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# A case study of epistemic order in mathematics classroom discourse

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*This exploratory study analyses the discursive frames through which ideas are developed and evaluated during one section of an early secondary lesson. The study employs a refined version of the classic IRF framework to analyse the interaction structure of classroom dialogue, linking this to semantic analysis of the ideological stance conveyed by participants' utterances and actions. The epistemic order which emerges emphasises the evaluation of ideas primarily in terms of whether they are understandable and make sense. The predominant discourse pattern is one in which the teacher exercises epistemic initiative but offers little overt epistemic appraisal. Occasionally, however, the teacher passes the epistemic initiative to a pupil and provides some form of supporting or concluding epistemic appraisal.*

**Keywords:** Classroom dialogue, discourse analysis, school mathematics, IRF.

## MOTIVATION FOR THE STUDY AND THEORETICAL FRAME

In this paper we report an analysis of how classroom dialogue functions to create what we will term an *epistemic order*. By this term we refer to the system of discursive frames within which ideas are developed and evaluated in the classroom. Recent theorisation of classroom discourse has distinguished two crucial dimensions, one concerned with *discourse structure* – the forms of talk and patterns of interaction in play – and the other concerned with *ideological stance* – the degree to which knowledge and ideas are taken as fixed and given as opposed to fluid and open (O'Connor & Michaels, 2007). Such theorisation has also challenged the assumption that these aspects are necessarily aligned; as fostered by the archetypical Initiation-Reply-Evaluation (IRE) structure of classroom recitation in which the opening Initiation move accords the teacher the *epistemic initiative* in posing

the question, just as the closing Evaluation move makes the teacher the agent of *epistemic appraisal*.

However, within linguistic research, the limitations of the IRE template – even in representing the structure of conventional classroom dialogue – have long been known, and a broader and more flexible Initiation-Response-FollowUp (IRF) model has been preferred (Sinclair & Coulthard, 1992). Linguistic scholarship has also suggested modifications to the original IRF framework to better model the nuances of classroom dialogue (Coulthard & Brazil, 1992). In particular, the modified version of the IRF framework that we employ is designed to acknowledge the uncoupling of two aspects of the teacher's management of classroom dialogue which typically takes place as that dialogue moves away from an IRE pattern: management of the taking of turns by speakers in interaction slots, and of the substantive exchange of ideas through communicative acts. Thus, our adapted IRF approach introduces a distinction between the *interactional initiative* of launching an exchange, and the *epistemic initiative* of introducing the idea on which an exchange focuses. While one move often combines both types of initiative – as in the classic teacher I within IRE – this is not always so. In the transcript analysis which follows, for example, see E4 where the teacher simply initiates interaction by inviting a pupil to speak, followed by E5 where, by making a substantive contribution in response, that pupil initiates the idea to be discussed.

More recently, pedagogically motivated research on classroom dialogue has shown that triadic IRF interaction patterns continue to play an important part even in more enquiry-oriented classrooms, but fulfil a wider range of functions (Nassaji & Wells, 2000; Truxaw & DeFranco, 2008). This literature has identified markers of what is termed 'dialogic activity' in which classroom talk is more varied in its forms of interaction and more open to exploring differing perspectives.

Such markers include the extent to which questions are posed by pupils, the types of question posed by the teacher, and the kinds of teacher follow-up to pupil responses, including the extent to which responses are not explicitly evaluated and/or are taken up in further exchanges.

## DESIGN OF THE STUDY AND ANALYTIC METHODS

In this paper we analyse one section of a video-recorded lesson. Our purpose is to employ an IRF system, adapted for analysis of epistemic order, to establish a baseline against which a later section of the same lesson will (in future) be compared. This later section is of particular interest because it appears to offer a strong example of 'dialogic activity' displaying a distinctive epistemic order. Our adapted system aims to underpin deeper analysis to provide a more rigorous basis for such judgements.

Coding in particular, and analysis more generally, were undertaken against a transcript of the classroom dialogue but involved referring also to the original video-recording. We employed an approach to transcription in which the emphasis was on capturing both the taking of speech turns and the development of substantive ideas (so, for example, excluding exchanges only concerned with classroom management, and omitting repetitions, stumbles or repairs in spoken expression which proved to have no analytic significance). This produces more accessible transcripts while ensuring that all analytic judgements are backed by the source video-record.

