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Revisiting the roles of interactional patterns in mathematics classroom interaction

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The ways in which teachers and students interact about mathematics in lessons can be more powerful in influencing learning than the materials and resources that teachers use. Interactional patterns structure all interactions and there are many such patterns that occur frequently in mathematics lessons. This paper focuses on one such pattern, the funneling pattern, which is widely discussed in the literature. Three distinct examples described in the literature as a funneling pattern are examined in order to examine the different roles sequences of closed questions can have and the opportunities these patterns can provide or constrains to students in the learning of mathematics.

Keywords: Interactional patterns, funneling, questioning.

Introduction

The aim of this paper is to contribute to the discussions around the roles different interactional patterns have in the teaching and learning of mathematics. The simplest, and most prevalent, pattern that is discussed widely in the mathematics education literature is the IRE pattern of teacher initiation, student response, and teacher evaluation (Mehan, 1979). Many authors describe this pattern as doing little to encourage students to reason, give explanations or articulate their thinking (e.g. Cazden, 1988; Nystrand, 1997). Yet the discussion has now moved on, with authors pointing out that it is not the IRE pattern itself that is the issue, but rather how it is used. This IRE pattern continues to dominate classroom interaction because it enables students to know when to speak, how to speak and about what to speak (Ingram, 2014; Wood, 1998). This pattern can be used by mathematics teachers to convey and establish different norms. It creates opportunities for students to communicate in classroom interaction, but it is largely teachers who can both constrain or enhance their students' opportunities to communicate mathematics or to communicate mathematically.

This paper focuses specifically on another interactional pattern called the 'funneling' pattern (Bauersfeld, 1980; Wood, 1998) that comprises of a series of IRE sequences. Four extracts that have many of the features of the 'funneling' pattern are discussed with a view to illustrating here that again it is not the pattern itself that focuses student thinking on "trying to figure out the response the teacher wants instead of thinking mathematically himself" (Wood, 1998, p. 172), but rather it is the way that it is used by the teacher that can affect student thinking.

The funneling pattern

The funneling pattern was initially described by Bauersfeld (1980, 1988) and consists of a series of teacher questions and student responses that has particular features. The sequence follows an incorrect answer from the student, or some other form of difficulty with the mathematics. The teacher uses "more precise, that is, narrower, questions" (Bauersfeld, 1988, p. 36) to lead the student to the correct answer. This narrowing effect of questions towards a particular correct answer (hence the term funneling) contrasts with sequences of questions that leads students step-by-step through a process (e.g. Herbel-Eisenmann, 2000), however both invite students to do little more than complete the

teacher's sentences (e.g. Franke et al., 2009). These different examples have led to further terms, such as leading questions (Franke et al., 2009), guiding questions (Moyer & Milewicz, 2002) and scaffolding (Wood, Bruner, & Ross, 1976), becoming associated with funneling. The distinction between these terms and the precise relationship with funneling is often not made but we believe it is an important one as we outline below. As a result, funneling has become used more broadly in the literature to describe any sequences of IRE patterns that lead students through a series of specific narrow questions, often only requiring short factual response from the students.

Particular concerns have been raised about the implications of such funneling interactions. For example, Brousseau (1984) refers to the Topaze effect in which the sequence of 'funneling' questions disguise the mathematical knowledge that is being targeted by the interaction as a whole. Indeed such interactions in which students do not need think about mathematical relationships, patterns or structures in order to answer the teachers' questions (Wood, 1998) the most frequently cited instantiations of 'funneling' patterns. Wood (1998) argues that in funneling patterns of interaction students are only responding to the surface linguistic patterns in order to respond appropriately to the teacher's initiations. However, Temple and Doerr (2012) have shown how this aspect of the funneling pattern can be used by mathematics teachers to activate prior knowledge and offer them opportunities to talk about newly learned concepts. This indicates the possibility that the funneling pattern can have a variety of roles within the classroom, some of which support students' learning and communication of mathematics. Wood also connects funneling to "certain beliefs about the nature of mathematics and the relationship between teacher and students" (p. 175) but we would suggest that it is not the pattern itself that indicates these beliefs, but how it is used by teachers.

Data and methods

The data used in this paper to illustrate the different functions of a funneling pattern of interaction comes from two sources. The first is transcripts from two videos of mathematics lessons collected as part of a larger project looking at the role and use of language in mathematics teaching and learning. Both lessons were from the same school, a small inner-city comprehensive secondary school with high levels of students in receipt of free school means and over 50% of the students with English as an additional language. The lessons are taught by two different teachers and the students are aged 11-12 years old. The second source is transcripts from a published article (Drageset, 2015) focusing on categorizing language use in mathematics classrooms that also uses conversation analysis as its methodology. A conversation analytic approach is taken in the analysis of the transcripts, which is an approach that focuses on the identification of patterns of interaction. Conversation analysis (CA) looks specifically at what participants are doing in their turns at talk through a careful analysis of how the turn is designed, both in terms of its content but also in terms of how it is spoken, i.e. quickly, hesitantly, emphasizing particular words. A key feature of any analysis based on CA is the reflexivity of turns at talk. Each turn is designed in response to the turns that it follows and affects the turns that follow. This makes it a particularly useful approach for examining the relationship between teacher questions and student responses.

