

A CASE STUDY OF EPISTEMIC ORDER IN MATHEMATICS CLASSROOM DIALOGUE

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We define epistemic order as the way in which the exchange and development of knowledge takes place in the classroom, breaking this down into a system of three components: epistemic initiative relating to who sets the agenda in classroom dialogue, and how; epistemic appraisal relating to who judges contributions to classroom dialogue, and how; and epistemic framing relating to the terms in which development and exchange of knowledge are represented, particularly in reflexive talk. These components are operationalised in terms of various types of structural and semantic analysis of dialogue. It is shown that a lesson segment displays a multi-layered epistemic order differing from that of conventional classroom recitation.

Keywords: Classroom dialogue; Dialogic teaching; Discourse analysis; Initiation-response-feedback; School mathematics

Un estudio de caso del orden epistémico en el discurso de la clase de matemáticas

Definimos orden epistémico como el modo en que se produce el intercambio y desarrollo de conocimiento en el aula, de acuerdo con un sistema de tres componentes: iniciativa epistémica respecto a quién y cómo establece la agenda del diálogo de clase; evaluación epistémica respecto a quién y cómo valora las contribuciones a este diálogo; y marco epistémico respecto a los términos en los cuales el desarrollo e intercambio de conocimiento se representa, particularmente en el habla reflexiva. Operativizamos estos componentes mediante varios tipos de análisis estructurales y semánticos del diálogo. Con los datos de un segmento de clase, se muestra un orden epistémico de múltiples niveles que difiere de formatos convencionales de relato en el aula.

Términos clave: Análisis del discurso; Discurso de clase; Enseñanza dialógica; Inicio-respuesta-realimentación; Matemáticas escolares

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 prevalent assumption that discourse structure is necessarily aligned with ideological stance. That assumption has been fostered by the continuing salience of recitation—with its classic initiation-reply-evaluation (IRE) structure (Mehan, 1979)—as an archetype of classroom dialogue much referred to in the educational literature. In the opening initiation move of a recitation exchange, the teacher takes the *epistemic initiative* in posing pupils a question—typically one to which s/he already has some answer in mind, while in the closing evaluation move the teacher provides an *epistemic appraisal* of the answer given by a pupil in the intermediate reply move—typically an appraisal approving or disapproving the answer given. This particular pattern of initiative and appraisal, and the terms in which it frames the exchange and development of knowledge, constitute an example of what we will term an *epistemic order*.

However, within linguistic research, the limitations of the IRE model—even in representing the structure of conventional classroom dialogue—have long been known: Instead, a broader and more flexible model, initially initiation-response-feedback, later initiation-response-followup—both IRF, has been preferred (Coulthard, 1992; Sinclair & Coulthard, 1975). While Mehan's IRE model represents one particular manifestation of an IRF interaction structure, Sinclair and Coulthard's empirical research demonstrated that patterns of classroom interaction were more varied, establishing the greater power and versatility of the IRF model. More recently, pedagogically motivated research on classroom dialogue has shown that triadic interaction patterns of this IRF type continue to play an important part even in more enquiry-oriented classrooms, but fulfil a wider range of communicative functions, both specifically in mathematics (Truxaw & DeFranco, 2008) and more widely (Nassaji & Wells, 2000).

Other components of Sinclair and Coulthard's system, with a more explicitly pedagogical focus, have attracted less attention. We are interested in examining how techniques of analysis which incorporate some of these other components may be helpful in throwing light on classroom discourse. In particular, we are interested in how different patterns of classroom discourse function to create a particular epistemic order relating to the way in which the development and exchange of knowledge takes place. We take an epistemic order to be constituted by a pattern of epistemic initiative—relating to who sets the agenda in classroom dialogue, and in what terms and manner—and epistemic appraisal—relating to who judges contributions to classroom dialogue, and in what terms and manner, along with the associated epistemic framing—referring to the terms in which development and exchange of knowledge are represented, particularly in reflexive talk. This paper introduces and explains an apparatus developed from

Sinclair and Coulthard's wider system, and applies it to analysis of a segment from a school mathematics lesson. By triangulating analyses of different types and at different levels we hope to throw light not just on the epistemic order in evidence during this segment, but on the functioning of the analytic methods being employed.

STUDY DESIGN

We chose to study the dialogue of a particular lesson from a collection video-recorded in connection with an earlier project because it appeared to differ in important respects from archetypical recitation. The lesson involved an experienced teacher working with a class—aged 11/12—in their first year of secondary education in England. The material came from one of the later lessons in a module on probability covering the topics specified for that age group in the national curriculum (Ruthven & Hofmann, 2013). We confine ourselves here to five episodes making up a lesson segment in which the teacher led the whole class in addressing 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 the teacher had used earlier to support a short introductory exposition. These two slides are shown in Figure 1.

The facts of earlobe life

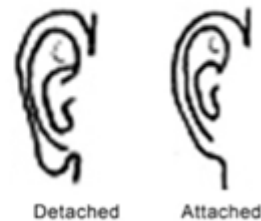
A genetic model has been developed of how people inherit *attached* or *detached* earlobes.

In the model, this characteristic is determined by a pairing of genes, one inherited from the mother, one from the father.

There are just two different versions of this gene, known as *alleles*, represented as **e** and **E**.

Only people who inherit an **ee** pairing have attached earlobes; others have detached earlobes.

Because of this property, the **e** form is said to be *recessive*, and the **E** form *dominant*.



What pairings of alleles produce detached earlobes?

What is 'dominant' about the E form?

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

The spin on earlobes

Children inherit one form of the earlobe gene (one allele) from each parent.

A parent can't pass on an allele that's not in their own pairing.

If a parent has both alleles, then these are equally likely to be passed on.



If a father-to-be has a mixed pairing of **e** and **E** alleles, what is the probability of his child inheriting the **e** form from him?

If a mother-to-be has attached earlobes, how likely is she to pass on the **e** allele to her child?

Figure 1 (Continuation). The slides supporting the section of the lesson under analysis

Coding and analysis 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 relating to the mathematico-scientific task under consideration—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.

ANALYTIC METHODS

In this section we describe in detail the conceptual framework guiding our analysis, and the way in which it was made operational.

Exchange Structure

In Sinclair and Coulthard's (1975, 1992), initiation-response-followup (IRF) model, the pivotal unit of analysis is the teaching *exchange*, realised through a sequence of participant *moves*. An idealised exchange opens with an Initiation (I) move in which the speaker contributes and/or solicits information: This is the only element required for an exchange to be constituted. In this paper, we add a suffix to an (I) code to indicate, respectively whether the move contains—or is taken by a respondent as containing—a solicitation (Is) or only a contribution (Ic). An Is move expects an ensuing Response (R) move by another speaker.

Finally, an Ic or R move is open to—but does not expect—a Follow-up (F) move reacting to it.

