Patterns of interaction that encourage student explanations in mathematics lessons

Jenni Ingram, Nick Andrews and Andrea Pitt

University of Oxford

In this paper, we identify three different interactional structures that lead to students offering explanations or reasoning in their responses to a teacher. Students explaining their mathematics is a key part of the teaching and learning of mathematics yet there is little research into how to enable and support students in giving these explanations. All whole class interactions from 22 lessons with 7 different teachers were analysed. Using conversation analysis, we look at situations where students gave explanations of some form in order to identify features of the preceding interaction that provoked the student into offering their explanation.

Keywords: explanations; conversation analysis; contingency

Introduction

Student explanations give teachers, and other students, vital assessment information on what students' understanding is. Explaining can also help students develop their understanding (Rogoff, 1991; Sidney, Hattikudur & Alibali, 2015). The majority of research into student explanations have focused on the questions or prompts teachers can use to develop student explanations (e.g. Franke et al., 2009) or on the quality of written explanations and justifications (Bailey, Blackstock-Bernstein & Heritage, 2015). In this paper we focus on whole class interactions and the interactional structures that surround student explanations as they naturally occur in lessons. We identify three structures that include student explanations and differences in the nature of the explanations that depend upon the turns that preceded the explanation.

Using a conversation analytic approach (CA) we examine sequences of interaction that contain a student explanation and in particular the structures of interactions the lead to a student offering an explanation in their turn. The focus is on how students use explanations to respond to teachers' initiations, emphasising the social action of explaining as an appropriate response within a classroom interaction, rather than any cognitive approach focusing on what students know or understand.

The analysis draws on three key features of classroom interaction and interaction more generally. Firstly the notion of an *adjacency pair* which is made of two reflexive turns, most commonly in a classroom a question and an answer. A question requires an answer, and an answer is usually only given to a question. Another common adjacency pair in classrooms includes requests and grants. In classrooms, the first part of an adjacency pair is usually taken by the teacher and the second part by a student, and these are then usually followed by a third turn taken by the teacher and this is commonly referred to as the IRF or IRE sequence (Sinclair & Coulthard, 1975; Mehan, 1979). The second key feature of interaction used in this paper is that of *conditional relevance*. Each first part of an adjacency pair makes a particular second part relevant. For example a question requires an answer, an invitation requires an acceptance, and a request requires a granting of that request. This does not necessarily mean that the second part occurs, but that it is expected and is obviously absent (Schegloff, 1968) (or noticeably absent (Bilmes, 1988)) if it does not occur. If the expected second part is not given then some form of account for why it cannot be given is expected (Schegloff, 2007). The final idea is that of *preference* which refers to the idea of affiliate or disaffiliative actions rather than the psychological notion of liking or disliking. This idea refers to the notion that some responses are preferred over others. In the classroom, preferred responses are those that are affiliative with the teacher and/or the other students and contribute to moving the interaction forward in line with the goal of the lesson. For example an answer to a question is usually preferred over a 'I don't know' response, even though both are can be considered to be answers to a question. When giving a dispreferred response the responder needs to do interactional work to minimise the disaffiliation, such as by including an account or explanation.

Methods. The data analysed comes from a corpus of 2 secondary mathematics lessons, with students aged 11, 12 or 13 years old. These lessons involve 7 different experienced teachers from 7 different schools, ranging from a fee-paying independent school to comprehensive schools serving areas with high levels of social deprivation. These lessons were video-recorded and then transcribed. The teachers were not given instructions over what or how to teach and as such the lessons can be considered as naturally occurring.

The initial analysis began by looking for student turns that contained an explanation, usually marked by their use of 'because' in their turn. At this stage student turns than contained multiple parts such as descriptions of their working that included more than one step, were also included but were included as a separate category of describing rather than explaining. These turns did not include words like 'because' but were similar to the examples of explaining given by Drageset (2015). The sequence of turns in which the identified explanation or description was then examined to take into account the turns that led to the student explanations and also the turns where the student explanation was reacted to. In total 113 student turns were identified, 87 included the word because and were therefore categorised as explanations and 26 were categorised as descriptions. At this stage, no judgements were made about the quality or nature of the explanation. As a result of this initial analysis three interactional structures were identified that preceded the student explanation, these are outlined briefly below.