One of the reasons that we chose to update the classic IRF system is that it is very rigorously specified. Here, however, space permits us only to set out the essentials of the modifications we made to the original IRF analytic framework. First, a prefix is added to the coding of each move to indicate whether it was undertaken by teacher or pupil. Second, recognising the way in which interaction slots are sometimes linked in practice, the familiar repertoire of I, R and F slots was extended through the addition of two composite types: the R/I type (in which a Response consists of, or develops into, a further Initiation) and the F/I type (in which a Follow-up consists of, or develops into, a fresh Initiation). All moves are given a speaker prefix and slot code.

Next, to distinguish the interaction slot that a move occupies from the communicative acts that it accomplishes, a further code string indicates the character of such acts. Moves which convey some substantive idea about the operative topic (typically I or R moves) are coded either as a solicitation (s) or as a contribution (c), depending on whether they explicitly seek to elicit a response or not. Equally moves (typically F moves) receive a code if they provide an explicit evaluation indicating approval (a) or disapproval (d) of a prior contribution; and if they repeat, restate or revoice (all or a salient part of) a prior contribution (v). Thus in an archetypical IRE exchange the initiating teacher question would be coded tIs, the pupil reply pRc, and the teacher evaluation something like tFav or tFd. The purpose of refinement, however, is not just to enhance the information carried in the code string but to better model moves in dialogue. So, for example, a teacher move which simply nominates a pupil to speak would be coded tI; and the ensuing move in which the pupil poses a question pR/Is.

When italics are used this indicates a part of the code that has had to be inferred.

Finally, as well as recognising the basic interactional unit of the IRF *exchange*, we acknowledge two larger units. A *transaction* is a higher level unit consisting of one or more exchanges, grouped because there is linkage between these exchanges through uptake of ideas (often signalled by the presence of F/I moves). We refer to one particular type of transaction as a *duologue*: where interaction extends over more than one exchange and is restricted to the teacher and a single pupil. An *episode* is a still higher level unit consisting of one or more transactions forming a recognisable structural component of the lesson as marked out by participants and/or resources.

The lesson involved an experienced teacher with a class (aged 11/12) in their first year of secondary education in England. The lesson material came from a module on probability, making connections between mathematics and science (Ruthven & Hofmann, 2013). For reasons of space, we confine ourselves to five episodes making up a lesson section in which the whole class addressed a series of related questions. These questions appeared on two slides about the genetic model of the inheritance of the characteristic of attached/detached earlobes which had also supported a

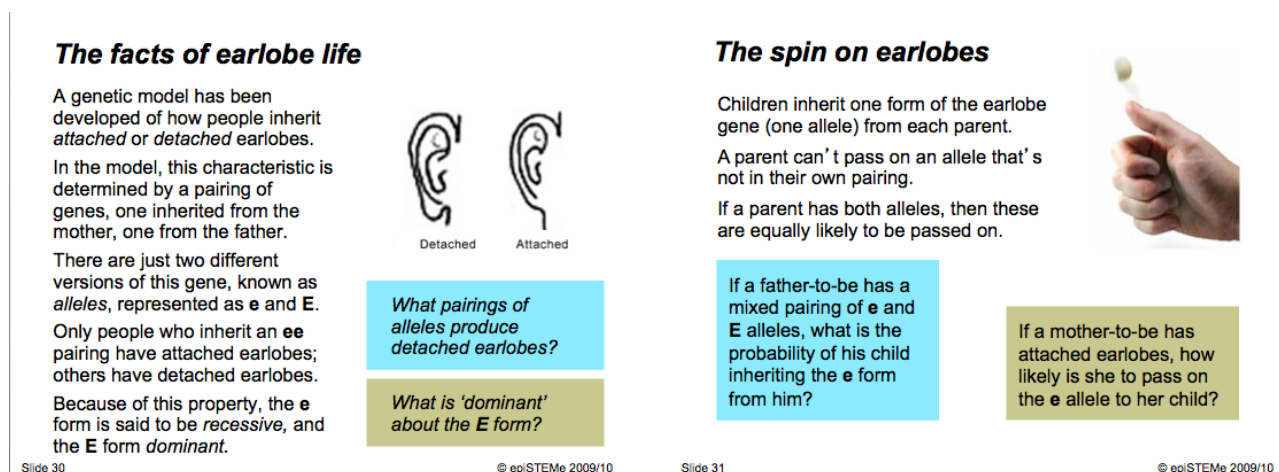


Figure 1: The slides supporting the section of the lesson under analysis

shorter introductory exposition by the teacher. These two slides are shown in Figure 1.

