Illustrating teacher modelling of engaging in the learning of mathematics or how 'to be' when learning mathematics

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Teaching is both a cognitive and emotional undertaking, but we know less about how emotions are used by teachers in the classroom. This paper draws from observations and interviews with mathematics teachers in the UK. I attend to what is meant by teacher modelling and provide the context of the wider study. Using two examples from experienced teachers' practices and a classification system, this paper considers one form of modelling, which I call 'stepping back'. I explore some affective associations of this form of modelling, including that modelling is affectively driven. Some possible next steps for exploring modelling are suggested.

Mathematics Teacher, Modelling, Engagement, Experience, Secondary

Defining modelling in this context

In mathematics there are several ways in which the word 'modelling' is used. Modelling is defined here as socially located deliberate actions, designed to change and shift the actions of others, or to indicate how students should be feeling about their mathematics. This definition is adapted from Eggen & Kauchak (2013) who suggest the outcome of modelling is, "…changes in people that result from observing the actions of others" (p.236). This position defines experiencing modelling as continual and shifting actions of reconstructing self in social contexts, guided by the influence of others. Hence, although still a continuous two-way constructed relationship between students and teacher, it is not an equal one. Modelling is one of the roles of any teacher in action that enables pupils to see how they can learn from others. From a teacher perspective, according to the DfES, in a continuing professional development training package,

> "Modelling is an active process, not merely the provision of an example. It involves the teacher as the 'expert', demonstrating how to do something and making explicit the thinking involved. Through modelling, the teacher can 'think aloud', making apparent and explicit those skills, decisions, processes and procedures that would otherwise be hidden or unclear" (DfES, 2004, Unit 6, p.3).

The examination of modelling as presented in this paper emerged from a larger study on the affective practices. Common affectively orientated characteristics from the practices of experienced teachers (Lake, 2018) include the social interaction within play and storytelling, taking pleasure in mathematics for self and, as discussed in this presentation, modelling of 'how to be' when learning mathematics. All of which, I will argue, are affectively directed. In this paper, the term emotion refers to fluid and transitory 'in-the-moment' states (Goldin, Epstein, Schorr & Warner, 2011; Hannula, 2012), emotional experiences that even the teacher may be unaware of.

Data and method

The data is drawn from research on teacher emotional expression. The sample was from teachers with at least three years teaching experience as teaching is an emotionally intense experience in early career, and perhaps becomes less intensely emotional as experience develops. The intention was to examine episodes drawn from daily teaching where teachers express emotions, such as shared laughter. The study incorporated using a galvanic skin response (GSR) sensor to begin to access internal affective changes, as well as video and post-observation stimulated recall interviews to access 'in-the-moment' emotions (Lake, 2019). Experienced teachers have meta-emotional skills, which Mottet and Beebe (2000) define as, "knowledge of strategies that can be used to control and regulate emotions (e.g. coping strategies) and the competence to consciously and effectively use them" (p.486). Without the meta-level, which they call second order, a person cannot regulate by control or anticipation or make judgement by appraisal. Appraisal in their terms means whether achievable and whether worth investing effort.

Analysing emotions in combination with modelling

Episodes were primarily selected when emotions were observable in conjunction with (usually peak) GSR readings (Lake, 2019). The observation data is supported by before and after accounts of the teachers. The outcome is a set of case studies for each teacher, comprising of interview, observation, graph of GSR (Fig.1 & Fig.4) and discussion of short lesson episodes. In the episodes examined I observed five forms of modelling. These were 'stepping back', modelling and measurement, modelling dealing with mathematical error, modelling merging work and play through neoteny (an adult modelling behaving as a child) and social teaching and modelling mathematics as procedural or conceptual. 'Stepping back' is the common classroom practice of one or more students leading the learning. This usually takes the form of a student demonstrating a solution on the board or explaining a term, concept or method. Adam and Edward both 'step back' to briefly hand over an instructional position to students. Recalling that the episodes are selected by emotions, we can assume that 'stepping back' is an intense experience for a teacher.

