Role that Mathematics plays in education

Presentation: ASSAf Mathematical Sciences workshop

15-16 September 2016

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Role of mathematics in teaching and research in …

- **Social sciences + humanities**
  - RCT - Quantitative studies
  - Development economics
  - Psychology … cognition
  - Sociology … equity
- **Mathematics education**
  - Ball and Bass collaboration - MKT
- **Science Education**

Two questions for us

Where in a discussion of the future of the mathematical sciences in a rapidly changing and challenging and exciting world, do we locate the career of the future school mathematics teacher?

What does this mean for a mathematical sciences curriculum or education in the university?

What do we know?

- Increasing agreement on significance of mathematical knowledge that is specific to teaching
- Lack of agreement about definitions, language, basic concepts
- When mathematics taught connects with classroom practice, it is moderately associated with improved teaching and learning
- Coursework in calculus influenced learner achievement in algebra but not geometry
- Advanced mathematics beyond a threshold does not impact quality of teaching

Hoover, Mosvold, Ball, Lai (2016) Making progress on mathematical knowledge for teaching. *The Mathematics Enthusiast, 13, p.12 - 14*

What do we need to know and think about?

If we are concerned with mathematics from pre-school through to tertiary studies, then we must have the career of a mathematics teacher at different levels in our landscape …

And accepting that teaching mathematics entails specialised ways of knowing mathematically then:

- What are the mathematical thresholds for various levels of teaching?
- What is this **mathematical knowledge for teaching?**
- Where and when is it taught/learned?
- Who teaches (and researches this)
- What differences for primary and secondary teachers?

Current practices

B Sc Maths + PGCE

maths depts + educ dept

All the specialised knowledge is condensed into one year (methodology) in education departments

? Geometry, Statistics, probability, financial maths …

Hoover et al … knowing calculus deeply does not transfer to geometry

B Ed degree (secondary)

Education departments

Algebra, calculus, linear algebra, geometry, stats and probability, financial maths, mathematical modelling

- Revisiting school maths (advanced and pedagogic perspective)
- 'new' maths

? Horizon?

Methodology courses

wits maths connect supporting secondary math

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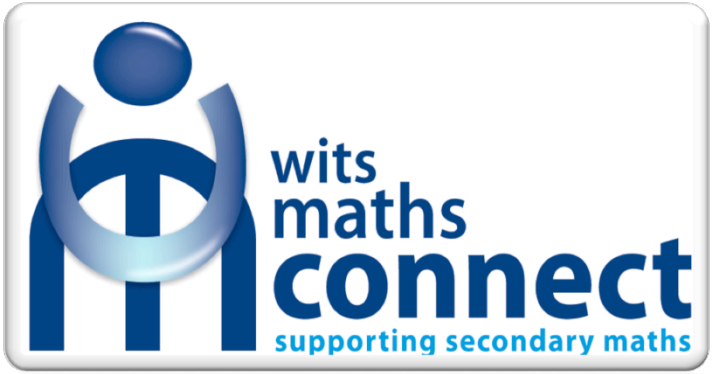
Linked research and development

Improving the teaching and learning of mathematics in secondary schools in one province in SA, through professional development of mathematics teachers

Improving teachers MfT

Improving teaching

Impacting learning
Learner gains



Mathematics for teaching course

Lesson study

Phase 1: 2010 – 2014
Promising results

Phase 2: 2015 – 2019

Phase 1 – 2010-2014: Developments

- Two Mathematics for Teaching courses
  - TM1 – Grade 9 – 10
  - TM2 – Grade 11 - 12

- A model for doing Lesson Study with groups of teachers – professional learning communities

