A DIALOGIC APPROACH TO PLENARY PROBLEM SYNTHESIS

Kenneth Ruthven
University of Cambridge

Riikka Hofmann
University of Cambridge

Neil Mercer
University of Cambridge

In this case study, a classroom episode featuring a dialogic approach to plenary problem synthesis is analysed, drawing on ideas and methods from recent research, including reassessment of the triadic model of instructional interaction. The over-arching framework of teacher-led class discussion is identified, as well as more specific discourse features associated with student contributions and their handling.

BACKGROUND TO THE MODELLING OF CLASSROOM DIALOGUE

Our current research involves devising resources to help mathematics and science teachers develop effective use of dialogic approaches to classroom teaching and learning. A 'dialogic' approach is one that takes different points of view seriously (Scott, Mortimer & Aguiar, 2006), encouraging students to talk in an exploratory way that supports development of understanding (Mercer & Sams, 2006). One of the classroom activity structures that we have been examining is the commonplace one in which a problem situation is introduced to the whole class, students tackle it together in small groups, and a plenary discussion then synthesises ideas. Orchestrating this type of discussion to advance the learning of the whole class is acknowledged to be a significant challenge: pedagogical goals include facilitating public expression and respectful examination of students' thinking; focusing – but not funnelling – discussion to prevent it becoming overly fragmented and incoherent; and guiding students towards accepted disciplinary norms of reasoning and communication (Franke, Kazemi & Battey, 2007; Stein, Engle, Smith & Hughes, 2008). Helping teachers to meet this challenge involves finding productive and efficient ways to 'read' and shape classroom discourse. What, in operational terms, can serve as crucial indices of dialogic discussion and as effective mechanisms for sustaining it?

Until recently there has been a pervasive assumption that the triadic structure of conventional instructional discourse acts against dialogic talk. In defining this triadic structure, it is generally agreed that the opening *move* of a classroom *exchange* is an *Initiation,* typically (but not necessarily) by the teacher, in which typically (but not necessarily) a question is posed. The second move of an exchange is a *Response*, typically (but not necessarily) from a student nominated by the teacher. In the third move of an exchange, the initiator acknowledges the response, and possibly reacts to it. Where the pedagogical function of the exchange is to allow students to apply or rehearse their knowledge, the teacher's positioning within the exchange is typically authoritative: thus, in the third move, s/he provides an *Evaluation* of, or *Follow-up* on, the student response to the initiation. Hence this triadic structure is often referred to as IRE or IRF. Frequently, an E- or F-move is followed by a further I-move within

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the same teacher turn. In this way an initial *nuclear* exchange can give rise to further *bound* exchanges that combine to form a single coherent *sequence* of talk. Likewise, while a move within an exchange is often accomplished through a single conversational *turn* by one speaker, it may include further turns from other speakers.

Researchers have come to realise that triadic interaction pervades classroom discourse across the spectrum of pedagogical activity from inquiry to instruction. They have suggested that fostering interactive, multivocal, dialogic discourse depends on using the triadic structure in particular ways, such as shifting from providing authoritative evaluation within the E- or F-move towards promoting further reflection or argumentation. Also highlighted have been increasing the ratio of exploratory and accountable talk by students to monologic and leading talk by the teacher (Truxaw & DeFranco, 2008), and carefully managing sequence initiation, knowledge authority, and reflexive commentary (Nassaji & Wells, 2000).

THE CASE UNDER STUDY AND METHODS OF ANALYSIS EMPLOYED

This particular episode of plenary problem synthesis was chosen for study because it appeared to be a promising example to bootstrap reflection on dialogic teaching in action. Analysing this case would help us to scaffold discussion of it with teachers during professional development activity, and provide input to construction of an analytic instrument for purposes of research and training. The episode involved a first-year secondary-school class of around 30 pupils (aged 11/12 years) of above-average attainment, taught by a teacher who had recently become involved in the *epiSTEMe* project. The class had undertaken preparatory activities aimed at establishing suitable ground rules for effective classroom discussion. This particular episode occurred while the class were undertaking a subsequent probability module.