### PRESENTATION AND ANALYSIS OF THE INDIVIDUAL EPISODES

#### Episode A

The first episode takes place when the teacher brings the whole class together after they have independently tackled the first question posed on Slide 30.

- A1 T: Dan, what pairings have you got, because I think you look like you've finished? So for detached earlobes. tIs
- A2 P: Two large ees. pRc
- A3 T: Two large ees. [Records on board] tFv
- A4 Ps: A big ee and a little ee. pRc
- A5 T: A big ee and a little ee. [Records on board] tFv
- A6 P: A small ee and a big ee. pRc
- A7 T: A little ee and a big ee. [Records on board] tFv

Rather than repeating the scientific question about pairings posed on the slide, the teacher invokes it at one remove, asking a pupil to report the pairings that he had found (A1). The teacher follow-up (A3, A5, A7) to the pupil responses (A2, A4, A6) (which adequately answer the scientific question) repeats them in a neutral tone and records them on the board without offering any explicit evaluation.

- A8 T: Everybody happy so far? tIs

- A9 P [Hal]: No I don't get it. pRc
- A10 T: What don't you understand, Hal? tF/Is
- A11 P [Hal]: The big ees and the little ees. pRc
- A12 T: What about the big ee and little ee don't you understand? tF/Is
- A13 P [Hal]: How that represents anything. pRc

The transition to a new transaction is marked by the teacher's next solicitation (A8). She asks pupils whether they are "happy" with what has been presented (A8) (rather than, for example, whether it is correct). In response, Hal expresses unhappiness (A9) in terms of his "not getting it". This framing is taken up by the teacher in her subsequent solicitations (A10, A12) about what he "doesn't understand". This co-construction of the situation underpins the reflexive and diagnostic duologue which takes place, in which the teacher's probes serve to elicit Hal's thinking.

- A14 T: Can anybody help him? Hal says he doesn't understand about the big ee and the little ee, and he doesn't understand what they represent. Can anybody help him? tIs
- A15 Ps: [Inaudible. Many pupils speaking over each other.] pRc
- A16 T: Not necessarily. No. No no no. No no. Forget about X and Y. Forget about boys and girls. Just think earlobes please. tFd/Ic

- A17 P: A little ee and a big ee are detached, and a big ee and a little ee are detached, so [inaudible]. pRc
- A18 Ps: *[Inaudible. Many pupils speaking over each other.]* pRc
- A19 T: All right. I'm not sure that Hal's getting the answer to his question. Hal, are you? tFd/Is
- A20 P [Hal]: Yeah. pRa

Opening the final transaction, the teacher invites pupils to help Hal (A14). However, this solicitation (A14) elicits a tangential line of thinking in response (A15; inferred from A16) which the teacher follows up with strong disapproval and a steer back towards the issue at hand (A16). This elicits further pupil responses (A17, A18). It is ambiguous whether the follow-up to these (A19) alludes to the breakdown of orderly talk or to the substance of the help being offered. The teacher solicits Hal's evaluation (A19), positioning him as the arbiter of whether his difficulties have been resolved. His positive response (A20) is allowed to conclude the episode.

In this episode, then, all solicitations are made by the teacher, and so epistemic initiative remains firmly with the teacher. However she exercises little overt epistemic appraisal. In this epistemic order, the teacher directs the unfolding of ideas which are to be evaluated by pupils according to whether they make sense to them. To this end, the teacher employs discursive strategies such as eliciting pupils' ideas and self-assessments, as well as avoiding evaluative follow-up to their responses. Where such follow-up does become evaluative, it relates to redirecting pupil contributions to the matter at hand or establishing their helpfulness to other pupils.

