Trainee teachers' perceptions of solving word problems and the bar-model as a strategy to support children in solving word problems.

Sarah Ankers

University of Chester

Problem solving is one of the three main aims of the National Curriculum for Mathematics in England, but the literature suggests that solving word problems can be difficult for many children. The bar model is a strategy used in Singapore to bridge the gap between the word problem and the symbolic representation of the solution. It has recently been introduced to some primary mathematics classrooms in England. As a new teacher-educator researcher, I was interested in how my group of PGCE trainee teachers perceived the bar model as a strategy for supporting children in solving word problems. Findings, which are pertinent to this study, suggest that some trainee teachers experience the same issues in solving word problems as children, and that the introduction of the bar model should be structured alongside the teaching of key mathematical concepts rather than as a discrete topic.

Keywords: teacher training; problem solving; bar model; perceptions

Introduction

Over the last 20 years, patterns in mathematics achievement have been monitored globally through the Trends in Mathematics and Science Study (TIMSS). The TIMSS 2011 data for the achievement of Year 5 children shows that countries such as Singapore and Chinese Taipei have been outperforming England (Mullis, O'Martin, Foy & Arora, 2012).

According to Mei & Li (2014), Singapore's rise in international rankings in mathematics education is due to an emphasis on problem solving in the primary curriculum and the introduction of the bar model method to help children solve problems. Problem solving is now one of the three main aims of the National Curriculum for England (Department for Education [DfE], 2013) cementing the place it has in the curriculum.

These recent developments in the mathematics curriculum, my interest in the problem solving process, and my change of role from a primary school teacher to a teacher trainer are what have drawn me to research problem solving, and in particular word problems and the bar model as a strategy for solving word problems. I am interested in the perceptions of trainee teachers on these issues to support my development as a teacher trainer.

Methods

The PGCE trainee teachers were introduced to the bar model as a strategy for solving word problems at the beginning of the PGCE year in university led seminars. Field notes from these sessions were taken and used as evidence of the trainees' initial

perceptions of solving word problems and the bar model. After completing their first placement in school, three trainees were interviewed. During this interview, I engaged the participants in examining and solving past key stage 2 SATs questions that could be solved using the bar model method. I used the trainees' experience of solving these problems as a stimulus for discussing how useful they perceived the bar model might be in supporting children to solve word problems in school. Finally, close to the end of their PGCE year, a questionnaire was used to ascertain the trainees' perceptions of the bar model once they had used it as a strategy in school.

Findings

Trainees' responses to solving word problems

Four main themes were identified: solving problems using formal, abstract methods; frustration with word problems; issues with reading and understanding the problem; and how to teach problem solving.

Theme: solving problems using formal, abstract methods

Fig 1.1

Evidence from field notes
Session 1: "one trainee used an algebraic representation to solve the 'buns and cakes' question"; "Another trainee explained that she knew she had solved the problem using her 'adult brain', but could not see how solving these problems could be taught to KS2 pupils"

In Figure 1.1, the use of algebraic representations or the 'adult brain' by some of the trainees to solve the problems could support Lee and Ng's (2011) assertion that solving problems algebraically is more demanding on attentional resources; if the trainees were struggling to remember the procedure for solving word problems algebraically, or if they had not been taught how to solve them algebraically, then it would appear that they were left with no strategy with which to solve them. The use of formal algebra or the 'adult brain' suggests that the trainees may perceive the mathematics in the question to be too difficult for primary school children. This could be indicative of the way that the trainees had been taught to solve problems (Fujita & Hyde, 2014).

Theme: feelings about word problems

Fig 1.2

Evidence from field notes	Evidence from interviews
Session 1: "some trainees …were <u>happy</u> with their solutions; some others were <u>confused</u> and did not know how to solve the problems." Session 2: "some trainees admitting that they <u>enjoy</u> attempting problems such as the KS2 past SATs paper problems, and others describing how quickly they '<u>switched off</u>' from even attempting to solve a problem"; "one trainee described how <u>frustrated</u> she <u>felt</u> when presented with these problems"; "but others felt <u>confused</u> and could not see where to start"	Interview 1: REBECCA – So then would you minus 6? JAYNE – Or would you divide the 3? 30 by 3 and see what they could have if it was equally. REBECCA – Wouldn't you have to take the 6 off first though, so they've got 2 more? <u>I don't know</u>. JAYNE – No, she's got 5. <u>I don't know</u>. REBECCA – <u>I can't do this</u>. Interview 2: CATHERINE – Urm, altogether 30 marbles, okay if I look at that, Meena has 5 more marbles, Kirsty has, oh it's 3<u>. What?</u> There's 4 people, oh no there's 3 people, oh Meena has 5 more marbles than Kirsty, Kirsty has 2 more marbles than Sam<u>, let's just calm down here.</u>

