Beginning teachers learning to teach mathematics through problem-solving

Judy Bailey

Te Kura Toi Tangata – Faculty of Education

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

An overview…

- problem solving - heart of mathematics
- New Zealand curriculum documents: mathematics as problem-solving for 25+ years
- overlooked for many years (Holton, 2009), likely many beginning teachers not familiar with problem solving
- 3 beginning teachers – longitudinal study
- familiarity with a structure for mathematics lessons that fosters problem solving and reasoning (Sullivan, Walker, Borcek and Rennie, 2015) supported beginning teachers' learning about teaching mathematics through problem-solving

What do we mean by problem solving?

- "the solution of problems, the method of which is not immediately obvious to the potential solver" (Holton, Anderson & Thomas, 1997, p. 3)

- differs considerably from traditional "triple-x" mathematics lessons of teacher explanation followed by examples and exercises (Foster, 2013)

- "In a range of meaningful contexts, students will be engaged in thinking mathematically and statistically. They will *solve problems* and model situations …." (Ministry of Education, 2007)

What do we know so far?

- *experiencing* problem solving in pre-service teacher education (Bailey & Taylor, 2015)
- *observe* in action and *co-teach* (Cavanagh & McMaster, 2017)
- need for more *professional development* (Holton, Anderson & Thomas, 1997)
- agreement about the importance of problem-solving and reasoning ….. *limited specific advice* about how to do this (Sullivan, Walker, Borcek and Rennie, 2015)

Lesson structure for fostering problem solving and reasoning

Four phases:

- 'Launch'; 'Explore'; 'Summary'; 'Consolidation'

LAUNCH:

- critical phase, positioning children as mathematical thinkers and capable problem-solvers

- establish common language – so task has been interpreted correctly and so students can contribute to later discussion

- consciously maintain the cognitive demand of the task

(Sullivan, Walker, Borcek and Rennie, 2015)

Lesson structure for fostering problem solving and reasoning

EXPLORE: individual and/or group work

- thoughtful walking around desks, individuals, groups

- differentiate task by:
  - Enabling prompts – reduce the number of steps, simplify numbers, varying representations
  - Extending prompts – elicit abstraction and generalisation

- prompts offered after students have engaged with the original task for some time

(Sullivan, Walker, Borcek and Rennie, 2015)

Lesson structure for fostering problem solving and reasoning

SUMMARY: review of students' solutions and strategies

- select particular responses for presentation – give advance notice
- sequence responses so reporting is cumulative
- connect strategies together

CONSOLIDATION:

- pose additional experiences to consolidate learning
- similar in structure and complexity to the original task

(Sullivan, Walker, Borcek and Rennie, 2015)

Context, Data Collection and Analysis

- qualitative action research – participation, collaboration, negotiation

- 3 beginning teachers - first year teaching; 3 schools:
  - Julia: year 0-1, small country school; single cell class
  - Charlotte: year 5-6, large city school; single cell class
  - Reine: year 7-8, small country school; modern learning environment

- facilitator – experience as mathematics educator and researcher

- data: focus group discussions; workshops; observations

Context, Data Collection and Analysis

Focus group discussion 1 – beginning of 1st year

reflect problem-solving aspects of the maths ed paper; brainstorm how to incorporate in first year of teaching; choose and plan actions for the year

Two workshops – end of terms 1, 2

1. reflect on experiences; Polya's model for PS; what is a problem?; plan how to create a successful PS lesson; problem for year 0-1 children
2. See next slide

Observations – term 3

Focus group discussion 2 – end of 1st year

Context, Data Collection and Analysis

Data analysis:

- occurred alongside data collection
- emergent analytical approach
- themes provided direction for workshops

Two notable themes from first workshop:

- concern re: catering for diversity
- knowing problems more deeply

Second workshop:

- Sullivan, Walker, Borcek and Rennie (2015) “structure”
- engaging in problem suitable for NZC level (2)3-5
- facilitator modeling the sequence of phases
- group analysis/reflection of experience

Results and discussion

Analysis of data from workshop 2, observations in term 3 and the final focus group discussion yielded two key findings:

1. structure helpful for beginning teachers learning to teach mathematics through problem-solving.
    - addressed concern re: catering for whole class
    - extended structure with own suggestions, eg. two stage launch process
    - enabled Reine and Charlotte to 'give PS a go'

2. examining structure alongside the first-hand experience of solving a problem enabled personal reflection for improving future practice.