The roles of funneling

In this paper we will outline three distinct patterns of interactions described in the literature as funneling. The first is used by the teacher to make assumed knowledge publicly available. The second

offers students the opportunity to use recently introduced vocabulary. The third involves two extracts that are used in combination to draw attention to structures within a sequence of mathematical interactions.

Making assumed knowledge publicly available

The funneling pattern of interaction does not occur very often in the lessons collected as part of the larger project, which contrasts with other studies looking at mathematics classrooms (e.g. Temple & Doerr, 2012; Franke et al. 2009). Yet using a conversation analytic approach in the analysis of this pattern reveals that each instance of the pattern is doing different things. For example, in the first lesson the students have discussed the meaning of some key words on the whiteboard associated with probability. The extract in Figure 1 follows this discussion and then is followed by an activity where students are tossing a coin twenty times and then combining the results. No connection is made between this interaction and the tasks that came before it or after it.

T: ...lovely. so what would be the probability of rolling an e:ven (.) number. how many e:ven numbers are there? s1 (0.4) how many even numbers are there (0.3) o:n a: dice.
(1.1)

S1: u:m ↑three
(0.6)

T: what are the total (0.4) numbers on a dice?
(0.5)

S2: six?
(0.8)

T: okay so the probability (0.6) of rolling an e:ven number would be what,

S3: three sixths.
(0.9)

T: pardon

S3: three ... or [a half]

S4: [half.] a ha[lf]

T: [thr]ee sixths. (1.2) which you're quite right i:s a half. (1.9) okay are we happy with that? are we ha:ppy with how to find the probability of an event.

S: ye::[a[h]]

S: [yeah]

T: [(beautiful)] okay. ...

Figure 1: Calculating the probability of getting an even number

See Jefferson (2004) for details of the transcript conventions used here

The teacher asks a series of questions requiring short factual answers, which are given by the students. These questions lead the students through a step-by-step process for calculating a probability. The fact that these responses are given hesitantly, as indicated by the pauses, ums and phrasing the response as a question, is ignored by the teacher. The sequence of questions focuses on the identification of the numerator and the denominator when identifying the probability and this is emphasized through the teacher's choice of accepting the answer three sixths rather than the half, which is acknowledged but not treated as the answer to the probability of rolling an even number.

The interaction ends with the teacher checking that the students are happy with this process and treating them as such by moving on to the next task. Yet there is little in the interaction to indicate that the students as a whole could calculate the probability themselves. This is a feature of the funneling pattern that Wood (1988) draws attention to: that it can give the impression of learning even though it is the teacher that has done the cognitive work. However, what the teacher has done through this interaction is explicitly to make the process public and has involved the students in this process (as opposed to just telling them how to calculate the probability). The ability to calculate the probability of an event is taken as assumed knowledge in the following task where the students have to calculate the relative frequency of getting a head when tossing a coin. So, whilst there is no evidence that the students are doing more than responding to the immediate initiations, the funneling pattern of questions and responses does make public knowledge that is needed later in the lesson. So the teacher's questions are doing something other than just assessing whether students have the required knowledge. This is demonstrated further in other examples where incorrect responses are ignored such as the second student's suggestion of larger in the second extract (Figure 2), which comes from a lesson focused on solving linear equations.

Opportunities to use terminology

The majority of the lesson on linear equations is spent with students working independently through a set of differentiated exercises. At the start of the lesson a student asks a question about the difference between an expression and an equation and the extract follows this question. Again, the teacher leads students through a series of closed questions requiring short factual responses from them. This example shows the teacher using questions that offer students opportunities to talk about newly learned concepts and new terminology in a similar way to the example offered by Temple and Doerr (2012). The questions serve to support the students in recalling processes and words introduced in previous lessons such as simplifying and collecting like terms. Each use of a technical word is connected to the specific example, $3x + x$ becoming $4x$, and $3x + x = 4x$ being an expression is contrasted with $4x = 12$ being an equation. Throughout the interaction student responses that do not fit with the use of the language the teacher is focusing on are ignored or built on by the teacher who turns them into a form that does fit. This sequence of questions again is doing other than assessing students' knowledge. The questions are providing students with the opportunity to use mathematical terminology and hear it used in a mathematical way by the teacher. This sequence could be considered a form of scaffolding (Wood, Bruner & Ross, 1976) if the support the teacher is giving, through his questioning and phrasing of his responses, is withdrawn over time until the students are using the language in their own descriptions of their work on mathematical tasks.

