The Wits Maths Connect Secondary research and development project: some processes, results, outputs, reflections

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2009 – Call for proposals

Research and Development Chairs in Mathematics Education

- 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 and learning**
- 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

BRIDGING PRACTICES

Skovsmose – 2008
90% of the research in mathematics education is in service of 10% of the world's children – typically in resourced environments

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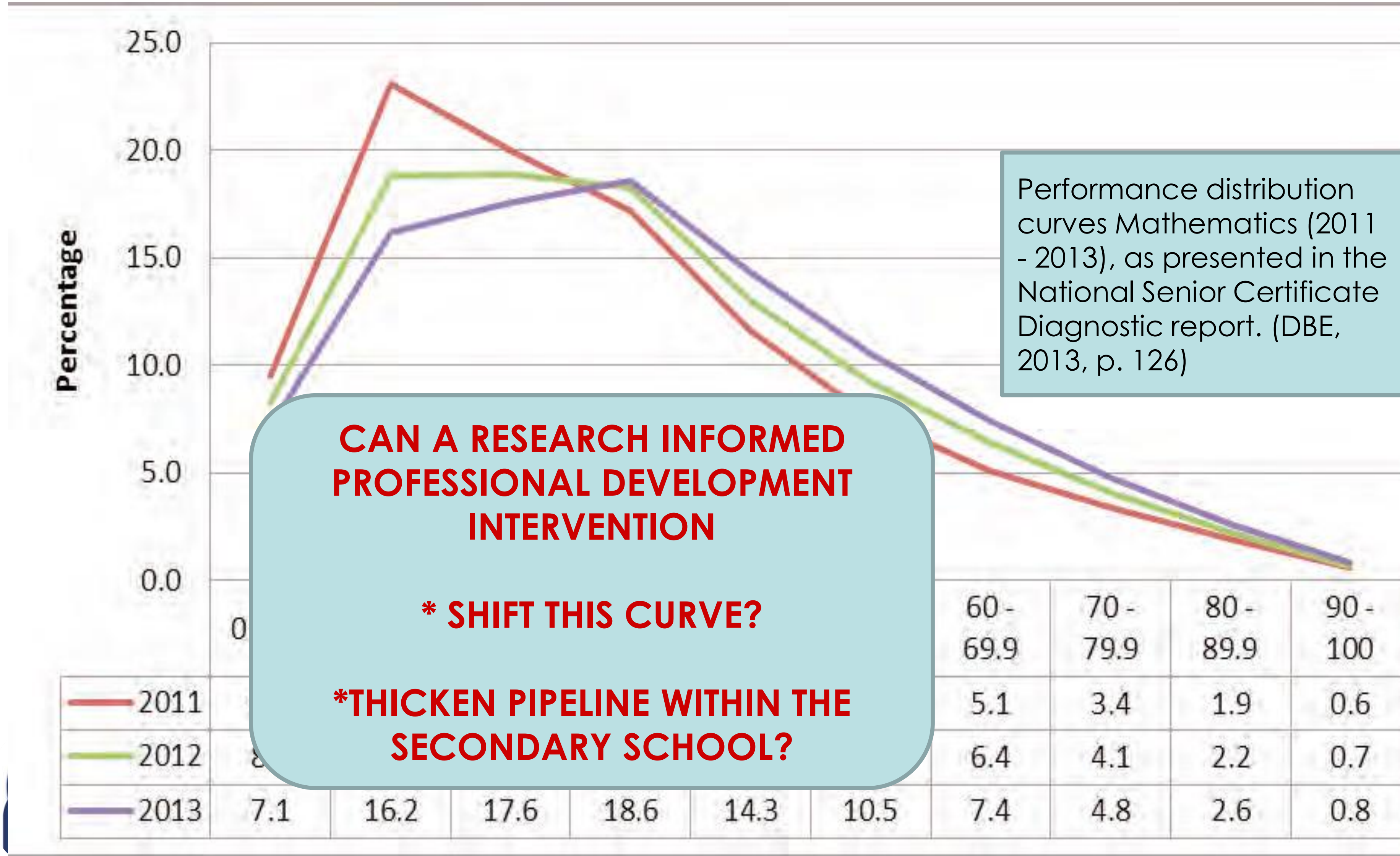
Access for all - learning for some



