Observing teacher questioning and teacher attention in a mathematics classroom

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Given that teachers cannot attend to all aspects of the complex environments of mathematics classrooms in an equal way, following the locus of teacher attention might provide insight into teacher awareness of the learning of students. Such insight, in turn, might open spaces in which teachers can explore their practice. This report considers the questions asked by a mathematics teacher in a classroom as a possible mechanism for tracing teacher attention through observable behaviours. Drawing on a framework based on attention, within an enactivist stance, observations made in a series of mathematics lessons with a group of 14- and 15-year-old students are considered. Differences in the classifications of questions made by the teacher and the researcher are used to highlight moments of ambiguity which are, in turn, used to probe the awarenesses of both participants. Methodological implications are discussed, with a view to further data collection and analysis.

Keywords: teacher attention; teacher questioning; awareness; mathematics classroom; observable behaviours

Motivation

The work describing in this report forms part of a larger project, the aim of which is to provide accounts of experiences of the mathematics classroom, primarily from the teacher's perspective, with the intention of supporting other mathematics teachers choosing to or being required to adapt their pedagogy. Whether the motivation for a teacher focusing on specific aspects of their professional practice arises in response to imperatives perceived as arising within themselves or as directed by others, the research project is creating opportunities for reflection in the light of the experiences of others, echoing the description of teaching itself as "expanding the space of the possible and creating the conditions for the emergence of the as-yet unimagined" (Davis, 2004, p.184).

This report takes a methodological focus, i.e., it is engaging with the philosophical and practical underpinning of the research methods used to turn collected information into data. The positioning for this work is enactivist, specifically that in our interactions we are co-implicated in the creation of a world that both transforms and is transformed by these interactions, since "knower and known… co-evolve in a constant process of becoming" (Proulx & Simmt, 2013, p.66), a constantly dynamic co-emergence (Davis, 1995). Knowledge is an interaction with an environment, and it is this interaction, enacted mathematical activity in this case, that is observable (Maheux & Proulx, 2015). Furthermore, interaction occurs through the accumulation of lived experiences of previous interactions: "Knowing is doing, and all doing arises from a rich and ongoing history of structural coupling with a complex and active environment" (Davis, 1996, p. 193). In a mathematics classroom, then, possibilities for action on the part of teacher and students arise in response to triggers

associated with past interactions. Reid (2014) highlights the strength of an enactivist position in considering classroom settings, given that this mechanism for knowing is based on cognitive systems, "including human beings, human conversations and larger human social groups" (p.137). It is, however, recognised that even whilst being engaged in observation of interactions between a teacher, students and mathematical activity, we cannot have direct access to the awareness of others, since this is not observable. Observations themselves are a process of interaction with other cognitive systems and it is through consideration of what happens in me, an observer, as I observe in a particular context, that I might begin to make sense of what I observe.

In this positioning, the observer takes on the crucial roles of identifying the activity to be described and of giving an account of that activity. The researcher does not merely observe what is there; rather, observations are of our individual coupling with the observed; later, in the act of analysis, certain aspects of what has been recorded (and what is absent) come to the fore and set up a feedback mechanism, influencing in turn the focus of attention in analysis and further observation. The research reported here is located in the context of such a feedback mechanism.

A framework

In developing an approach to observing interactions related to secondary school mathematics, specifically with an enactivist stance that locates knowledge in action, questions of how to look become highly significant (Brown, 2017). As a useful starting point for establishing a framework for observations, I take Mason's notion of disciplined marking:

> It is useful to distinguish between ordinary-noticing, or perceiving, in which sufficient memory is established accessibly to be jogged and reconstructed by what someone else says, and marking, in which not only do you notice but you are able to initiate mention of what you have noticed. (Mason, 2002a, p.33)

Mason captures here a sense of movement towards an even more informed and intentional state of observation, one which is constructed in the light of research questions and methodology and focused on observable behaviours which might give insight into awarenesses of teachers and students. Such a use of awareness describes core actions or functions that must be present in order to learn (Mason, 2008). Developing the powers to recognise changes in awareness is problematic, since students may exhibit behaviours of a mathematician with or without possessing the associated awarenesses (Coles, 2016). It is more practical to focus on observing *shifts* in attention that might indicate a change in an awareness has occurred or is imminent (Brown, 2017).

