Analysing improvisation in the mathematics classroom

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This paper starts from two assumptions: that expert teachers of mathematics (and other subjects) regularly improvise, and that theatrical improvisation is a teachable skill. If it can be shown that the improvisational moves of an expert mathematics teacher draw on some of the same skills as those of a stage performer, existing theatre training approaches may be of use in supporting the professional development of maths teachers, begging the question: to what extent are teachers and performers improvising in the same way? Using thematic analysis, this paper compares two parallel accounts of a single lesson episode involving an expert mathematics teacher: as an improvised performance observed by the author and as an interactive lesson recalled by the teacher. It further suggests that these narratives can be seen as a development of Schoenfeld's model of 'teachers' in-the-moment decision making' while exemplifying aspects of his earlier model for 'teaching-in-context'.

Keywords: Secondary school mathematics, creative teaching, decision making.

Introduction

Zoe (not her real name) is in her 12th year of practice as a secondary mathematics teacher. Highly respected by colleagues, she has been consistently identified as an excellent practitioner, and I am observing her teach a mixed-attainment class of 30, year-7, 11-12 year-old students an inner-city school. This is the 5th lesson in a sequence addressing the topic of directed numbers and is focused on the subtraction of negative values. Zoe has just spent around 5 minutes working through the calculation -5 – -3 using several different representations but emphasising the use of a horizontal number line. She has now moved on to a second example: the calculation -9 – -4, and this time, asks her pupils to draw their own number-line representations independently. This activity had been planned as quick review of their number line drawing skills, but after a full minute of lesson time and two rounds of additional guidance by the teacher, a significant proportion of the class were still struggling to draw their number lines correctly. At this point, the teacher began to improvise.

Stage improvisation and its analogue in the mathematics classroom

The understanding of stage improvisation adopted here was developed by the playwright, theatre director and teacher, Keith Johnstone, during the 1960s and 70s. He frames the practice as an unscripted succession of 'offers' and 'acceptances' explaining:

> I call anything that an actor does an 'offer'. Each offer can either be accepted, or blocked. If you yawn, your partner can yawn too, and therefore *accept* your offer. A block is anything that prevents the action from developing, or that wipes out your partner's premise. If it develops the action it isn't a block. (Johnstone, 1981, p.97).

During an improvisation of this sort, the expectation is that performers will accept every offer they receive, a convention which is often codified as the 'yes and...' principle (e.g. Salinsky & Frances-White, 2017), and the normal way in which stage improvisers develop their skills in doing so is through co-operative exercises – often described as ‘games’ – which are ‘played’ in the rehearsal room with no audience present. There are entire books devoted to describing such games, but a key feature of nearly all of them is the importance of players *listening* to one another, as it is only through understanding what has gone before that a performer can productively build upon it. According to Johnstone “the improviser has to understand that his first skill lies in releasing his partner’s imagination” (1981, p.93). Although it is unrealistic for a teacher to accept, without question, every offer made by every pupil, it is argued below that well-judged ‘yes, and…’ moves by the teacher, based on careful listening, have the potential, to paraphrase Johnstone, to ‘release the mathematical imaginations of their learners’.

So, what form do ‘offers’ and ‘acceptances’ take in the mathematics classroom, and what would a ‘yes, and…’ move by the teacher look like? Many interactions in the mathematics classroom begin with the teacher setting a task – often in the form of a question – which the pupils then try to complete. In such instances, the teacher will often evaluate those responses and move on, completing what Mehan (1979) termed an ‘initiation-response-evaluation’ or I-R-E cycle, exemplifying the process in the following dialogue:

1	Speaker A:	What time is it, Denise?
2	Speaker B:	2:30.
3	Speaker A:	Very good, Denise.

Mehan (1979, p.285)

Using the theoretical codes of ‘offer’ and ‘acceptance’ suggested by Johnstone, this exchange can be described as follows:

1	Speaker A:	OFFER of a question to a named pupil.
2	Speaker B:	ACCEPTANCE of that question by the pupil and OFFER of an answer.
3	Speaker A:	ACCEPTANCE of the pupil answer and a BLOCK on further development.