Performance distribution curves Mathematics (2011 - 2013), as presented in the National Senior Certificate Diagnostic report. (DBE, 2013, p. 126)

CAN A RESEARCH INFORMED PROFESSIONAL DEVELOPMENT INTERVENTION

*** SHIFT THIS CURVE?**

***THICKEN PIPELINE WITHIN THE SECONDARY SCHOOL?**

There is compelling evidence that **socio-economic status is the strongest predictor of educational success in school** (e.g. Coleman et al, 1966; Hoadley, 2010). This, however, does not mean that quality differentials in schooling do not matter. Indeed, recent studies of quality within schools have 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.**

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Important results

“the spine”

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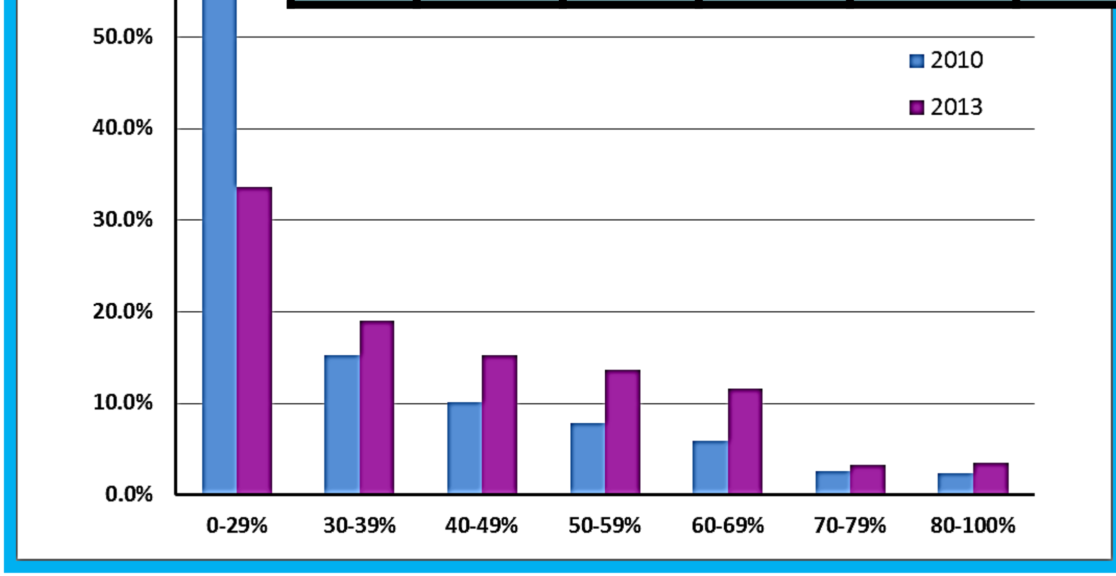
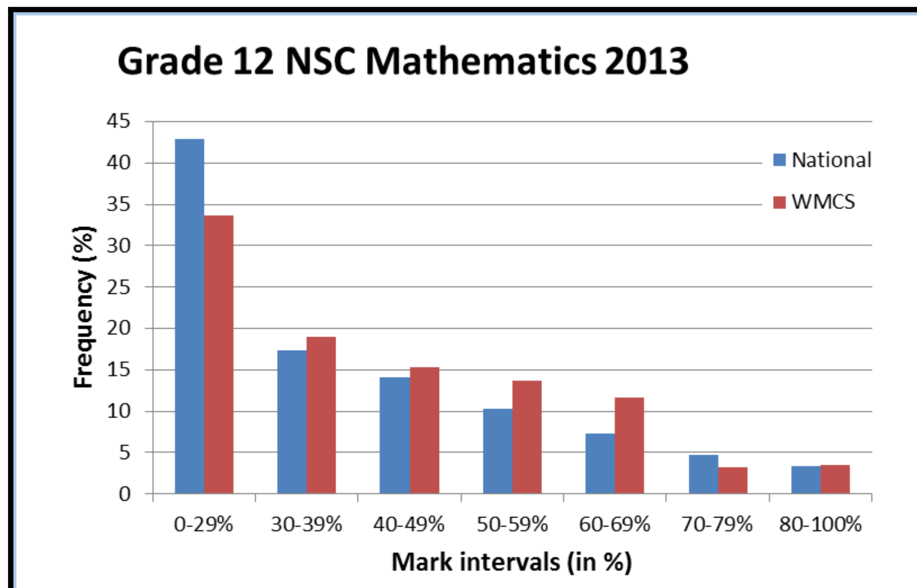
No. of A, B, C symbols				% A, B, C symbols			
2010	2011	2012	2013	2010	2011	2012	2013
79	50	74	90	10.9%	8.6%	13.3%	18.4%



NSC results Shifting the curve

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%.



