

SHIFTING ATTENTION

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What is learnt depends upon what the learner is aware of. A teacher can direct learners' awareness through their choice of task, activities and images and there is a wealth of literature exploring the affordances different tasks or images offer mathematically. In this article, I take a more micro approach to examine how the interactions surrounding particular tasks and images reveal shifts in the focus and structure of attention of one teacher, Tim, and his students. As attention shifts from one aspect to another, its structure alters and connections are made, relationships are perceived and new ideas are appreciated. The learning of mathematics occurs through these shifts in attention and students' developing awareness of them. Mason suggests that these shifts in attention "*constitute* change in understanding" (2004, p. 12).

In any teaching episode, there may be a number of features, ideas and relationships that require shifts in attention (Ainley & Luntley, 2007). The different ways in which attention is structured and focused has implications for the mathematical features that are emphasised or ignored and the connections that are made. An important role of the teacher, therefore, is to direct attention to enable learners to make the connections, discern the details and appreciate the structures needed to learn mathematics, whilst still enabling the students to experience the relationships for themselves.

Hewitt argues "where I place my attention affects what I become aware of, and what I am already aware of affects where I place my attention" (2001, p. 58). Choices over which contexts, tasks, activities and representations can affect how attention is structured (Klymchuk & Thomas, 2011). There is a great deal of literature discussing choices of tasks or images as ways in which teachers can direct attention in order to appreciate particular features or make particular connections, yet "tasks do not in themselves generate learning" (Watson & Mason, 2007, p. 207). In episode discussed in this article, the teacher has chosen

the (dynamic) image of an equilateral triangle and a specific context (donating money to charity) to support his students in making connections between the process of repeatedly taking a quarter and the limit of this process, a third. The episode follows an activity looking at limits of sequences. The lesson begins with this problem spoken by the teacher:

I've just inherited twelve thousand pounds, and being the generous man that I am I want to donate some of that to charity. But because I'm not totally generous, I'm going to donate one quarter of the twelve thousand pounds, then the following week I want to donate a quarter of that amount, following week a quarter of that amount. How much will I donate in each of the first four weeks, how much will you donate in total? [1]

I take a conversation analytic (CA) approach to examine shifts in attention in a two minute extract from a teacher-led explanation from during the episode. I cannot know where any particular person's attention is focused or how it is structured, but I can examine how their attention shifts through what they do and say in their interactions (Barwell, 2002). The focus and structure of attention is not readily observable. CA offers a way of examining shifts in attention by examining how attention is socially managed in interactions.

My focus is on how language and gestures reveal the structure and focus of attention, and on how this changes during the interaction during the episode. The affordances of the particular image used or the context within which the problem is set are only explored in the ways that are made relevant through the interaction. Shifts of attention within the discourse are examined to show the connections being offered and the relationships being explored and the variation in these affordances (Marton & Tsui, 2004). As I show, what is at the fore of attention changes rapidly and this influences the connections that the students can make and the mathematics that can be learnt. The rapid shifts of attention in the short

episode offer a window onto the complexity of how opportunities are made available to students in terms of their learning of mathematics. The analysis also offers a method that can be used to raise awareness of the multiple shifts and changing structure of attention with teachers and the impact these may have on the teaching and learning of mathematics.

The relevance of context

A CA approach takes a very localised view of context, in contrast to many other approaches to analysing classroom interaction (*e.g.*, Wood, 2013; Straehler-Pohl, Fernández, Gellert & Figueiras, 2014). For example, Moschkovich (2007) talks about the range of Discourse (Gee, 1999) that both teachers and learners draw upon in their interactions. She makes a distinction between academic and everyday Discourse as well as mathematical discourse, whilst at the same time acknowledging that these Discourses are not mutually exclusive or easily identifiable. An ethnomethodological approach, such as CA, takes a far more constrained view of context, drawing only upon aspects that the participants themselves make relevant to the interaction (Wooffitt, 2005). The role of this local context is particularly relevant to the analysis of diectic terms, which are bound to the context of the interaction (Radford, 2002). An analysis focusing on the localised context allows for this variation in the structure of interaction to be explored.

