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Describing expert classroom practice in inquiry-based mathematics and science

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ESTABLISH & SMEC 2012
Dublin

Overview

- The problem of articulating classroom practice and a new theoretical model
- A research study of classroom practice
- Inquiry in mathematics and science education: the Fibonacci project
- An example of the role of attention and its importance in teaching

A study of classroom practice: the need for a vocabulary

> *while we recognise that there are those with mastery of some aspects of teaching, we have no coherent account of what they are masters of or how they achieve what they achieve*
>
> (Brown and McIntyre, 1993)

- Lack of an appropriate vocabulary leads to relative invisibility of aspects of classroom practice amongst the features which are assessed (and hence valued) in Teacher Education

- Relatively high importance is placed on areas of teachers' practice more easily observable and more clearly articulated, such as lesson planning and record keeping.

Theoretical background: the problem

- An important aspect of good teaching is responding ‘in the moment’ to events in the classroom

- Accounts of **subject** and **pedagogic** knowledge do not provide an adequate explanation for how teachers do this

- Models based on rule-following seem too cumbersome to account for the speed and subtlety of action

Theoretical background: our conjecture

Experienced teachers have a repertoire of **generalised attentional skills,**

which generate **attention-dependent knowledge** particular to the context

Experienced teachers 'see' the classroom differently from novices

(Luntley, M. 2004, 2005)

Theoretical background: elaborating the model

- Attention-dependent knowledge informs subsequent actions

- A teacher's response to a situation is highly particular, not driven by a general rule that could be articulated in advance

- Attention is active perceiving and involves judgement, rather than rule-following

A model for a study of classroom practice

Understanding the performance of experienced teachers requires an account of the interplay between

subject and **pedagogic** knowledge
(articulated in lesson plans)

attention-dependent knowledge
(that can only be revealed in the classroom)

The Study

What?

- One year pilot study
- Three schools : 2 secondary, 1 primary
- Six teachers' mathematics lessons

Attention and the knowledge bases of expert practice funded by the Arts & Humanities Research Board (Ainley & Luntley, 2007a, 2007b)

The Study

How? (step 1)

- observed 1 or 2 lessons for each teacher
- video and audio recording

- annotated transcript
- two observers' field notes identifying points when the teacher appeared to act on the basis of attention to classroom activity

The Study

How? (step 2)

- researchers discuss and agree focus **episodes**, using video and transcript
- interview with teacher based on extracts: aim to imaginatively re-enter the episode

- Annotated transcripts of the lesson and the interview for each episode
- Codings developed and revised during the study

- ‘Composite’ teacher-characters

The Study

Two important challenges in our methodology:

- to balance the voices of teachers and researchers

- to distinguish between

  accounts of teachers' actions

  accounts for those actions (Mason 2002)

An example episode: Jenny and Colin

Jenny posed a question to Lauren and she seemed unable to answer:

> Jenny continued to ask further questions and scaffolded a response.

Jenny posed a question to Colin and he seemed unable to answer:

> Jenny said “Don’t worry”, and passed the question to another pupil (Hilda).

Jenny: It's Colin. He doesn't know [*pause*] oh, love him [*pause*] He was alright on the carpet actually. Again, he's incredibly lacking in confidence. He's actually a lot better than Lauren at maths. Urm, I don't know why I didn't keep going with Colin but I didn't. I went to Hilda and got her to do it, didn't I? And then I went back to him. I didn't want to leave him without knowing what to do, but I didn't want to draw attention to the fact that he didn't know. So I must have decided quickly to get Hilda up there and then go over it with him. But he was okay actually and often he [*pause*] He was almost there. He was almost there, but not quite there [*pause*] So, I suppose it was that I didn't want to draw attention to the fact that he didn't know, but I wanted to make sure he did. So I went back to him afterwards. Must have been. I didn't even know that I had done that.

Account for

Int: … what we are interested in was what it was you were picking up on that made [that] feel right ...

Jenny: I suppose it was that 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. Lauren will tell me. She'll say: I'm beginning to panic now. He won't but you can see it in him. There is this sort of rising panic.