This does not constitute an improvisation as the term is being used here, which requires a *succession* of ‘yes, and…’ moves. The dialogue above contains only one such move – from the pupil in line 2 – with the teacher signalling the end of the dialogue in line 3 when they deploy what Johnstone would describe as a ‘block’. Throughout this paper, the threshold for any interaction to be considered as improvisation is at least one ‘yes, and…’ move by the teacher, and perhaps many more. In Mehan’s terms, an improvisational sequence would not take the form I-R-E, but rather I-R-R-R-R-…

So far, improvisation has been described, but there has been no attempt to provide a formal definition. This is because Johnstone (1981), in common with many other theatre practitioners, shies away from any attempt to do so. One definition that has been used in a range of non-theatre settings is Crossan and Sorrenti’s “*intuition guiding action in a spontaneous way*” (2001, p.27, author’s italics), which places it within a conceptual map relating ‘improvisation’ to ‘planned-for scenarios’ but during the pilot stage of this investigation it became clear that ‘intuition’ is hard to identify with any confidence. The central problem is that it tends to be associated with “tacit hunches or feelings that come to mind with little conscious awareness of processing” (Brock 2015, p.128). As an internal, mental process, it is obviously invisible to any outside observer, and because of its tacit nature, it may even go unnoticed by the individual who has experienced it. Because of this difficulty, the following, simpler definition of improvisation is used here: *a spontaneous, often rapid response to specific, emerging circumstances*. The key feature of this revised definition is the notion of ‘specificity’: to be regarded as genuine improvisation, the teacher needs to be responding to details of the classroom environment which could not have been fully predicted.

Research design

To identify those moments when teachers depart from their initial plans mid-lesson, it is necessary to know what the original plans were. Experienced teachers do not usually write extensive lesson-plans, so prior to each lesson, an audio-recorded interview was conducted with the teacher during which they described their intentions. The lesson itself was then audio-visually recorded by the researcher using handheld camera – an approach which was found to capture over 95% of pupil and teacher speech and nearly all teacher actions – and immediately after the lesson, the entire recording was downloaded to a secure laptop. This recording was quickly analysed using the codes 'offer', 'acceptance' and 'block' as defined above in a "theory-driven" approach to thematic analysis described by Boyatzis (1998, p.29). Episodes which showed the teacher making at least one 'yes, and…' move in response to a pupil offer were identified as potential improvisations and discussed with the teacher in a post-lesson interview, which was held as soon as possible after the lesson had been taught, and invariably on the same day.

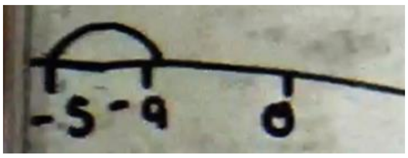
The interview used an approach identified by Lyle (2003, p.861) as 'stimulated response', "in which (normally) videotaped passages of behaviour are replayed to individuals to stimulate recall of their concurrent cognitive activity." The protocol used here was slightly different from Lyle's, in that it did not start by showing the video-recording to the teacher, but first asked them to recall any instances in the lesson where they remembered departing from their original plan. In every case so far, all the episodes identified by the teacher as an unplanned change or adaptation had already been noted as a potential improvisation during the initial, theoretical coding phase, providing at least some validation to that process. During the interview, episodes being discussed were played back to the teacher, who was invited to pause the recording whenever they chose, and where necessary, view the relevant parts a second or third time before describing what they recalled thinking at the time. These interviews were audio-recorded, transcribed and analysed using a reflexive approach to thematic analysis proposed by Braun & Clarke (2006). This paper, which represents only one part of a larger PhD study, used only the first two of the six stages they propose – data familiarisation followed by the development of initial codes – and the inductive codes that emerged from those interviews were then used to re-code the improvised parts of the lesson. The two accounts were then brought together using Schoenfeld's (2008) model of teachers' in-the-moment decision making alongside his earlier (1998) account of teaching-in-context.

