The evolution of one stem sentence in a primary mathematics fractions lesson

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Stem sentences (speaking scaffolds) are used in many mathematics lessons in England but research on their effectiveness is lacking. Using Anna Sfard's understanding of commognition, this article presents discourse analysis on the use of one stem sentence in a fractions lesson with 10- to 11-year-olds. Considering words, visual mediators, routines and endorsed narratives, analysis is presented of an observed classroom episode involving the stem sentence: *Only the numerator is divided by the integer'*. The teacher uses the stem sentence, adjacent mediating tools and learners' utterances to construct, substantiate and recall the mathematical narrative that the stem sentence endorses. This example demonstrates how stem sentences can feature in classroom routines beyond the ritualized practice of verbal repetition they are sometimes associated with.

Keywords: commognition, fractions, stem sentences, routines, exploration

Origins and mobilization of stem sentences

Stem sentences are speaking scaffolds or sentences popular in literacy learning and modern language teaching (Barko-Alva and Chang-Bacon, 2023). Stem sentences are used and seen as effective by many schools in England who engage with Teaching for Mastery (Coles and Helme, 2022). Although there is some research on the effective use of sentence stems to springboard thinking e.g. *'I noticed that...'* (Gaunt and Stott, 2018) and dialogic teaching in mathematics, the effectiveness of fill in the gap scaffolds or the verbal repetition of full sentences is lacking beyond anecdotal accounts yet highly endorsed across multiple subsidiary documents to the English primary mathematics curriculum (Coles and Helme, 2022). This paper problematizes stem sentences and offers an analysis of the evolution of one stem sentence, framed by commognition, to explore the complexity of a seemingly simple mediating tool in classroom discourse beyond the ritualized act of verbal repetition.

Commognition: The four domains

This research utilizes theory to make sense of an endorsed-by-many practice and frames discourse as a particular type of communication, defines a community and is characterized by actions and reactions (Sfard, 2008, p. 297). Commognition (Sfard, 2008) aims to capture the iterative and complex relationship between thinking and communicating. Sfard's (2008) four overarching domains have shaped the analytical framework used: w*ords* (including phrases and grammar); v*isual mediators* (spatial and visual entities which mediate learners towards mathematical realizations); *routines* (collective actions); *endorsed narratives.*How stem sentences feature in the first three domains will extend or diminish pre-existing or new mathematically endorsed narratives (Sfard, 2008, p. 98). In this research, stem sentences are framed mediating

discursive objects (d-objects) to make sense of primary-objects (p-objects) not p-objects themselves; learners are not 'doing' mathematics by using and repeating stem sentences but rather stem sentences can be used to support learners to do mathematics. In this paper, I outline the analysis of an episode of learning which demonstrates that stem sentences needn't be over-ritualized in routines and can be an effective d-object when carefully considered alongside visual mediators and routines.

Routines

D-objects can feature across three types of routines (Lavie et al., 2018; Sfard, 2008); *rituals* are a performative aspect of social interaction where we objectify collectively; *deeds* are practical, where the collective transformation of a mathematical object creates a new object and; e*xplorations* occur via a process of deritualization where mathematical narratives are endorsed and individualized. All routines start as rituals which is expected with younger learners (Lavie et al,. 2018). An observed episode of *deritualization* is presented here whereby the commonly ritualized stem sentence moved beyond the act verbal repetition and evolved to become part of genuine individualized discourse through guided, visually mediated exploration.