In practice, a single Is move may precipitate several cycles of response: As, for example, where a speaker poses a question, receives one response and follows that up, then another response and so potentially on. In our transcripts we indicate this situation by prefixing any additional R move with the symbol \uparrow to indicate that it is responding to an earlier Is move—prefixed by \downarrow —and creating a further bound exchange. In our coding, too, following a critique of the original IRF system by Coulthard and Brazil (1992), we recognise what can be regarded as two forms of composite move: where a speaker responds to a solicitation or follows-up a contribution by making a further solicitation, so initiating a new exchange—in which case the utterance is coded R/Is or F/Is respectively. Thus, while a speaker's utterance typically corresponds to a single move, this is not always the case. Conversely, one speaker may interrupt another to, in effect, continue the same utterance and complete a single move; in this case the two turns are shown separately in the transcript, and both given the code for the type of move involved.

In the course of coding we encountered some marginal situations. For example, occasionally, pupils would respond to a teacher question by prefacing their answer with *surely* and changing their intonation accordingly—as could be heard on the video recording, turning what would otherwise be a statement into a question seeking validation of that statement by the teacher. This called for an operational decision to be made about how to classify such an action; judging that this represented more of a continuation of the existing exchange than the initiation of a new one, we decided to code such actions as R, rather than R/I, moves.

Exchange Types

Building on their model of the internal interactional structure of teaching exchanges, Sinclair and Coulthard (1975, 1992) proposed an overarching typology of the basic communicative function of such exchanges. The five fundamental types of exchange relevant to the analysis presented in this paper are summarised in Table 1. This table provides a characterisation of each of the exchange types and shows its internal interactional structure—with any optional move shown in brackets.

Table 1

Fundamental Types of Teaching Exchange (adapted from Sinclair & Coulthard, 1975, 1992)

Type	Characterisation	Code	Structure
Teacher inform	Teacher seeks to contribute substantive information	tInform	tIc_(pF)* ¹
Pupil inform	Pupil seeks to contribute substantive information	pInform	pIc_tF
Teacher elicit	Teacher seeks to elicit substantive information from pupils	tElicit	tIs_pR_(tF)
Pupil elicit	Pupil seeks to elicit substantive information from teacher	pElicit	pIs_tR_(pF)*
Check	Teacher checks with pupil(s) how they are faring	tCheck	tIs_pR_(tF)

The first four of these exchange types form a system covering dialogue directly about the substantive topic under discussion; defined first by whether the exchange is initiated by teacher or pupil; and second by whether that initiator seeks to contribute information or to elicit it. To clarify the key actors in both move and exchange codes, we prefix each move code with “t” or “p” to indicate, respectively, whether it is undertaken by the teacher or by a pupil, and we prefix each exchange code likewise to indicate from which side it is initiated. The final exchange type is intended to cover dialogue which is only indirectly related to the substantive topic, involving the teacher seeking information from pupils about how well they are getting on: While the interactional structure of *tCheck* is identical to that of *tElicit*, the difference is that while the latter focuses directly on the topic matter itself, the former focuses on pupils’ progress in understanding the topic and completing tasks associated with it.

¹ We use the symbol * in order to point out that Sinclair and Coulthard (1975) text treats tInform and pInform exchanges differently, considering the structure of the former to be tIc_pR; of the latter, pIc_tF. We regard this asymmetry between R and F as problematic because it reflects the conflation between structure and semantics which the later Coulthard and Brazil (1992) text criticises. This critique leads them to redefine a Response move as one that is predicted but not predicting and a Follow-up move as one which is neither predicted nor predicting. In this light, we have modified the move structure of a tInform exchange in which the reactive move is not predicted by the initiating move to conform with those definitions and so to parallel the move structure of a pInform exchange. Likewise, the Sinclair and Coulthard (1975) text assumes that there will be no pF move in a pElicit exchange, breaking the parallel with the tF move in a tElicit exchange. While we agree that this asymmetry is very likely to be found in practice, we have preferred to make this a matter of empirical investigation rather than prior assumption.

In practice, in coding the dialogue examined in this paper, we found that there were very occasional violations of the structures assumed by the typology. While the existence of such violations emphasises that the model is an idealised one, their infrequency testifies empirically that the model is a rather sound one. For example, we found one exchange which opened with a pIc move but continued with a pF move rather than the tF move expected in a pInform exchange; a small but significant difference—because it signals dialogue between pupils—that we have coded pInform*. Occasionally, too, one exchange is embedded within another: For example, when, in response to a teacher's question a pupil seeks and receives clarification from the teacher of some point related to that question, before proceeding to answer it. Finally, some auxiliary exchanges make no substantive contribution: For example, a preliminary exchange in which the teacher simply nominates a pupil to speak; or an intermediary exchange where the teacher seeks repetition of a pupil turn that s/he has been unable to hear clearly. While such exchanges are included in the transcript, they are not given a code and are indicated as follows: [].

Encompassing Episodes

While the exchange provides a useful basic unit of analysis, dialogue typically consists of sequences of exchanges forming larger lesson units. Thus we recognise a larger unit, the episode, forming a recognisable structural component of the lesson as marked out by participants and/or resources. In this study, each episode consists of all the dialogue relating to a particular set question in the lesson materials—or, in the last episode, an emergent hybrid of the final two set questions. It is also notable that the exchanges making up an episode often form chains, created through follow up and uptake of contributions, and by continuity of participants.

Epistemic Initiative

By epistemic initiative we refer to the way in which an unfolding agenda for the knowledge to be exchanged and developed is set. In the archetypical IRE exchange, epistemic initiative is exercised through the I move in which the question posed sets the agenda for the exchange. Within the broader IRF framework, the substantive topic is developed through Inform and Elicit exchanges, and the initiating move can again be seen as setting the agenda for each exchange. Equally, the exchange that launches an episode tends to set its agenda (although in our analysis this is treated as open to examination). In some respects, too, to initiate an Inform exchange is to exercise a stronger form of epistemic initiative by virtue of both formulating the topic of the exchange and proceeding to provide information about that topic, whereas the initiator of an Elicit exchange undertakes the former action but devolves the latter.

Nevertheless, more nuanced analysis of epistemic initiative, taking account of the semantic content of an exchange and its wider context, may generate

deeper insight into how an agenda is being set and the substantive topic advanced. For instance, there is a great difference in the degree of initiative between an opening pElicit exchange which introduces a fresh idea that launches an entire episode and an embedded pElicit exchange in which a pupil seeks clarification of a reference in the question already posed by the teacher. Thus our approach to analysis of epistemic initiative encompasses both these structural and semantic modes.

