WHAT TEACHERS KNOW: THE KNOWLEDGE BASES OF CLASSROOM PRACTICE

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*This paper reports on a pilot project that has investigated the hypothesis that, in addition to subject and pedagogical knowledge, much of what experienced teachers know is what we call **attention-based knowledge**, and that it is this knowledge that enables them to respond effectively to what happens during lessons. A study of mathematics lessons taught by six teachers has led to some further conjectures about the role of attention-based knowledge in teaching, and about the interplay between different knowledge sources in planning and teaching.*

In this study[1] we have attempted to address the question of how experienced teachers deal with the enormous complexity of classroom environments: what is it that teachers know which enables them not only to plan good lessons, but also to operate effectively in the complexity of a class of 30 pupils? What is it that teachers can learn from the experience of teaching particular classes which enables them to apply their expertise to teaching other, possibly very different, classes?

We argue that attempts to describe the knowledge base of teachers in terms of subject knowledge and general and subject-specific pedagogical knowledge (e.g. Shulman, 1987) may offer tools for analysing particular aspects of practice, but fail to provide an adequate account of what is required to function effectively minute by minute in the classroom. There have been a number of studies which have attempted to give accounts for the ways in which teachers make choices about how to act 'in the moment', for example, in terms of decision trees (Peterson and Clark, 1978), or the balance of influence of knowledge, beliefs and goals (Schoenfeld, 1998).

In contrast to these relatively complex accounts we offer a different hypothesis: much of what experienced teachers know is what we call *attention-based knowledge*. This attention-based knowledge not only is not reflected in what is written down in lesson plans, but *cannot* be written down. However, we conjecture that it is this knowledge that enables teachers to respond effectively to what happens during the lesson. Understanding the performance of experienced[2] teachers requires an account of the interplay between the subject and pedagogic knowledge that will be articulated in learning objectives and lesson plans, and attention-based

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[1] 'Attention and the knowledge bases of expert practice', funded by an AHRB Innovation Award. A report of this project can be found at www.warwick.ac.uk/fac/soc/philosophy/research/akbep

[2] By 'experienced' we mean those who have developed their expertise through experience; this is not the same as simply counting years in the classroom.

knowledge that can only be revealed in the classroom. It is well documented that experienced teachers often find it difficult to articulate what it is that they do successfully in the classroom, other than in highly situated accounts of particular pupils or aspects of the curriculum (e.g. Edwards & Collison, 1995). We argue that it is attention-based knowledge, and the skills which give access to this, which teachers find difficult to describe, possibly because of the relative lack of attention paid to such learning in formal teacher education (Edwards & Protheroe, 2003).

In this study we have developed a methodology for a qualitative exploration of this hypothesis by looking for evidence of the existence of attention-based knowledge, characterising attention-based knowledge and locating its role in shaping teacher deliberation in class and legitimising expert performance.

Theoretical framework

The study offers a novel conceptual apparatus for understanding the role of attention-based knowledge. The conceptual innovation is to characterise the situatedness of attention-based knowledge in terms of specialised attentional skills. The idea is that experienced teachers have a repertoire of attentional skills for attending to cognitive and affective aspects of pupil activity. In other words, experienced teachers ‘see’ the classroom situation differently from novices. We might compare this to the game-warden who sees the African bush in a way which the tourist cannot. Similarly, Edwards and Protheroe (2003) claim that student teachers are more likely to ‘close down on complexity’ in the classroom.

The teacher’s attentional skills are generalisable. The knowledge they make available on any given occasion is, however, highly situated and is often only expressible in a contextualised proposition as a response to 'that situation', 'this cognitive difficulty/insight, etc.' A teacher's response to a situation, characterised in this way, is highly particular and not a response driven by a general rule that could have been articulated in advance of the teaching encounter. Edwards and Protheroe (2003) argue that current approaches to initial teacher education in the UK are underpinned by a model of professional knowledge as something which can be ‘called up and applied’ and offer a critique of initial teacher education which does not offer opportunities to develop what we would call ‘attentional skills’ (and which they refer to as skills of ‘interpretation’) through peripheral participation in the practice of experienced teachers.

Furthermore, attention is an active perceiving and involves selection on behalf of the subject. The knowledge which is gained by and from this attention informs subsequent actions. This means that the concept of judgement, rather than rule-following, lies at the heart of the account we offer. Fuller theoretical discussion can be found in Luntley (2004).