This localised view of context, combined with the rapid shifts in attention made during the extract, require detailed transcriptions of the interactions. I used Jefferson's (2004) transcription system with the addition of gestural information about the teacher's actions. This level of detail enables us to look at not only the content of turns but also the structure of these turns and how these may mark shifts in attention. I have simplified the transcript here for ease of reading (see [2] for details of transcription notation).

In my analysis, I focus on the design of each turn in the interaction and particularly on how the teacher designs his turns for the recipients of these turns, *i.e.*, his students (Drew, 2012). Specifically, shifts in attention are revealed through the choices of words and the gestures made, as well as what the teacher is doing in a particular utterance. This type of analysis also reveals the ambiguity in analysing the structure of attention and the immense variation possible in how participants' attention may be structured following different stimuli.

Introducing the triangle

The 'donation' problem is part of the context within which the interaction arose. The participants themselves make this initial problem explicitly relevant to the interaction analysed. The extract below occurs around 30 minutes after the initial problem above has been introduced and towards the end of the lesson.

01 Tim: ↑this was on the corner of the board
02 (2.0)
03 okay, (.) ↑this was on the corner of
04 the board because this is actually a
05 useful wa:::y, (.) of you actually
06 looking at it (.) imagine ↑that's my
07 money
08 (1.2)

In lines 1-6, Tim introduces the image of the triangle pictured in Figure 1. During these lines, Tim is facing the whiteboard and is manipulating the image of the triangle, enlarging it and centering it until it fills the whiteboard. He is not directing his talk to the class until line 6, where he walks and turns to face the class in time to begin the phrase "imagine that's my money". Tim emphasises the word "that" in this turn and points to the image of the triangle as he speaks it.

<Insert Ingram Figure 1>

Figure 1.

Initially, Tim directs attention to the image of the triangle which is emphasised through his continual manipulation, enlargement and centering of the image. In line 6, Tim is directing attention to a relationship between the image of the triangle and the earlier problem on donating money. This shift in attention is also marked by Tim's physical position, which has changed from manipulating the image on the electronic whiteboard to him facing the class. Tim is shifting the structure of attention from initially recognising and observing the image of the triangle, to perceiving the relationship between the image and the numeric problem and what the triangle then represents. The image of the triangle and the numeric problem are simultaneously in the fore of Tim's attention. In the beginning of this turn, Tim uses "it" without indicating what it refers to, but follows this with a specific request for the class to see the image as representing the initial amount of money in the previous problem. The pause of 1.2 seconds that follows offers the pupils some time for the image of the triangle to come to the fore of their attention simultaneously alongside the earlier numerical problem to make this connection. Tim's turn continues:

09 *Tim*: o↑kay, (.) a qua::rter of that I'm_____

10 going to throw awa:y and donate,

11 (.)

12 this is my ↑quarter

13 (0.6)

14 I've just given ↑tha::t

15 (0.4)

16 away.

Tim continues to direct attention to the connection to the earlier problem by describing himself as throwing away and donating, as well as talking about a quarter, using the same language as the first task. The proportion being “taken away” is invariant and by using the same language, Tim is emphasising the variation in the representation of the problem. During line 10, Tim turns to face the whiteboard again and in line 12 begins to shade in the centre triangle, as in Figure 2. The beginning of the shading coincides with an emphasised “quarter” and ends with an emphasised and elongated “that”. At this point, there is no direct reference to what it is a quarter of. The reference is to giving the quarter away or donating a quarter and hence the connection to the earlier numerical problem where a quarter of £12 000 is donated. However, in order to perceive this central triangle as representing a quarter, its relationship to the larger triangle as a whole also needs to be apprehended. In order for the triangle image to be understood as a representation of the earlier numerical problem, these two relationships need to be perceived simultaneously.