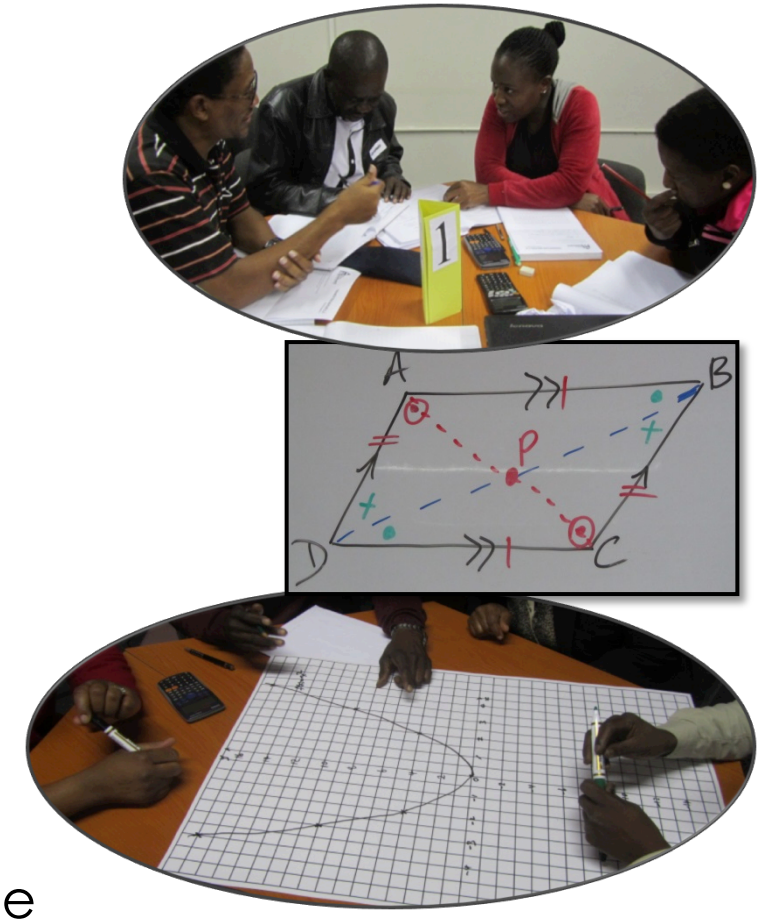
- Both informed by a framework for describing and working on mathematics teaching – MDI (process and product)

Who are the TM1 teachers?

- Don't teach beyond Grade 9
- "Out of field" teachers
- Primary school trained
- Experienced teachers of other subjects
- Teachers recently qualified
- Many lack confidence in their mathematical knowledge
- Earlier research on their teaching showed that their explanations lacked clear focus and coherence

Overview of TM1

- 8 x 2-day units over 1 year
- Mathematics (75%)
  - Algebra
  - Function
  - Euclidean geometry
  - Trigonometry
- Teaching (25%)
  - Examples, tasks, representations
  - Explanations and justifications
  - Learner participation
- Independent work between course days



Content weighting & selection criteria

Topic	No. of days	Scope
Algebra	6	Gr 8 – 11
Functions	4	Gr 9 – 11
Trigonometry	3	Gr 10 – 11
Euclidean geometry	3	Gr 8 – 10

- Importance of topic within GET curriculum
- Importance of topic in preparing learners for FET Mathematics
- Extent to which topic is high leverage in terms of learning gains
- Teachers' existing knowledge of topic
- Current contextual imperatives

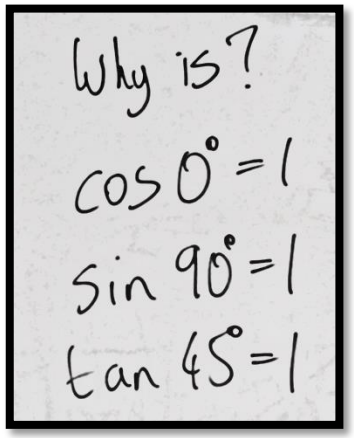
Our approach to Maths in TM1

- Revisiting known mathematics
  - Build on, strengthen and extend teachers' existing knowledge
  - Explore extreme cases, problematize taken-for-granted aspects
  - Make connections between different representations, different sections of the curriculum

- Learning new mathematics
  - "may as well be new"
  - Beyond the grade-level currently taught
  - Related to school curriculum
  - Extends beyond curriculum