The empirical study: developing a methodology

In this exploratory study, our initial approach was to watch some lessons, identify the ‘episodes’ in which we felt that teachers were acting on the basis of attention-

based knowledge, and then interview teachers about them. The remaining sections of this paper discuss the development of our methodology and present some initial findings. We have worked broadly using a grounded theory approach. Although data collection and analysis are described separately here, they were largely interwoven.

The study was carried out with an 'opportunistic' sample of experienced teachers, two in a primary school, and 4 teaching mathematics in secondary schools. There were two cycles of observations. In each cycle one mathematics lesson (and occasionally two) from each teacher was observed, and recorded using a video camera and a radio microphone. The lessons to be observed were chosen by the teachers, generally on the basis of convenience. We did not ask the teachers to give us written lesson plans, as this would have imposed a level of formality which we wanted to avoid. However, whenever possible we had a brief discussion with the teacher about their plans immediately before the lesson.

Three members of the research team were present in each lesson, one operating the camera, and the other two making unstructured observation notes. The video camera was focussed on the teacher throughout the lesson. The audio tape was transcribed in full straight after the lesson. Later the transcripts were annotated to add non-verbal behaviour and contextual detail from the video tape. The aim of the observers in the lesson was to identify episodes in which the teacher appeared to be acting on the basis of attention to aspects of the classroom activity, rather than in ways which could have been predicted from a lesson plan. Clearly there could be very many instances of such behaviour in any lesson, since even the most detailed lesson plan will not specify the exact words to be spoken, or the pace and nuances of speech. Our observations needed to focus on relatively 'big' incidents that were accessible to observers as the lesson progressed. Typical examples of potentially interesting episodes were:

- when a pupil was unable to answer a teacher's question,
- when a pupil gave an answer which was clearly unexpected,
- when a pupil asked for help, or was clearly confused or inattentive,
- when a teacher appeared to change the pace or direction of the lesson,
- when a teacher reacted to, or ignored inappropriate behaviour.

After the lesson, the researchers exchanged initial impressions about their observations. Two days later, they met to discuss the lesson in more detail, with both the video tape, and the transcript available. They used their notes to identify the episodes in the lesson that would form the focus of an informal interview with the teacher, which took place immediately after this discussion. This was structured around watching the video sequences. Interviews were audio taped, and full transcriptions made. The transcriptions of the lessons and the related interviews were subsequently coded using categories which emerged during the data analysis.

Developing the approach to data collection

The key features of our methodology were the researchers' ability to identify the kinds of episodes that we were interested in exploring as the lesson was in progress, and developing an interview strategy that would enable the teachers to talk about their actions during those episodes. Identifying potentially interesting episodes involved speculation about what had prompted a particular action. We were creating stories about what we had observed, and inevitably our stories were a function of our attention during the lesson. Initially, there were some interesting differences in the ways in which each of us attended to the progress of the lesson, which we might attribute to our differing professional backgrounds. Re-viewing parts of the lesson through the video recording was therefore important in our identification of episodes. As our experience of the individual styles of the teachers increased, and we developed a clearer picture of the kinds of episodes which were proving interesting, there was an increasing level of agreement in the examples identified.

During the interview, one of our concerns was to test out our stories about the episodes. In some cases these turned out to be mistaken: what we took to be a spontaneous decision had actually been planned, or the interaction with a particular child was based on previous history. In other cases, the teacher did not have particularly clear recall of the episode, even having seen it again on the video. In order to maintain a neutral approach, the technique we adopted was for one researcher to provide the basic structure of the interview, setting the scene for each video extract, and using an opening question such as 'What's going on here?'. The second researcher then brought in different questions to try to probe the teacher's thinking further. Productive questions which emerged were:

- If you could run that lesson again, would you change anything?
- Can you think of a similar occasion when you have acted in the same way/differently?
- Is that a common strategy for you to use?

Without exception, the interviews were relaxed occasions. As they became more familiar with our style, the teachers often offered spontaneous comments in response to the video extracts. All the teachers seemed to enjoy the opportunity to discuss their pupils and the content of their lessons in this way.

Analysing the data

Our first attempts at analysing the data focussed on the episodes themselves, based on the lesson transcripts, the observation notes and the video recordings. We coded contextual details (e.g. whether the episode involved an individual, group or the whole class, whether it was initiated by teacher or pupils), and the underlying focus of the episode, as **cognitive** or **behavioural/affective**. The vast majority of the episodes we identified were cognitive, and we sub-divided these into **cognitive *problems***, where pupils were showing differing understandings of mathematical

ideas and the teacher was trying to address this, or **cognitive *opportunities***, where the teacher was trying to extend the pupils' thinking.