A key aspect of the design which has not so far been discussed is the process of sample selection: how were these 'expert teachers of mathematics' to be located and recruited? Due to the acknowledged difficulties in identifying 'effective' teachers (e.g. Wiliam, 2016), and the range of views about the criteria by which 'effectiveness' might be assessed, for the purposes of this study, a teacher is regarded as 'expert' if they have consistently been recognised for their high level of classroom proficiency by colleagues and managers for at least three years. As a further control on the legitimacy of those judgements, they will be based in schools, and departments within schools, that have been described as effective by external inspections or reviews. The teacher being discussed here exceeded all the necessary criteria by some considerable measure, although in her case there was the complicating factor that she had been well-known to the author for a number of years and may therefore have been the beneficiary of unwitting bias in any judgements that were made. It is hoped that by adhering to the analytical approaches laid out above that these were kept to a minimum.

Findings and discussion

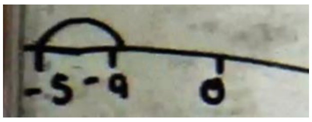
During the episode that was introduced at the start of this paper, Zoe was initially reluctant to depart from her lesson plan. However, after two unsuccessful 'blocking moves' in which she rejected the answers being offered and tried to direct her pupils towards more acceptable responses, she changed her tactics and accepted not just one, but three sets of student answers as shown in Table 1.

Table 1: Lesson extract 1 with improvisational coding

SPEAKER	SPEECH/ACTIONS	IMPROVISATIONAL CODING
1 ZOE	Okay, actually… so… I'm going to take yours… (TEACHER TAKES A BOARD FROM A PUPIL)	***ACCEPTANCE*** of pupil answer
2 ZOE	…wait, don't rub anything out… don't rub anything out, don't rub anything out… (SHE PICKS UP A 2nd BOARD)	***ACCEPTANCE*** of 2nd pupil answer
3 ZOE	…don't rub anything out. (SHE PAUSES TO PICK UP A 3rd BOARD)	***ACCEPTANCE*** of 3rd pupil answer
4 ZOE	Okay, so, I've picked up these three boards, 'cos I want to have a look at our representation of the number lines. So, I think I'm going to show you this one first, okay? (TEACHER HOLDS ONE BOARD BUT DOES NOT REVEAL IT) I want you to maybe talk about… no, not maybe, I want you to talk about this to the person next to you about why I picked this up. There is a reason I've picked this up. (REVEALS BOARD)  So, think about what we want to say about this. 10 seconds to discuss	***OFFER*** of an open question about the first of the three boards

Reflecting on this, the teacher talked about wanting her pupils "to have a number line to lean on" echoing comments she had made during the preliminary discussion of her plan. During that initial conversation she had stressed the centrality of this image to the entire unit of work. As well as this prioritisation of an over-arching goal for the unit, Zoe also talked about the more practical issue of teaching the content of the current lesson, pointing out that "if they are struggling to place the numbers on the number line… talking about moving up and down the number line is not going to make a lot of sense." The teacher's conscious change of goal from the very short term one of 'move on to the next problem on the next slide’ to the more fundamental ‘consolidate pupil understanding of the number line’ aligns with Schoenfeld’s (2008) model of the decision-making process. In Schoenfeld’s terms, this change in goal has been ‘triggered’ by the misconceptions that have just emerged. According to the definition being used here, the specificity of the question in utterance 4 also marks out the episode as improvised. The improvisation continues as shown in Table 2.

Table 2: Lesson extract 2 with improvisational coding

SPEAKER	SPEECH/ACTIONS	IMPROVISATIONAL CODING
5 ZOE	What do we want to say about this, [Pupil Name]?  	***OFFER*** of an open question repeated
6 PUPIL 1	The 5 and the 9 should swap places because… because the number isn’t… because it isn’t…(INAUDIBLE) like … on the positive side	***ACCEPTANCE*** of question ***OFFER*** of unclear answer
7 ZOE	It doesn’t go on the positive side… I think I know what you’re trying to say to me. So you’re saying that the negative five and the negative nine should be the other way round. Why should they be the other way around? Think about the language that we’re using with this. [Pupil Name]	***PARTIAL ACCEPTANCE*** of pupil answer ***OFFER*** of slightly adjusted question with a hint
8 PUPIL 2	Because negative nine isn’t closer to zero than negative five	***ACCEPTANCE*** of question ***OFFER*** of correct but convoluted answer
9 ZOE	Yes, negative nine isn’t closer to zero than…isn’t closer to zero than negative five. Very nice. Anything… any other ways of phrasing that? That was really nice, actually. [Pupil Name]?	***ACCEPTANCE*** of pupil answer ***OFFER*** of same question again
10 PUPIL 3	Negative nine is more negative than negative five.	***ACCEPTANCE*** of question ***OFFER*** of correct clear answer
11 ZOE	Okay, negative nine is more negative than negative five. So they seem to be the other way round on our number line (PUTS DOWN BOARD) [Pupil Name] what do you want to say?	***ACCEPTANCE*** of answer ***PARTIAL BLOCK*** (put down board) ***OFFER*** of invitation to speak
12 PUPIL 4	Negative 5 is closer to zero than negative nine	***ACCEPTANCE*** of question ***OFFER*** of correct clear answer
13 ZOE	Yeah, negative nine… negative five is closer to zero than negative nine. So that’s almost the same as what [Pupil Name 2] was saying. Okay, then… this one (PICKS UP NEXT BOARD)	***ACCEPTANCE*** of answer ***BLOCK*** on further discussion with ***OFFER*** of new board