In common usage, paying attention and being aware might seem interchangeable, but attention and awareness are taken here as expressions of different states. It seems to me that Mason sees the state of awareness as having a sense of focus: "Being aware is a state in which attention is directed to whatever it is that one is aware of" (Mason, 1998, p. 254). In their discussion of shifts in attention, Mason & Davis identify that we might experience such shifts as sudden or gradual. In our current investigation, it is sudden shifts in a teacher's attention, arising in the moment, during lessons, that we are interested in marking through observable behaviours.

Mechanisms

In recognition of the complexity of systems which comprise a teacher and a group of students all interacting with mathematics, much energy has been given to the study of what teachers notice or, in the language we are using here, what is the focus of teachers' attention in a lesson. Consideration of in-the-moment attention has been studied using various mechanisms, including *framing* (Levin, Hammer & Coffey, 2009), following the teacher's formation of a sense of "what is going on here?", and *teacher noticing* (Sherin, Russ & Colestock, 2011), broadly seen as teachers attending to and making sense of classroom events. From our enactivist stance, the researcher and the classroom system cannot be separated, meaning that the researcher must pay attention to their own locus of attention, even as they seek to observe indicators of the attention of a teacher. The mechanism for observation should, then, allow the researcher to attune their attention to particular observable behaviours. In early discussions between the researcher and the teacher during this study, the recording of questions asked by the teacher emerged as such a mechanism. In a discussion after the second lesson observation, the teacher identified their use of questions as a focus for active development of their pedagogy to support students in developing awareness of approaches to solving mathematical problems:

> Teacher: I am trying to do more of 'What's the next step?' rather than 'What's 3 times 2?', which is giving them the next step.

Taking questions asked by the teacher as a focus for observation was also seen as having the potential to highlight shifts in attention, through a shift in the content or nature of the questions being asked.

To support exploration of questions asked by the teacher, we adopted the definition of question as "any utterance which expects a response" (Mason, 2002b, p.248) and worked to develop a shared protocol for coding the nature of the questions captured in field notes, open to validation against the video recording of the lesson. Our coding used Mason's four-way classification (2002b): controlling questions (CQ), cloze technique (CT), genuine enquiry (GE) and meta-questions (MQ). Controlling questions exert authority in a classroom situation, socially or in terms of student attention: "How do we begin?", "What is the coefficient of x?". Cloze technique questions, although inviting students to supply a stage of reasoning, tend to be testing students' capacity to fill in a gap with a specific response: "The first place after the decimal point is called…", "We check our answer by ….". In contrast to each of these two classes of question, a genuine enquiry question will be one to which the teacher does not know the answer and invites a student to share their own thinking: "What decisions did you make in choosing your method?", "What led you to choose that value?". Finally in this classification, meta-questions direct the attention of students to something beyond or above the peculiarities of the task at hand, pointing to a higher-level process: "How might we recognise another question of this type?", "What question do you think I will ask next?". Having begun to apply these four categories to the sets of questions noted during lesson observations, as researcher and teacher-participant we added a fifth class, other management (OM), designed to capture utterances which, while expecting a response, were directed at managing the classroom environment: "Are you ready?", "Write this example down.".

A pattern of working together was established in which the researcher would transcribe their field notes and share the list of recorded questions with the teacher. Each would then work on a classification of questions independently and these would be compared, with differences in classification being used as prompts for subsequent

discussion. An extract of the question list from one particular lesson (the ninth to be observed) is shown below in Figure 1, along with the researcher and teacher coding.

ID	Wording used	Researcher	Teacher
1	What parts of maths will you need? Think about this whilst I take the register.	CQ	CQ
2	I'm going to give you one minute to talk to people on your table.	OM	OM
3	X, what are your thoughts?	GE	GE
4	X, do you agree with that?	**GE**	
5	Why do you not agree with that?	GE	GE
6	Do we have to pick one or the other?	**GE**	**CQ**
7	In general? In this case?	CQ	CQ
8	What would you pick?	**CQ**	**GE**
9	Why would you pick trigonometry?	**GE**	**CQ**
10	But what about the question makes you think its trigonometry?	**GE**	**CQ**
11	And X, what part of the question makes it feel Pythagoras-y?	**GE**	**CQ**
12	X, do you think we need some other parts of mathematics?	GE	GE
13	None at all?	CQ	CQ
14	X?	**GE**	**CQ**
15	Why do you think we need circumference?	**GE**	**CQ**
16	X, do you think we need some other parts of maths?	GE	GE
17	Are there any formulas you'd like to know?	CQ	CQ
18	Do you know it? Would you share it?	CQ	CQ
19	Somebody said squared… What do we think?	**GE**	**CQ**
20	Diameter is equal to what, X?	**CQ**	**CT**
21	X, what other formulas do we need to know?	CQ	CQ
22	When we're doing a trigonometry question, what is the first thing we always, always do? X?	**CQ**	**CT**
23	But even before that?	**CQ**	**CT**
24	Try this. Talk to people on your table but have a go.	OM	OM

Figure 1: Extract of transcript of questions asked by the teacher. *X* is used to replace any occurrence of a student name. Bold font is used to highlight classifications where teacher and researcher differ.