A second kind of coding of the episodes was to distinguish between occasions when the teacher seemed to be **reacting** to the classroom context by using a familiar strategy, and those when the teacher was **responding** in a novel way[3]. The distinction between reactions and responses was not, however, always clear-cut. A further coding was to indicate whether, at interview, the teacher seemed to have been aware of making a (**conceptual**) choice in that particular episode, or whether their reaction/response had been more intuitive (**non-conceptual**). This distinction was also not always straightforward.

The interview transcripts were initially coded in fairly pragmatic ways. More detailed analysis of the interview transcripts provided some clear evidence that teachers were acting, in part, on the basis of attention-based knowledge. Their accounts contained references to (for example) the expression on a particular child's face, a sense of restlessness in the class as a whole, an interaction they had observed between particular children. Further, it emerged that for many of the episodes the teacher talked explicitly about what they thought underlay particular actions on the part of the pupils. Our most recent analysis of the interview data has identified sections of the teachers' accounts that indicated that their attention had been focused on what pupils' were attending to. This knowledge about the pupils' attention seemed to be particularly significant in episodes in which we saw teachers moving the mathematical content of the lesson forward.

The significance of this form of attention did not emerge until after the data collection was completed. For some episodes, the interview transcript provides evidence for the teachers' attention focussing on what pupils are attending to. For others, there is nothing explicit in the transcript. This may be because the teacher was not, in fact, attending in this way, or it may be that the structure of the interview did not support discussion of this. It would be a priority in future research to adapt our interview technique to try to elicit such commentary, for example by asking 'Did you have a sense of what the pupils were thinking about?'

Further analysis of episodes in which the teacher is attending to pupils' attention led to a further coding. In some the teacher appears to be **interrogating** the mismatch between the pupil's attention and the teacher's expectations in a way that allows the teacher to adapt their teaching to move towards shared attention. In others, although the teacher is clearly **noting** the pupils' attention as different from their expectation, they do not work directly on this difference, but use some other strategy.

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[3] We are grateful to John Mason for offering us the vocabulary for this distinction.

Planning and teaching styles: exploring the interplay between knowledge bases

Within the group of six teachers in our study, we observed a range of styles in the way in which teachers both planned their lessons and worked with these plans in their teaching, which suggested that teachers were drawing on different knowledge bases (subject knowledge, pedagogical knowledge and attention-based knowledge) in different ways. The three accounts which follow are not attempts to characterise individual teachers. Rather they are sketches drawn from our data of particular episodes, amalgamated to characterise distinctive styles which we observed.

Clinging to the lesson plan

Jenny knows her primary-school class extremely well. The episodes that we identified in her lessons suggest that she attends closely to patterns of behaviour which give her insights into both cognitive and affective issues.

In one lesson Jenny asked Colin a question that he was unable to answer. After looking at him for a few moments she said 'Not sure? Don't worry' and then asked another child (Hilda) to give the answer. Later Jenny to returned quietly to Colin and asked if he had understood Hilda's explanation. After Jenny had watched the video of this episode we asked her what had made this approach feel right.

> I could sense a sort of panic in Colin that I didn't want to make worse. And yet I banked on Hilda knowing it. I just knew she would be fine and she'd be able to do it. So I could reinforce it for everybody at that point and then I could go back to Colin and ease that worry that he was having. That panic that he was feeling. He won't say that he is struggling … but you can see it in him. There is this sort of rising panic.

We categorised this episode as **Cognitive problem/Affective, Reaction, Non-conceptual, Noting**. Jenny **reacted** to Colin's 'rising panic' intuitively by using a familiar strategy of asking another child to help out. She was able to **note** Colin's difficulties, but her priority was to keep the lesson moving for the whole class.

Later Alan offered an explanation which showed a more sophisticated level of reasoning than Jenny had expected. During the lesson, Jenny appeared to challenge his reasoning, but in the interview she commented:

> I couldn't work [out] where I was going next, what I was going to do. I knew Alan was right and I thrilled to bits that he made the link … I think he did it out of his head and he was being logical and it was a great piece of working definitely. I just couldn't get my head around why I was going to do it and what I wanted to do next. And I was ~~ 'no is it?' but then he said: course it is! Course it is! And I was thinking ~~ I was actually completely thrown by it

We categorised this as **Cognitive opportunity, Reaction, Conceptual, Noting**. Jenny **noted** Alan's idea, but did not develop it, and moved on. Later she said:

> So if I hadn't been following the script I would have done [another activity] because it was just perfect wasn't it? And it was the perfect opportunity but because I needed to get on, I needed to get through and make sure that they knew the factors of 12, I didn't and I should have and I knew it at the time and I was debating whether I should just go with it but I knew I'd run out of time and I knew I wouldn't get anything done

> that I wanted to do … And I am always aware of the time and I did want to have a bit of leeway. I did want to make sure I could get through everything and make sure that they understood. … It's a tough one to call isn't it?

