Identifying improvisation in the secondary mathematics classroom

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This paper argues that improvisation is a common feature of expert mathematics teaching, but that the processes involved remain under-explored by the research community. Drawing on ideas from organisational theorists and improvisational theatre practitioners as well as educational writers, it proposes a framework for identifying and analysing the practice of improvisation in the secondary mathematics classroom. It then goes on to place a more clearly defined concept of classroom improvisation within a wider understanding of teacher expertise and suggests future directions of study.

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

Why improvisation matters.

'Good teachers think on their feet,' was the opening statement of Robert Yinger's 1986 paper presented at the AERA Conference that year (Yinger, 1986, p.263). He clearly regarded this as a self-evident truth, making no attempt to justify the claim beyond the assertion that 'few educators or researchers of teaching would deny this' (Yinger, 1986, p.263) and going on to use the term 'improvisation' on four separate occasions as he discusses the key skills that underpin successful, interactive teaching.

Yinger's discussion is entirely theoretical and does not focus on any particular subject, but his ideas were developed by Borko and Livingston (1989). They found that the 'expert teachers' of mathematics (identified as such by both school and county leaders) were very skilled at keeping the lesson on track while including the comments and questions of their students in the discussion whereas novices struggled to accommodate student input in their lessons. Borko and Livingston concluded that a key marker of maths teacher expertise is a capacity to improvise productively.

Berliner (1994) draws on a range of different sources including Borko and Livingston in an influential survey exploring the nature of teacher expertise more generally. He proposes eight characteristics that distinguish the 'exemplary performance' of expert practitioners including the practice of being 'more opportunistic and flexible in their teaching than are novices' (Berliner, 1994, p.161), and, like Yinger, repeatedly uses the term 'improvise' to describe this behaviour. Rowland, et al. (2003) choose the term 'contingency' in preference to 'improvisation' as one of the four pillars of 'The Knowledge Quartet', which they propose as a framework for understanding mathematics teacher knowledge, but are clearly describing a very similar phenomenon, echoing Yinger when they define it as 'the ability to "think on one's feet"', (Rowland, et al. 2003, p.98). More recently, Pinto (2017), explicitly linked expert mathematics teaching to jazz improvisation in title of his paper delivered at the CERME conference that year.

Improvisation appears to be a recurring theme in discussions of teacher expertise, including expert mathematics teaching, and the brief account offered above draws on a much wider body of work. Despite these frequent references, however, there are very few detailed descriptions of what improvisation might actually look like in the classroom, and still fewer suggestions about how teachers might develop their skills in this area. Borko and Livingston, for example, offer only a few, quite general indications of teacher practice, such as the post-lesson reflection by expert teacher 'Scott' who explains: "I sort of do a little and then they do a little. And then I do a little and then they do a little" (Borko & Livingston, 1989, p.484). This, seemingly casual approach to defining such a key concept is because Borko and Livingston are not primarily concerned with the practice of improvisation, but with the nature of mathematics teacher expertise. Specifically, they are trying to articulate the distinctive ways in which novices and experts conceptualise their mathematical knowledge and conclude that the experts have 'an extensive network of interconnected, easily accessible schemata' (p.485) which enable them to respond more quickly and productively than novices with less well-connected schemata. For Borko and Livingston, therefore, the capacity to improvise well is a pointer towards the structure of this expert teacher knowledge. The implication is that such schemata are a necessary condition for improvisational teaching; the question that remains unasked is whether it is also a sufficient one.

Borko and Livingston (1989) link the notion of improvisation to the metaphor of the teacher as a performer. Developing this line of inquiry, Barker and Borko (2011) explicitly connect classroom practice to a number of seminal texts on stage improvisation such as Spolin (1963) and Johnstone (1981). This is an appealing prospect, because improvisation for the stage is recognised as a teachable skill by drama schools and theatres across the world. If similarities between successful classroom and theatrical improvisation can be identified, well-established methods for developing improvisatory skills on the stage may offer a route for mathematics teachers to move towards expertise more rapidly. The remainder of this paper is devoted to a consideration of how this might be accomplished, offering a conceptual framework for re-examining existing literature and undertaking further investigation.