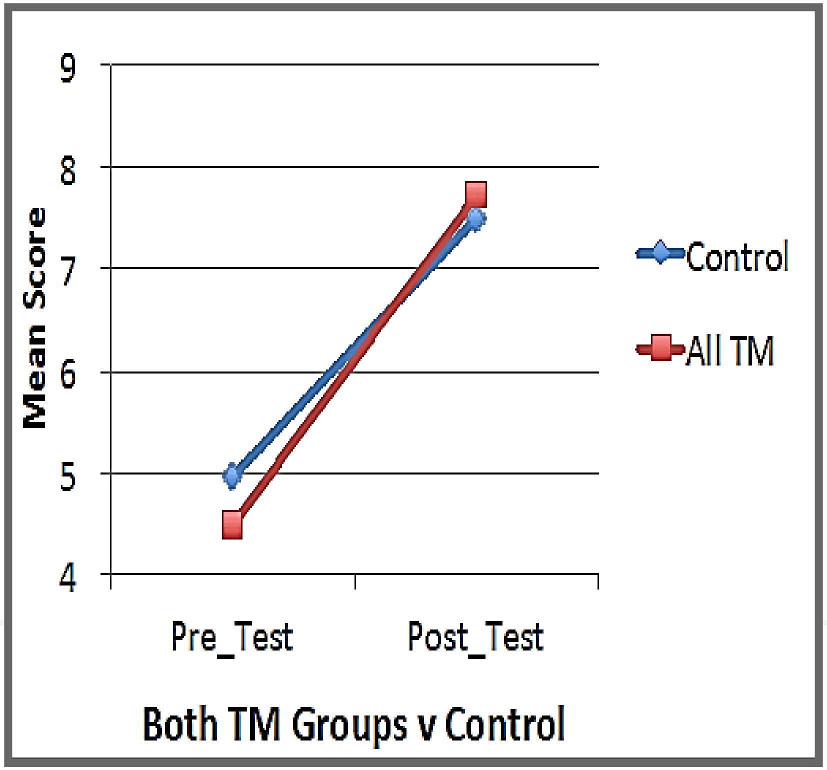
Learning gains

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

Course, year	Registered	Completion	Success
TM 1 2012	21	18	10
TM 1 2013	15	10	9
TM 2 2012-13	15	11	9
TM 2 2014	21	17	

Teachers' MDI – mediation of the object of learning

	Exemplification				Explanatory talk				Engagement	
	Examples		Tasks		Naming		Legitimating		Learner partic	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
T1	L1	L3	L2-L1	L2-L1	L2	L4	L1	L2	L1	L1
T2	L3	L3	L2	L1	L2	L2	L1	L3	L1	L2
T3	L3	L3	L2-L1	L2-L1	L3	L2	L3	L3	L2	L1*
T4	L1	L3	L1	L2-L1	L1	L3	L2	L2	L1	L2
T5	L1	L3	L2-L1	L3	L3	L4	L2	L3	L2	L3

PD itself

- Learning study – examples (Pillay)
- Model – object focused PD (Moalosi)

Teachers/teaching

- Textbook use (relationship)(Leshota)
- Recontextualising explanation (Luxomo)
- Smk/pck interview scenarios (Patahuddin)
- Identity (Kambule)

Learners/learning

- Functions discourse (Essack)
- Algebra (test items and interviews)
- Identity (Otulaja)

Qualitative studies/stories

Outputs

Development

- Model of PD and materials
- Teachers and teacher educators
- Schools
- Learners

Research

- Publications
- Graduate students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Teacher's 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 teachers' mathematical **discourse** in instruction supports (or not) mathematical learning

Our starting point on teaching

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

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

- we privilege the development of scientific concepts, including movement towards objectification in mathematics discourse.