Epistemic Appraisal

By epistemic appraisal we refer to the way in which public judgements are made about knowledge under exchange and development. In the archetypical IRE exchange, epistemic appraisal is exercised by the teacher through explicit evaluation within the E move in reaction to the pupil response in the R move. Within the broader analytic framework set out above, the F move within an Inform or Elicit exchange provides the equivalent site for epistemic appraisal. These types of exchange provide scope for pupils as well as the teacher to undertake an F move. However, in the dialogue analysed in this paper, the only pupil moves of this type occur in one exceptional pInform* exchange which has already been referred to.

As well as identifying explicit teacher evaluation of pupil contributions it is important to look for more implicit forms of evaluation and other forms of epistemic appraisal. Structurally, teacher reaction to a pupil contribution may be expressed either in a Follow-up move within the same exchange or in the Initiation move of the subsequent exchange—also encompassing the hybrid form of F/I move noted earlier. Equally, the absence of teacher follow-up or uptake can represent a form of reaction.

Table 2
Types of Teacher Reaction to Pupil Contributions

Type	Characterisation	Code
Approve	Explicitly indicate approval of pupil contribution	App
Disapprove	Explicitly indicate disapproval of pupil contribution	Dis
Repeat	Repeat (key part of) pupil contribution in same words	Rep
Restate	Restate (key part of) pupil contribution in different terms	Res
Translate	Translate (key part of) pupil contribution into equivalent form or idea	Tra
Redirect	Redirect train of thought shown by pupil contribution	Red
Probe	Probe pupil contribution	Pro
Expand	Expand on pupil contribution or build on it	Exp

Table 2
Types of Teacher Reaction to Pupil Contributions

Type	Characterisation	Code
Revert	Revert to (repeat, restate, refer to) earlier question or contribution	Rev
Devolve	Devolve consideration of pupil contribution to another pupil or to class	Dev

Table 2 provides a typology covering the forms of teacher reaction found to feature in the dialogue analysed in this paper. The list starts with overt indication by the teacher of approval or disapproval of the preceding pupil contribution. Beyond those explicitly evaluative actions, the teacher may follow up a pupil contribution by repeating all or part of it literally, by restating it—perhaps more fully, clearly or precisely, by translating it into some equivalent, and/or by expanding on it in some more extensive way. Conversely follow-up or take-up may seek to redirect the train of thought behind a pupil contribution. Similarly, in initiating the next exchange the teacher may take up a pupil contribution through a solicitation that probes that contribution or that builds on it; or the teacher may pass over the pupil contribution—take it up in a deficient mode—by reverting to an earlier solicitation or contribution. Such actions may imply an evaluation, which may become clearer by the manner in which they are carried out and the terms in which they are expressed. Finally, there is a mode of reaction in which the teacher devolves examination of a pupil response to another pupil, or to the class as a whole, through initiating a further exchange for that purpose.

Just as the launch of an episode tends to represent a key moment of epistemic initiative, so the conclusion of an episode often represents a key moment of epistemic appraisal—although in our analysis this is treated as an open question. Thus examining the terms in which the teacher draws the episode to a close—or allows it to come to a close—can throw light on epistemic appraisal.

Epistemic Framing

By epistemic framing, we refer to the terms in which knowledge and knowing are represented within classroom discourse. For example, Wagner and Herbel-Eisenmann (2014)² differentiate several types of discursive authority, identifying general semantic indicators and specific linguistic cues associated with each type. However, for the purposes of this analysis, we have decided to retain, where available, the forms of language employed by the participants themselves to represent the development and exchange of knowledge, particularly in reflexive talk by participants about the activity in which they are involved. Thus we proceed in a grounded manner to establish salient constructs within such talk.

² See their Table 1 for details.

These lead us to make a distinction between an *objectified* register referring simply to the mathematico-scientific *objects* of knowledge and a more *subjectified* register which also makes reference to the knowing *subjects* exchanging and forming knowledge.

EPISODE ANALYSES

Analyses of each of the episodes forming this segment of the lesson are now presented in chronological order.

Episode α

We present the annotated transcription of episode α in Table 3.

Table 3

Annotated Transcript of Episode α

Turn	Speaker	Utterance	Move	Exchange reaction
$\alpha 1$	T	Dan, what have you got, what pairings have you got? So for detached earlobes.	↓tIs	tElicit
$\alpha 2$	P [Dan]	[inaudible]	pR	
$\alpha 3$	T	Two large ees. [Records on board]	tF	Rep
$\alpha 4$	Ps [unknown]	A big ee and a little ee.	↑pR	
$\alpha 5$	T	A big ee and a little ee. [Records on board]	tF	Rep
$\alpha 6$	P [unknown]	A small ee and a big ee.	↑pR	
$\alpha 7$	T	A little ee and a big ee [Records on board]. Everybody happy so far?	tF/Is	RepDev tCheck
$\alpha 8$	P [Hal]	No I don't get it.	pR	
$\alpha 9$	T	What don't you understand, Hal?	tF/Is	Pro tCheck
$\alpha 10$	P [Hal]	The big ees and the little ees.	pR	
$\alpha 11$	T	What about the big ee and the little ee don't you understand?	tF/Is	Pro tCheck
$\alpha 12$	P [Hal]	How that represents [inaudible]. [Many pupils speaking over each other].	pR	

Table 3
Annotated Transcript of Episode α

Turn	Speaker	Utterance	Move	Exchange reaction
$\alpha 13$	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?	↓tF/Is	ResDev tElicit
$\alpha 14$	Ps [unknown]	[inaudible] [Many pupils speaking over each other]	pR	
$\alpha 15$	T	Not necessarily. No. No no no no. No no. Forget about boys and girls, just think earlobes please.	tF	DisRed
$\alpha 16$	P [unknown]	A little ee and a big ee are detached, and a big ee and a little ee are detached, so [inaudible]. [Many pupils speaking over each other].	↑pR	
$\alpha 17$	T	All right. I'm not sure that Hal's getting the answer to his question. Hal, are you okay now?	tF/Is	Dev tCheck
$\alpha 18$	P [Hal]	Yeah.	pR	
$\alpha 19$	T	Are you okay now?	tF/Is	
$\alpha 20$	P [Harry]	Yeah.	pR	

The teacher instigates this episode by asking a pupil, Dan, to report “what [he has] got” by way of an answer to the first set question posed on the projected slide. In this opening passage ($\alpha 1$ - $\alpha 7$), comprising an iterated TElicit exchange, pupils respond with elements of an answer, each of which the teacher follows up by repeating and recording it, until all pupil offers have been exhausted. The teacher then refers this accumulated answer to the class, asking whether “Everybody [is] happy so far”. In the ensuing passage ($\alpha 7$ - $\alpha 12$), one pupil, Hal, reports that he “do[es]n't get it”, leading to the teacher probing his responses through a chain of TCheck exchanges, helping him articulate “what [he] do[es]n't... understand” with increasing precision. In the concluding passage ($\alpha 13$ - $\alpha 20$), the teacher first refers this situation to the rest of the class, inviting them to “help... Hal... understand”. In the first ensuing tElicit exchange, the first pupil response offers a tangential line of thinking which the teacher follows up with very explicit—indeed delivered so parodically as to be almost apologetic—disapproval, pressing a change of perspective. In the ensuing tElicit exchange, the connotation of the follow-up is more ambiguous: When the teacher talks of

“not [being] sure that Hal’s getting the answer to his question” she could be taken as attributing that to pupils speaking over each other and/or to the content of their responses. The episode concludes with a tCheck exchange in which the teacher gives Hal the last word on this, establishing that he is “okay now”.

