Beginning Teachers’ Mathematical Knowledge: What is needed?

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Background

• Longstanding interest in beginning teacher knowledge
• What do beginning teachers need to know?
• Shulman
  – Content knowledge
  – Curricular knowledge
  – Pedagogical content knowledge
Standards

• Standards for excellent teachers of mathematics (AAMT, 2002)
  – Professional knowledge
  – Professional attributes
  – Professional practice

• Australian Institute for Teaching and School Leadership generic standards at 4 career stages beginning with graduate standards

• Accreditation of teacher education providers
CEMENT: Culture of Evidence-based Practice in Mathematics Education for New Teachers

• 2 year project

• Aims to provide:
  – Evidence-based changes to mathematics education teaching within participating universities;
  – Recommendations about effective models of teacher education for teaching mathematics;
  – Processes for bringing about change at unit and course level; and
  – Progress towards a national culture of evidence-based practice in relation to mathematics teacher education.
Participants

• Initially
  – 7 diverse universities
  – All states and NT
  – Wide variety of courses

• Later
  – Other universities
  – Other disciplines
Preservice teacher survey

- Web-based automatically scored items
- 45 item online test
- Beliefs – 10 items
- Content knowledge (CK) – 13 items
- Pedagogical content knowledge (PCK) – 23 items
Beliefs items

• 5-point Likert scales from Strongly Disagree to Strongly Agree

• The most strongly endorsed items were those indicating a broadly student-centred view of mathematics learning,
  – E.g., “The teacher must be receptive to the children’s suggestions and ideas” and “Teachers must be able to represent mathematical ideas in a variety of ways”.

• Also strongly endorsed “Acknowledging multiple ways of thinking may confuse children”

• Difficult to endorse:
  – “The procedures and methods used in mathematics guarantee right answers”,
  – “Mathematics is a beautiful and creative human endeavour”
  – “Mathematical ideas exist independently of human ability to discover them”
Lessons from the belief items

- Perhaps have not been prompted to think about the meaning or implications of statements that they endorse and that fit with messages from their course.

- Challenge to develop items that better match the abilities of preservice teachers – i.e., positive belief statements that are more difficult to endorse.
Mathematical Content Knowledge

• MCK is a major concern of initial teacher education

• A selection of illustrative items:
  – What response you expect graduating teachers to choose? (Why?)
  – What would you expect your own student to choose?
Example 1

• The product of an odd number and an even number is odd. Is this:
  – Always true 38%
  – Sometimes true 29%
  – Never true 33%
Example 2

Which one of the following contains a set of three fractions that are evenly spaced on a number line?

\[\frac{3}{6}, \frac{3}{5}, \frac{3}{4}\]
\[\frac{3}{4}, \frac{19}{24}, \frac{5}{6}\]
\[\frac{4}{5}, \frac{5}{6}, \frac{6}{7}\]
\[\frac{3}{4}, \frac{19}{24}, \frac{7}{8}\]

19% 40% 32% 9%
Example 3

- I think of a number, multiply it by 5 and add 7 to get an answer of 52. If my number was $x$, what equation represents this?
  - $5(x + 7) = 52$ 7%
  - $5x + 7 = 52$ 88%
  - $7x + 5 = 52$ 1%
  - $7(x + 5) = 52$ 1%
  - $x = 52x + 5 + 7$ 4%
Pedagogical Content Knowledge

• Shulman: the particular form of content knowledge that embodies the aspects of content most germane to its teachability

• Some examples (Chick et. al.)
  – Knowledge of typical student thinking
  – Knowledge of cognitive demand
  – Knowledge of useful representations and examples

• Content knowledge in a pedagogical context, e.g,
  – Profound Understanding of Fundamental Mathematics (Ma, 1999)
  – Knowledge of mathematical structure and connections
  – Procedural knowledge
Challenges for investigating teachers’ Pedagogical Content Knowledge

• PCK is about the work of teaching
  – It is highly contextualised: students, previous experiences, resources
  – It is highly dynamic: responses and reactions in the moment

• How to survey pre-service teachers?
  – On-line
  – “Marked” by computer
The straight multiple choice item

• A 270g packet of chocolate says “35% more chocolate for free”. What is the best way to use this with an upper primary class to develop their mathematical understanding?
  – As a starter for a research project about the use of maths in advertising.
  – I could get students to calculate 35% of 270g.
  – As a starter to discuss percentage increase.
  – I wouldn’t use it – the numbers are too hard.
A “looser” item

• When asked to measure the above angle with a protractor, Kylie answered that it was 30°. She asks you if she is correct. For each of the following statements, indicate if you would definitely say it to Kylie, definitely not say it to Kylie, or might say it to Kylie.
A “looser” item

<table>
<thead>
<tr>
<th>Question</th>
<th>Would definitely say</th>
<th>Might say</th>
<th>Definitely would not say</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you measure the amount of space between the lines?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well done, Kylie, you’re absolutely correct</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make sure you line up the protractor correctly.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remember that angles are about the amount of turn, and the arrow shows the direction of turn.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>You need to subtract that from 360°.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>This one’s tricky because your protractor will only measure angles up to 180°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can you show me which angle you are trying to</td>
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</tbody>
</table>
Some thoughts while constructing the tasks

- INVESTIGATING PCK outside a real classroom is somewhat fraught. Any scenario we construct in order to examine PCK is, of necessity, fictional and incomplete: the student has no history, the teacher has no a priori knowledge of the students’ understanding, and so on ... and the options you give me in a multiple choice question may not be the ones I would really do.

- Even in a classroom—where we know the students more and the situation is real and we can ask the questions we want—the script will still be uncertain, and the “what happens next” will have to be decided in the moment, based on the “what happened just now ... and just now ... and just now”.
Early findings

<table>
<thead>
<tr>
<th>Scale</th>
<th>N items</th>
<th>N persons</th>
<th>Mean ability score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs</td>
<td>10</td>
<td>221</td>
<td>0.77</td>
</tr>
<tr>
<td>Content</td>
<td>43</td>
<td>156</td>
<td>0.32</td>
</tr>
<tr>
<td>PCK</td>
<td>29</td>
<td>115</td>
<td>-0.18</td>
</tr>
</tbody>
</table>
Graphical representation

![Box plot graph showing data distribution for BELF, MCK, and POK categories.](image)
• Pre-service teachers find it easy to endorse beliefs
• Their content knowledge appears to develop
• It is difficult to translate the beliefs and mathematical understanding into pedagogical content knowledge
Another intriguing finding
Conjectures

- Beliefs are developed during schooling and are resistant to change
- Content knowledge improves because of familiarity
- PCK???
  - Influence of prac?
  - 1 year training (Dip Ed)?
  - Placement of maths units through the course?
Questions and discussion