<Insert Ingram figure 2>

Figure 2.

Additionally, the act of shading makes this image dynamic, emphasizing the doing in the present, rather than something that has been done, which is consistent to the changing tenses that Tim uses in this turn, shifting from future tense in line 10, to present tense in line 12 and past tense in line 14. This changing in tenses again reinforces the connection between the shading of the centre triangle and the donating of a quarter. However, Tim continues to use terms such as “this” in line 15 and “that” in line 17, which are indexical and vague terms. From the interaction so far there is no evidence of how the students’ attention is structured though it is clear that not all the students have made these connections and perceived the relationships, as illustrated by Alex who calls out:

17 Alex: why
18 (0.9)
19 Tim: that's my three thousand pounds
20 Alex: oh
21 (0.7)
22 Tim: o↑kay, this is my ↑three
23 thou:sa:nd pou:nds (.) o↑kay,
24 each one of those triangles is _
25 three thousand pounds
26 isn't it
27 Ps: °yeah,°
28 Tim: ↑yea:h? (.) so:: (.)

Tim turns to face Alex and then after a pause of 0.9 seconds responds to Alex in line 19. Tim uses “that” without any accompanying gestures to indicate what he is referring to and follows this with “three thousand pounds”. In his previous turn, Tim had described the middle triangle as “a quarter” rather than making a direct reference to the money that the image represents. In this turn, the connection between the centre triangle and its representation of £3 000 is still not explicit, but Alex indicates understanding in line 20 both by using the change of state token “oh” and by the lack of a pause following Tim’s previous turn (Schegloff, 2007). This reveals that Alex had made at least some of the connections needed. Tim emphasises this connection by writing £3 000 in the middle triangle in lines 22-23.

Tim shifts the focus again in line 24 by pointing to each of the smaller triangles in turn and saying that each is three thousand pounds, emphasising “each”. Tim has directed attention from the centre triangle, to the collection of four smaller triangles, equal in size. There are now many different relationships that the students can discern. First, the equivalence of the four smaller triangles in terms of what they represent, or in terms of them being congruent with the centre triangle, or in terms of them being congruent with each other. Second, that as a consequence of this equivalence, each of the smaller

triangles represents £3 000 within the context of the original problem. Other relationships include the relationship between each of the smaller triangles and the original triangle as representing a quarter, and that the larger triangle represents £12 000. Which of these relationships is in the fore of the students' attention will affect how this extract is interpreted by them. For example, you could interpret each of the triangles being equivalent as meaning that it does not matter which one is shaded in, and that the choice of the central triangle is arbitrary. It is also possible to interpret the equivalence of the four triangles as emphasising the centre triangle as representing a quarter, since one out of the four equal triangles is shaded.

Line 24 is the first time that Tim has referred to the three small triangles that he has not shaded. The use of "each" implies that he is talking about more than one but "those triangles" remains vague and his gestures towards the image are done from a distance and are also vague. This vagueness offers the possibility of students' attention focusing on a variety of objects, structures, connections or relationships.

In line 27, the students answer "yeah" to Tim's tag question "isn't it". Whilst the students confirm that they understand that each one of the triangles is three thousand pounds, there is a strong preference for agreement to phrases such as "isn't it". As such, whilst it is a common feature of teacher-led interactions, it offers little evidence of which relationships, structures or features the students are attending to.