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)**
  - Not only FET – 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)**

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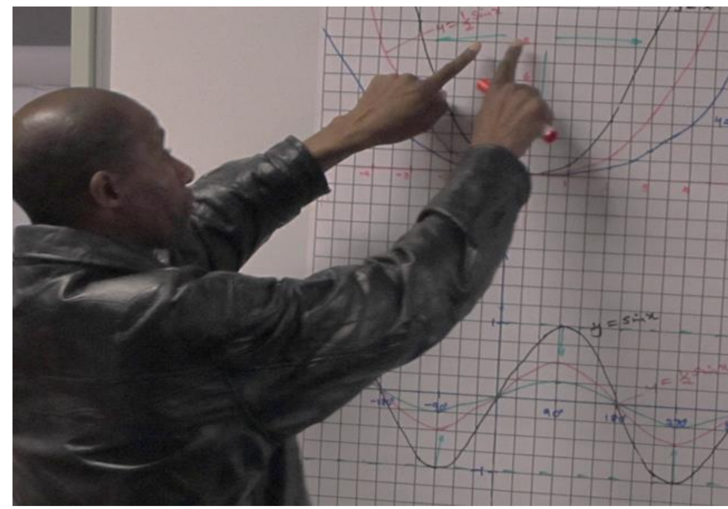
The model

- **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
  - Working on practice – maths teaching framework



- **Reversioned learning/lesson study’**

Key operating principles

- Participation as joint commitment and enterprise of the school, individual teachers and the project (and so the University).
- 20 days – 8 X 2 days at Wits (Release from school on 10 days; 6 days teacher's time); 4 days equivalent support in school
- Time for teachers to work at their mathematics and teaching over time, and between sessions
- Resources for the school … supporting 'successful participation' of the teachers (funds, technology).
- Potential for 'spreading out' - lean and so "cost effective"

Transition Maths courses

Transition Maths 1

- Grade 9/10 teachers
- Maths content: **algebra, functions,** geometry and trigonometry
- Teaching content: exemplifying, explaining, learner engagement
- Technology – for mathematising (geogebra), information access and communication

Curve and pipeline …

More learners better prepared for Grade 10, more teachers available for FET

Transition Maths 2

- Grade 11/12 teachers
- Maths content: **algebra, functions, calculus,** geometry and trigonometry
- Teaching content: exemplification, explaining, learner engagement.
- Technology

Curve and pipeline …

More As Bs and Cs. Increase cognitive demand, increasing pace and coverage

In school learning/lesson study with a structuring framework (MTF)

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

Our discursive resource – Maths Teaching Framework v1

<table>
<tr><th colspan="3">Object of learning : teaching x to y</th></tr>
<tr><th>Examples and tasks</th><th>Explanations and talk</th><th>Learner activity</th></tr>
<tr>
<td>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 are the associated tasks?
• What are learners required to do with the example/s?

➢ How do these combine to build key concepts and skills?</td>
<td>What kinds of explanations are offered?
• What (and why)
• How (and why)

• What representations are used?

➢ How do these help to build the key concepts and skills?</td>
<td>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

➢ How does their activity help to build key concepts and skills?</td>
</tr>
<tr><td colspan="3">Coherence: Are there coherent connections between the object of learning, examples, tasks and explanations?</td></tr>
</table>

Week 1

Design lesson

Decide on:

- Mathematical focus
- Examples & tasks
- Learner acti
- Key explana
- Representat
- Who will te

Week 2

Teach and reflect

- Teacher A teaches lesson to group A
- Other teachers

Questions to reflect on

What was said?

What was written?

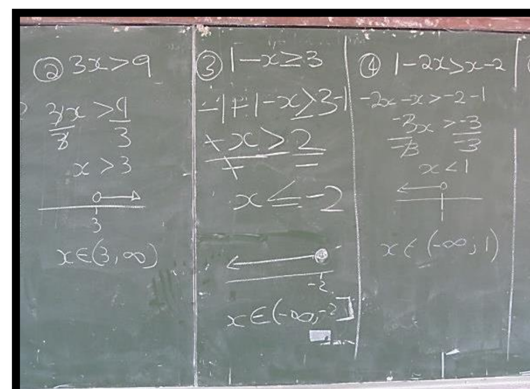
How was it justified?

Did they learn what we intended?