Identifying improvisation in existing Maths Education literature.

The near silence of Borko and Livingston (1989) with regard to the processes involved in improvisation has already been noted. A decade later, Remillard (1999) described improvisation as 'on-the-spot curriculum development' (p.331), claiming that the practice is central to the way in which textbooks and other curriculum materials are used in the classroom. In contrast to Borko and Livingston, Remillard's primary concern is on the effect this practice has on the way teachers use textbooks and other materials, rather than the way their knowledge is structured, but like them, her interest in the processes involved is secondary; she does, nonetheless, identify one broad category of improvisatory practice – that of 'task adaptation' (Remillard, 1999, p.328) – as an important feature of expert teaching and gives some thought to the way in which this accomplished.

Remillard situates improvisation within a framework of curriculum development comprising three 'arenas' in which teachers participate: the over-arching arena of 'curriculum mapping' which defines the organisation and content of the entire school mathematics curriculum and two distinct, subsidiary arenas of 'design' and 'construction' where the day-to-day decisions made by individual teachers take place (Remillard, 1999, p.322). In this conception, a central feature of the construction arena is 'improvising in response to students' (p.322), and although it is not her primary focus, Remillard offers some analysis of what she terms the process of 'task enactment', breaking it down into two distinct activities, first '*reading* of students' performances, that is, observing and listening to students in order to assess their understandings' then '*improvising* in response' (Remillard, 1999, p.329, author's italics).

Brown (2009), develops Remillard's discussion of the way teachers improvise in their use of curriculum materials, explicitly associating the process with the way in which jazz musicians interact with a musical score. Drawing on of Yinger's proposal that teaching can be seen as a 'design profession' (Yinger, 1986, p. 275), he describes this design process as one which treats 'curriculum artifacts' – textbooks, slides, worksheets and so on – as tools with which the teacher interacts. In Brown's model, these interactions can be placed on a 3-point scale that characterises the level of teacher agency involved according to the way the artifact is used. The lowest level of agency is labelled '*offloading*' (Brown, 2009, p. 24, author's italics), which would be exemplified by a teacher simply issuing a worksheet without offering any guidance to pupils beyond that provided by the publisher. The next level is termed '*adapting*' (ibid., p. 24) and involves the use of some existing artifact but involves the teacher making some adjustment to its original use in response to the needs of the class. It is worth pointing out that this kind or adaptation could potentially be planned prior to the lesson, distinguishing from highest point on Brown's teacher-agency scale, which he identifies with the term '*improvising'* (ibid., p. 24). To be classified as falling into this final category, Brown envisages the teacher moving beyond the scope of the original artifact and devising their own spontaneous strategy.

Like Remillard, Brown's focus is on the use of curriculum resources, but he also identifies three types of 'teacher resource' that have a significant impact on the way those curriculum resources are used, 'a) subject matter knowledge, (b) pedagogical content knowledge (Shulman, 1986), and (c) goals and beliefs' (Brown, 2009, p. 27). In terms of relating these concepts to practice, however, the discussion is largely theoretical and focuses on 'The Design Capacity for Enactment Framework' which the author proposes as 'a starting point for identifying and situating the factors that can influence how a teacher adapts, offloads, or improvises' (ibid. p. 27). While the notion of teacher-as-designer is an intriguing one, and Brown's framework offers an indication of the factors that may be in play when a teacher is engaged in the kind of 'on-the-spot curriculum development' described by Remillard (1999), it offers little insight into the processes involved in classroom improvisation.

Any attempt to explore existing literature on classroom improvisation soon encounters the problem that the term is often deployed in studies that appear to be addressing quite different issues. Even the Borko and Livingston study which uses the term in its title is addressing the broader issue of expertise, while Remillard and Brown are concerned with the use of curriculum materials. To identify what is known about improvisation in the mathematics classroom, the first step is therefore to identify the terms in which it has been discussed in the past. In their systematic review of adaptive teaching in mathematics, Gallagher et al. (2022), use the term 'Teacher Improvisation' as one of several for their initial database trawl (although for some reason they ignore 'contingency'). The mere fact that they have placed improvisation within the scope of their search shows that they are adopting a far broader understanding of 'adaptation' than the one proposed by Brown, and indeed some of the studies cited in that review seem to regard the terms 'improvisation' and 'adaptation' as virtually interchangeable. In fact, the Gallagher et al. review offers a useful collection of related terms for conducting a survey of improvisation-related research in Mathematics Education, including adaptive teaching, responsive teaching, unexpectedness, noticing and orchestrating.