Developing a vocabulary

Codings for episodes developed as we analysed interview data

behavioural/affective

cognitive *problems*

cognitive *opportunities*

Conceptual (conscious choice)

non-conceptual

reaction (a familiar strategy)

response (a novel approach)

Deepening the study

Discussion of some episodes led us to consider not only teachers' attention

but also the focus of pupils' attention

Focussing on pupils' attention: Alice

Following a sorting activity, Alice had made a list of shape names on the whiteboard which contained several quadrilaterals and two triangles. As the focus of the lesson was to be on quadrilaterals, she asked,

"*Can you work out which two of those words don't fit with the rest?*"

The first pupil suggested:

"*Rhombus and arrowhead*"

After some further questioning, Alice abandoned her lesson plan, and switched to a different activity.

Alice: I had no idea what it was that [he] 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 [*pause*] 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.

Focussing on pupils' attention: Jenny

In a lesson on percentages, children had coped well with several problems involving percentages of 100 items, but became confused when they were given a problem about percentages of 200 seats in a theatre.

Jenny tried to sort out the confusion, but decided to come back to this another day, and moved on to another part of the lesson.

In the interview Jenny acknowledged that she knew that most of the class were confused.

Jenny: 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.

Focusing on pupils' attention: Martha

Pupils in a first-year secondary class were working on tasks involving simplifying fractions. One pupil, Kim, successfully simplified *Eight-tenths* to *Four-fifths*.

Martha asked for further examples and Damien said, rather indistinctly, "*Is that two over two and a half?*"

Martha replied "*No. No, you don't do that. That would be making it more complicated. That wouldn't be simpler, would it?*"

Martha: Now what did he say? Um, he was talking about one of the other fractions, I can't remember. I think [it] was one of the fractions … two thirds? 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 three point five over something. But I don't think he did. No I can't actually remember.

Developing the vocabulary further

based on researchers' view

behavioural/affective

cognitive *problems*

cognitive *opportunities*

based on teachers' view

interrogating pupil attention

noting pupil attention

reaction (a familiar strategy)

response (a novel approach)

conceptual (conscious choice)

non-conceptual

Composite charaters: the interplay between knowledge bases

Clinging to the lesson plan *(Jenny)*

- good attentional skills and pedagogical knowledge
- plans lessons in great detail based on learning outcomes
- weakness in subject knowledge seems to override attention-dependent knowledge
- feels she has to 'stick to the script' and get through the lesson as planned

- more **reactions** than **responses**
- **notes** pupils' attention but rarely **interrogates** this.

Composite characters: the interplay between knowledge bases

Going with the flow *(Alice)*

- good attentional skills
- good subject knowledge and pedagogical knowledge
- plans lessons carefully, but more in terms of activities than learning outcomes
- uses attention-based knowledge to adapt lessons

- **responses** and **interrogation** of pupils' attention more frequent than in Jenny's lessons

Composite characters: the interplay between knowledge bases

Pressing ahead *(Martha)*

- sound subject knowledge and pedagogical knowledge
- plans lessons carefully, and gives rationale for choices
- appears to lack attentional skills to access attention-based knowledge during the lesson

- little evidence of **noting** or **interrogating** pupils' attention
- we conjecture this makes it difficult for her to make effective use of pedagogical knowledge
- in the interviews, more *accounts for* than *accounts of*

Conclusions

Our methodology gives us evidence for the role of attention-dependent knowledge informing classroom practice

We have begun to develop a vocabulary that can be used to describe and discuss classroom episodes, particularly:

- noting / interrogating children's attention
- reacting / responding

Attention and inquiry

In many teaching contexts, tasks are designed to direct children's attention in quite specific ways: *as teachers we assume we know what children will attend to*

The essence of inquiry-based teaching is to open up possibilities and give children ownership of their activity and decisions: *we cannot make assumptions about the focus of their attention*

This increases the demands of teaching in inquiry-based approaches

An integrated approach to inquiry in mathematics and science

We see the process of inquiry as similar in both subjects:

- Observing a environment or phenomenon
- Collecting initial data / asking questions
- Making a conjecture or prediction
- Designing an investigation
- Collecting and analysing evidence
- Drawing conclusions / asking more questions

	Science	Mathematics
Inquiry	Observation, posing questions, collecting data, analysing data to draw conclusions, predicting, hypothesising, evaluating, modelling, raising further questions, …	

We see strong similarities at this level which can be reinforced with different emphases.