Emergences

Differences in the classifications of individual questions by teacher and researcher, have seeded discussions that have led to reflection by the teacher on shifts in attention. In questions 9 to 11 in Figure 1, the researcher classification identified these as genuine enquiry questions, but the teacher spoke about a strong in-the-moment awareness of the responses being sought. The teacher described question 14, which consisted purely of a student's name, as a "continuation", passing the focus to another student. This was seen be the teacher as a move in response to "wanting to keep up the pace" and suggests a shift in the focus of attention between working with students on mathematics and managing the practical constraints of the lesson. The theme of attention shifting to and away from the pace of the lesson occurred in each discussion that made use of the classification of questions. Such discussions were informed strongly by the recall (stimulated by reviewing the transcript of questions asked) of the experience of the lesson on the part of both researcher and teacher.

Given the current focus on development of this as a methodological approach, a workshop at the BRSLM meeting offered an opportunity to work on this data with those in attendance, inviting participants to share what they saw in the set of questions from the same lesson represented in Figure 1 and to comment on perceptions of affordances and constraints in the approach. It should be noted that a 'cartoonised' version of the video recording of the lesson, obscuring physical features of the

teacher, was available in the event that participants asked to view it. The lack of lesson context was a theme that was expressed strongly by participants in the workshop session. In this case, the classification of individual questions was found to be of distinctly limited value; a number of participants identified that they could 'hear' a given question being asked in many different ways, making almost any classification possible. The experience of viewing, as a group, an extract of video recording containing a specific question gave a context of paraverbal and nonverbal cues but there was still not an easy consensus in classifying the question. Even with these philosophical and practical obstacles, working on the questions as data generated several possible routes to explore the original intention, i.e. seeking a mechanism to track observable behaviours as markers of shifts in attention for the teacher. One group of workshop participants had begun to look at the patterning of *wh-* questions, particularly *what* and *why* questions. Several participants commented on possible affordances of looking at *sequences* of questions for indications of a shift of attention in the teacher. As an example, questions 9 and 10 in Figure 1 are suggestive of the teacher refocusing attention on the substance of (what can be inferred as) the answer given:

> 9 Why would you pick trigonometry?
>
> 10 But what about the question makes you think its trigonometry?

A similar pattern appears in questions 22 and 23, although this time there is an implication of the teacher having a sense of the answer they are listening for, consistent with the teacher's classification of these as cloze technique questions:

> 22 When we're doing a trigonometry question, what is the first thing we always, always do?
>
> 23 But even before that?

Such patterning gives a possible route to tracing the attention of the teacher and, hence, to identify points where the attention appears to shift. In order to explore this, a further conversation with the teacher was recorded, in which the teacher was invited to group the questions into distinct sequences. The teacher discussed a repeated pattern of initial exploratory questions, followed by one or more questions that brought student contributions to a particular point in the mathematics at hand. Such sequences of questions were seen as being followed by another question, possibly another exploratory question, that expanded the focus again. An example of this pattern, identified by the teacher, was questions 3 to 8 in Figure 1, with a break before question 9:

> 3 X, what are your thoughts?
> 4 X, do you agree with that?
> 5 Why do you not agree with that?
> 6 Do we have to pick one or the other?
> 7 In general? In this case?
> 8 What would you pick?
>
> 9 Why would you pick trigonometry?

The teacher reported a sense of waiting for "an offer relevant to the question", so that once a particular response to these exploratory questions had been received, attention shifted to working with that particular aspect of mathematics, (an application of trigonometry, in this case).

Implications

Examination of patterning in questions has emerged as a refinement of a mechanism used to explore routes from observable behaviours to shifts in attention, in order to reflect further on a teacher's in-the-moment awarenesses. This report gives an account of a process of methodological development informing an on-going research project. The account is itself an indication of the essential co-emergent nature of classroom research. Considerations of how the methodology emerges and evolves is seen here as a necessary part of the research process, which has valuably involved participants in the research and conversations with the wider research community.

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