Adam

Adam in lesson A2 (stem and leaf), whilst seated at his computer early in the lesson, asks a year 10 student (Amy) to explain the process of constructing a 'stem and leaf' diagram (used for ordering unsorted data). Whilst Amy explains, Adam mirrors the explanation, using a PowerPoint displaying the data. His positioning enables modelling of interest in and listening to the mathematics for the class. The physical positioning shifts the engagement distance (encouraging proximity between students and mathematics), by allowing students to direct the discussion. The video shows his listening and approval of the explanation through his facial expression, body position, nodding in agreement and appreciative 'uh-huh' sounds, all without interrupting Amy.

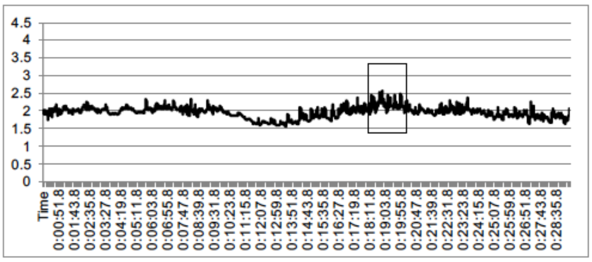


Figure 1: Adam's GSR graph. The box indicates the peak value used to identify the episode for post-observation discussion.

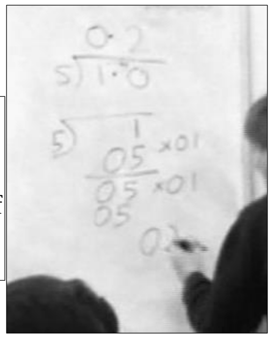
When he returns to position of teacher, Adam repeats Amy's explanation, shifting to an emphasis on exam mark allocation. Adam accords value through language, as when he labels Amy as ‘the expert’ who will tell ‘us’; the audience of teacher (positioned as student) and the students, about stem and leaf diagrams (the mathematics). By not interrupting, his subtle message is ‘we don’t interrupt experts when they are talking about mathematics’. He also implies that the students can already process, positioning them as able for the future tasks, only now requiring a quick revision, “well... Have you done this before? (Yeah) yeah. Could you... Roughly know how to use them? (Yeah) so yeah, right, a quick recap on how they work.” This positioning works as a subtle emotional message of trust and confidence in both Amy and the class. In the lesson, Adam models the process of engaging with the topic for maximum marks. He uses tonal emphasis to signal to students to pay attention to key words. Similarly, Adam's silence whilst Amy is explaining shifts attention away from him towards the whole class as audience. This shift is shown by his positional use of ‘us’ rather than ‘me’ labelling of the audience within modelling in this form, I would suggest such pronoun use is crucial for modelling interest for students. Adam accepts Amy's eventual rejection of position of teacher as her confident explanation becomes repetitive number crunching. He quickly responds, almost interrupting, increasing the pace, and draws attention back by reforming ‘you’ to be directed at the class as audience, “Well... Have you done this before?”

Edward

In Edward's lesson, as part of a lesson on converting fractions to decimals, two students, Joe and Sam, consecutively explain their method for division on the board (Fig. 2 & Fig. 3). In the first case, Joe does not explain his thinking clearly (despite being a correct yet unusual mapping method), whereas Sam uses Edward's stated preferred ‘bus-stop’ division method. Whilst the students are modelling, Edward stands at the back of the classroom. His body language shows attentive listening and he uses a neutrally positive tone of voice. In both cases, Edward uses guiding questioning, but he reiterates only Sam's method (Fig. 3).