29 *Tim*: are you happy the:n that to
30 give away a qua:rter of **t**that
31 amou::nt (.) would be the same as
32 me doi:::ng
33 (0.6)
34 **t**that?
((shades triangle))
35 (0.4)
36 giving away that

37 Ps: [ye]ah
38 P: [no]
39 Tim: because I've given away another
40 quarter of three thousand (.)
41 t yeah?
42 Ps: °yea:h°
43 Tim: if I t do that agai:::n
44 (3.6)
((draws triangles and shades))
45 and a t gain
((draws triangles and shades))
46 (0.8)
((continues to shade))
47 a:nd a t gain
((draws triangles and shades))
48 (0.4)
((continues to draw and shade))
49 a:nd a t gain (.) okay, (.) if I
*((continues to draw))*____
50 zoo:med in and zoomed in I could
51 keep dra:wing little triangles
52 couldn't I
53 Ps: °mm°

Tim continues to direct attention to the connection between the original problem and the image through his choice of words “give away”, “quarter” and “amount”. In line 31, Tim points to the centre triangle and pauses briefly before beginning to draw a new triangle and shading it in, as in Figure 3. Tim is drawing this new triangle until line 36 and, again by drawing and shading this triangle in while the students are watching, the image is dynamic and again this reinforces the connection between giving away and shading the triangle.

In lines 29-42 a variety of relationships or meanings could once more be perceived. Importantly, the students need to perceive the new smaller triangle as representing a quarter of the shaded central triangle. This can be perceived in different ways. For example, the new smaller triangle may be identified as representing a quarter of the top unshaded triangle, in the same way that the central shaded triangle is a quarter of the largest triangle, and then the equivalence of this top triangle to the central triangle means that this smaller triangle can also represent a quarter of the central triangle. Alternatively, the new smaller triangle could be perceived as a translation of a quarter of the central shaded triangle. This second possibility reinforces the images of the triangles as representing the numerical problem but both of these alternatives enable the students to appreciate the infinite process and the limit of this process. Alternatively, students could accept that this new smaller triangle represents a quarter because the teacher says it does. The relationships between the image and the earlier numerical problem continue to be explicitly indicated by Tim and, in particular, that this new shaded triangle represents a quarter of £3 000. This could also mean that some students are perceiving the new triangle within the context of the numerical problem and not in relation to the rest of the triangle image.

<Insert IngramFigure 3>

Figure 3.

In line 39, Tim begins to offer an explanation for why drawing and shading the new triangle is the same as giving away the quarter, but he refers to the quarter as “another quarter”, emphasising the general process of giving away a quarter each time whilst referring to the specific case of this being a quarter of three thousand in the same turn. Here, Tim’s attention is shifting from the general process of removing a quarter each time to the specific case of removing a quarter of the middle triangle and the £3 000 it represents. Moving between the general and specific is a key process in the learning of mathematics

(Mason & Pimm, 1984). Again, Tim finishes his turn with another tag question and some students respond with a “yeah” in line 42.

During the pause in line 44, Tim draws another triangle above the most recently drawn triangle and repeats this process in lines 45-46, 47-48 and 49. Tim’s attention has shifted back to the process of taking a quarter each time but Tim’s language is vague, referring to doing “that again” as he shades in another triangle and the connection to the donating of money is not explicitly made. In line 49, Tim talks about zooming in and the drawing of little triangles, shifting the focus onto the dynamic image with no connection to the donation of money or quarters. The idea of zooming in implies, but does not make explicit, the infinite nature of the process of taking a quarter each time. In the earlier numerical context, the notion of dealing with money leads to constraint on the infinite process as it is not physically possible to give away less than a penny, as a student points out during the task. The following shift in attention moves from the infinite process to the finite limit of that process:

54 *Tim*: yea:h? (.) but **↑**what fractio::n
55 (0.8)
56 what fraction of that triangle
57 have I shaded
58 (0.8)
59 what fraction of that triangle
60 have I actually sha::ded
61 (.) Jamie,

In line 54, Tim shifts the focus onto a fraction, emphasising the word “fraction”, and pauses for 0.8 seconds. In line 57, Tim shifts the focus onto the fraction of the triangle that has been shaded, although several triangles have been shaded in. Even here, the reference to “that triangle” is vague and could

possibly refer to a range of triangles, including the image as a whole. There are no gestures accompanying any of the lines that would indicate to which triangles Tim is referring.