Week 3

Teach and reflect

- Teacher B teaches lesson to group B
- Other teachers observe
- All reflect on lesson in relation to MTF tool
- Revise aspects of lesson



From PD and so working on mathematics and teaching (and discursive resource)

to

Researching teaching (and so analytic device)

Our framing

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

With discursive (Sfard, 2008) and sociological (Bernstein, 1996) influences; and analytic resources recruited from variation theory (Marton et al, 2004)

Teachers MDI – mediation towards scientific concepts		
Object of learning		
Exemplification	**Explanatory talk**	**Learner engagement**

Operationalising for research

Object of learning – mediation towards scientific concepts				
Exemplification		**Explanatory talk**		**Learner engagement**
Examples	**Tasks**	**Naming**	**Legitimating**	
Examples provide opportunities within lesson for learners to experience **Level 1-** contrast or generalization **Level 2-** contrast and generalization **Level 3-** fusion	**Level 1 –** *Carry out known operations and procedures* e.g. multiply, factorise, solve equation if these had been taught previously **Level 2 –** Apply level 1 skills;& learners have to decide on (explain choice of) operation and /or procedure to use e.g. Compare/ match representations, classify, …; also includes tasks about the current lesson **Level 3 –** *Multiple concepts and connections.* e.g. Solve problems in different ways; use multiple representations; pose/construct problems; prove disprove; explain reasoning, etc	**Level 1 NM** (Non-Math) *Colloquial language* – everyday language and/or ambiguous referents such as 'this', 'it', 'that', 'thing' are used to refer to signifiers. **Level 2 M** (Math) *Some mathematical language* to refer to signifiers, or to read a string of symbols **Level 3 M** – *Appropriate mathematical language* used to refer to signifiers, procedures.	**Level 1NM** (Non- Math) *Visual:* Visual cues or mnemonics *Metaphor:* Relates to features or characteristics of real objects *Positional:* Statement or assertion (typically by teacher) as if 'fact' (Authority lies in how things look or sound; in everyday; or in the position of the teacher) **Level 1M** (Math) - *Local Specific* /single case (real-life application or purely mathematical); Established shortcuts; conventions **Level 2M** (*General, partial*) Equivalent representations, definitions, previously established generalization but explanation unclear or incomplete, principles, structures, properties but unclear/partial **Level 3M** (*General full*)	**Level 1** –Learners answer *yes/no questions or offer single words* to teacher's unfinished sentence **Level 2** –Learners answer (what/ how) questions in phrases/sentences **Level 3-** Learners answer why questions; present ideas in/for discussion

Teacher 3 – township school

2012

OoL: Simplifying exponential expressions	Examples	Tasks	Naming	Legitimations	Learner Participation
H: Laws of Exponents	L1	L1	L3	NA	L1
Simplifying expo. expressions	L3	L2-L1	L3	L3	L2
Practice: Simplifying. expo.	NA	L2-L1	L2	L2	L2

2013

OoL: Simplifying Algebraic Fractions	Examples	Tasks	Naming	Legitimations	Learner Participation
Defn. term and factor	L3	L1	L3	L3	L1
Simplifying alg. fraction	L2	L2-L1	L2	L3	L1
Division of alg. fraction	L3	L2-L1	L2	L3	L1
Equiv. expression with neg. expo.	L2	L2-L1	L2	L2	L1

MDI: Summary

	Examples		Tasks		Naming		Legitimation		Lear. Part.	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
T1	L1	L3	L2-L1	L2-L1	L2	L4	L1	L2	L1	L1
T2	L3	L3	L2	L1	L2	L2	L1	L3	L1	L2
T3	L3	L3	L2-L1	L2-L1	L3	L2	L3	L3	L2	L1*
T4	L1	L3	L1	L2-L1	L1	L3	L2	L2	L1	L2
T5	L1	L3	L2-L1	L3	L3	L4	L2	L3	L2	L3

- The MDI framework is thus helpful in directing work with the teacher (teaching), and in illuminating take up of aspects of MDI within and across teachers (research)

- The MDI framework provides for responsive and responsible description.

- Illustrated MDI on what many would refer to as a ‘traditional’ pedagogy. MDI works as well to describe lessons structured by more open tasks, indeed across ranging practices observed.

- We set out to strengthen secondary teachers' relationship to mathematics, and through this shape their 'discourse', firstly in and for themselves, and then in their practice **(PD)**

- And then to be able describe whether and how this shifts over time, in what ways, and how related to what is made available to learn, and to learning gains **(RESEARCH)**

Closing comments – critique

- Progress?
- Constraints?
- Contributions?

Thank you