Role that Mathematics plays in education

Presentation: ASSAf Mathematical Sciences workshop
15-16 September 2016
Professor Jill Adler
SARChI Chair of Mathematics Education

School of Education
University of the Witwatersrand
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

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
Phase 1: 2010 – 2014
Promising results

Phase 2: 2015 – 2019
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

Mathematics for teaching course
Lesson study

Improving teachers MfT
Improving teaching
Impacting learning
Learner gains
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

<table>
<thead>
<tr>
<th>Topic</th>
<th>No. of days</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>6</td>
<td>Gr 8 – 11</td>
</tr>
<tr>
<td>Functions</td>
<td>4</td>
<td>Gr 9 – 11</td>
</tr>
<tr>
<td>Trigonometry</td>
<td>3</td>
<td>Gr 10 – 11</td>
</tr>
<tr>
<td>Euclidean geometry</td>
<td>3</td>
<td>Gr 8 – 10</td>
</tr>
</tbody>
</table>

- 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
  – e.g.s

• 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.g.s

Why is?
\[
\begin{align*}
\cos 0^\circ &= 1 \\
\sin 90^\circ &= 1 \\
\tan 45^\circ &= 1
\end{align*}
\]
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

<table>
<thead>
<tr>
<th></th>
<th>Learners</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM1</td>
<td>392</td>
<td>10</td>
</tr>
<tr>
<td>Control</td>
<td>217</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td><strong>609</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Gain</th>
<th>Pooled SD</th>
<th>Effect size (d)</th>
<th>Equivalent progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80</td>
<td>3.78</td>
<td>0.21</td>
<td>3 months</td>
</tr>
</tbody>
</table>

Limitations

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

Higgins et al (2012)
Teaching and Learning Toolkit

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