In the opening passage where the teacher is reacting to pupil responses to the set question posed on the slide, discourse remains largely in the same objectified mathematico-scientific register as the set question, although her initiating “What have you got?” intimates the shift that will come. In the later passages, the teacher’s contributions typically make reference to the state of mind of participants: “Everybody happy so far?”; “What don’t you understand?”; “Can anybody help him?”; “I’m not sure that Hal’s getting the answer to his question”; “Are you okay now?” As well as the framing of teacher contributions conveying this shift to a more subjectified discourse semantically; the presence of tCheck exchanges also signals it structurally.

The teacher exercises a relatively high degree of epistemic initiative. The episode is instigated by the teacher and consists entirely of tElicit and tCheck exchanges initiated by her. Nevertheless, the teacher’s use of more reflexive talk and her sequencing of passages of tElicit and tCheck exchanges can be seen as seeking to scaffold a deeper structure of virtual interaction between pupils; *virtual* in the sense that this interaction does not occur directly between pupils, but more indirectly through the mediation of the teacher. In the opening tElicit exchanges, the teacher refers the class to the set question and scaffolds the production of a cumulative answer by Dan and other members of the class. In the ensuing tCheck exchanges, the teacher scaffolds a form of collective appraisal of this answer by the class, first in the form of—non-dissenting—silence from other pupils and Hal’s declaration of incomprehension, and then in terms of Hal’s increasingly precise articulation of his difficulty. In the ensuing tElicit exchanges, the teacher scaffolds the production by other members of the class of explanations intended to resolve Hal’s difficulty, and in the final tCheck exchange she scaffolds a personal assessment of these by Hal. Thus, if we strip out teacher scaffolding, a shadow dialogue emerges consisting of two virtual exchanges. The first of these virtual exchanges is initiated by the set question posed on the slide, responded to by the composite answer from Dan and others, and followed up through appraisal by the class as a whole and Hal in particular. This precipitates the second virtual exchange, initiated by Hal’s articulation of his difficulty, responded to by the explanations from other pupils, and followed-up by Hal’s appraisal of these. Thus the teacher’s more personalised framing and associated techniques of scaffolding act as devices for fostering this type of virtual exchange between pupils.

In terms of epistemic appraisal, the teacher’s predominant use of a subjectified discourse of personal states means that none of the solicitations with which she initiates exchanges position her as already knowing the answer to the question that she poses; rather, their phrasing gives them the form of genuine

enquiries on her part, seeking information about pupils' findings or understandings. In general, her follow-up actions maintain this stance. In the opening tElicit exchange, she repeats and records successive offerings, and then devolves them for further reaction. While the teacher offers no explicit evaluation of the accumulated answer, the act of recording the offerings could be interpreted as according some status to them, and the terms of devolution—"Everybody happy so far?"—carry a connotation of a stage having been completed satisfactorily in a larger process. In the ensuing chain of tCheck exchanges, the teacher's follow-up consists of neutral probing, and take-up of Hal's emergent issue is devolved to the class. In the iterative tElicit exchange that then takes place, explicit teacher evaluation surfaces, in the form of disapproval and redirection in follow-up to the first response. Nevertheless, the teacher devolves to Hal appraisal of the second group of responses, and his resulting approval is allowed to conclude the episode. Here, then, the teacher speaks and acts in ways that position pupils as agents of epistemic appraisal, but when pupil contributions fail to accord sufficiently with her purposes, she reclaims agency for epistemic appraisal, explicitly evaluating such contributions.

Episode β

Table 4 shows the annotated transcription of episode β .

Table 4

Annotated Transcript of Episode β

Turn	Speaker	Utterance	Move	Exchange reaction
$\beta 1$	T	Bet, you had a question.	tI	[]
$\beta 2$	P [Bet]	Oh yeah. [Referring to projected slide] Like what is dominant about the ee then?	pR/Is	pElicit
$\beta 3$	T	What is dominant about the ee form? [Bet raises hand] So if you've got a big ee, what is dominant? What are you going to see?	↓tR/Is	tElicit
$\beta 4$	P [Bet]	If you, the little ee, you have to have two of them to have attached, but and like you only need one big ee and one small ee to have detached, so there's more like ways you can have big ee than little ee.	pR	
$\beta 5$	T	Yes [in affirmative tone].	tF	App
$\beta 6$	P [Tia]	Surely if you have a big ee then you're going to have detached earlobes?	↑pR	

Table 4
Annotated Transcript of Episode β

Turn	Speaker	Utterance	Move	Exchange reaction
$\beta 7$	T	Yes [in affirmative tone]. Yes. So if you've got at least one big ee, then you are going to have detached earlobes.	tF	AppRes

This episode is instigated by a pupil, Bet, who refers the second set question on the projected slide to the teacher, so initiating a pElicit exchange. The teacher responds with a manoeuvre through which she repeats the question, restates it, and refers it back to Bet, initiating a tElicit exchange. Bet provides a response which the teacher follows up with approval of her answer. Echoing the language of the teacher's earlier reformulation of the set question, Tia then offers a further response, doing so in terms which seek validation of her answer. The teacher reciprocates with approval, restating the answer in slightly more precise terms: "at least one big ee".

In this episode, discourse remains at the objectified level, reflecting the way in which the teacher is typically reacting to contributions by pupils which either raise or respond to the set question posed in these bald mathematico-scientific terms. In respect of epistemic initiative, the episode is instigated by a pupil, even if this is simply to raise a set question from the projected slide. Moreover, the manoeuvre through which the teacher segues from the opening pElicit exchange to the ensuing tElicit, tacitly declining the pupil's request for an immediate answer to the question, has the effect of giving this pupil—and then another—the opportunity to answer the question that she herself brought into play. This pattern, then, is more than one of pupils simply seeking information from the teacher, but one in which pupils introduce new substantive ideas. In this respect, the transaction comes close to being the equivalent of a pInform exchange, indicative of the exercise of a relatively high degree of epistemic initiative by the pupils concerned. With regard to epistemic appraisal, the two teacher follow-up moves both feature explicit evaluation, the second reciprocating a pupil request for validation.