Figure 2: Edward and his class. On the board is Joe’s method

Figure 3: Sam demonstrating his chunking. Above is an earlier example of bus-stop method for division



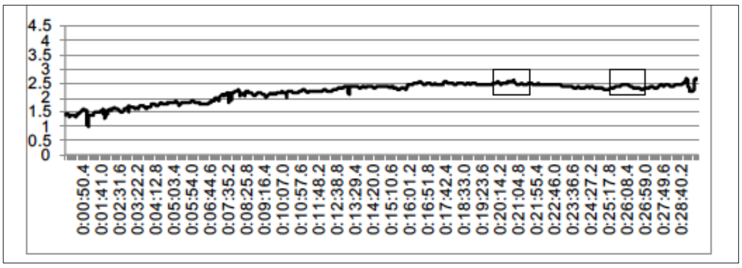


Figure 4: Edward's GSR graph. The boxes show the maximum reading, used to select the first episode. In this case the episode structure was repeated (second box).

One of Edward's subtle underlying messages is that division should be done using ‘bus-stop’. He communicates this message by his language, such as when he repeats Sam’s demonstration (using ‘bus-stop’ method). His interview comments also show this view,

"…the bus-stop, to me, seems to me the most efficient way of doing it. I think there is a certain elegance to it I suppose…" Yet in his overt discourse, he states that students can use any preferred method for division. Edward also reiterates comments, showing approval for comments about bus stop, whereas for chunking he just moves on. He uses a positive stance and models careful consideration. In particular, Edward uses careful phrasing, such as, "do you want to come [to the board] and show me what you do?" Such pronoun emphasis in his phrasing implies both choice and positions the student as having ownership of mathematical skills, although, in this sentence, positioning Edward as the one who needs to be shown.

Examining the episodes through an Engagement Structure and Positioning theory lens

There are few analysis models for examining affect in-the-moment, most use post-event recall which is problematic for fluid and transitory emotions. Defining emotion as a predominantly socially triggered impetus for action made Goldin et al.'s (2011) Engagement Structures (ES) seem useful. This 'constellation' model was developed from examining classroom problem-solving behaviours of students. There are nine distinct Engagement Structures derived from contributing 'strands' (e.g. underlying desire, need, evocation, observable behaviour and emotional reward), which are allocated acronyms, but at any moment, only one Engagement Structure is dominant. Previous work (Lake, 2018) explored whether student Engagement Structures were also applicable to teachers, with the aim of generating a unifying model suitable for studying classroom interactions. Yet the fluidity of local interaction was found to be not sufficiently captured by this model alone, so it was used in conjunction with Harré and van Langenhove (1999) Positioning Theory which captures interaction in detail. Fig. 5 illustrates just one of the nine Engagement Structures (IRIT: I'm Really Into This)."

Adam has a dominant Engagement Structure of LMTY (Let Me Teach You). This is examined in more detail elsewhere (Lake, 2016), but is a structure where a person (either teacher or student) positions themselves as a more knowledgeable other and is willing to share their knowledge. For Adam this dominant Engagement Structure was supported by LHSIA (Look How Smart I Am), a performance orientated Engagement Structure, and IRIT (I'm Really Into This) (e.g. Fig. 5). These structures, in terms of modelling, imply that Adam's teaching can be generalised as an expert who models reflection and taking time to think, as well as apparent absorption in mathematical task in a 'flow' sense. Adam uses out loud thinking and overt modelling of thought processes.

Edward teaches predominantly in the Engagement Structure of GJD (Get the Job Done) and CTO (Check This Out). In terms of modelling, Edward's teaching is characterised by carefully constructed questions and taking time to consider (characteristic of CTO) but is primarily outcome orientated, as in GJD. Both teachers commonly use facilitating rather than instructional positions. The full details of each Engagement Structure can be found in Goldin et al. (2011). Despite the same activity taking place in a class, there is little overlap between the structures of each teacher.