Explorations and deritualization

Explorations occur when the rules of mathematics and the endorsement of p-object narratives can be constructed and individualized (Lavie et al., 2018). This construction, mediated by d-objects such as stem sentences, allows for individual meaning making (Sfard, 2008, p. 223). Mathematical narratives are constructed, substantiated and then recalled (Sfard, 2008, p. 225). *Construction* is an essential first move when endorsing new or possible mathematical narratives or building upon previously endorsed narratives. Some narratives can be fully proven whereas others need to be proven via substantiation. *Substantiation* occurs when the narratives reincarnate via realizations and the 'why' is made meaningful in individual thinking (Sfard, 2008, p. 233). *Recalling* is where former narratives are remembered to support discursive fluency; some are immediately available whilst others must be reconstructed and even re-substantiated. A ritualistic, repetitious use of stem sentences may encourage collective speaking, but an explorative use is more likely to encourage; connection making between interpersonal and intrapersonal thinking; co-construction of mathematical narratives between teachers and learners and; potentially more meaningful recall of these narratives (Sfard, 2008, pp.234-235).

Context of the episode

The Year 6 classroom (ages 10-11) was led by an experienced class teacher (Florence). Of the 30 learners, 92% were multilingual. The episode includes the utterances of 4 multilingual learners. The mathematics lesson was on dividing non-unit fractions by an integer. The initial, complete stem sentence '*Only the numerator is divided by the integer'* evolved over the course of the lesson accompanied by other visual mediators (concrete manipulatives and pictorial representations). Both the teacher and learners

played a role in its evolution whereby the original p-objects discussed, numerators and integers, were replaced by talk about denominators and then not spoken of at all, but rather implied.

Construction moves

Key utterances and visual mediators were identified as legitimizing the narrative endorsed by the original stem sentence (outlined in Figure 1). Teacher utterances are blue, and student utterances are green.

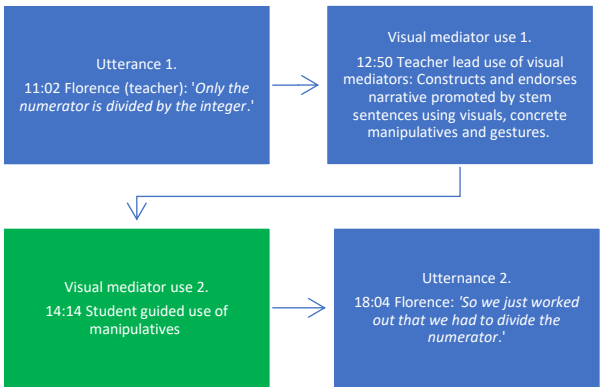

Figure 1: Construction Moves – utterances and employment of visual mediators

In utterance 1, Florence presents a calculation (8/10 ÷2 = 4/5) and asks whether this is true or false. After some discussion, she reveals the stem sentence which endorses a meta rule of mathematics in relation to the performance of a procedural deed (transformation of mathematical objects): '*Only the numerator is divided by the integer'*. Florence also decides to employ visual mediators to support the construction of this narrative. Using multilink cubes, she demonstrates how 2/3÷2 = 1/3 by showing a row of 3 blocks, attributing the value of 1/3 to each, removing one block, where the 2/3 is significant, and then physically and gesturally splitting the blocks in half (dividing by 2). Simultaneously, a visual is shown on the board of a vertical line being drawn down a bar model showing 2/3. She asks the learners to notice that the numerator has been affected by the division, but the denominator has not, endorsing the narrative presented by the original stem sentence but built from the discussion.

In visual mediator use 2, Florence encourages the learners to use 5 cubes to show that 4/5÷2 = 2/5. Collectively, they attribute the value of 1/5 to each, remove one, as the 4/5 is significant, and again demonstrate dividing by 2 as splitting in half, or sharing between themselves and their partner. This collective act of construction was done alongside a visual mediator of a bar model representing 4/5 with a red vertical line indicating division by 2. She reiterates how one aspect will change (the numerator), but one will not (the denominator).

Finally, in this construction phase, Florence informalized the stem sentence, now only referring to the numerator and not the integer and utters '*So, we just worked out that we had to divide the numerator'*. This act of construction, although heavily guided, is presented as co-construction with the use of the word '*we'*.