### Episode B

- B1 T: Bet, you had a question. tI
- B2 P [Bet]: Oh yeah. *[Referring to question on slide]* Like what is dominant about the ee then? pR/Is
- B3 T: *[Reading question from slide]* What is dominant about the ee form? So if you've got a big ee, what is dominant? What are you going to see? tR/Is
- B4 P [Bet]: If you, the little ee, you have to have two of them to have attached, but you only need one

- big ee and one small ee to have detached, so there's more ways you can have big ee than little ee. pRc
- B5 T: Yes. tFa

The next episode begins with the teacher inviting a pupil to speak (B1). Bet draws attention to the second question on Slide 30 by restating it (B2). Rather than responding by answering this question, the teacher restates it to create a fresh solicitation (B3). Through this discursive manoeuvre the teacher leads Bet to answer the question that she herself raised. When Bet responds with a broadly well conceived answer (B4) the teacher approves it (B5).

- B6 P [Tia]: Surely if you have a big ee then you're going to have detached earlobes. pIs
- B7 T: Yes. Yes. So if you've got at least one big ee, then you are going to have detached earlobes. tRav

The final exchange starts with a solicitation from another pupil seeking validation of a variant of the same answer (B6). The teacher approves and slightly refines it (B7).

In this episode, then, the opening solicitation for each transaction comes from a pupil. In both, the pupil puts forward her answer to the question under consideration in a rhetorical form which invites endorsement. The answer is duly approved (and in one case restated) by the teacher. Here, the discursive frame is one in which the teacher cedes epistemic initiative to the pupil but becomes the agent of epistemic appraisal.

### Episode C

The next episode relates to the first question on Slide 31.

- C1 T: *[Reading question on slide]* If a father to be has a mixed pairing of ees, so a little ee and a big ee, what is the probability that the child will inherit the little ee. Tia? tIs
- C2 P [Tia]: Surely it's quite low, because like pR/Is
- C3 T: Can we put a figure on it? tR/Is
- C4 P [Tia]: Zero. pRc



- C5 T: So he's got one of each. He's got a big ee and a little ee. What is the probability that the baby will have a little ee, from their dad? tF/Is
- C6 P [Tia]: Zero. I think it is. pRc
- C7 T: Zero. You think it's impossible? tFv/Is
- C8 P [Tia]: Surely if you have a big ee, somewhere... you're going to have detached? pR/Is
- C9 T: Yes, but this question isn't about what sort of earlobes the child will have. It's about which of those two alleles the child will inherit. tRc

then there is equal chance, and if it goes up to one there's a half chance. pRc

- C16 T: So it does indeed. [Reading from slide] Equally likely to be passed on. So that makes sense doesn't it. So the probability of a little ee is going to be a half. tFva

The teacher then restates the question and nominates another pupil to answer (C10). Lea does so (C11). The teacher does not evaluate but, acknowledging a signal from Tia, refers Lea's answer to her (C12), eliciting Tia's agreement that it "makes sense" (C13). The teacher then solicits explanation of "why" from another pupil (C14). Kit's response refers to the key piece of information on the slide and pinpoints how it leads to the answer (C15). The teacher's concluding follow-up endorses this contribution, and reiterates the key point as the basis for the answer "making sense" (C16).

The first transaction in the episode consists of a duologue between the teacher and Tia. It opens with the teacher reading the scientific question posed on the slide, restating some elements of it, and then nominating Tia to respond (C1). Tia's emergent answer to the question is ill conceived (C2, C4, C6) and is taken up by the teacher through a series of follow-up and solicitation moves which successively press for greater precision (C3), restate the question (C5), and draw attention to an implication (which would be incompatible with the question situation) (C7). In response to this last probe, Tia finally articulates the reasoning behind her answer (C8), allowing the teacher to pinpoint the misinterpretation of the question that underlies Tia's responses (C9). While the teacher makes no explicit evaluation of these responses, the direction and persistence of her questioning does imply dissatisfaction with them. This duologue, then, has a more dialectic quality.