62 *Jamie*: um (.) w- ↑half?
63 (0.6)
64 *Tim*: Have I shaded a ↑ha::lf
65 (1.0)
66 *Harry*: no
67 *Tim*: I haven't shaded a ha::::lf
68 (1.3)
69 G::eorge=
70 *George*: =quarter
71 (1.4)
72 *Tim*: I'm shading a quarter each
73 ti::me but I'm shading a
74 quarter of a quarter of a
75 quarter of a quarter so (.) it's
76 not going to be a quarter
77 exactly (.) look at it look at
78 it in ↑ro::ws
79 *Chris*: °six thousand pounds°
80 *Tim*: look a rows of sa:me triangles.
81 *Charlie*: a thi::rd
82 *Tim*: goo::d.
83 (0.4)
84 o↑kay if I look at th_o::se ↑that
85 row (.) I've shaded a
86 ↑thi::rd, (.) that row
87 I've shaded a ↑third, (.)↑that
88 row I've shaded a third, (.)
89 that row, (.) and from
90 then on it is always sha::red,
91 I'm actually sharing,

92 (0.4)
 93 ↓sha:ding (.) in a thi::rd, (.)
 94 so in the ↑e::nd (.)
 95 ↑how much am I actually going
 96 to give awa:y
 97 *Ps:* a thi::rd
 98 (0.8)
 99 *Tim:* so how much is that
 100 (1.7)
 101 *Ashley:* four thousa[nd pounds
 102 *Tim:* [four thou]sand
 103 pounds. [ok?]
 104 *Ps:* [oh yeah]

Jamie offers a hesitant response of “a half” in line 62, also indicating his uncertainty by phrasing it as a question (Bills, 1999). The pause in line 63 and the structure of Tim’s turn in line 64 are indicators that Tim sees Jamie’s response as a source of trouble (Schegloff *et al.*, 1977) and in CA terms, he initiates a repair in line 64, including an indication of the location of the trouble through his phrasing of “half”, offers Jamie the opportunity to self-repair in line 65, before negatively evaluating Jamie’s response in line 67. Similarly the pause in line 71 indicates a trouble source in George’s response in line 70. There is no indication in the interaction of the origin of Jamie’s answer of a half. Tim handles George’s response by explaining that a quarter is shaded each time, but Tim is after the result of the process of shading a quarter each time in lines 72-75 and he indicates that George’s answer is not what he wants in line 76. George’s and Jamie’s responses, reveal that the students’ attention is structured differently to the way Tim’s attention is structured. They have both offered answers that are fractions, so the need for a fraction answer is in the fore of their attention, but we cannot tell whether their answers arose from considering different wholes and different shaded parts from Tim or that from considering the large triangle as the whole and the total of the shaded triangles as the part but did not recognise this as a third.

In lines 77-78, Tim shifts the attention again, this time onto the rows within the image of the triangle, and the question becomes about what fraction of a row has been shaded. The answer Tim was looking for is given in line 81 as indicated by the positive evaluation in line 82. Then, in lines 84-93, Tim shifts the focus from the general image of rows, to each row in turn, indicating that a third of each row has been shaded. Again, there is no evidence of which features of the image the student, Charlie, was discerning when he gave his response of one third. Whilst Tim's previous response may mean that Charlie has discerned one of the rows of the triangle and that one out of the three triangles is shaded and therefore one third is shaded, it is also possible within the context of this interaction that Charlie is answering Tim's original question posed in lines 54-60. It is also possible that Charlie has focused on the earlier numerical problem and recalled that the answer to this was a third. Tim treats Charlie's response as an answer to his implied question in lines 77-78 and goes on to draw attention to the sequence of rows, each of which has a third shaded, another limiting process, to lead to the conclusion that a third of the total triangle is shaded in line 93.

