Ritualised routines dominate, substantiations reliant on perceptual features ….

Example space and substantiations

- Potential in the example space, but notice discontinuity in the narrative with respect to products of expressions and the distributive law

- Discursive analysis of teacher's MDI, while only a few episodes, illustrative of wider practice(s), rituals dominate, opportunity to learn restricted to imitation and memory

Concluding comments

- Illuminated what and how of MDI - NOT why
- Suggested in introduction – complex conditions and prevailing discourses at work - reinforced by analysis of dominant textbook – disappearing ‘object’.
- Hence our focus in WMCS – bringing the object of learning into focus
- Potential of boundary object for working ‘on’ the boundary and across practices – and ‘impacting teacher knowledge and practice.