A secondary analysis was then performed taking into account the nature of the explanation in terms of whether the student turns referred to concepts, properties or features of the question and student turns that included descriptions of procedures that were followed or could be followed. Noticeable differences in the turns that preceded the student turn and the nature of student explanations were identified. There were 5 student turns that included the word because but the following words could not be heard and therefore the nature of the explanation could not be identified.

Findings

Three interactional structures in which a student explanation or description occurred were identified. Firstly, where a preceding turn explicitly asks for an explanation by including words such as 'why', 'explain', or 'how' in the initiation. In almost all occasions this was the teacher's turn, but there are two examples where another student initiates with a 'how' or 'why'. These initiations makes an explanation conditionally relevant (Schegloff, 2007) in the turn that follows. That is, the student is expected to include an explanation or reason in their response and this is 'obviously absent' when it does not occur (Schegloff, 1968). The vast majority of student explanations or descriptions followed these explicit initiations (74%).

The second structure is where the student is responding to a question that has already been answered. This response could be building on or adding to the previous answer, or could be offering a different or contrasting response. In this structure the student needs to account for why they are answering a question that has already been answered to show why their response is needed, as this action is dispreferred (Heritage, 1984). 16% of students' explanations or descriptions occurred within this structure.

The final structure occurs where a student has given an answer without an explanation but the teacher does not respond immediately as is usual within the IRF structure that dominates (these) classrooms (Wells 1993). Instead there is a pause (often described as wait-time (Ingram & Elliott, 2016)), or the teacher follows with a continuation marker, such as 'mhm' or 'go on' both of which indicate that the turn returns to the student and that they need to continue speaking. This continuation is what includes the explanation or reasoning. Examples of each of these structures can be found in Ingram, Andrews & Pitt (forthcoming).

The subsequent analysis also revealed relationships between the structure and the nature of the student's response. For the first structure teachers predominantly ask 'why' in their initiation (63% of initiations), with other initiations such as 'explain' or 'how' occurring frequently. Only initiations including 'why' were responded to with explanations that did not refer to the content of the lesson, for example "*because he just told me*' or failed attempts at explanations, '*because the a- if there's a- f- the- there- no if there's (.) I dunno. forgot it*'.

More noticeably only responses to initiations including 'why' included explanations that specifically referenced the initiating question or task. Such explanations related to the ideas, properties or features of the question or task, rather than the specific procedure that was used. For example, '*because you could roll any number'* or '*because the number keeps getting smaller*'. 72% of student explanations following a why initiation included direct specific references to the features of the question or task. In contrast, the majority of the student explanations or descriptions following an explicit teacher initiation that did not include the word 'why' included the specific details of what the student did to get their solution (87%), e.g. '*because seventy times five equals'*, '*because you do six, you do err six times four'.*

Within the second structure, where a student was offering an answer that built on a previous answer or contrasted with the previously given answer, the vast majority of the student explanations or descriptions included specific references to features or properties within the original task or question, and often included counter examples. Only two explanations included a description of the procedure followed to get the new answer.

The vast majority of explanations offered by students were accepted by the teacher in the following turn and on only three occasions were students invited to add more to the explanations given and these both occurred in the same lesson

Discussion.

In this paper we have reported three different interactional structures that include student explanations or descriptions, and distinctions within these structures relating to the nature of the explanation given. This categorisation builds on the work of Drageset's (2015) categorisation of explanations as 'explain reason', 'explain concept', and 'explain action'. Explain concept relates closely to the category used by us where the explanation is grounded in the ideas, features or properties within a task or question. The main difference in the categorisation occurs between Drageset's categories of 'explain reason' and 'explain action' and our categories of explanations involving procedures, and descriptions. The category of explain reason referred to explanations that gave a reason as to why something was correct and in the examples offered by Drageset these were procedures or calculations used to get to an earlier answer. This corresponds to our second category of explanations which included the word 'because' followed by a description of a procedure. However, Drageset's third category of 'explaining action' were treated as descriptions of what was done, rather than explanations as they were treated as such by the students through their own choice of words.

Research with younger children (Bailey, Blackstock-Bernstein & Heritage, 2015) and Drageset's research (2015) both found that attempts at explanations were often unpolished yet this is common of many turns in spoken interaction which is littered with false starts, self-corrections and ungrammatical sentences. From a CA perspective, a student response is an explanation if both the students and the teacher treat it as such in the interaction. There are only two occasions in the data where a student terminates an attempt at an explanation before sufficient information is offered to know what the student is saying, and there are only three further occasions where the teacher does not treat the student's response as acceptable. Consequently this analysis shows that students are capable of constructing explanations that meet the demands within their classrooms. Other categorisations of explanations that focus on the quality of an explanation do not take into account the appropriateness of the explanation in the moment that it occurs. Given that the vast majority of explanations are treated as appropriate in the interactions and that these interactions continue without a perturbation indicating that there was some difficulty with the explanation, any further distinctions around the mathematical nature of the explanations are not meaningful from an interactional perspective such as CA.