Episode γ

We present the annotated transcription of episode γ in Table 5.

Table 5
Annotated Transcript of Episode γ

Turn	Speaker	Utterance	Move	Exchange reaction
γ_1	T	[Reading from projected 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	tElicit
γ_2	P [Tia]	Surely it's quite low, because like.	pR	
γ_3	T	Can we put a figure on it?	tF/Is	Pro tElicit
γ_4	P [Tia]	Zero.	pR	
γ_5	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?	tIs	Rev tElicit
γ_6	P [Tia]	Zero. I think it is.	pR	
γ_7	T	Zero. You think it's impossible?	↓tF/Is	RepProTra tElicit
γ_8	P [Tia]	Surely if you have a big ee, somewhere, you're going to have .	pR	
γ_9	P [unknown]	It's going to be dominant.	pIc	[pInform*]
γ_{10}	P [Tia]	Yeah. [pause] No.	pF	
γ_{11}	P [unknown]	Well no.	pF	
γ_{12}	P [Tia]	It's going to be, you're going to have detached.	↑pR	
γ_{13}	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. 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?	tF/Is	RedRev tElicit

Table 5
Annotated Transcript of Episode γ

Turn	Speaker	Utterance	Move	Exchange reaction
γ 14	P [Lea]	[Inaudible] make it a half. [pause] Yeah fifty percent.	pR	
γ 15	T	Lea says it is a half. [Reacting to non-verbal cue from Tia] Tia, you're now saying that makes sense.	tF/Is	Dev tCheck
γ 16	P [Tia]	Yeah.	pR	
γ 17	T	Could somebody just confirm why. Why does that make sense? Kit?	tF/Is	AppPro tElicit
γ 18	P [Kit]	It says up on the board, if a parent has both alleles, whatever, then there is equal chance, and if it goes up to one there's a half chance.	pR	
γ 19	T	So it does indeed. [Reading from projected 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.	tF	AppRes

The teacher instigates this episode by referring to the class the first set question on the—next—projected slide, and by nominating a pupil, Tia, to respond. This develops into a passage featuring a chain of tElicit exchanges involving the teacher and Tia (γ 1- γ 13). The teacher reacts to Tia's responses by successively probing for greater precision, reverting to the original question, and repeating Tia's answer and probing it by translating it into an equivalent form—carrying a confounding implication. Tia's unfolding response to the teacher's last solicitation is interrupted by another pupil who initiates a very brief pInform* exchange with Tia who vacillates in her evaluative follow-up. Tia then appears to return to finish her interrupted response, in effect resuming the earlier tElicit exchange. The teacher reacts with a strategic comment that differentiates the question implied by Tia's answer from the one posed by her, and then reverts to the original question, nominating another pupil, Lea, to respond. In the ensuing passage of tElicit and tCheck exchanges (γ 13- γ 19), the teacher follows-up Lea's response by explicitly attributing her answer and referring it to Tia, eliciting Tia's agreement that she was “now saying that makes sense”. In a further tElicit exchange, the teacher then seeks confirmation and justification of this answer from a third pupil, Kit. In the turn that then concludes the episode, the teacher

follows up Kit's answer by confirming and elaborating her reference to information on the projected slide, taken as representing established knowledge, averring "So that makes sense doesn't it", and finally restating Kit's answer prefaced by another "so" according it a conclusive status.

The episode is instigated by the teacher and conducted predominantly through tElicit exchanges, suggesting a high degree of epistemic initiative by the teacher. In the opening passage the teacher pursues the set question with a single pupil, over several exchanges. The teacher alternates between probing the pupil's answer in more subjectified terms and reverting to the more objectified terms of the set question: the subjectified "Can we put a figure on it?"; the objectified "What is the probability that...?"; and then the subjectified "You think it's impossible?". The immediacy, direction and persistence of the teacher's supplementary questioning imply dissatisfaction with the pupil's answer, particularly as she tacitly declines to offer the approval invited by the phrasing of two of the pupil's responses. Thus, the cumulative effect of these various teacher reactions is to establish the pupil as occupying an opposed position and to convey an increasingly strong negative evaluation of that position, even if there is no explicit evaluation. This situation is resolved, following the brief pInform* exchange and the subsequent pupil answer, when the teacher identifies the pupil as not addressing the question posed. In this passage, then, the teacher exercises a high degree both of epistemic initiative and appraisal.

In the ensuing passage, the opening tElicit exchange yields what later proves to be an answer acceptable to the teacher. However, at this stage the teacher follows it up by introducing a personalised framing which attributes the answer to the pupil concerned and then by devolving reaction to another pupil. Taking up this pupil reaction the teacher approves the answer but probes for explanation, "Could somebody just confirm why", nominating a third pupil to respond. Again, the teacher follows up that pupil's response with approval and restatement. Thus, while this passage initially moves towards the pattern of teacher-mediated indirect exchange between pupils displayed in Episode α , as it unfolds the teacher reclaims the direct exercise of epistemic initiative and appraisal. In terms of semantic framing, the teacher introduces a construct of "making sense" which becomes central to the discourse of the passage: "Tia, you're now saying that makes sense"; "Why does that make sense?"; "So that makes sense doesn't it." The teacher employs this construct, then, to evoke what appear to be the terms for testing a new claim to knowledge on the basis of its being comprehensible to the person and grounded in established knowledge.

Episode δ

We present the annotated transcription of episode δ in Table 6.

Table 6
Annotated Transcript of Episode δ

Turn	Speaker	Utterance	Move	Exchange reaction
$\delta 1$	T	[Reading from projected 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	tElicit
$\delta 2$	P [Tom]	Certain.	pR	
$\delta 3$	T	Certain. Hundred per cent. Why is that?	tF/Is	RepTraPro tElicit
$\delta 4$	P [Tom]	Because if she's got attached earlobes, then she's got ee ee.	pR	
$\delta 5$	T	She's got two little ees.	tF	Res

This short episode is initiated by the teacher and consists of two tElicit exchanges focusing on the second set question on the second projected slide. The teacher reads out the question and nominates a pupil, Tom, to respond. Tom does so succinctly. The teacher follows up, repeating Tom's answer, translating it into an equivalent, and then probing "Why is that?" Tom then highlights the key idea and the teacher follows up by restating part of his explanation to increase its clarity: "two little ees".

Discourse during this episode remains in the objectified terms of the set question. In terms of epistemic initiative, the teacher instigates the episode and initiates both tElicit exchanges. In terms of epistemic appraisal, the teacher's follow-up contains no explicit evaluation although the way in which she allows the episode to conclude, by adding her own small point of detail to Tom's answer and seeking no further elaboration or explanation, implies approval.

Episode ϵ

We present the annotated transcription of episode ϵ in Table 7.