Goals for Maths component

- Knowledge of key concepts
  - egs
- Fluency in essential procedures
  - Factorising, solving equations, completing the square, sketching graphs,
- Ability to explain concepts and procedures
  - What and why
  - How and why
- Appreciate how mathematical truth is established
  - Algebra as a tool to prove conjectures
  - Role of definitions
- Mathematical practices
  - E.gs



Learning Gains study

- **Goal**

  Linking teachers' participation in PD with learner achievement over 1 academic year

- **Quasi-experimental**

  Pre-test February 2013

  Post-test October 2013

- **Sample**

  Grade 10 learners in 5 schools

- Test

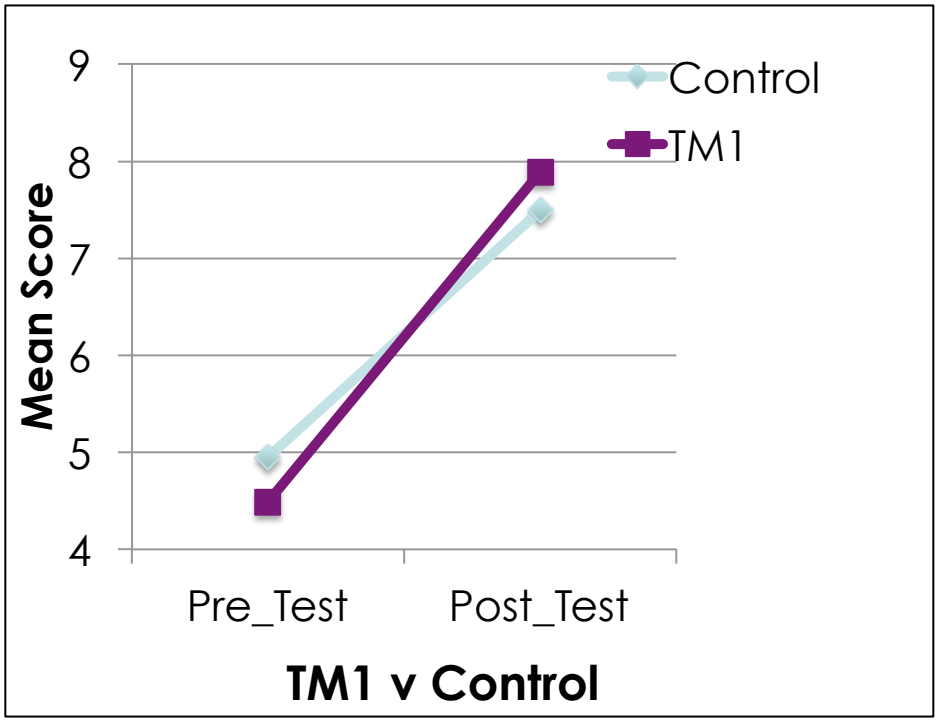
  Typical curriculum items for Grade 10

  Algebra, functions, Euclidean geometry

  Rasch analysis – fit for purpose

	Learners	Teachers
TM1	392	10
Control	217	7
	609	**17**

Learning Gains results



Learners taught by teachers who had done the TM1 course outperformed learners in the same schools taught by teachers who had not done the TM1 course.

The practical significance of the results

Gain	Pooled SD	Effect size (d)	Equivalent progress
0.80	3.78	0.21	3 months

Higgins et al (2012) *Teaching and Learning Toolkit*

Limitations

- Low scores
- Small gains
- High variation in scores
- Indicative results

Pournara, C., Hodgen, J, Adler, J. & Pillay, V. (2015). Can improving teachers' knowledge of mathematics lead to gains in learners' attainment in Mathematics? *South African Journal of Education*, 35 (3).

Relevance for this forum?

How might a well rounded UG curriculum also suit Mathematics teacher education and so be on the landscape of a review of the mathematical sciences

Some extrapolations for boundary crossing/weakening

- Broadening curricula, weakening boundary between mathematics and [*pedagogy*]
  - Breadth vs depth (specialisation – integration)
  - Identities and expertise of 'educators' and their 'reproduction'
- Identifying core concepts, skills, practices, dispositions
- Living with less is also more

What I have not discussed

- School curriculum
  - Data – statistics and probability
  - modernising