Having established an approach to identifying the work that has addressed improvisation in the past, an even more fundamental question arises, namely: what do all these different concepts have to do with 'expert improvisation' as it is understood in the theatre? To answer that question a clear definition of improvisation is required alongside an account of what constitutes expertise in both the classroom and the theatre. The next section proposes a conceptual framework for understanding both ideas in these two very different settings, and perhaps surprisingly, starts in the office.

Improvisation and expertise in the office, on the stage, in the maths classroom.

Organisational theorists Crossnan and Sorrenti define improvisation as '*intuition guiding action in a spontaneous way*' (2002, p. 27, author's italics). They are concerned with behaviour in commercial settings which are very different from a secondary mathematics classroom, nonetheless, aspects of their theoretical framework shown in Figure 1 offer useful insights into how it might be possible to differentiate between spontaneous classroom actions that might be considered fully improvisatory and those which are to some extent prepared.

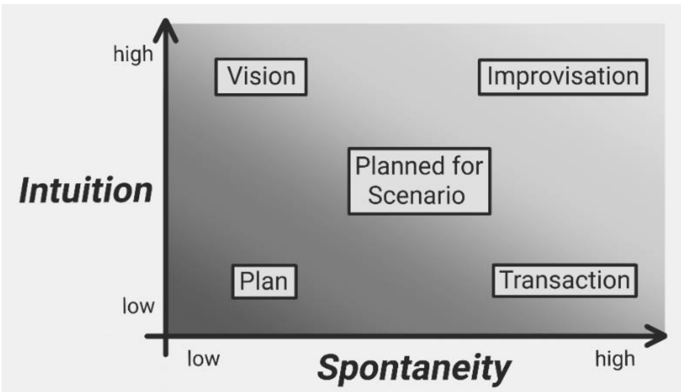

Figure 1: Adapted from Crossnan and Sorrenti (2002)

A key insight of this model is way it places planning and improvising at opposite ends of a spectrum, with the intermediate notion of 'planned for scenario' in between. The proximity of 'planned for scenario' to 'improvisation' in the diagram hint at the possibility that improvisation may be more accessible for teachers who have considered possible scenarios more thoroughly, as they are able to move easily into the semi-improvised region of working within anticipated contingencies, bringing improvisation within easy reach, but it is premature to read too much into what is, after all, a conceptual structure with no obvious scale. The other aspect of the structure which is of interest at this stage is the positioning of the 'transaction' category to describe 'spontaneous but not intuitive' actions. The Crossnan and Sorrenti model therefore allows for the possibility of actions which are spontaneous – in the sense of being immediate but not part of the teacher's formal plan – and yet not improvised. This distinction narrows the concept of improvisation being explored here from the wider category of 'adaptation' described by Gallagher, Parsons and Vaughn as 'any diversion from the lesson plan stimulated by some classroom event' (2020, p.1).

A drawback of Crossnan and Sorrenti's definition of improvisation is that it rests on two other concepts: spontaneity and intuition. Their understanding of spontaneity as acting 'in-the-moment' without time for serious forethought is clear enough, but their view of intuition as 'an unconscious process based on distilled experiences' (2002, p.28) is more elusive. The view taken here is captured in the aphorism: 'intuition and judgment – at least good judgment – are simply analyses frozen into habit' (Simon, 1987, p.63). Intuition is therefore seen as a rapid decision-making process rooted in prior learning which may be inadvertent or deliberate.