Table 7
Annotated Transcript of Episode ε

Turn	Speaker	Utterance	Move	Exchange reaction
$\varepsilon 1$	P [Tia]	But, if the mother to be and the father to be, like, are the same mother and father, and they both make, like.	pIs	pElicit
$\varepsilon 2$	P [unknown]	Yeah, does it matter? Is it like the same child, like, that they're talking about, or not?	pIs	
$\varepsilon 3$	T	I don't think it's a particular child. [pause] [Pupils talk while teacher consults teaching notes]	tR	
	P [Bet]	[Makes bid to speak]	pI	[]
$\varepsilon 4$	T	Yes.	tR	
$\varepsilon 5$	P [Bet]	About the question that we've just said. The baby might not definitely have attached earlobes 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.	pIc	pInform
$\varepsilon 6$	T	So if we actually, if we actually join this mother and this father together to make a child.	↓tF/Is	Exp tElicit
$\varepsilon 7$	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.	pR	
$\varepsilon 8$	T	Definitely going to have a little ee.	tF	Rep
$\varepsilon 9$	P [Bet]	But it could, it could get a big ee from the father, it could get a little ee.	↑pR	
$\varepsilon 10$	T	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?	tF/Is	Exp tElicit
$\varepsilon 11$	P [Hyp]	Detached	pR	
$\varepsilon 12$	T	Attached?	tF/Is	[]

Table 7
Annotated Transcript of Episode ε

Turn	Speaker	Utterance	Move	Exchange reaction
$\varepsilon 13$	P [Hyp]	Detached	pR	
$\varepsilon 14$	P [unknown]	Big ee is attached?	pIs	pElicit
$\varepsilon 15$	T	Big ee is de-tached, and big ee is dominant. Cat, any thoughts if we mix these two parents together?	tR tIs	 Rev tElicit
$\varepsilon 16$	P [Cat]	Which two parents?	pR/Is	pElicit
$\varepsilon 17$	T	The two parents on [the slide]. 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.	tR tIs	 Rev tElicit
$\varepsilon 18$	P [Jay]	Half and half, because of the father, because if you then get a big ee then it will be dominant, and so it'll be detached. [Pupils talk while teacher consults teaching notes]	pR	

This episode is instigated by a pair of pupils speculating about whether the two set questions on the projected slide refer to the same child. This initiates a pElicit exchange which evokes a teacher response of qualified rejection of this hybrid situation formed by combining the terms of the two set questions ($\varepsilon 1$ - $\varepsilon 3$). Nevertheless, in the ensuing passage ($\varepsilon 4$ - $\varepsilon 9$), Bet initiates a pInform exchange in which she proceeds to elaborate the posited situation by outlining alternative possibilities in some detail. The teacher reacts with what could be regarded as an expansion, explicitly postulating the hybrid situation raised in the earlier speculation. This initiates a tElicit exchange in which Bet responds, again in some detail, with the teacher following up by echoing her turn of phrase.

In these opening passages, then, pupils exercise a high degree of epistemic initiative, instigating, in the opening pElicit exchange, the speculation out of which the episode emerges, and initiating the subsequent pInform exchange from which the idea is developed. However, with the ensuing tElicit exchange, initiative shifts back towards the teacher. This creates what might best be described as joint initiative, bearing in mind the continuity of development between Bet's earlier contribution and her response to the teacher's solicitation.

Nevertheless, the teacher contributes a crucial piece of epistemic (re)framing by introducing the idea of “if we actually...” in place of the more passive “[w]hat they’re talking about”, so claiming a more active epistemic agency for herself and the pupils as classroom participants over the authors of the set questions on the projected slide. That apart, discourse within these passages remains largely in the objectified terms of the underlying set questions. Epistemic appraisal is limited, but resides with the teacher when it does occur: most notably in her follow-up of Bet’s response, implying approval by repeating a snatch from it and then expanding on it, “so....”

In the third passage of this episode (ϵ_{10} - ϵ_{18}), the teacher takes up Bet’s idea, posing a related problem question, first to the class as a whole, and then, securing no response, to a specific pupil, Hyp. In this initial tElicit exchange, Hyp does offer an answer, but a further auxiliary exchange is needed for the teacher to establish what it is. There is no further teacher follow-up, perhaps because another pupil intervenes to initiate a bound pElicit exchange seeking information from the teacher. The teacher initiates a second tElicit exchange, but only loosely invokes the original problem question, so that the nominated pupil, Cat, responds by initiating a bound pElicit exchange seeking clarification. The teacher initiates a third tElicit exchange in which she reverts to the original problem question, restating it more fully, and attributing ideas to individuals. This attracts an extended response from Jay which provides both an answer to the problem and a supporting argument for it. The episode ends amidst a high level of pupil talk with the teacher consulting her notes.

In this final passage, then, the teacher reclaims the epistemic initiative by posing a new problem question related to the situation examined in the earlier passages. This is pursued over a sequence of tElicit exchanges, punctuated by bound pElicit exchanges in which pupils seek clarification. These pElicit exchanges interrupt the flow of development, and appear to prompt the teacher’s subsequent reversions to the problem question. Only towards the end of the episode does the discourse move away from an objectified framing, when reference is made in more personalised terms to the provenance of the ideas guiding the problem question. The aspect of epistemic appraisal barely surfaces but the way in which this passage is allowed by the teacher to conclude after Jay’s answer might be taken as signalling her implicit approval of his answer and explanation.

Because of the shift in dynamic between the opening two passages and the third, in the summary that follows, we will differentiate between these phases, with the former becoming subepisode ϵ' (ϵ_1 - ϵ_{10}) and the latter subepisode ϵ'' (ϵ_{10} - ϵ_{18}).

OVERALL PATTERNS

We now examine patterns of epistemic initiative, framing and appraisal across the episodes, with a view to building a model of the epistemic order in operation.

Epistemic Initiative

Looking structurally at each episode (α , β , γ , δ) and subepisode (ϵ' , ϵ''), four are instigated by the teacher (α , γ , δ , ϵ'') and two by pupils (β , ϵ'), suggesting that, while epistemic initiative at this level is weighted towards the teacher, pupils also exercise it to an appreciable degree: crudely a two-thirds to one-third division. However, because initiative tends to pass from pupil to teacher during the course of pupil instigated episodes, the overall picture is rather different at the next level, that of initiation of exchanges. Whether measured by the proportion of exchanges of a particular type or by the proportion of turns forming exchanges of a particular type, overall results are similar. tElicit exchanges make up two-thirds of dialogue, and tCheck a further one-sixth, amounting to five-sixths in all. The remaining one-sixth of exchanges is shared between pInform and pElicit.