An explorative use of the stem sentence has allowed space for co-construction and collective sense making. Both Florence's choice not to ask learners to repeat the

sentence but rather ask learners if this is true or false, and then use visual mediators to convince learners allowed for greater learner agency.

Substantiation moves

This lesson is the learners first encounter with dividing fractions. Although this new-to-them narrative is plausible, it is yet to be fully endorsed via substantiation (see Figure 2).

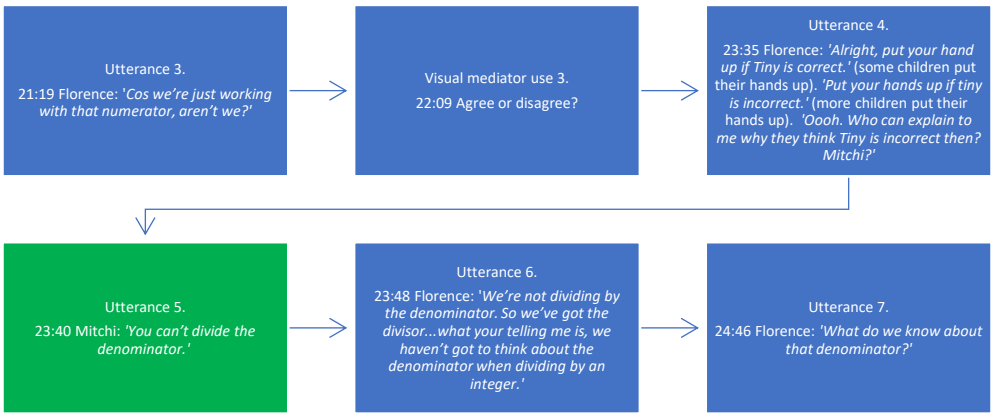

Figure 2: Utterances and visual mediator use in substantiation

In utterance 3, Florence informalized the original stem sentence in Utterance 3; '*Cos we're just working with the numerator, aren't we?*'. Again, with the use of *'we'*, she is reiterating the act of co-construction that just took place. Next, Florence assesses if the narrative constructed can be fully endorsed yet. Tiny the tortoise (White Rose Education, 2023) presents his thinking and the learners then agree or disagree: '*8/16 ÷ 4 = 2/4'*. Interestingly, not all learners disagreed indicating that the narrative has yet to be fully endorsed (utterance 4). Florence then asks a learner why they disagree. Mitchi says, '*You can't divide the denominator'* (utterance 5). As the original sentence evolves, the talk of one p-object (numerators) has been replaced, by Mitchi, with talk of another (denominators). With the concern that Mitchi might over-substantiate this narrative beyond division of non-unit fractions, Florence revoices Mitchi and reiterates the rule '*…we haven't got to think about the denominator when dividing by an integer'* (utterance 6). Returning to the whole class, talk about the numerator is now replaced by talk about the denominator, influenced by Mitchi.

The substantiation phase connected interpersonal and intrapersonal communication and thinking. An explorative use of the stem sentence, as opposed to ritualistically repeating it. meant that Florence had a better insight into students' individual thinking and could mediate this appropriately.

Recall moves

When moving from substantiation to recall moves, Florence chooses to re-substantiate to help solidify the narrative for more meaningful recall. In this phase, there is less employment of visual mediators than there was in the construction phase, and more

utterances from the learners themselves as they begin to individualize the discourse (see Figure 3).

