The assessment of newly qualified teachers' beliefs about the teaching and learning of mathematics

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Beliefs are hard to pin down. Whether or not they are successfully translated into practice, they give important indications of intentions for the future. The "IMAP web-based beliefs survey" was developed in order to assess beliefs about the teaching and learning of mathematics held by prospective elementary teachers (IMAP 2003). This survey gathers data by asking teachers to respond to video clips and teaching scenarios in their own words. The study reported here investigated beliefs held by three newly qualified secondary teachers. In particular the aim was to evaluate the IMAP survey in the secondary context by comparing it with the alternative data collection methods of interview and observation. Results indicate the general effectiveness of the IMAP survey for assessing the beliefs of such teachers.

Keywords: Mathematics; Beliefs; Teaching; Learning; Beginning teachers.

Introduction

Teaching is an extremely complex process. Research indicates the important role of teachers' beliefs about the teaching and learning of mathematics and how these connect with the practice of teaching mathematics effectively. (Thompson 1992; Leder et al. 2002) Whether or not a teacher's beliefs are successfully translated into practice, they give an important indication of the teacher's intentions for the future. Social constructivist beliefs are widely promoted through Initial Teacher Education (ITE). Anecdotal evidence suggests that teachers may turn away from such beliefs during the early years of teaching and revert to the traditional teaching methods they themselves experienced at school. Such concerns highlight the need to understand how beliefs might change during the early years of teaching, and clearly there are implications for ITE and induction programmes.

The difficulties of assessing beliefs are widely acknowledged by researchers. Beliefs are inherently complex, dynamic and situated, so that beliefs expressed in interview with a researcher may appear to contradict those expressed in conversation with a teaching colleague or enacted in the classroom. Some researchers conclude that teachers can hold clusters of quite contradictory beliefs, isolated from each other (Thompson 1992). In contrast, Leatham argues that teachers' beliefs can be viewed as 'sensible systems' (2006, 91). Apparent inconsistencies may be explained by:

- inability to put beliefs into practice (e.g. due to deficient subject knowledge)
- school factors preventing the teacher from putting beliefs into practice (e.g. preparation time, resources, instructions by more senior staff).

- beliefs being overridden by other more strongly held beliefs. (e.g. beliefs about investigative approaches overridden by beliefs about the importance of exams).
- the 'situated' nature of beliefs (Hoyles 1992, 32)
- difficulties in articulating / interpreting belief statements. (e.g. 'active maths')

These arguments highlight the need for careful choice of methods to enable in-depth investigation of teachers' beliefs.

The study

This study set out to explore beliefs about the teaching and learning of mathematics held by three newly qualified secondary teachers. In particular the aim was to evaluate the 'IMAP web-based beliefs survey' (IMAP 2003) in this context by comparing it with the data collection methods of interview and observation.

The participating teachers graduated with a Postgraduate Diploma in Education (PGDE) in secondary mathematics in June 2006. Jim, Rob and Beth (not their real names) were not randomly selected, but considered sufficiently representative to provide evidence of the effectiveness of the IMAP beliefs survey for newly qualified secondary teachers. Data was gathered in June 2007 from observations of teaching, interviews and responses to the survey.

The IMAP survey

The 'IMAP Web-Based Beliefs Survey' is a 'constructed-response-format' survey developed by US researchers as an instrument for assessment of beliefs about the teaching and learning of mathematics (IMAP 2003). The survey attempts to elicit evidence of seven specific beliefs claimed to be 'core beliefs' for the learning and teaching of elementary school mathematics (Ambrose et al. 2004). These may be broadly characterized as constructivist:

Belief 1. *Mathematics, including school mathematics, is a web of interrelated concepts and procedures.*

Belief 2. *One's knowledge of how to apply mathematical procedures does not necessarily go with understanding the underlying concepts. That is, students or adults may know a procedure they do not understand.*

Belief 3. *Understanding mathematical concepts is more powerful and more generative than remembering mathematical procedures.*

Belief 4. *If students learn mathematical concepts before they learn procedures, they are more likely to understand the procedures when they learn them. If they learn the procedures first, they are less likely ever to learn the concepts.*

Belief 5. *Children can solve problems in novel ways before being taught how to solve such problems. Children in primary grades generally understand more mathematics and have more flexible solution strategies than their teachers, or even their parents, expect.*

Belief 6. *The ways children think about mathematics are generally different from the ways adults would expect them to think about mathematics. For example, real-world contexts support children's initial thinking whereas symbols do not.*

Belief 7. *During interactions related to the learning of mathematics, the teacher should allow the children to do as much of the thinking as possible.* (Ambrose et al. 2004, 65)

Data about teachers' beliefs are commonly collected using Likert scales, where respondents are asked to rate the strength of agreement or disagreement with a list of belief statements. This method has a number of disadvantages. First, there is the danger that respondents may have different interpretations of the language used. Second, Likert scale statements are usually given without context, whereas beliefs tend to be context specific. Third, respondents may be pushed into expressing an opinion even if they have never previously considered the belief stated, thereby giving a misleading overview of their beliefs. The IMAP survey avoids such problems by asking participants to respond to video clips and learning scenarios in their own words. Ambrose et al (2004) argue that teachers' beliefs affect their interpretation of classroom situations, and motivate their teaching actions. The survey mirrors these aspects by inferring beliefs from teachers' interpretation of classroom scenarios, and from their responses when asked to make teaching decisions.