While organisational theory has provided a succinct definition, the practical appeal of improvisation is its supposed 'teachability', at least in the sense in which it is understood by stage performers. This raises the obvious question of how the improvisational performances that might win applause in a theatre relate to those that have the potential to support learning in a mathematics classroom. To address these difficulties, the first step is to move the 'theatrical' metaphor from the public setting of the stage to the relative privacy of the rehearsal room. This simplifies the analogy by removing the audience but leaves the teacher in the role of director and continues to situate the pupils as performers. The next step, therefore, is to move yet further from the metaphor of the stage, and rather than envisaging the classroom as a rehearsal space, view it as an 'improvisation workshop.'

One of the most influential figures in the development of improvisational theatre in the mid-twentieth century was the American, Viola Spolin. She talks at length of the 'workshop' (Spolin, 1963, p.18), as the space where performers can develop the skills they need before embarking on formal rehearsals. For Spolin, the key task of the workshop 'teacher' – and it is interesting to note how often she uses the term teacher – is '*giving problems to solve problems*' (Spolin, 1963, p.20, author's italics) through 'problem-solving games and exercises' (Spolin, 1963, p.9). The final step in mapping an improvisational performance to an improvisational mathematics lesson identifies the students as workshop participants the with the teacher adopting the dual role of 'workshop leader' (or 'game-chooser') and player.

To explain the connection between Spolin's notion of a 'problem-solving game' and the mathematics classroom, the key improvisational principle of 'accepting offers' is required. In improvisational theatre, an 'offer' is defined as 'anything that an actor does' (Johnstone, 1981 p. 97); to 'accept' an offer, another performer – or player of the game – must acknowledge that action and build on it, a strategy that is sometimes codified as the 'yes, and…' principle. The brief extract below illustrates this principle in action during a Year 7 class (11– 12 years old) in the autumn of 2020. To make sense of the exchange, the reader needs to know that the pupil has mistakenly interpreted the marker for '–6 degrees' on a temperature scale as 'negative four'.

1	Teacher:	How did you know that one's a negative four?
2	Pupil:	Because it's like, one line behind negative five.
3	Teacher	Yeah, we're at negative five and we've gone one down…
4	Pupil	…negative six!
5	Teacher	Negative six degrees, okay. Remember, when we're going in the negative direction, we're counting down the number line

In line 1, the teacher starts the game by making an 'offer' which involves questioning a pupil who has given an incorrect answer. In line 2 the pupil 'accepts the offer' by answering the teacher using the ambiguous term 'behind' and in line 3, the teacher uses a 'yes, and…' structure to accept the pupil’s offer while simultaneously clarifying the term ‘behind’ through what they say, and by moving their pen one unit to the left along the number line drawn on the board. In line 4 the pupil accepts the teacher’s offer and corrects their earlier answer, then in line 5, the teacher accepts the pupil’s new offer and builds on it by offering a more general description of what is meant by the word negative, again reinforcing their spoken words with actions, this time, walking backwards across their pre-drawn number line in a ‘negative direction’. The way in which the teacher responded, incorporating details of what the pupil had said in their responses provides strong evidence that their remarks were spontaneous rather than planned, and the ease with which the dialogue flowed, with no pause for deliberation, indicates that any decision-making process was intuitive. It is therefore argued that this exchange demonstrates genuine improvisation according to the definition being used here.

According to Johnstone, ‘good improvisers seem telepathic; everything looks prearranged. This is because they accept all offers made – which is something no 'normal' person would do’ (Johnstone, 1981, p. 99). Lines 2 to 5 demonstrate both participants immediately accepting each other’s offers, but the interaction seems rather brief to serve as an exemplar of expert practice. In fact, the offer-acceptance structure continues and is shown below

6	Teacher:	This is just a number line; it’s just a number line disguised a thermometer.
7	Teacher:	Negative six degrees.

At the end of line 5, the teacher had reintroduced the number line (which was discussed earlier in the lesson) and in line 6, they ‘accept their own offer’ taking the idea of the number line and relating it back to the thermometer on which the original question was based. Finally, in line 7, the teacher rejects their own ‘offer’ of the thermometer, and simply restates the correct answer offered by the pupil earlier, ending the improvised episode. Johnstone describes this kind of rejection with the rather pejorative term ‘blocking’ and regards it as something to be avoided, but in this instance, the teacher is using the tactic deliberately to end a diversion from an existing plan, judging that enough time has been spent on this particular question.