In the opening duologue of this episode, epistemic initiative remains firmly with the teacher, exercised through a series of questions probing the pupil's ideas. While the pupil also makes solicitations, these are by way of response, and in a rhetorical form which insists on a point and appeals for its endorsement. It is the absence of such endorsement from the teacher, accompanied by her probing of the point, that tacitly implies epistemic appraisal. This probing by the teacher leading to the diagnosis which concludes the transaction could, however, be viewed as compatible with the epistemic order enunciated in the ensuing transaction: that ideas should be appraised in terms of whether they make sense and are consistent with the institutionally approved knowledge available. In this transaction, while the teacher retains the epistemic initiative through a series of solicitations, she designates pupils as the primary agents of appraisal, only exercising such a role herself in the final move.

- C10 T: So he's got one big ee and one little ee, the father. What is the probability that any baby he makes will inherit the little ee. Lea? tIs
- C11 P [Lea]: [Inaudible] make it a half. [Pause] Yeah fifty per cent. pRc
- C12 T: Lea says it is a half. Tia, you're now saying that makes sense. tF/Is
- C13 P [Tia]: Yeah. pRa
- C14 T: Could somebody just confirm why. Why does that make sense? Kit? tF/Is
- C15 P [Kit]: It says up on the board, if a parent has both alleles, whatever,

#### Episode D

The fourth episode comprises a short duologue on the second question on Slide 31.

- D1 T: [Reading from slide] If the mother to be has attached earlobes, so the mummy has attached earlobes, how likely is she to pass on a little ee? Tom. tIs
- D2 P [Tom]: Certain. pRc

- D3 T: Certain. Hundred per cent.  
Why is that? tFv/tIs
- D4 P [Tom]: Because if she's got at-  
tached earlobes, then she's got ee ee. pRc
- D5 T: She's got two little ees. tFv

The opening teacher solicitation restates the question and nominates a pupil to respond (D1). Tom does so succinctly and correctly (D2). The teacher follows up by repeating and elaborating Tom's answer, and then solicits an explanation of it (D3). Tom highlights the key idea (D4) which the teacher follows up by refining it (D5).

Here, the teacher takes the initiative in posing questions but offers no explicit evaluation of pupil answers. Unlike previous episodes, the notion of appraisal by other pupils in terms of whether an idea makes sense is neither articulated nor enacted here. Indeed, by not subjecting the ideas put forward to such scrutiny, the teacher might be taken to be signalling her own approval of them, so employing a tacit form of appraisal within a more conventionally authoritative epistemic order.

### Episode E

The final episode develops from public exploratory talk by two pupils which raises the question of whether both questions on the projected slide are intended to refer to the same situation (E1, E2), a suggestion rebuffed at this stage by the teacher (E3).

- E1 P: But, if the mother to be  
and the father to be, like, are the  
same mother and father, and they  
both make, like pIs
- E2 P: Yeah, does it matter? Is  
it like the same child, like, that  
they're talking about, or not? pR/Is
- E3 T: I don't think it's a particu-  
lar child. [Pause] tRc

However, after a short period during which the teacher consults teaching notes and pupils talk amongst themselves, the teacher gives Bet the floor (E4).

- E4 T [In response to indication  
from Bet] Yes. tI
- E5 P [Bet]: About the question that  
we've just said. The baby might

not definitely have attached ear-  
lobes but it would definitely have  
a little ee because she has two little  
ees so she you'll definitely have one  
of them. But depending on what the  
father might have, detached ears he  
might have. pRc

- E6 T: [Intervening] So if we  
actually join this mother and this  
father together to make a child.  
[Gestures to Bet to speak] tF/Is
- E7 P [Bet]: It could have two little ees  
or one big ee and one little ee. So  
he's got one big ee. It's definitely  
going to have a little ee. pRc
- E8 T: Definitely going to have a  
little ee. tFv
- E9 P [Bet]: But it could get a big  
ee from the father, it could get a  
little ee. pIc

Bet starts to put forward her ideas (E5). The teacher intervenes by commencing a statement that explicitly restates the hybrid situation, inviting Bet to complete it (E6). Bet does so (E7), the teacher repeats a key phrase (E8), and Bet expands further (E9).