The IMAP survey was devised to assess the beliefs of prospective elementary teachers. This study set out to consider its effectiveness in assessing the beliefs of a different target group: newly qualified secondary mathematics teachers.

Space does not permit a detailed description of the survey. Discussion of segments 4 and 7 will be used to illustrate the general approach. Segment 4 of the IMAP survey seeks evidence of belief 3. Respondents are asked to consider the subtraction 635-482 and to predict whether children would find Lexi's approach (the standard written algorithm) or Ariana's (more conceptual) approach to subtraction easier. According to the IMAP rubric, respondents who indicate that Ariana has better understanding, rate the conceptual approach as easier, and would like their pupils to use it (or both strategies) score 3: *strong evidence* of belief 3. Similar rubrics specify scores appropriate to various responses. Similarly, segment 7 is used to seek evidence of belief 7. Participants respond to the video clip of a teacher helping a child work out how many cars are needed to transport 20 children. The scoring rubric focuses on whether the respondent considers the teacher to be too leading.

The three newly qualified teachers

Jim

Jim chose a lesson on scientific notation for observation (top set pupils aged 12-13). During the lesson, opportunities to links with understandings of place value, indices etc. were not taken, and a procedural approach was promoted. For example, to change from standard to normal form pupils were encouraged to refer to the clue:

(1) Write the question.

(2) Write digits without decimal point.

(3) Count jumps from old position.

(4) Write answer.

Pupils were set questions to work on (in groups/ pairs) such as "The diameter of Earth is 12750. Jupiter is 11.2 times the diameter of the earth. Calculate the diameter of Jupiter. Write your answer in scientific notation to 3 sig.figs." Jim interspersed such tasks by displaying pictures showing the relative sizes of the planets. The intention may have been to link these visual representations with the measures written in scientific notation in order to promote conceptual understanding. However such links were not discussed. In the interview, Jim commented on the value of cross curricular work in terms of motivation rather than understanding.

When asked to pick out his most important beliefs Jim mentioned group work, self / peer assessment and explaining common misconceptions. None of these ideas are included in the list of IMAP beliefs but all are promoted in ITE. They may be seen as teaching strategies that support beliefs about the value of conceptual understanding (IMAP belief 3) or the need to avoid teaching by telling (belief 7). However, the same strategies can promote instrumental learning: groups can rehearse rote learned procedures, peer/self assessment can identify gaps in memorised material, teachers can tell pupils what not to write in the exam. The evidence gathered suggests that these may often be the outcomes in Jim's classroom.

In response to IMAP segment 4, Jim acknowledged that "Lexi's method … can be learned without clearly understanding", but stated that this was the method he preferred pupils to use. The rubric assesses this response as showing *no evidence* for belief 3. In segment 7, Jim did not initially criticise the teacher but he questioned "whether [the pupil] had learned from this experience or just followed the teacher's lead". After prompting Jim did acknowledge the "excessive teacher intervention". This response was coded as showing *some evidence* of belief 7 (later combined with evidence from segment 5 to give an overall assessment of *weak evidence* for belief 7). Although the observed lesson did not provide evidence to support this, there were hints in the interview: "I think if we had the time to allow them to explore for themselves then I think there would be maybe some better learning there." On balance, the IMAP survey provides a fair assessment of Jim's support for belief 7, which is in practice often over-ridden by the need to ensure syllabus coverage.

In general, the beliefs Jim identified in the interview tended to be student centred (group work, caring for pupils, providing variety/relevance to increase motivation) or to focus on supporting pupils for exam success. Jim's caring attitude was evident in all observed dealings with pupils. In contrast the IMAP beliefs are subject centred. The survey found no strong evidence of Jim holding any of the seven listed beliefs (*no evidence* of beliefs 3 & 4; *weak evidence* of beliefs 1, 2 & 7; *some evidence* of beliefs 5 & 6).

Rob

Rob was observed during a revision lesson (3rd of 4 sets, 12-13 year olds) using 'voting pad' software. He had prepared a number of multiple choice questions on fractions, equations and volume. After individual voting, Rob led pupils in a discussion of their thinking about each question.

When interviewed, Rob frequently emphasised his belief that the teacher should get pupils to talk about their understanding of mathematics. The clear aim in doing this was to promote the construction of relational understanding. When asked how he might help a pupil struggling to understand, he emphasised the pupil's action:

> I would ask them to point out the key information in a question and discuss why it might be important, looking for them to see how the problem fits together. More open questioning wherever possible.