In a lesson on percentages children had become confused when they met a problem about percentages of 200. In the interview she acknowledged that she knew that most of the class were confused, but went on:

> One of those times when you think, you know, Oh my God! What do you do next? But if I would have thought, which I didn't today, cos I was in a panic with you there (…) If I'd have thought of using the numberlines then, with the percentages at the bottom, they would have seen instantly why it wasn't 138%, and we could have worked it out from there. But it was sheer, utter and total Oh my God moment.

We categorise this episode as **Cognitive problem, Reaction, Conceptual, Noting.**

Jenny clearly has the attentional skills which give her access to attention-based knowledge about her pupils' understanding, or lack of understanding. She plans her lesson in great detail, focussing on specific learning outcomes, and often makes use of planning resources provided as part of the National Numeracy Strategy, which she thinks are very good. However, she is not a mathematics specialist, and we see here weakness in her subject knowledge which makes her feel she has to 'stick to the script', overriding the attention-based knowledge she gains during the lesson. In episodes in Jenny's lessons we see more **reactions** than **responses**, and although she often **notes** pupils' attention, there are very few instances of her **interrogating** this to develop thinking.

Going with the flow

Alice is a secondary mathematics specialist who appears very confident in her subject knowledge. She prepares her lessons thoughtfully in terms of tasks and resources, but her planning relies less than Jenny's on detailed learning outcomes.

In a lesson on quadrilaterals, the class played a matching game with shapes, which included both quadrilaterals and triangles, and Alice realised that they were not as familiar with the vocabulary of shape names as she had anticipated. Alice collected a list on the whiteboard of the shape names that the pupils said were difficult (Parallelogram, Isosceles right angle triangle, Scalene triangle, Rhombus, Quadrilateral, Arrowhead, Isosceles trapezium). Alice wanted to focus on quadrilaterals, so her first strategy was to eliminate the two triangles from this list.

> Alice: Let's look at these words on the board then. …. There are two words on there that don't fit with the rest. Can you work out which of those two words don't fit with the rest? Tod?
>
> Tod: Rhombus and arrowhead?
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> Alice: Why do you think that?
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> Tod: Well, they don't seem like regular shapes.
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> Alice: They don't seem like regular shapes. Ok. Could be rhombus and arrowhead, but that's not what I am looking for.

Ellie: Is it rhombus and arrowhead because they're not like - they're not like a certain shape.

After getting one or two more responses which did not identify the triangle names, Alice changed approach and focused on each item in the list in turn, asking pupils to describe and draw it. At interview Alice made the following comment:

> I had no idea what it was that [Tod] was trying to say. I couldn't see any link between the two he had given me. I couldn't think, arrowhead and rhombus? What are the … Apart from the fact that the words themselves may be as opposed to the shape. And I had no idea. And when the next person said the same two things, I was beginning to think: Oh God! There is something I am missing here. [Laughter] Something that is obvious to them but not obvious to me. Because you know sometimes with child's eyes you see something. Then I realised that they obviously didn't even look at those words and think, oh that's a three sided, that's a four sided. They obviously didn't have that connection as an obvious connection between the number of sides and the actual words. There was obviously something else they were looking at, if you know what I mean. Which is why I then thought I am going to have to try and pull out here how many sides do these things have.

We categorised this episode as **Cognitive problem, Response, Conceptual, Interrogating**. Alice recognised a mismatch between the pupils' focus of attention and her own, and was able to **interrogate** this in order to **respond** in a way which changed the direction of the lesson, but enabled her to re-focus the pupils' ideas.

In another lesson pupils were practicing their skills with using compasses to draw perpendicular bisectors of line segments. Alice had set the exercise in the context of bisecting the sides of a triangle, hoping that some pupils would get as far as finding that the three bisectors cross at a single point (the circumcentre). After a demonstration on the whiteboard, pupils were asked to draw 'any triangle' in their exercise book, and then draw the perpendicular bisector of each side. While moving around the class, Alice noticed that several pupils had become confused with their drawings. She asked the class to stop, went back to the whiteboard, wiped off the original drawing of a triangle, and instead drew a single line. She then demonstrated the process of drawing the bisector again before adding a second side of the triangle, and indicating that the process had to be repeated.

Alice described what she thought the pupils had 'got in their heads'.