The discussion above highlighted several similarities between theatrical and classroom improvisation, but the exchange on which it is based also illustrates several key differences, one being the very different levels of knowledge possessed by the participants. In a workshop situation, it is reasonable to expect all those involved to be aware of the ‘yes and…’ principle, but this does not apply to a mathematics classroom. In a well-run class, the teacher can reasonably expect a pupil to ‘accept’ a direct question and ‘offer’ an answer, which is exactly what happens in line 2. The teacher is then able to incorporate the answer into their next statement. However, the next utterance by the pupil was not so much an offer as an inadvertent calling out of the correct answer, and it was only the skill of the teacher that allowed them to transform line 4 into an offer by responding instantly, accepting, and incorporating it into their next statement. Realising that they could not rely on the pupil to productively maintain the dialogue any longer, the teacher then elected to continue with the offer and acceptance structure in the form of a monologue for as long as they felt necessary. A second important difference between theatrical and classroom improvisation is its purpose: in classroom, it serves to draw in the student by including them in a learning dialogue that serves the teacher’s wider goal. This contrasts sharply with a workshop where the priority is to explore a situation until is mutually agreed that the scene has run its course. Given the different priorities of the classroom, ‘blocking’ by the teacher is legitimate strategy. It is therefore argued that the episode above shows expertise in theatrical improvisation re-interpreted for the classroom.

It is further argued that this brief exchange includes behaviours which are consistent with the account of expert teaching outlined by Winch (2017). In this model, successful learning is identified as ‘epistemic ascent’ (EA), which is explained using the following metaphor: consider a subject expert (who may or may not be an expert teacher) as someone with an overhead view of a room, that room represents the subject, and the view they have of every item within it and all the relationships between those items represents their knowledge. The novice is ‘gradually opening the door to that room, initially gaining partial glimpses of apparently unrelated items’ (Winch, 2017, pp. 80-81), and the process of EA is moving from the view of the novice to the view of the expert. To facilitate this journey among their students, the expert teacher must therefore understand ‘the kind of difficulty that they may be experiencing in learning’ (Winch, 2017, p. 137, author’s italics). To take the learner on this journey, the teacher obviously needs a thorough grasp of the relevant subject knowledge – metaphorically, an ‘expert’ grasp of where all the items within the room lie and the relationships between them – but Winch goes further, suggesting that the expert teacher needs the ability to switch between the perspective of the omniscient expert and that of the novice at will (2017, p. 81). The teacher response in line 3 could be explained by imagining the teacher making such a perspective-shifting move: ‘seeing’ how their pupil has (mis)read the number line, then moving rapidly to teacher mode and homing in on the point where they moved in the wrong direction from the correctly interpreted ‘–5’ marker. The speed of the pupil’s response in line 4 adds weight to this hypothesis.

Conclusion and next steps

This paper adopts Crossnan and Sorrenti’s (2002) definition of improvisation as ‘*intuition guiding action in a spontaneous way*’, going on to argue that the language of theatrical improvisation – in particular, the so-called ‘yes and…’ principle – offers an approach for identifying the practice in mathematics classrooms. It embeds these ideas within a wider understanding of teacher expertise and proposes a mechanism by the which the interconnected framework of knowledge referred to by Borko and Livingston and further explored by Winch might facilitate the practice.

The published evidence cited here is inevitably limited. Borko and Livingston's observations from 1989 are consistent with the view of expert teachers as skilled in perspective shifting, but a more detailed review of existing literature, starting with the terms noted earlier in this paper, needs to be undertaken to ascertain whether there is widespread support for this view. The empirical research described here is still sparser, and the few lines of classroom dialogue merely hint at the ways in which expert teachers might exercise their improvisational skills. More thorough investigation is clearly required. Nonetheless, the prospect of finding simpler ways to articulate, and ultimately teach others to productively engage in spontaneous classroom interactions continue to inspire this author to keep searching.

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