Schoenfeld uses a flow chart for modelling the details of “flexible, interruptible routines” (2008, p. 63) such as the one recorded above, and the same approach could be used here, but that model makes no claim to be representing the actual thought processes of the teacher. The aim of this study is to arrive at an account with the potential for instructional, as well as analytical use, so an attempt is now made to capture some sense of what the teacher believed herself to be doing during the succession of 'acceptance-offer' (or 'yes, and…') moves during utterances 6 to 12. The improvised exchange is therefore reproduced in Table 3, but this time, using a set of codes suggested by the post-lesson interview. Note that all of these codes, including those alongside pupil utterances, describe what the *teacher* was thinking or doing at the time.

Table 3: Lesson extract 2 with inductive coding based on post-lesson interview

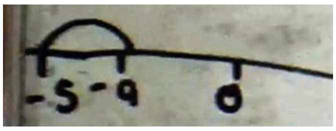
SPEAKER	SPEECH/ACTIONS	TEACHER CODING
5 ZOE	What do we want to say about this, [Pupil Name]? 	***OPEN QUESTION*** avoiding any hints about right or wrong-ness
6 PUPIL 1	The 5 and the 9 should swap places because… because the number isn't… because it isn't…(INAUDIBLE) like … on the positive side	***LISTENING*** *for* ***REASONING*** ***LISTENING*** *for* ***LANGUAGE***
7 ZOE	It doesn't go on the positive side… I think I know what you're trying to say to me. So you're saying that the negative five and the negative nine should be the other way round. Why should they be the other way around? Think about the language that we're using with this. [Pupil Name]	***PARTIAL VALIDATION*** *of* ***PUPIL REASONING*** ***PROBING*** *for* ***MORE PRECISE LANGUAGE*** ***PROBING*** *for* ***CLEARER THINKING***
8 PUPIL 2	Because negative nine isn't closer to zero than negative five	***LISTENING*** *for* ***REASONING*** ***LISTENING*** *for* ***LANGUAGE***
9 ZOE	Yes, negative nine isn't closer to zero than… isn't closer to zero than negative five. Very nice. Anything… any other ways of phrasing that? That was really nice, actually. [Pupil Name]?	***VALIDATION*** *of* ***REASONING*** ***PARTIAL VALIDATION*** *of* ***LANGUAGE*** ***PROBING*** *for* ***MORE PRECISE LANGUAGE***
10 PUPIL 3	Negative nine is more negative than negative five.	***LISTENING*** *for* ***REASONING*** ***LISTENING*** *for* ***LANGUAGE***
11 ZOE	Okay, negative nine is more negative than negative five. So they seem to be the other way round on our number line (PUTS DOWN BOARD) [Pupil Name] what do you want to say?	***VALIDATION*** *of* ***REASONING*** ***VALIDATION*** *of* ***LANGUAGE***
12 PUPIL 4	Negative 5 is closer to zero than negative nine	***LISTENING*** *for* ***REASONING*** ***LISTENING*** *for* ***LANGUAGE***
13 ZOE	Yeah, negative nine… negative five is closer to zero than negative nine. So that's almost the same as what [Pupil Name] was saying. Okay, then… this one (PICKS UP NEXT BOARD)	***VALIDATION*** *of* ***REASONING*** ***VALIDATION*** *of* ***LANGUAGE*** ***LINKING*** *to* ***PRIOR REASONING***