- E10 T: [Turning away from Bet  
towards class] So which sort of  
earlobes is it more likely to have?  
[Pause] If these two parents get  
together which sort of earlobes is  
it more likely to have? Hyp, any  
thoughts? tIs
- E11 P [Hyp]: Detached. pRc
- E12 T: Bet was just saying that  
it's guaranteed to have one little  
ee but it could get a big ee, and I'm  
saying, what sort of earlobes is it  
most likely to have. Yes Jay. tF/Is
- E13 P [Jay]: Half and half because, be-  
cause of the father, because if you  
then get a big ee then it will be dom-  
inant, and so it'll be detached. pRc
- E14 P: Yeah. pFa

In the final transaction of this episode, the teacher puts a new question to the class and nominates a pupil (E10). Hyp gives an incorrect answer (E11) which the teacher follows up without evaluation. Rather, she recapitulates part of Bet's earlier exposition, restates

her own question, and accepts another pupil's bid to speak (E12). Jay's response provides both correct answer and supporting reasoning (E13), which appears to be approved by another pupil (E14). Again, by allowing the transaction to conclude in this way, the teacher might be taken to be tacitly signalling approval.

The teacher's rebuff to the idea proposed in the opening transaction, serves to reclaim the epistemic initiative in the face of an apparent digression. But, in the second transaction, she passes the initiative to another pupil who productively develops the idea. The teacher now changes her position, lending support to the idea, and eventually appropriating it in formulating the question to be pursued in the final transaction. The duologue is launched by Bet, punctuated by shorter contributions from the teacher which extend and revoice key points. In the final transaction, the teacher reclaims the initiative, and dialogue returns to interaction around teacher questions. The teacher makes no explicit evaluation of responses, but she follows up the incorrect answer to her first solicitation by restating the question. She then allows the episode to conclude without following up the sound answer to this second solicitation (or an apparent pupil endorsement of it). This pattern could be interpreted as one of tacit appraisal within a more conventionally authoritative epistemic order.

## SYNTHESIS AND DISCUSSION

The epistemic order which emerges from these episodes is one in which initiative is generally exercised by the teacher. The predominant discourse structure involves a  $tI_s > pR_c > tF$  move sequence, where the  $tF$  component takes a  $tF_v$  or  $tF/I_s$  or  $tF_v/I_s$  form. It is notable that in such an interaction pattern, the teacher does not exercise any overt epistemic appraisal, at least not in the form of an explicit evaluation. Rather she probes the pupil response (C3, C5, C7, D3) or refers it to other pupils for approval and/or explanation (A8, C12, C14). The ideological stance guiding this approach is conveyed by the teacher's references to evaluating ideas in terms of whether they are understandable and make sense (A10, C10), and also whether they are consistent with institutionally accepted knowledge (C16). In particular, in the opening episode, this stance is articulated and enacted through the reflexive duologue concerning Hal's understanding (A8–13) and the ensuing transaction in which the teacher moderates the provision of help by other pupils (A14–21);

although when she doubts whether the lines of explanation being put forward by pupils are appropriate, she does make an explicit evaluation (A16 and possibly A19). However, in later episodes (D, E) the referral of responses to other pupils falls away, leading to their ending as soon as a pupil has enunciated an institutionally accepted resolution of the issue of the matter under discussion. This could be interpreted in terms of the teacher exercising – and conveying to those alert to this scheme – tacit epistemic appraisal within a more conventionally authoritative epistemic order.

Beyond this predominant pattern are two occasions when the teacher passes epistemic initiative to a pupil (B1–7, E1–9). With few examples, all that be confidently said is that substantive development of ideas originates from a  $pI$  move. On the first occasion, the teacher exercises epistemic appraisal by concluding her exchange with each pupil with an explicit evaluation (B5, B7). On the second occasion, the teacher exercises a supportive, if tacit, epistemic appraisal through expanding on (E6) and echoing (E8) the ideas put forward by a pupil over a series of moves.

Both these discursive frames, then, grant pupils a degree of epistemic agency: over appraisal in the first type, and initiative in the second. In maintaining such frames, of course, the teacher exercises a more fundamental epistemic authority. Indeed, all five of the episodes conform to a pattern in which, once an institutionally accepted resolution of the topic has been enunciated, the teacher directs any further discussion towards elucidating that resolution. Such authority is apparent too on those occasions where the teacher judges it necessary to explicitly evaluate and steer pupils' exercise of agency. Such interventions show devolution of agency to pupils as conditional.

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