In lines 95-96, the connection with the earlier problem is remade by shifting the language from talking about the rows and triangles, to talking about giving away. The response given by several pupils in line 97 is the answer to what fraction of each row is shaded, what fraction of the triangle as a whole is shaded and what fraction of the twelve thousand pounds is given away in total. It is also a repeat of Charlie's answer in line 81 that Tim positively evaluated. This response is followed by a pause of 0.8 seconds indicating that it was not the preferred response and Tim repeats the question in line 99, beginning with "so", an indication that more is needed than the response of "a third". The final response of "four thousand pounds" is given by Ashley in line 101 and is what Tim was looking for, as indicated by him repeating and overlapping the response.

Discussion

My analysis shows that during this short interaction, attention is directed to a number of different features of both the image and the original contextualised problem and the connections and relationships between and within the two. These different foci and structures in attention afford the making of different connections between the image of the triangle and the problem of donating money, but also the different relationships between different parts of the triangle and what they represent in terms of the original problem. The range of potential ways in which the students' attention may be structured and what is at the fore of their attention at different points in time is vast and these different structures will result in different learning.

Tim directs attention both through what is said and through his gestures and interactions with the image on the whiteboard. He supports his students in shifting their attention through allowing pauses at particular points and through his choice of words and gestures. The combination of word choice and gestures sometimes makes the direction or structure of attention clear, but at other times it is ambiguous and there is likely to be considerable variation in the structure of the students' attention.

Due to the nature of the interaction, there are very few turns taken by the students so we know very little of how the students' attention is structured at any point in the interaction and, therefore, what they have learnt. The different possible structures of attention afforded by the task, images and teacher interaction will affect what the students have learnt and what meaning they attach to terms such as a limit, or images such as that of the triangle. However, the complexity and occasional ambiguity of the teacher's explanation offers lots of opportunities for the students to make different connections, perceive relationships and appreciate different structures. Each of these is part of learning mathematics, so whilst the students may or may not have made all the shifts in attention that Tim has made, they have potentially done a great deal of mathematical thinking which may not only contribute to their understanding of limits and limiting processes, but also their understanding of fractions, interpretation of

representations, experiences of generalising and specializing, as well as attending to different structure within images.

The level of detail examined through a conversation analytic approach allows us to perceive a level of complexity that is not necessarily apparent when first considering the task, the representations or the interaction itself. This fine-grained approach makes the teacher's decisions in action visible and the opportunities these decisions offer in terms of mathematical connections, relationships and structures. It makes more explicit what the students have the potential to learn as well as how this learning may be structured and enabled. This approach may also be useful when working with teachers to explore the interpretive possibilities as "greater awareness [...] may help mathematics teachers [...] to develop more purposeful and hence more effective use of language" (Morgan, 2002, p. 17).

Notes

[1] Transcription details have been omitted from the extract above as this extract is not part of the analysis itself but sets the context within which the later extract occurs.

[2] Transcription notation (Jefferson, 2004)

[] Mark the start and end of overlapping speech. They are aligned to mark the precise position of overlap

the Indicates emphasis; the extent of underlining within individual words locates emphasis.

°I know° "Degree" signs enclose hearably quieter speech.

(0.4) Numbers in round brackets measure pauses in seconds.

(.) A micropause, hearable but too short to measure.

(()) Additional comments from the transcriber, *e.g.*, gestures.

wa::nted Colons show degrees of elongation of the prior sound; the more colons, the more elongation.

, 'Continuation' marker, speaker has not finished; marked by fall-rise or weak rising intonation, as when delivering a list.

? Question marks signal stronger, "questioning" intonation, irrespective of grammar.

- . Full stops mark falling, stopping intonation (“final contour”), irrespective of grammar, and not necessarily followed by a pause.
- bu- Hyphens mark a cut-off of the preceding sound.
- = = ‘Equals’ signs mark the immediate “latching” of successive talk.
- ↑↓ Up or down arrows indicate a shift in pitch, higher or lower respectively.

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