During the observed lesson he continually pressed for deeper understanding rather than just accepting the right answer. For example, when one pupil used the formula for volume of a cuboid, Rob was not content to leave the discussion there. He guided the discussion to emphasise the links between this and another pupil's method of counting the number of cubes in each layer and multiplying by the number of layers.

In response to IMAP segment 4, Rob indicated that "Lexi … might be able to perform the calculation, but Ariana seems to be able to manipulate the numbers … and would be able to adapt this approach…" providing *strong evidence* of belief 3. In segment 7, Rob did not criticise the teacher's excessively leading approach, and since he commented that he was "not confident that [the pupil] could have tackled the problem without assistance from the teacher (given his age)", strict interpretation of the rubric leads to an assessment of *weak evidence* for belief 7. However the raw data includes his response when asked to identify weaknesses: "Discussion of what the pupil did to get to that answer was missing. Pupil should have been encouraged to talk about what he was doing". It can therefore be argued that, although the IMAP assessment underestimates Rob's enacted and stated belief in allowing pupils to do as much of the thinking as possible, the raw IMAP data does include some evidence of belief 7.

In general, interview and observation indicate that Rob's beliefs are close to the IMAP list. The IMAP assessment found evidence for all listed beliefs (*weak evidence* for beliefs 2 & 7, *some evidence* of belief 5, *strong evidence* of beliefs 1, 3, 4 & 6).

Beth

Beth was observed teaching a lesson on positive and negative numbers (pupils aged 12-13). Groups were asked to sort statements (e.g. "If you add two negative numbers you get a negative number") into categories: "always true", "sometimes true" or "never true". The activity could facilitate building of conceptual understanding through discussion. However it appeared that the pupils depended on memorised rules for calculations with integers in order to carry out the task. They had rote learned a song: "… a positive and a negative is a negative, and two negatives make a plus…" No reference was made to any real life contexts such as debts or temperatures.

When asked to pick out her most important beliefs about teaching maths, Beth cited variation (group work, making posters, avoiding too much textbook use), use of mini whiteboards (to access prior knowledge) and enthusiasm. For the observed lesson she chose activities that involved all these ideas. These strategies are clearly promoted in teacher education and are viewed as ones that support pupils in building concepts. They can be used to support constructivist beliefs. However if, as in the case of the observed lesson, these strategies are used in conjunction with rote learning then the outcome may be very different.

In response to IMAP segment 4, although Beth acknowledges Ariana's greater understanding, she predicts that pupils who use this method will be less successful and "may well think too much about how best to break down the sum". Due to technical difficulties Beth's responses to segments 7- 9 are not available so IMAP results are based on incomplete data.

In general, Beth's beliefs, like Jim's, tend to be student centred rather than subject centred. Observation and interview provide little evidence of the seven listed beliefs and these results are broadly reflected by the IMAP results (*No evidence* of beliefs 3, 4, 6, 7; *weak evidence* of beliefs 1, 2, 5).

Conclusions

The combination of observation, interview and survey enabled the building of a rich picture of the beliefs held by participating teachers. The IMAP data was in certain ways better than that gathered by observation and interview. Observation allowed the possibility of assessing beliefs in the classroom situation, but only in the context of one particular lesson. Interview allowed possibilities of discussing beliefs in relation to a variety of groups of pupils or topics, but in a situation more distant from the classroom where a more progressive discourse may be used (Sosniak, cited by Hoyles 1992). The IMAP format provided the best of both worlds by enabling access to beliefs in a variety of contexts close to that of the classroom. It also enabled inference of beliefs and avoided problems associated with use of Likert scales.

The three participating teachers were sufficiently representative of newly qualified secondary mathematics teachers in Scotland to illuminate some possible problems in using the IMAP survey to assess beliefs of this group. The recasting of segments 2, 3 and 4 to make them more relevant to secondary mathematics teaching would be desirable. It could be argued, for example, that secondary teachers who value conceptual understanding above memorisation of procedures may nevertheless expect their pupils to use standard written algorithms. Their belief could be wrongly assessed in this circumstance. Questions may be raised about the inclusion of belief 4 as a core belief for the learning and teaching of mathematics. Also, it can be argued that belief 6 should be reworded for the secondary context, where pupils' initial thinking about higher level abstract concepts may be supported by abstract rather than real world examples. (See Forrester 2007 for more detailed discussion).

Despite such concerns, analysis of other data collected supports the IMAP analysis on 13 out of 21 assessments. In 7 cases the IMAP assessment underestimates the strength of belief indicated by other data by at most one scale point. (The format means that respondents may not happen to mention some belief that they do hold, so there is an inbuilt tendency to underestimate). In only one case does the IMAP rating indicate stronger evidence for listed beliefs than other data suggests.

Findings therefore indicate the general effectiveness of the IMAP survey in the context of secondary mathematics teaching.

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