The underlined words in Figure 1.2 could reflect how the trainees were feeling as they solved the problems suggesting that some of the trainees were struggling with the word problems presented to them; this reflects much of the literature surrounding

problem solving (Schumacher & Fuchs 2012). Fujita and Hyde (2014) point out that many trainees embark on a teacher training course, particularly primary teacher training, bringing with them a lack of confidence in mathematics; this could have affected the trainees as they attempted to solve the problems. The trainees were talking about how they felt about doing mathematics; although some were frustrated with the process, others seemed to relish the challenge and enjoy the problem solving process.

Theme: issues with reading and understanding the information

Fig 1.3

Evidence from field notes	Evidence from interviews
Session 1: "We discussed how reading and understanding the problem was a skill in itself" Session 2: "one trainee described how frustrated she felt when presented with these problems, because she felt they were worded in such a way as to be confusing. They felt there was too much information, and several trainees described having to read the problem over and over again in order to make sense of the problem"	Interview 1: JAYNE- …it's something my class like really struggle with. When they get like a word problem, they just don't understand it. Even though when you're doing the method with them in class, they can come to a problem and they don't understand. Interview 2: CATHERINE – 30. 30 equals cheese, c and s, okay. 15 equals t no s. 35 equals s, okay. How many sandwiches have cheese without salad, is this the trick question? This is a trick question isn't it?

The trainees' frustrations appeared to lie with understanding what the problem was asking them to do, perhaps indicating an issue with the language or vocabulary of the word problem (Schumacher & Fuchs, 2012). During the interviews, Jayne commented on how children within her classroom struggled to 'understand' word problems, even though they would be able to perform the calculation required to solve it. This, again, reflects what the literature suggests (Schumacher & Fuchs, 2012).

Theme: how to teach problem solving

Fig 1.4

Evidence from field notes	Evidence from interviews
Another trainee explained that she knew she had solved the problem using her 'adult brain', but could not see how solving these problems could be taught to KS2 pupils"	Jayne: "but I'm not really too sure how it would be taught to them to how to choose or to how to problem solve. That's what I've got to try and figure out really."

Fujita and Hyde (2014) suggest that the biggest influence on how the trainees perceive teaching and learning will be their own experiences; from Figure 1.4, this appears evident in how the trainees reacted to the word problems. From the university-based session, there was a sense that there was one way to solve the problems (algebraically), and if you did not know this method, you would fail.

Trainees' perceptions of the bar model

Data from the field notes, the interviews and the written statements from the questionnaires was coded and emerging themes sought. Themes identified were: trainees' confidence in using the bar model; and trainees' perceptions on the usefulness of the bar model as a strategy for solving word problems.

Theme: trainees' confidence in using the bar model

Fig 2.1

Evidence from field notes
Some of the other trainees did need guidance on which model to use for each question, but they appeared to

accept that the model was a good way for children to make sense of the data within the question. Comments from the trainees varied, with one trainee suggesting that they needed to try the bar model with a fresh set of questions in order to see exactly how it worked, and another, who had said at the beginning of the session that she could never solve these problems because they were worded in such a way as to be confusing, asking why this method had not been taught to her in primary school, as she would have found it easier to solve problems with a visual.
Evidence from interviews
Rebecca – That's confusing. I've done it wrong haven't I? Rebecca – I didn't read the question. R – Don't worry about if you want to start again. That's fine. Rebecca – Okay. 75 have salad. R – So what does that tell you about how many do not have salad? Rebecca – 25. R – So now looking at the information you've put here, how many of those no salads are tuna with no salad? Rebecca – 15. R – So how many are cheese with no salad? Rebecca – 12. We got there in the end.
Evidence from questionnaires
I already have a sound understanding of how the bar model can be used to solve numerical reasoning tasks I love the visual learning side to it! Seeing the representations in front of you makes it a lot easier to picture what a certain amount looks like and how to split it up accordingly when solving the problem. It makes long problem solving questions have a structure to them for example when I read a really long problem solving question I start writing numbers down left right and centre but drawing makes it a lot clearer! The only issue I had with teaching the bar model method was that my explanations weren't very clear to start with! I think because I understood it, I wasn't explaining it clearly enough. Once I broke it down it was a lot easier to teach! I feel it's quite hard to grasp at first but once you know how to use it then it's very effective!