ES	Applicable strands	Description	Additional information
I'm really into this	Desire	*"The desire is to experience the very activity of addressing the task, ideally in "flow" (Csikszentmihalyi, 1990)… intrigued by the mathematics or the problem-solving*	*"Math, mathematical representation, and/or problem-solving are intriguing, with internal logic and coherence. The* […] *self-concept is as an effective problem solver, serious, an engaged*

IRIT		*process. 'Tuning out' the other elements of the environment."*	*thinker. Problem-solving or learning activity is valued for its own sake".*
	Need	*"Behind this desire (in the case of mathematics) may be the need Murray calls understanding: "to represent in symbols the order of nature (p. 224).""*	*"In context, it may express a mastery goal orientation."* *"Some of the specific motivating desires described here can be understood as 'counterparts' to longer-term goal orientations: thus, the motivating desire for 'I'm Really Into This' seems more like a mastery-approach goal."* *"In the context of 'I'm Really Into This', frustration is more likely to be experienced positively, signifying challenge and heightening intrinsic mathematical interest in the problem."*
	Evoked by	*"The opportunity presents itself with social support for deep engagement in a challenging problem."*	
	Behaviour	Apparent task absorption	
	Emotional satisfaction	*"Satisfaction derives from achieving mathematical understanding, solving a difficult problem, or simply experiencing fascination".*	

Figure 5: The formation of the Engagement Structure IRIT (Goldin et al., 2011:550-553)

Modelling by 'stepping back'

In this paired illustration, I have drawn attention to two teachers modelling apparent enjoyment of reflective listening to students talking about mathematics, and how this modelling gives students an impression of positive expectations. The teachers physically distance themselves from the mathematics by this action, but the effect may be to draw the students closer to positive engagement in the mathematics. It also provides the teacher with an opportunity to extend and clarify.

The episodes show teachers attempting to model ideal Engagement Structure patterns for learning, which, in positioning terms, students may then mimic, synchronise with or reject, hence choices in modelling may prove to enable (or hinder) student shifts in engagement. This is despite the differing Engagement Structure patterns for each teacher. These episodes highlight two dimensions of modelling; subtle modelling and a modelling of attention to what is deemed important within the mathematical topic.

I have briefly suggested that there is potential within modelling for influencing student engagement, such as encouraging students into the Engagement Structure of LMTY (Let Me Teach You), which is likely to be supportive for a discussion based and collaborative orientated classroom, conditions that we know are conducive for developing problem solving. The Engagement Structure model used was originally developed from observing students engaged in problem solving in class and locates within social collaborative learning.

Taking the teacher role may be an enjoyable student experience. This pleasure is most evident for Sam in Edward's class, who deliberately and cheekily causes class laughter by gently mimicking the teacher's mannerisms whilst he is centre stage. In both cases, there was evidence of more intense teacher affect as shown by the highest values recorded by the ESensor for each teacher. This suggests that modelling is effortful and may be directly associated with emotional intensity, or at least suggests modelling seems closely connected to emotions, an association that merits further investigation. The examples illustrate how a teacher might model, which contributes to the emotional climate. It seems reasonable to assume that repetition of such modelling provides, over time, a norm of reflective positive engagement in learning for students.

Modelling choices such as 'stepping back' may act to blur differing roles in the classroom, with the effect of shifting the teacher/student power relationship. 'Stepping back' gives students an opportunity to articulate their mathematical thinking, especially if, as in both cases, the opportunity is attached to the teacher expressing confidence in the pupil's ability to explain. This is highlighted after the lesson by Edward who, after showing confidence in the student (Joe) in the lesson, says, "Especially with that student there, I am thinking 'this is not actually not going to push my lesson on, this is going to be more trouble than it's worth.'" Yet Edward still offers shared ownership of learning, which he may see as motivating as well as providing an opportunity to model for the students how to engage and 'to be' as a student (as part of learning to notice for both teacher and students). Yet it may be simply that variety of pedagogy, which offers novelty or deviation from norms, has a positive effect on engagement. The importance of modelling has been known for some time (DfES, 2004), but more research is needed on how an experienced teacher models, and how emotions connect to modelling. It would be useful to follow up this research with interviews of experienced teachers to discuss where, when and why they model, to explore whether this is effortful and to consider how to develop effective modelling with trainee teachers.

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