Table 2's account of Zoe accepting of every pupil's offer, even when they are hard to understand, is interpreted by her as "validating their explanations" on the grounds that "all of their answers were right in in a different way" and this desire to validate pupil thinking helps to explain the teacher's repetition of their initial acceptance move at the end of utterance 9 when she says, "that was really nice, actually". The repetition has a kind of 'underlining' effect, transforming the previous acceptance move into what might be termed a 'strong acceptance'. It is interesting to see how the nuanced nature of the teacher's responses, based on her personal understanding of 'validation', leads to a development of Johnstone's basic concept of 'acceptance' to include the possibility that acceptance moves can be made stronger or weaker. This is particularly helpful in a mathematics class, where students and teachers alike can easily become trapped in binary 'right versus wrong' thinking.

In order to make these nuanced moves, however, the teacher had to listen carefully to her pupils. During the discussion of her lesson plan, Zoe had made repeated reference to the language of "more positive" and "more negative". Her desire for the pupils to express themselves in this way, and the fact that she makes no attempt to end the discussion until she hears a pupil uses these specific words (utterance 10) strongly suggests that she is listening for that language. Her responses to the offers made in 6 and 8 show that she is simultaneously listening for the reasoning that lies behind the words, and utterance 9 demonstrates that she is able to differentiate between accurate reasoning and clear, accessible language.

When the teacher hears the desired form of words, she accepts the answer (utterance 11) and then puts down the whiteboard they have just been discussing in what could be thought of as a fairly gentle blocking move. This either goes unnoticed, or is simply ignored by Pupil 4, and it is interesting to see that the teacher's desire to validate her pupils' thinking overcomes her wish to move on as she invites them to speak. Her subsequent words in 13 show that she is still listening carefully and is able to connect their reasoning to an earlier pupil statement before placing a clear block on any further discussion. This impulse to continually validate pupil thinking suggests that Zoe has an underlying belief in the importance of doing so; such a belief would also help to explain the commitment she shows in her listening to the details of what her pupils say.

Schoenfeld's (1998) examination of 'teaching-in-context' argues that the interplay of beliefs, goals and knowledge, drive the in-class decision-making process. The preceding discussion has already mentioned the first two of these factors and the post lesson interview made it clear that Zoe's extensive knowledge of mathematics teaching had played a key role in her decision to embark on this improvised discussion. Describing the number lines that prompted her departure from the lesson plan, she explained: "I wanted to show a correct one, but I saw two other mistakes… I have seen…in other places; not in this class but in other year groups…. So I'm like 'well, if I can fix this now, then this is going to help five years down the line.'" The conscious decision to address those misconceptions and embark on the subsequent improvisation seems to have been driven by that knowledge and represented a deliberate shift in goals. The moment-by-moment decisions made within the improvised interactions recorded in extracts 2 and 3 all pursued the revised goal of 'consolidate understanding of the number line' and appeared to lean more heavily on her underlying beliefs.

Conclusion

This paper defines classroom improvisation as '*a spontaneous, often rapid response to specific, emerging circumstances*. Using two forms of thematic analysis it presents two parallel accounts of an expert teacher developing an improvised dialogue to address an important misconception about the representation of negative numbers on a number line. It argues that the teacher, with varying levels of deliberation, draws on her beliefs and knowledge to execute a series of 'moves' which are similar in structure to those which might be seen during an improvised theatre performance, and that central to this connection between stage and classroom improvisation is importance of listening. For stage improvisers this means listening carefully to other performers, for the mathematics teacher it means carefully listening to the words – and the thinking that might lie behind the words – that are used by learners. There are many well-established theatre games and exercises known to be effective in developing listening skills for performers and it may be that they can be adapted for use by teachers.

The project within which this brief study sits is in the early stages of the data-gathering phase, and the material discussed here is a very small part of even that limited dataset. Notwithstanding these limitations, the emerging parallels between classroom and theatre improvisation are intriguing. It is hoped that further analysis of a larger dataset will cast more light on the mechanisms that might support productive classroom improvisation by expert mathematics teachers.

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