Figure 2.1 appears to reveal a changing confidence in the use of the bar model. Initially, during the seminars, the trainees' comments were mixed. The need for guidance appeared to be highlighted in the interviews. The example in Figure 2.1 was representative of the dialogue for several of the problems the trainees were presented with. The evidence from the questionnaires seems to show that those trainees who had used the bar model during their placement in school were now confident in using it themselves (Figure 2.2), but perhaps still needed to develop confidence in teaching the bar model (Figure 2.3 & Figure 2.1). This apparent increase in confidence in the use of the bar model supports the literature which suggests that it is possible to change trainee teachers' beliefs about mathematics teaching and learning over time (Swars, Hart, Smith, Smith and Tolar, 2007).

Fig 2.2

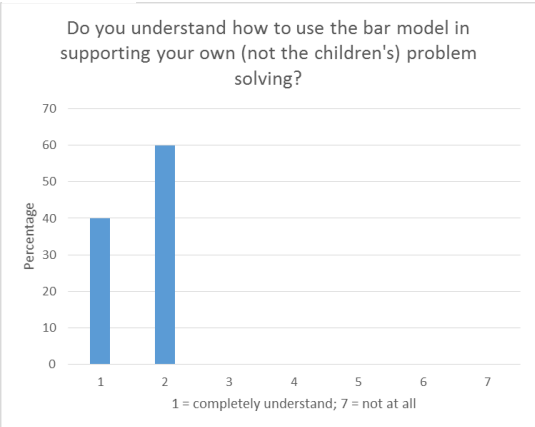
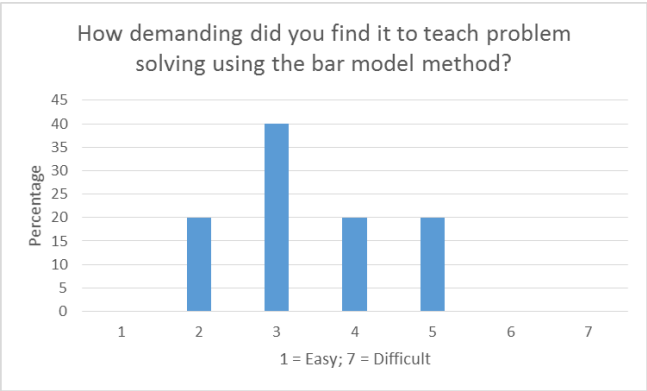


Fig 2.3



Theme: Trainees' perceptions on the usefulness of the bar model as a strategy for children when solving word problems

Fig 2.4

Evidence from field notes
…they appeared to accept that the model was a good way for children to make sense of the data within the question.
Evidence from interviews
Rebecca – Yeah. I don't know, maybe they'll use it lower down the school than, a bit like the resources, I think they'll try and take them away to the written methods Catherine – This one I'd use it for fractions, it really helps me with fractions.
Evidence from questionnaires
It makes long problem solving questions have a structure to them for example when I read a really long problem solving question I start writing numbers down left right and centre but drawing makes it a lot clearer! I feel it's quite hard to grasp at first but once you know how to use it then it's very effective! For the HA children they didn't understand why they had to use the bar model to solve a word problem or a reasoning problem, when they could do it a way which was much quicker and simple for them. However they have only just been introduced to the bar model, so they are new to it. For the LA children it was another visual representation, so they gained a better understanding of the question through seeing something visual rather than just words and numbers.

Figure 2.4 suggests that initially, some trainees said they could see the how the bar model could help children to make sense of the information, but in the interview Rebecca appeared unconvinced, suggesting that the model was only for those children lower down the school, but that higher up the school, the children would need to move to a more formal, written method. Some considered that the visual nature of the bar model supported the lower ability children, which supports the literature (Cheong, 2002; Looi & Lim, 2009), whereas others seemed to suggest that the lower ability children struggled to know which type of model to use, or how to use them to solve a word problem. This could suggest that they were using the model as a procedural tool rather than a conceptual tool.