At the same time, the varying proportion of tElicit and tCheck exchanges across the four teacher-instigated exchanges signals an important variation in the way in which epistemic initiative is exercised by the teacher, and this is confirmed by contextualised semantic analysis. The first exchange (α) opens with a conventional tElicit exchange which yields (what proved to be) an acceptable answer to the set question; a further five tCheck and tElicit exchanges are then spent by the teacher animating indirect dialogue between one pupil who has not understood the answer and other pupils in the class. By contrast, the next teacher-instigated episode (γ), opens with a chain of tElicit exchanges between the teacher and one pupil which, despite the teacher's probing, fails to yield (what proved to be) an acceptable answer to the set question. However, when the next tElicit exchange does yield such an answer, the teacher uses the ensuing tCheck exchange to refer that answer to the first pupil, and the ensuing tElicit exchange to extract a supporting argument for it from a third pupil, again edging towards a form of indirect dialogue between pupils.

In the two pupil-instigated episodes, the observations that a pElicit exchange quickly gives way to a much lengthier tElicit exchange (β), and that a pElicit then pInform sequence is followed by a lengthy tElicit exchange (ϵ'), might be taken as evidence that pupil exercise of epistemic initiative does not persist for long. However, closer analysis shows that both these tElicit exchanges represent teacher manoeuvres which actually support further development by pupils of the line of thinking that they have introduced, albeit creating a form of joint initiative. At the same time, we should note that, in both episodes, this initiative is exercised by the same pair of pupils, highlighting an asymmetry between this pair and other pupils which is potentially as significant as any between teacher and pupils.

Epistemic Framing

As noted above, the absence or presence of tCheck exchanges appears to be an important structural marker of differences in the epistemic framing of discourse. These exchanges are found only in those passages of teacher-instigated episodes where the semantic markers of a more subjectified and personalised discourse emerges. These semantic markers differ between the two episodes in question. In the later passages of Episode α , the teacher employs constructs which refer to personal states of *happiness* or *understanding* on the part of participants. In the later passage of Episode γ , the teacher introduces the construct of a knowledge claim *making sense*, linking that both to its consistency with officially sanctioned knowledge and to the personal state of individuals. Finally, the relevant passages of both episodes also feature some devolution from teacher to pupils of responsibility for reacting to other pupil contributions. Through these linked structural and semantic features, the teacher mediates an indirect form of interaction between pupils.

However, such passages are the exception: Indeed, even in these short sequences there are some breakdowns in this alternative epistemic order. Beyond and beneath these passages is a more basic pattern which guides the unfolding of all of the teacher-instigated episodes. Essentially it is the conventional one of tElicit exchanges repeated until pupils have provided an acceptable answer and supporting argument, with knowledge exchange and development typically formulated in bald mathematico-scientific terms. For example, in the third teacher-instigated episode (δ), two tElicit exchanges extract from the same pupil, first an acceptable answer and then a supporting argument for it. The final teacher-instigated subepisode (ϵ'') opens with a chain of tElicit exchanges involving different pupils (punctuated by pElicit exchanges seeking clarification), unsuccessful until (what appear to be accepted as) answer and supporting argument finally emerge.

Turning to the two pupil-instigated episodes, there is no reflexive framing within Episode β and the language remains at a bald mathematico-scientific level. The teacher allows this episode to conclude after a pair of pupils has offered acceptable answers. In subepisode ϵ' , there is some (re)framing by the teacher which gives the participants licence to pose their own set question rather than speculating about the intentions of the original authors of the set question. The episode concludes with the teacher posing such a question, again in objectified mathematico-scientific terms.

Epistemic Appraisal

Conventionally, the provision by a pupil of an acceptable answer and/or supporting argument is met by some form of teacher approval. Looking first at those teacher-initiated episodes that follow only the basic pattern (δ , ϵ'') there are no explicit reactions of approval or disapproval. In Episode δ , the probing in the first teacher reaction implies that more needs to be said and the restatement in the

second that what has been said is, subject to this rephrasing, acceptable. In subepisode ϵ'' , the reversion reactions signal that an acceptable answer has not yet been reached, but there is no overt reaction to the concluding response. Nevertheless, in both these cases, the fact that the teacher initiates no further exchanges implicitly indicates that an acceptable resolution of the set question has been achieved.

Turning now to the other teacher-instigated episodes, we can see a difference in patterns of reaction between their earlier passages and their later ones. Episode γ opens with a conventional passage which—like δ and ϵ'' —displays probing and reversion reactions until an acceptable answer is forthcoming. Episode α , too, opens with a conventional passage, but this features only acceptable answers which are repeated by the teacher and recorded on the board. However, in both these episodes, the pattern changes as the teacher moves towards mediating indirect dialogue between pupils. In particular, as has been noted, these later passages feature a mode of teacher reaction which takes the form of devolving substantive reaction either to a nominated pupil or to the class as a whole. Correspondingly, one might expect to find no teacher approvals or disapprovals during such passages, yet this expectation is breached in both episodes. In Episode α , the teacher makes a disapproving redirecting reaction to one pupil contribution. In Episode γ the teacher makes approving reactions to the final two pupil contributions. This indicates that devolution is qualified, with pupils' actions still subject to the teacher's appraisal and ultimately to her explicit evaluation.

In both the pupil-instigated episodes, there is overt or covert evaluation of pupil contributions by the teacher. In Episode β , the teacher explicitly approves both pupil contributions; in subepisode ϵ' , the teacher's echoing of Bet and her expansions of Bet's ideas represent implied approval. Thus, in these episodes where greater initiative is exercised by pupils, the teacher offers more immediate and clear evaluation. More notable, perhaps, is the converse, as found in particular in Episode δ and subepisode ϵ'' , where a high degree of initiative by the teacher is accompanied only by very covert evaluation by her of pupil contributions.

Epistemic Order

In summary, then, the epistemic order displayed in this lesson segment has three layers.

In the first of these layers, the teacher exercises initiative with respect to a set problem, questioning pupils to elicit contributions, appraising these in a manner which avoids explicit evaluation, and continuing until an acceptable solution to the problem is forthcoming. This layer is visible in the opening passages of Episodes α and γ , and in Episodes δ and ϵ'' and is marked by tElicit exchanges conducted in a largely objectified register. It differs from conventional recitation dialogue only by virtue of the absence of explicit evaluation of pupil

contributions by the teacher. The other layers, however, represent more substantial shifts away from recitation towards forms of classroom dialogue which accord greater epistemic agency to pupils and confer greater epistemic responsibility on them.

The second layer arises out of the absence of explicit teacher evaluation in the first. It appears only in the later passages of Episodes α and γ (but not in the correspondingly curtailed Episodes δ or ϵ'). It is marked by two linked forms of discursive shift instigated by the teacher: Towards a more subjectified and personalised register which asks whether a knowledge claim makes sense in terms—on the one hand—of the happiness or understanding of participants, and—on the other hand—of its consistency with officially sanctioned knowledge; and by the presence of tCheck exchanges alongside tElicit exchanges which devolve effective follow-up to, and take-up of, pupil contributions to other pupils, creating a teacher-scaffolded form of indirect interaction between pupils in which any teacher evaluation is deferred.