	Science	Mathematics
The School curriculum	Electricity Forces Properties of materials Plants …	Counting Calculation Naming shapes Measurement …
Inquiry	Observation, posing questions, collecting data, analysing data to draw conclusions, predicting, hypothesising, evaluating modelling, raising further questions, …	

Teachers need the reassurance of links at this level.

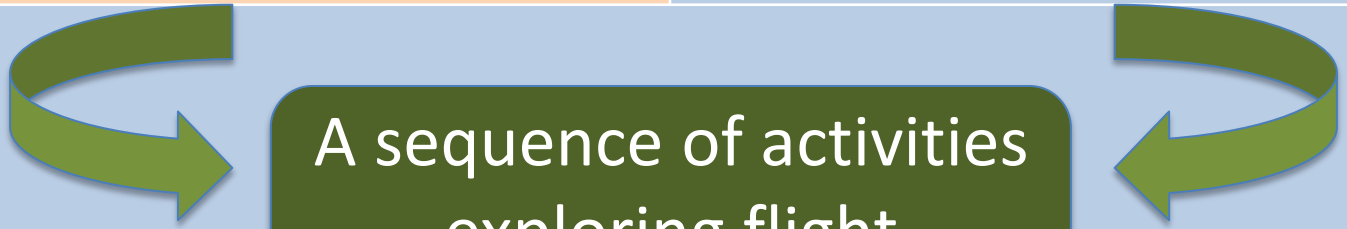
Links will be easier to make, but may be superficial and lack progression.

We see strong similarities at this level which can be reinforced with different emphases.

	Science	Mathematics	
The School curriculum	Electricity Forces Properties of materials Plants …	Counting Calculation Naming shapes Measurement …	*Teachers need the reassurance of links at this level.* *Links will be easier to make, but may be superficial and lack progression.*
'Big ideas'	Energy Particle theory Inheritance …	Pattern Proportion Equivalence Ratio…	*Links at this level are harder, but offer opportunities to develop sequential learning in both subjects.*
Inquiry	Observation, posing questions, collecting data, analysing data to draw conclusions, predicting, hypothesising, evaluating modelling, raising further questions, …		*We see strong similarities at this level which can be reinforced with different emphases.*