Alice: A lot of them were leaving it to two arcs and not cutting the line so they were going like that and like that and they thought they had done it. So they had lost sight of what the purpose was which was to cut the line in half. …

Int: Ok and when you went you went to the board you didn't draw the triangle?

Alice: No because if I had drawn the triangle they would have got triangle in their heads instead of bisecting the line in their heads. I wanted to remind them that they were bisecting a line before reminding them that they were doing the triangle. Does it make sense?

We coded this episode as **Cognitive problem**, **Response**, **Conceptual**, **Interrogating**. After this episode, Alice again changed the focus of the lesson in

response to attention-based knowledge about the pupils' progress. Later in the interview she commented specifically on her approach to planning.

> we've got to write lesson plans and hand them [in] … two weeks before you are going to be teaching some of those lessons and I can't do it. I've got colleagues who plan a whole term's lessons and try to stick to them but I tend to plan my lesson the night before really. I have in my head a long term plan, what I've got to do and I have actually written them down what I am going to do each lesson for the rest of the term, but that's just a single line and then you sort of construct your lesson around that. And that's just to make sure that you are actually doing what's in the syllabus and get it covered by the end of the term

Like Jenny, Alice appears to have good attentional skills which allow her to access attention-based knowledge about her pupils' focus of attention. However, her confident subject knowledge allows her to 'go with' what she learns during the lesson, and adapt her teaching accordingly. She does not feel the same need either to plan the structure and sequence of her lessons in detail, or to stick to the plans that she has made. The episodes in Alice's lessons show relatively more instances of **responses** and of **interrogation** of pupils' attention than Jenny's lessons.

Ploughing ahead

Like Jenny and Alice, Martha is an experienced teacher. She is a secondary mathematics specialist, and has sound subject and pedagogical knowledge. She plans her lessons around carefully chosen sequences of tasks. She is able to offer a clear rationale for her planning in terms of the difficulties her pupils experience in learning aspects of mathematics, and teaching strategies which she uses. However, observing Martha's lessons we were surprised to find many pupils disengaged from the activity, and relatively low levels of attention to Martha's presentation of the lesson. We found it quite difficult to identify episodes in Martha's lessons were we felt that she was drawing on attention-based knowledge, and of these there was only one instance where we felt that she was attending to the focus of pupils' attention.

A typical episode took place in a lesson on simplifying fractions. Kim had already offered 'four fifths' as a simplification of eight tenths. Damien then said (speaking rather indistinctly) 'is it two over two and a half?' This could have offered an interesting opportunity for developing the lesson. Martha, however, said '*That would be making it more complicated. That wouldn't be simpler, would it?'*, and then continued. We conjectured that Martha did not want to risk confusion by exploring Damien's idea, but in the interview a different scenario emerged.

Martha:	now what did he say? Um, he was talking about one of the other fractions, I can't remember. I think was one of the fractions 2/3s? I think he said 22 over 33. Something like that.
Int:	We think he said: 'could it be 2 over 2 and a half'.
Martha:	I don't think he did. Now the reason why I say this is difficult is because I've had a similar class, well doing similar things, and someone, you know someone in another class did suggest something

> like that the other day. Something like 3.5 over something. But I don't think he did. No I can't actually remember.

Martha's account suggests that at the time she did not attend closely to what Damien was saying, and it is also somewhat unclear how well she recalled the incident. There were several other episodes in which it seemed to us that Martha lacked awareness of things that were happening in the classroom which were apparent to us as observers. We conjecture that Martha lacked the attentional skills which would have allowed her to access attention-based knowledge, and that without this she was unable to put her subject and pedagogic knowledge into practice effectively.

Conclusions

On the basis of this small scale study, and the methodology we have developed, we have evidence for the existence of attention-based knowledge as part of what experienced teachers know, both in the sense that they have attentional skills which enable them to 'read' the activity of the classroom, and that they use the knowledge they gain by and from this attention in making judgements about how to act. Further, we argue that the recognition of attention-based knowledge is significant in explaining and justifying why experienced teachers act in the ways they do, and that the model of different knowledge bases enables us to give at least partial accounts of differing styles of planning and teaching. This may be seen as complementary to the more detailed model offered by Rowland, Huckstep & Thwaites (2005).

On the basis of our study we also conjecture that as teachers develop their experience as successful practitioners, their use of attention-based knowledge, and particularly the ability to attend to and interrogate the focus of pupils' attention, will increase. Edwards & Protheroe's (2003) study offers some interesting perspectives on how this development may, or may not, be supported by the practices of initial teacher education. We are currently planning a more extended study that will allow us to explore this conjecture with novice and experienced teachers.

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