T: ...wha- I mean what process, what mathematical process essentially has, has S1 demonstrated here by doing three ex and ex

S1: addition.

T: addition. and in which case what's happened to that expression.

(1.0)
 S1: i[t's been answered]
 T: [it's become,]
 (0.5)
 S2: ↑larger
 (1.5)
 S3: um
 S5: °it wha[t°]
 S4: [simpli]fied.
 T: ↑simplified. absolutely S4. you've got three ex plus ex, (0.8) we've
si:mplified that. by collecting our,
 (0.9)
 S: like [terms].
 S: [terms]
 T: like terms good. and we've managed to say three ex plus x has become
 fou:r ex. so that's simplified. but it's ↑still an expression. (1.2)
 whats- how can I turn this fou:r ex here, how can I turn that four ex
 from an expression (.) into an equation.
 S: make x three.
 (0.7)
 T: right, so if I make ex three, four times three would be twelve.
 that's still an expression.
 (2.0)
 S6: give er: would it be give what ex i[s]
 S7: [↑oh] take away
 the e[x and ((inaudible))]
 T: [so (.) go on then S8] hang on
 S8: would it u:m you would do ex equals, °you would- can't remember°
 T: so (0.6) if I did four ex equals: (2.8) twelve?
 S: yeah
 (0.9)
 T: that's no:w (.) an equation.

Figure 2: The difference between an expression and an equation

Drawing attention to regularities

The last two transcripts are taken from Drageset (2015) and have been coded as “closed progress details” which is one of the “main elements of funneling” (Drageset, 2014). In each extract the teacher takes a step-by-step approach in posing questions and students are only required to give short factual responses to the question asked immediately before:

Teacher: How much is one of... one-fifth then of ... of twenty-five?
 Student: Five.
 Teacher: It is five, yes. How much is two-fifths?
 Student: ...ten.

Teacher: Then it becomes ten. How much is three-fifths
 Student: Fifteen.
 Teacher: How much is four fifths?
 Students: Twenty.
 Teacher: And how much is five fifths:
 Students: Twenty-five.
 Student: One whole.
 Teacher One whole, yes. Yes, good. Great.

Extract 1: Extract 1 from Drageset (2015, p.260)

Teacher: Yes. So if I have thirty chips here and then divide them into six equal piles, then how many are there in each pile then?
 Student1: There are five (hold up five fingers).
 Teacher: Five. But how much is two-sixths of thirty, then?
 Student2: Ten.
 Teacher: Ten. How much is three-sixths?
 Student2: Fifteen.
 Teacher: And four sixths?
 Student2: Twenty-five.
 Student1: Twenty, twenty
 Teacher: and f...six sixths?
 Student 2: Thirty.
 Teacher: Yes. And... six sixths, how much do I have then?
 Student2: One whole.
 Teacher: One whole. And then, this time the entire quantity was?
 Student2: Thirty.
 Teacher: Thirty yes.

Extract 2: Extract 5 from Drageset (2015, p. 265)

Extracts 1 and 2 are not just narrowing sequences of questions, but are also specific, structured, and lead to a mathematical regularity within the sequence of questions itself. It is also the repetition of the pattern of interaction itself that offers students an opportunity to see the relationship between the fractions and the quantities. This is pointed to by the teacher in their penultimate turn with the phrase “and then, this time”. So, whilst the teacher does not explicitly talk about the meaning of ‘one whole’ the sequence of questions identifying each of the fractional parts goes in order, and stops when one whole is reached. The teacher does not ask what seven sixths is, and also does not stop at four sixths

for example. In both extracts the total number, twenty-five and then thirty, is said alongside one whole. The sequence of closed questions is leading students through a process in a similar way to the example offered by Herbel-Eisenmann (2000, p. 182). However, it is also the repetition of the sequence that makes this process more explicit and affords students' attention to be drawn to it.

Conclusion

In this paper we have explored three different interactional patterns referred to in the literature as a type of funneling pattern: one example of a narrowing pattern, one example of step-by-step pattern, and one example of connected step-by-step patterns. Each pattern includes a sequence of closed questions requiring short factual responses from the students. Each sequence is leading the students to a particular answer. However, we question whether the mathematical knowledge is always being disguised (c.f. Brousseau, 1984). Each pattern is doing something different to the other patterns and, in the final example the repetition of the pattern itself can be used to support the students' thinking. We have shown the possibilities for how teachers can use these sequences of questions to make assumed knowledge publicly available for subsequent work, offer opportunities to use technical vocabulary, and perceive regularity in mathematical processes. Each of these functions is an important part of the teaching and learning of mathematics. Whilst in each of the examples offered it is the teacher who is controlling the content, it is possible to imagine situations where the teacher is using a similar sequence of closed questions about a student's idea. The funneling pattern can and does have a role in the teaching and learning of mathematics but it is how it is used, rather than the structure of the pattern itself, that can offer or constrain opportunities for students to engage in mathematical thinking and communicating.

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