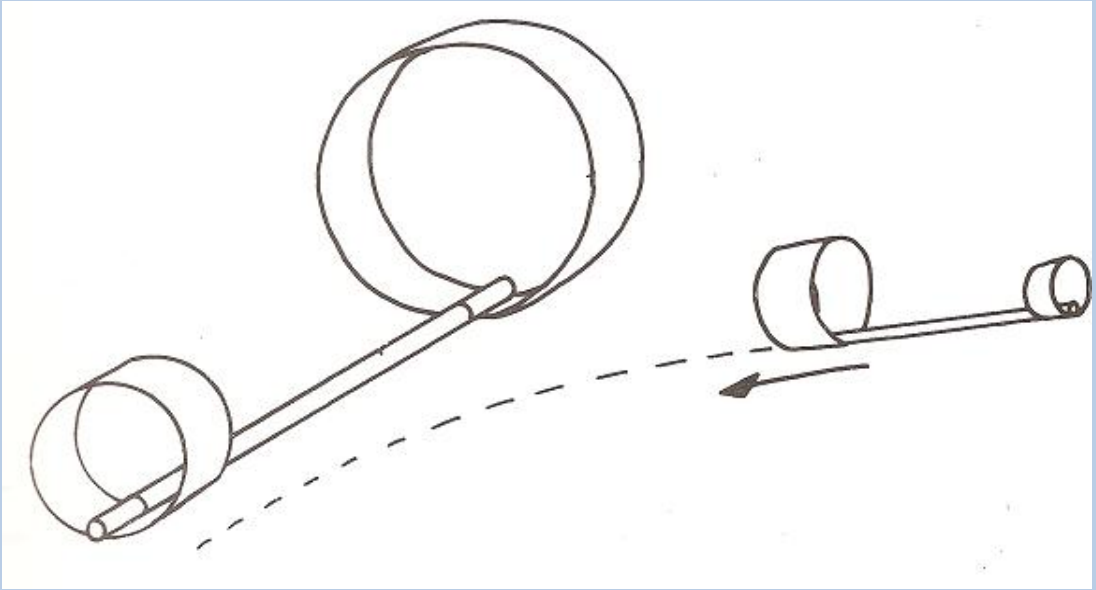
Planning from big ideas

Science	Mathematics & Statistics
Designing and conducting fair tests Variation Air resistance/flight	Collecting and analysing data Variation Use of averages



Inquiry about the flight of gliders

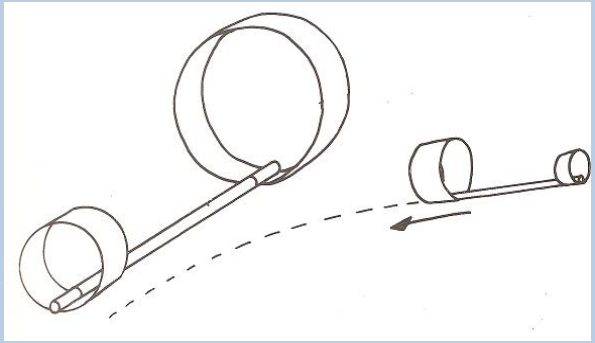
An example from work with our Fibonacci teachers



What affects how the glider flies?
Explore moving the position of the smaller loop

Inquiry about the flight of gliders

Teachers worked in pairs,
deciding how to organise their experimental work,
and how to record results.



Their activity initially appeared similar, but there were important differences as they developed their ideas.

We can interpret this in terms of the **focus of their attention**.

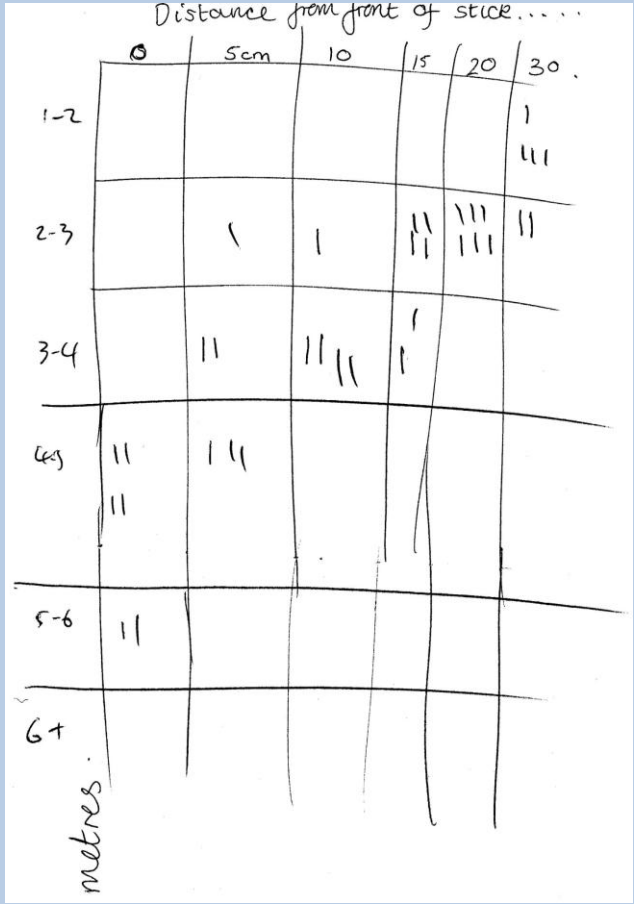
Richard and Zack

- tested each glider three times and recorded the results with markers on the floor
- initially only measured the distance of the longest flight from each set of three
- Zack described this as recording the average, but Richard corrected him

Attention appears to be on making the glider fly as far as possible

Val and Steph

- marked out the landing area in meter bands, and tallied where the gliders fell on a grid
- each tested gliders three times ‘because they had a lot to do’
- pleased with the emerging pattern in their results.