In the third layer, one or more pupils exercise initiative with respect to a set problem or some suggested variant, with subsequent exchanges allowing pupils to expand on this initiative. This layer appears only in Episodes β and ϵ' . It is marked by pInform exchanges or effective equivalent—a pElicit exchange followed by a tElicit exchange through which the teacher manoeuvres pupils into answering the problem they have just posed, conducted in a largely objectified register, with the teacher providing explicit or implicit evaluation. This layer differs from conventional recitation dialogue by virtue of initiative being exercised by pupils, but resembles it with respect to appraisal by the teacher being explicitly or implicitly evaluative.

CONCLUSION

This paper has defined epistemic order as the way in which exchange and development of knowledge takes place, breaking it down into a system of three components: epistemic initiative relates to who sets the agenda in classroom dialogue, and in what terms and manner; epistemic appraisal relates to who judges contributions to classroom dialogue, and in what terms and manner; and epistemic framing relates to the terms in which development and exchange of knowledge are represented, particularly in reflexive talk. These components have been operationalised in terms of various types of structural and semantic analysis of dialogue. The case study of a lesson segment has demonstrated how the triangulation of these types of analysis can provide a more nuanced model of epistemic order.

Using this approach, the lesson segment has been shown to display a multilayered epistemic order differing from that of conventional recitation, particularly in passages where the teacher moves towards scaffolding indirect

exchanges between pupils or manoeuvres exchanges so that pupils take more of a lead in developing knowledge and ensuring that it makes sense. In passages of the former type, the teacher also introduces a subjectified register which acknowledges participants as sense-making subjects exchanging and forming knowledge.

The most significant recent study to apply the approach initiated by Sinclair and Coulthard (1975, 1992) to classroom dialogue in school mathematics was conducted by Truxaw and DeFranco (2008). This study shares our interest in modelling overarching patterns of classroom dialogue, although it does not employ Sinclair and Coulthard's exchange types. Instead, as well as adapting the elaboration of the original IRF framework by Nassaji and Wells (2000), Truxaw and DeFranco (2008) introduced further codes based on constructs from pedagogical theories concerning types of interactive talk and forms of verbal assessment. Their study found three types of interactive talk present: *exploratory* talk—more hesitant and tentative exchanges, typically involving ideas being negotiated between speakers rather than presented to an audience, plus two forms of more presentational talk, *leading* talk—in which the teacher steers exchanges towards a preconceived conclusion—and *accountable* talk—in which exchanges feature ideas offered for more open scrutiny in terms of their appropriateness, accuracy and cogency. The study also distinguished two forms of assessment: *generative* assessment—promoting pupils' monitoring and regulation of their thinking—as *against inert* assessment—maintaining an intended instructional flow rather than attending to pupil understanding. Employing these analytic constructs, Truxaw and DeFranco identified a spectrum of instructional dialogue ranging from a *deductive* model, characterised by leading talk and inert assessment to an *inductive* model, characterised by a blend of leading, exploratory and accountable talk and by a degree of generative assessment alongside still predominant inert assessment.

Because Truxaw and DeFranco's additional constructs do not relate directly to Sinclair and Coulthard's IRF structure or exchange typology, it is not straightforward to compare our methods and findings with theirs. Nevertheless, their deductive model, featuring exclusively leading talk and inert assessment, appears to correspond closely to conventional recitation. This model resembles the first layer found in our case in respect of the high degree of teacher initiative, but—assuming that inert assessment features some level of explicit evaluation—differs by virtue of the absence of evaluation in this layer of our case. Truxaw and DeFranco's inductive model is closer to the second and third layers identified in our case. The element of generative assessment in their model parallels the more subjectified and reflexive discourse that characterised the teacher-initiated dialogue forming our second layer, which, like the pupil-initiated dialogue forming our third layer, gave rise to exchanges that appear closer to exploratory and accountable talk than to leading talk. Thus the wider range of types of talk and forms of assessment making up the profile of Truxaw

and DeFranco's inductive model—compared to their deductive model—appears to reflect a similar layering of patterns of interaction. This idea of the layering of distinct patterns of turn-by-turn interaction has the potential, then, not just to clarify how more ambitious models of teaching are enacted but to guide their development in practice. From this perspective, shifting from univocal recitation towards more dialogic teaching involves moving from relying on the base interaction pattern alone to overlaying further interaction patterns upon it. Equally, as in the case we have studied, such a shift may also involve suspending or downplaying one particular component of the base pattern, namely explicit evaluation in the follow-up move.

Another potentially relevant recent line of research, conducted by Wagner and Herbel-Eisenmann (2014), focuses on *authority structures* in the mathematics classroom; in particular, on markers of such structures in the form both of general indicators and more specific linguistic clues. Their analyses have led Wagner and Herbel-Eisenmann to a fourfold typology of authority structures. Two of these types locate authority within the classroom: *Personal authority*, marked by general indicators of someone following the wishes of another participant—typically the teacher—for no explicitly given reason, and by linguistic clues such as *I* and *you* in the same sentence, exclusive imperatives, and choral response; as against *personal latitude*, marked by suggestions that people are aware that they or others are making choices, and by inclusive imperatives, verbs that indicate a changed mind, and constructions that suggest alternative choices. The other two types locate authority beyond the classroom: *discourse as authority*, marked by depersonalised suggestions that certain actions must be done, and by modal verbs implying necessity; *discursive inevitability*, marked by people speaking as though they know what will happen without giving reasons why they know, and by the phrase *going to*. Wagner and Herbel-Eisenmann report that classroom talk typically ranges over these authority structures, with personal authority being the most prevalent and personal latitude the least.

In the case we have studied here, however, there is relatively little evidence of this form of personal authority being exercised; in particular, what little I talk there is involves people reporting their state of mind rather than directing others. Rather, the substantive mathematico-scientific talk is either in a depersonalised register or a more generically personalised you talk—“if you've got ... then you are going to have”—both of which imply discursive authority or inevitability. There is little dialogue indicative of personal latitude in the sense of making substantive mathematico-scientific choices: The single clear example is in Episode ϵ where pupils speculate about whether two set questions are meant to be related and the teacher legitimates exploration of the resulting hybrid. Nevertheless, an important feature of the dialogue in our case reflects the norm of testing a new claim to knowledge on the basis of its being comprehensible to the person as well as being grounded in established knowledge: This might be

regarded as personal latitude in the sense of active participation in the construction of collective knowledge. This suggests that the notion of personal latitude might need expanding or differentiating to encompass this more nuanced and dialogic co-construction of authority also referenced by Truxaw and DeFranco in the notion of accountable talk.

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