The implications of these findings include resources which teachers can use to structure the whole class interactions in their classroom to encourage students to give explanations or detailed descriptions in their turns. Whilst the obvious structure of explicitly asking for an explanation does lead to the majority of the student explanations, this strategy is not always successful and the specific structure of the initiation can give rise to different types of explanations. Asking why corresponds to higher proportions of student explanations that include references to properties or concepts within the topic, but also corresponds to higher failures to explain or explanations that do not refer to the mathematics at all. Whereas asking how or to explain are usually followed by student explanations or descriptions, a greater proportion of these focus on the procedures used or that could be used rather than the ideas within the topic.

Teachers also have other structures available to them that encourage students to offer explanations or descriptions without them being explicitly asked for. Beginning with questions or tasks were there are a variety of possible answers, or a likelihood of a common misconception where students are likely to disagree with each other also result in student explanations as they defend their position or justify the need for them to add their response. Finally, pausing or returning the turn to the student where it would usually return to the teacher within the IRF structure also results in students adding to their response, either including an explanation where there was not one before, or adding more to an explanation already given. These last two structures place the responsibility for initiating the explanation with the students and were the only occasions with the data where explanations were given without a preceding explicit request for an explanation.

Conclusion

The search for ways to support students in explaining and reasoning in mathematics has so far focused on the nature of teachers' questions and the design of tasks. In this paper we have looked closely at the structure of interactions where student explanations occur to identify additional features that enable or support students in giving explanations or reasons. This analysis has focused on linguistic features and structures rather than the mathematical quality but does reveal differences in the interactional structures and the structure of a student explanation.

References

Bailey, A. L., Blackstock-Bernstein, A. & Heritage, M. (2015) At the intersection of mathematics and language: Examining mathematical strategies and explanations by grade and English learner status. *The Journal of Mathematical Behavior*, 40(A), 6-28.

Bilmes, J. (1988) The concept of preference in conversation analysis. *Language in Society*, 17(2), 161-181.

Drageset, O. G. (2015). Different types of student comments in the mathematics classroom. *Journal of Mathematical Behaviour*, 38, 29-40.

Franke, M. L., Webb, N. M., Chan, A. G., Ing, M., Freund, D., & Battey, D. (2009). Teacher questioning to elicit students' mathematical thinking in elementary school classrooms. *Journal of Teacher Education*, 60(4), 380-392.

Heritage, J. (1984). *Garfinkel and Ethnomethodology*. Cambridge: Polity.

Ingram, J., Andrews, N., & Pitt, A. (accepted). Making student explanations relevant in whole class discussion. Paper to be presented at the 13th International Congress on athematical Education, Hamburg, July 2016.

Ingram, J. & Elliott, V. (2016). A critical analysis of the role of wait time in classroom interactions and the effects on student and teacher interactional behaviours. *Cambridge Journal of Education* 46(1), 1-17.

Mehan, H. (1979). *Learning lessons: Social organization in the classroom*. Cambridge, Mass: Harvard University Press.

Rogoff, B. (1991) Guidance and participation in spatial planning. In Resnick, J. Levine, & S. Teasley (Eds.). *Perspectives on socially shared cognition* (pp. 349-383). Washington DC: American Psychological Association.

Schegloff, E. A. (1968). Sequencing in conversational openings. *American Anthropologist* 70(6), 1075-1095.

Schegloff, E. A. (2007). *A primer for conversation analysis: Sequence organization*. Cambridge, England: Cambridge University Press.

Sidney, P. G., Hattikudur, S. & Alibali, M. W. (2015). How do contrasting cases and self-explanation promote learning? Evidence from fraction division. *Learning and Instruction* 40, 29-38.

Sinclair, J. & Coulthard, M. (1975). *Towards an analysis of discourse: The English used by teachers and pupils.* Oxford: Oxford University Press.

Wells, G. (1993). Reevaluating the IRF sequence: A proposal for the articulation of theories of activity and discourse for the analysis of teaching and learning in the classroom. *Linguistics and Education* 5, 1-37.