In line with an *epiSTEMe* design principle, the problem situation combined scientific with mathematical ideas. Earlier, the class had been introduced to the genetic model of how people come to have attached or detached earlobes. Earlobe type is determined by a pairing of genes, one inherited from the mother, one from the father. There are just two versions of this gene, known as alleles, and represented as **e** and **E**. Only people who inherit an **e-e** pairing have attached earlobes; others have detached. A parent cannot pass on an allele that is not in their own pairing. If a parent has both alleles, then these are equally likely to be passed on. After whole-class activity intended to help students grasp this model, they worked together in small groups on the following problem: *A couple are expecting their first baby. Both parents have a mixed pairing of **e** and **E** alleles. How likely is their baby to have this same pairing?*

To undertake analysis, classroom talk was transcribed from a video-recording of the lesson, and examined using methods drawing on the apparatus of discourse analysis and ideas about dialogic talk outlined in the previous section. In particular, we classify moves as I, R, or F; we also use F/I to indicate a move combining both these functions within a single turn. Limitations of space mean that we restrict ourselves to

presenting only the major sequences in the course of this 15-minute plenary episode with a view to conveying broadly how it unfolded from start to finish.

ANALYSIS OF THE MAJOR SEQUENCES IN THE PLENARY EPISODE

A1 T: So we have, both parents have one of each. *[Writing in margins of table drawn on board]* So the father has a big ee and a little ee, and the mother has a big ee and a little ee. And the question is, how likely is their baby to have the same pairing.

A2 Ss: *[Overlapping responses including]* Very very likely. / Fifty per cent. / A hundred per cent. / One third.

A3 T: So, we've been offered what? *[Recording on board]* A third. What else?

A4 Ss: *[Overlapping responses including]* A half. / A whole.

A5 T: *[Recording on board]* Shall we write fifty per cent? *[pause]* And what was the other one?

A6 Ss: *[Overlapping responses including]* One whole. / One hundred per cent.

In the I-move [A1] of the opening sequence, the teacher revoices the problem, distancing herself from authorship ("we have", "the question is"). This functions to request student groups to report their answers. With the teacher neither nominating a respondent nor intervening during contributions, the R-move [A2] encompasses brief student turns that report differing answers. In her F/I-move [A3], the teacher chooses one answer to start a listing, and requests that the others be repeated. From the R-move [A4] the teacher selects a further answer for listing in her F/I-move [A5], employing the equivalent expression used in the earlier R-move [A2], then requests the last answer. In the R-move [A6], students offer equivalent expressions for this.

B1 T: Okay. Would somebody like to sell us on a third please. So one of the groups that thought a third. Who thought a third?

B2 Ss: *[Overlapping responses]:* We did. / We did.

B3 T: You did. And you did. So we've got two groups. Who have we not heard from really. Vin. Can you tell us why you think a third, please.

B4 S[Vin]: Because there's really three ways of forming pairs, a small ee and a big ee, two big ees, and two small ees. *[inaudible]* So it'll be a third that they've got the same pairing, small ee big ee.

B5 T: Okay. What's this reminding you of? Anything? Coins. Who said coins?

In the ensuing I-move [B1], the teacher frames the next sequence as examining the persuasiveness of thinking behind the first proposed answer in the list. In a subsidiary exchange, she identifies groups favouring this answer and chooses a student speaker. She then repeats her request [B3], eliciting an extended R-move [B4] from the student. Her F/I-move [B5] accepts this as a response to the original request, then refers students back to an analogous problem that the class tackled earlier.

C1 T: Okay. Who thought fifty per cent?

C2 Ss: *[Overlapping responses including]* I do now. / We thought it.

C3 T: Hex.

C4 S[Hex]: Both parents have a mixed ee, a little ee and a big ee, and so you could either have a big ee or a little ee, it depends. Two big ees or a little ee and a big ee.