1. Sullivan et al. structure helpful

Reine: … *you can give the entire class a problem, you've just got to have a plan, [plus] your enabling and extension prompts.*

Charlotte: *yeah, I think the main thing is… it's important and it's useful for your whole class to be working on the same thing. And kind of [how] easy it is to have enablers and extenders to make sure that everyone feels successful. And also that approaching it, and how to present it to your class.*

Julia: … *I think around that planning. Yeah ensuring that I plan, and trialling the problem, planning it well so that we've got enabling and extending prompts. But the other thing I'm going to try and make sure I do is how they're recording what they're learning.*

1. Sullivan et al. structure helpful cont.

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Observations

Overall theme of delight, prolonged engagement, learning and being able to cater for all learners with the one problem.

Reine: *"Man, they were excited... so enthusiastic about it..... they're never like that for Maths"*

Charlotte: "*it really worked*"

Julia: "*The **only** way you teach Maths*"

1. Sullivan et al. structure helpful……

Later reflections:.

Julia: *"I think for me, it was talking about what a problem is. And the framework [referring to the lesson structure] of how to present a lesson that way"*.

Reine: *"I like the framework. So from start to finish, how you go through that whole lesson. So how you set it up. And then you go through the phases. Then off that I like the, the prompts that we went through…. knowing where, where you could go, if they're like, 'What do I do?' And then like if they get it too easy, then where can you go? So you've got all these little avenues"*.

2. Structure and experience enabled reflection

- enabled all 3 teachers to reflect on aspects of their practice they needed to change to more successfully conduct problem-solving lessons.

Charlotte: had not known how to extend problems

"I think that's what I'm kind of missing out is the... Like these kind of extensions, write it down as a general equation, write it as an equation. You know? Like I think I'm skipping that, 'cause they go, 'Oh yeah, but it's this many trips.' But then the generalising and the recording of it...."

2. Structure and experience enabled reflection

Julia and Reine: realised there were under-planning.

Julia: "*I feel like at times I've been underprepared with the problems I've used. Like I haven't spent enough time thinking about – or tried it, or spent any time thinking about what the kids might do with it*"

Reine: "*yeah sometimes I just print it all out the morning before*"

- similar finding (Sullivan, Walker, Borcek and Rennie, 2015) re: <u>teachers who are more successful in terms of improvement in students' responses are those who did the task/problems before the lessons</u>

Conclusion, limitations and speculations

- providing and analysing the lesson structure (Sullivan, Walker, Borcek and Rennie, 2015) in conjunction with a genuine problem-solving experience facilitated learning and reflection for this small group of beginning teachers

- small study,

- Speculations re: supporting beginning teacher learning:
  - valuable to have first-hand experience of solving problems and opportunity to analyse their experience against the lesson structure
  - potential for lesson structure as framework for practice and reflection tool

References

Bailey, J., &Taylor, M. (2015). Experiencing a mathematical problem-solving teaching approach: Opportunities to identify ambitious teaching practices. *Mathematics Teacher Education and Development 17*(2),111-124.

Cavanagh, M., &McMaster, H. (2017). A specialist professional experience learning community for primary pre-service teachers focussed on mathematical problem solving. *Mathematics Teacher Education and Development 19*(1),47-65.

Foster, C. (2013). Resisting reductionism in mathematics pedagogy. *Curriculum Journal*, 1-23.

Holton, D., Anderson, J., & Thomas, B. (1997). *OPE-N Plan for teaching mathematical problem-solving*. Dunedin: Ministry of Education.

Holton, D. (2009). Problem solving in the secondary school. In R. Averill & R. Harvey (Eds.), *Teaching secondary school mathematics and statistics: Evidence-based practice.* (pp. 37-52). Wellington: NZCER Press.

Ministry of Education. (2007). The *New Zealand Curriculum*. Wellington, NZ: Learning Media.

Sullivan, P., Walker, N., Borcek, C., & Rennie, M. (2015). Exploring a structure for mathematics lessons that foster problem solving and reasoning. In M. Marshman, V. Geiger & A. Bennison (Eds.). *Mathematics education in the margins* (Proceedings of the 38th annual conference of the Mathematics Education Research Group of Australasia), pp. 41-56. Sunshine Coast: MERGA.