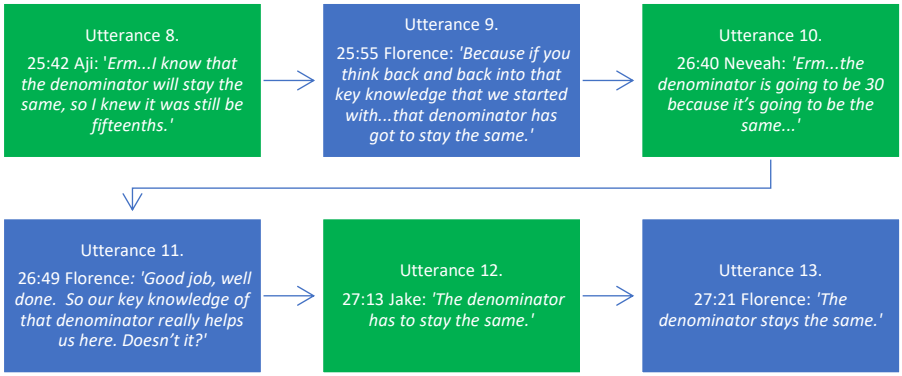

Figure 3: Utterances – from substantiation to recall

In utterance 7(figure 2), Florence transitions between substantiation and recall by asking '*What do we know about the denominator?'*. Aji answers in utterance 8 stating that he knows that the denominator will stay the same and performs a procedural deed to prove he can apply that narrative to transform p-objects. Florence then attempts to recall the substantiated narrative by asking learners to think back to the start of the lesson, when the original stem sentence '*Only the numerator is divided by the integer'* was first revealed. However, now the p-object focus is the denominator and not the numerator. Neveah then performs a procedural deed, only discussing the lack of change in the denominator as the act of dividing the numerator is now given. Florence praises Neveah and further legitimizes this narrative. Later, Jake re-substantiates, which is a part of recall (Sfard, 2007; 2008) and individualizes the discourse by saying '*The denominator has to stay the same'*. Using 'has to' is not seen as an over-substantiation as it was for Mitchi because, for Florence, the narrative is being recalled and no longer needs to be substantiated. She accepts this utterance as Jake's individualized discourse and reiterates it. Afterwards, Florence further informalizes the discourse where explicit talk of p-objects is no longer required (see Figure 4).

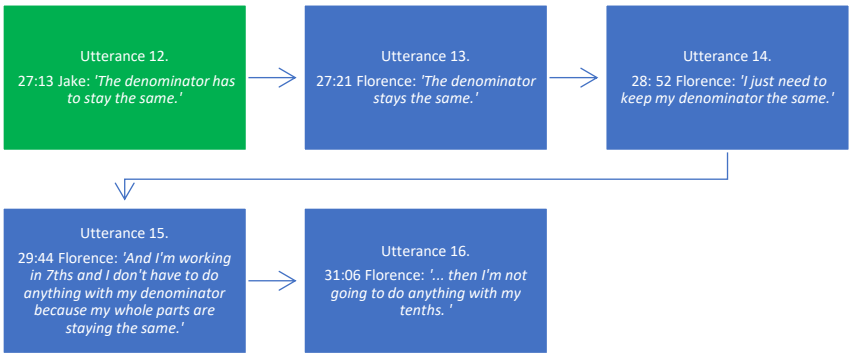

Figure 4: Utterances – recall

In utterance 14, Florence says *'I just need to keep my denominators the same'* framing the narrative endorsed as normal and given. Later, all talk of the original p-objects (numerators and integers) and the later discussed p-objects (denominators) is entirely removed and implied where the *'tenths'* are the denominators (utterance 16). The narrative is seen as a given and no longer needs to be endorsed as plausible,

allowing for some level of individual meaning making. The narrative endorsed is more likely to be meaningfully recalled as the learners have had a chance to explore the plausibility of this narrative in the lesson through a specialized routine (Sfard, 2008, pp. 234-235).

Implications and future considerations

Sfard's commognition provided a lens through which to better understand the stem sentences in explorative routines as opposed to being over-ritualized. In the episode, both the stem sentence and learner's thinking evolved. However, even in this explorative element the association of stem sentences and over-ritualized repetition was evident; when asked about the stem sentence, Florence did not think she used one because she did not ask the children to repeat after her. This highlights a potential need for guidance and professional development on how to help children to build conceptual understanding through dialogic teaching methods in mathematics.

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