C5 S: You what? *[Other student comments overlapping inaudibly]*

C6 T: Nan.

C7 S[Nan]: You can get a big ee, like the, whatever sort of earlobe it is you have, and you could have like two big ees and two small ees *[inaudible]*.

C8 T: Okay. Tia, do you want to add to that?

C9 S[Tia]: I'm starting to think it's a third because we've got a big ee and a small ee, that's one possibility and then you've got a big ee and a big ee, that's another possibility, and then you've got a small ee and a small ee, that's another possibility, so three possibilities. You've got to have one of those.

The opening of the next sequence echoes the preceding one, although the turns forming the teacher's I-moves [C1, C3] are briefer. On this occasion, however, the student R-move [C4] prompts an F-move in which other students express incomprehension [C5], and a teacher I-move nominating a new contributor [C6]. The ensuing R-move [C7] still does not develop a clear response to the request; a further F/I-move [C8] from the teacher asks another student to expand. In the R-move [C9] this student positions her thinking as being tentative, and develops a line of reasoning that leads to the first answer on the list, rather than to the second one as requested in the opening I-move. This elicits an F/I-move [D1] in which the teacher refers back to a probability principle introduced in earlier lessons. Because this refocuses the discussion, and introduces a fresh request, we treat it as opening a new sequence.

D1 T: Are those three equally likely?

D2 Ss: *[Overlapping responses including]* No. / Yes.

D3 S[Tia]: Because they've got *[inaudible]*.

D4 S No, no they're not.

D5 T: Hold on a minute.

D6 S[Tia]: Because you've got a big ee and a big ee and a small ee and a small ee. So there's not more big ees than small ees, and there's not more small ees than big ees.

D7 S[Nan]: But you only need one big ee to get the big ee type but you need two little ees. *[Other student comments overlapping inaudibly]*.

The teacher's opening F/I move [D1] raises the question of whether the principle applies to the set of possibilities just identified. The initial turns in the ensuing R-move [D2] evidence disagreement amongst students, then an attempt at explanation [D3]. The intervention by another student [D4] starts to counter this contribution, but the teacher reinstates the earlier speaker [D5]. This student continues her contribution [D6], eliciting a further counter from another student [D7]. These counters function as student F-moves [D4, D7] to another student's earlier R-move [D3, D6] as well as further student R-moves in response to the teacher's original question. We treat the redirection through the ensuing teacher I-move [E1] as opening a new sequence.

E1 T: *[Pointing to table drawn on board]* We have here the mother and the father so can this help us do you think?

E2 Ss: *[Overlapping responses including]* No. / Yes. / I don't know.

E3 T: *[Pointing to table drawn on board]* So the mother can give us a big ee and the father could give us a big ee. The mother could give us a big ee and the father could give you a little ee. The mother could give us a little ee and the father a big ee.

E4 S: *[Overlapping]* Oh, there's four there.

E5 T: And the mother could give us a little ee and the father could give us a little ee.

E6 S: So it's a quarter.

E7 S: No it's a half. *[Lesson is interrupted]*

In the I-move [E1], the teacher draws attention to a further available resource, prefigured by her when first presenting the problem [A1]. Her request is a very open one, and in the ensuing R-move [E2] students simply register differing reactions. The teacher's F-move then launches use of the resource for systematic analysis of the problem [E3, E5]. In doing so the teacher positions herself as knowledgeable, and embarks for the first time on an extended substantive turn. In parallel, however, in what might be termed *prevoicing*, students volunteer contributions that anticipate her conclusion [E4] and pursue its implications through statement [E6] and counter [E7].

F1 T: Vin, does this make any difference to you?

F2 S[Vin]: *[pause]* It's actually four possibilities instead of three possibilities.

F3 T: There's a difference isn't there between the combinations we've got here, the genes they might have, and what sort of earlobes they might have.