Conclusion

A finding that emerged from the study that did surprise me, was the extent to which some of the trainees struggled with solving word problems. Some trainees had solved the problems using algebraic methods they had been taught in high school, which Lee and Ng (2011) suggest could be an indication that they are using procedural methods to solve the problem.

The trainees' initial mixed response to the bar model was reflected again in the interviews. By the end of the year, nonetheless, the trainees who had used the bar model in their teaching all suggested that they understood how to use the model to support them in their own problem solving.

The mixed response at the three stages of the project suggests the trainees were not all yet convinced that the bar model was a good strategy for supporting children in solving word problems. Initially, they could see that there was a need for something to bridge the gap between the word problem and the symbolic representation of the solution, supporting the literature (Barmby, Bolden, Raine & Thompson, 2013). Even so, it appeared that some of the trainees found the new strategy uncomfortable to deal with (Campton & Stevenson, 2014).

I have come to appreciate that the bar model needs to be introduced in a structured manner that complements the concepts being covered at the time. On

reflection, I realise that though I appreciated how the bar model could reveal the underlying mathematical structure of a question, this was not always apparent to all the trainees. I am also intrigued by the notion that the bar model can be used as a procedural tool rather than a conceptual tool. This is an area I would like to investigate further. There could be schools who are taking on board the bar model method in their classrooms, and I worry that if there is a lack of conceptual understanding around how the bar model works, it could become a procedure that may be easily forgotten or used incorrectly, thereby diminishing the usefulness of the strategy.

References

Barmby, P., Bolden, D., Raine, S. & Thompson, L. (2013). Developing the use of diagrammatic representations in primary mathematics through professional development. *Educational Research*, 55 (3), 263 – 290. http://dx.doi.org/10.1080/00131881.2013.825164

Campton, I., & Stevenson, M. (2014). Partnering theory and practice in mathematics teaching. In R. Hyde., & J. Edwards (Eds.). *Mentoring mathematics teachers: Supporting and inspiring pre-service and newly qualified teachers* (pp 7 – 24). Abingdon, United Kingdom: Routledge.

Cheong, Y. K. (2002). The model method in Singapore. *The Mathematics Educator*, 6 (2), 47 – 64. Retrieved from http://math.nie.edu.sg/ame/matheduc/tme/tmeV6_2/05-Yan%20KC%20Final%20version.pdf

Department for Education, (2013). *The national curriculum in England*. Retrieved from: https://www.gov.uk/government/collections/national-curriculum

Fujita, T., & Hyde, R. (2014). Approaches to learning mathematics. In R. Hyde., & J. Edwards (Eds.). *Mentoring mathematics teachers: Supporting and inspiring pre-service and newly qualified teachers* (pp 42 - 58). Abingdon, United Kingdom: Routledge.

Lee, K. & Ng, S. F. (2011). Neuroscience and the teaching of mathematics. *Educational philosophy and theory*. 43 (1), 81 – 86. doi: 10.1111/j.1469-5812.2010.00711.x

Looi, C., & Lim, K. (2009). From bar diagrams to letter-symbolic algebra: A technology-enabled bridging. *Journal of Computer Assisted Learning, 25*(4), 358-374. doi:10.1111/j.1365-2729.2009.00313.x

Mei, L.Y., & Li, S.V. (2014). *Mathematical problem solving – the bar model method*. Singapore: Scholastic Education International

Mullis, I.V.S., O'Martin, M., Foy, P., & Arora, A. (2012) *TIMSS 2011 international results in mathematics*. Retrieved from http://timssandpirls.bc.edu/timss2011/downloads/T11_IR_Mathematics_FullBook.pdf

Schumacher, R.F., & Fuchs, L. S. (2012). Does understanding relational terminology mediate effects of intervention on compare word problems? *Journal of Experimental Child Psychology*, 111, 607 – 628. doi:10.1016/j.jecp.2011.12.001

Swars, S., Hart, L. C., Smith, S. Z., Smith, M. E., & Tolar, T. (2007). A longitudinal study of elementary Pre-service teachers' mathematics beliefs and content knowledge. *School Science and Mathematics, 107*(8), 325-335. doi:10.1111/j.1949-8594.2007.tb17797.x