Attention seems to be on getting the ‘big picture’

Simon and Mike

- recorded their results using data-handling software
- initially did three trials for each glider
- Simon decided they should do more tests on the two gliders that had flown the longest distances, but not on the others

Simon's attention appears to be on finding which glider flies furthest

Simon and Mike

Mike studied the spread of results on the computer to see whether there would be a straight line or a curve visible in the overall display

Mike's attention appears to be on looking for a mathematical relationship

Kathi and Sally

- tested each glider six times, using markers on the floor to show the landing places
- recorded their results systematically in a grid
- some gliders had landed under furniture and so had not had a true flight
- they recorded these distances anyway

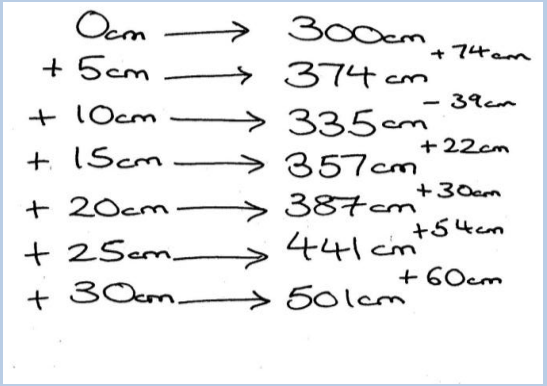
Kathi and Sally

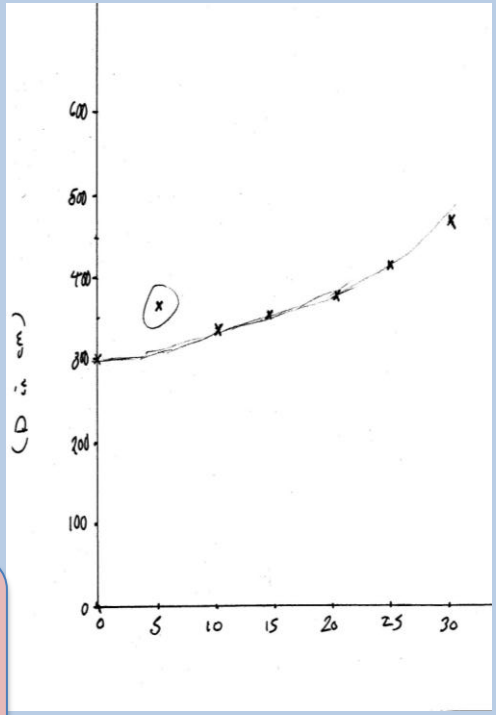
Distance from leading edge	1	2	3	4	5	6
0 cm.	3550	3360	4580	4180	4790	3960
4 cm	3000	3800	3200	3400	3200	2600
8 cm	2550	2780	3320	3730	4100	3630
12 cm	3000	3300	3000	3100	2800	2800
16 cm	2500	2940	2350	2600	2190	2560
20 cm	3100	2800	2700	2800	3000	3000
24 cm	1700	1700	2000	2000	2100	1900
28 cm	1700	1700	1400	2000	2400	2000

Attention seems to be on a ‘fair test’, so all results must be included

Alan and Afzal

- developed a ‘consistent’ method of launching gliders
- tested each of their gliders once only
- found the difference between successive results
- sketched a graph and a curve, although concerned about the one anomalous result





Attention seems to be on finding a mathematical relationship

Concluding comments

Inquiry-based approaches in mathematics and science make high demands on teachers' classroom practice:

- pedagogic knowledge
- subject knowledge
- attention-dependent knowledge from interrogating pupils' attention

We should not underestimate these demands,

and we should support teachers to make positive use of attention-dependent knowledge

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