Following an external interruption to the lesson, the teacher returns to the student who originally spoke in favour of the first answer. Her I-move [F1] requests him to describe whether his thinking has changed. His R-move shows his recognition that the four ordered pairings shown in the table constitute the appropriate set of outcomes rather than the (three) unordered combinations. The teacher's F-move [F3] highlights this distinction, and makes a further contrast with the (two) earlobe types.

Several student-originated sequences follow; in one of these a student raises the third of the listed answers, the only one that has not yet received public attention.

G1 S[Bet]: I think they're going to have one of each, because if its mum's got one of each and its dad's got one of each you have to raise all the possibilities, right? When I first looked at it I didn't like look as deep as we have, like I said that its mum's got one of each and its dad's got one of each, so it's definitely going to have one of each. Because that's how I first saw it, but like, now we've like dug in a bit deeper, whereas, because like, say your dad has brown hair and your mum has brown hair and people would say you would have brown hair, so that's how I looked at it, his mum's got both, one of each and his dad's got one of each so you'll have one of each.

G2 T: So you started off looking at it as though if they've both got one of each you're bound to have one of each. How do you think now?

G3 S[Bet]: Well I kind of still think that, because if you look there's like two possibilities.

G4 T: Are these not possible to happen then *[pointing to two pairings in table]*?

G5 S[Bet]: They are possible but I still think that you are probably going to have one of each because if you look, there's two like, there's small ee and a big ee, and then a big ee and a small ee, so I still think that you're more likely to have one of each.

G6 T: So can we put a number on this more likely? Bob.

G7 S[Bob]: Can we say fifty fifty, because there's four chances there *[pointing to table]* of what's going to happen, and two of them are the same as what the mother and father have, so that's fifty fifty.

G8 T: We can if we all agree.

After a teacher I-move that simply nominates a speaker, the student's R-move [G1 reports her current thinking and offers an account of how that thinking has evolved. The teacher's F/I-move [G2] revoices the student's shift away from a lay view of inheritance, and requests clarification of the student's current thinking. The student's R-move [G3] appears to continue to endorse some form of the lay view. The teacher's F/I-move [G4] is then a substantive one that focuses on those gene pairings that, according to the lay view, could not arise in these circumstances. In her R-move [G5] the student accepts that these pairings are "possible", and appeals to the displayed table to argue that the mixed pairing is "probable", refined to "more likely". The teacher's F/I-move [G6] requests quantification from another student. In his R-move [G7] the student provides supporting reasoning for his answer but invites approval of it ("Can we say"). The teacher's F-move [G8] appeals to class consensus as the criterion for accepting an answer, distancing herself from knowledge authority.

The teacher then polls the class, revealing continuing differences and uncertainties. Reacting to some restlessness, the teacher emphasises the goal of everyone being persuaded of an agreed answer [H1]. A little later in the ensuing sequence the teacher responds to further restlessness by elaborating norms of engagement for students taking the majority view [H8]. This ensuing sequence is again student-originated:

H1 T: There is an answer to this and we need to work out what it is. And we all need to believe it. Because this is really quite important. *[pause]* Lea.

H2 S[Lea]: If you do four time three then you get twelve so if you've got a large ee and a little ee you're going to get the same sort of thing, so it's sort of the same, which makes one third doesn't it?

H3 Ss: *[Overlapping responses]* Whaaaat?

H4 T: Do correct me if I'm wrong here Lea, what Lea's saying is that this one and this one *[pointing to two pairings in table]* are the same basically. And therefore she thinks that she's saying that there is still only three different outcomes and therefore they're a third each.

H5 S[Lea]: Yeah I'm a bit confused.

H6 T: Kit.

H7 S[Kit]: There's three different outcomes but there's two ways of getting one outcome so that outcome has a higher probability than the other two.

H8 T: Okay. So Lea, does that make, does that make any difference do you think? Kit's saying that although there are only three outcomes *[pause]* All those people who are getting restless think of something that you can tell us that will convince people of what's going on, convince them of what you believe, because the majority of you are saying that there's a fifty per cent chance they will have the same grouping as their parents. We have some people who don't agree, and they have good reasons for not agreeing, but, if you're sitting there fiddling, think of something you can say to help them understand. *[pause]*. So we were just saying that, what Kit said was, although these *[pointing to two pairings in table]* are the same, you've still got one of each, there are two different ways that it can happen. Is that right Kit? There are two different ways that this *[pointing to two pairings in table]* can happen.

H9 S[Kit]: Yes.

H10 T: So these ones have two chances, whereas there's only one way of a big ee big ee and one way of a little ee little ee, there are two ways for this to happen, and so they have a fifty per cent chance. Is that what you're saying?

H11 S[Kit]: Yes.

H12 T: Rather than a third.

The teacher's I-move [H1] nominates a student. Her R-move [H2] offers an analogy that prompts an F-move [H3] from other students voicing incomprehension. The teacher's F/I-move [H4] attempts repair through speculative revoicing, referring back to the student but eliciting an uncertain R-move [H5]. An I-move [H6] nominates another student. Her R-move [H7] highlights the crucial mathematical issue. Framing discussion as being between these two students, the teacher's ensuing F/I-moves [H8, H10] revoice this contribution, and refer back to its author, eliciting R-moves [H9, H11] granting approval. The teacher's final F-move [H12] makes the contrast with the answer that students had endorsed earlier. In this sequence, then, the teacher's extended turns serve mainly to revoice and interanimate student contributions.

After more student-originated sequences (which limited space prevents us examining here), the teacher concludes the episode [J1] as the close of the lesson approaches.

J1 T: We're going to leave it unresolved for the minute, so all of you *[pause],* all of you need to give it some thought, please, before the next lesson.

A FUNCTIONING APPROACH TO PLENARY PROBLEM SYNTHESIS

This case study has examined a dialogic approach to plenary synthesis in action. The opening sequence [A] identifies different viewpoints within the class, and the ensuing sequences [B, C, D] set out to elicit these more fully. This establishes an overarching dialogic framework within which teacher moves serve predominantly to organise and support student articulation of mathematical thinking, and to strategically prompt students to relate that thinking to examples [B5] or principles [D1] or tools [E1] that the class has already encountered. Equally, however, the teacher has anticipated that a particular representation of the problem is likely to support productive discussion. As contributions from a succession of students fail to develop a persuasive account of the mathematically accepted viewpoint the teacher originates a sequence [E] in which

she then actively enters the discussion. Her introduction of the representation triggers student contributions that enable her to resume [in F] the more detached position that is the default for the teacher. Likewise, in the following student-originated sequences [such as G, H], although initiative remains with the teacher, her moves predominantly serve to elicit, revoice and interanimate student contributions, and to strategically bound and focus the discussion. When she does enter the discussion more directly [as in G4, G6], she quickly moves to distance herself from knowledge authority [G8].

Thus the great majority of substantive contributions to the discussion are made by students, and these are relatively lengthy: typically around 20 to 40 words. While initial ideas come from earlier groupwork, students' reflexive commentaries [e.g. C9, G1] and tentative formulations [e.g. C7, G7] show how the unfolding discussion becomes more exploratory. Direct evaluation of, or feedback on, contributions comes only from students. Contrasting multivocal responses also provide more indirect feedback. Indeed, the relatively loose regulation by this teacher of background conversation and discussion turn-taking seems to play an important part not just in sustaining engagement of students, but in eliciting multivocal responses [as in A, B, C] and spontaneous voluntary contributions [most crucially in E]. As a majority view emerges and some students become restless, the teacher emphasises dialogic norms that call for them to continue formulating potentially helpful contributions [H1, H8].

Finally, as regards our analysis, although the apparatus of sequences and moves has provided a useful heuristic framework, we have noted how – as multiple voices and viewpoints enter an exchange – limitations of a simple IRF model are exposed. While previous research has shown how such a model could be elaborated, we remain somewhat sceptical about the practical and intellectual cost/benefit ratios of doing so.

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