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Performance Space & Time

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Précis: I would like to propose a view of digital mathematical performance that creates a liminal space – a passageway between worlds where boundaries are deliberately blurry: boundaries including disciplinary boundaries (math vs. applied skills, music, art or drama, for example), distinctions between “teacher as knower” and “student as listener” (already challenged by the use of computer networks in schools), the differentiation between performers and audience, boundaries among the virtual, imagined and real, and mind/ body boundaries that have long played a central role in shaping the image of mathematics.

“Performance” as a generic category has its own new academic discipline, Performance Studies, that came into being in the 1980’s and 1990’s. Performance studies draws together notions of performance from such diverse sources as theatre, literature, visual arts, anthropology, sociology, linguistics, artificial intelligence and cultural studies. The kinds of activities included as “performances” are tremendously varied:

The term *performance* incorporates a whole field of human activity. It embraces a verbal act in everyday life or a staged play, a rite of invective played in urban streets, a performance in the Western traditions of high art, or a work of performance art. It includes cultural performances, such as the personal narrative or folk and fairy tales, or more communal forms of ceremony – the National Democratic Convention, an evensong vigil march for people with AIDS, Mardi Gras, or a bullfight. It also includes literary performance, the celebration of individual genius, and conformity to Western definitions of art. In all cases a *performance act*, *interactional* in nature and involving *symbolic forms* and *live bodies*, provides a way to constitute meaning and to affirm individual and cultural values. (Stern & Henderson, 1993, p. 3; italics in the original.)

In recent years, theorists of performance have expanded the notion of performance to include digitally-mediated performances, especially since these can now have a strong interactive, “live” component rather than simply acting as an archive of an ephemeral live performances. Post-structuralist theories of the performative have been readily taken up by performance studies:

Performance will be to the 20th and 21st centuries what discipline was to the 18th and 19th, that is, an onto-historical formation of power and knowledge [...] Hyphenated identities, transgendered bodies, digital avatars, the Human Genome Project – these suggest that the performative subject is constructed as fragmented rather than unified, decentered rather than centered, virtual as well as actual. [...] While disciplinary

institutions and mechanisms forged Western Europe's industrial revolution and its system of colonial empires, those of performance are programming the circuits of our postindustrial, postcolonial world. [...] Research and teaching machines once ruled strictly and linearly by the book are being retooled by a multimedia, hypertextual metatechnology, that of the computer. (McKenzie, 2001, p. 18)

It is unusual (and energizing) to link mathematics and math education with performance, in no small part because many of the things that make a performance distinctive and interesting go squarely against many of the long-held traditions of mathematics. I will explore the human necessity of performance in mathematics, and suggest some of the varieties and features of performance that might be offered to mathematics education from other fields.

Later in this paper, I will consider the varieties of "live" performance included in performance theory and some of the ramifications of digital performance in mathematics education. First, however, some ideas about the necessity of mathematical performance in space and time.

Platonic vs. performative mathematics: "all-at-one-point" vs. space & time

Kurt Vonnegut, in his novel *Slaughterhouse Five* (Vonnegut, 1968), describes novels on the (fictional) planet Tralfamadore which exist "all-at-a-point" and are taken in all-at-once:

...Each clump of symbols is a brief, urgent message – describing a situation, a scene. We Tralfamadoreans read them all at once, not one after the other. There isn't any particular relationship between all the messages, except that the author has chosen them carefully, so that, when seen all at once, they produce an image of life that is beautiful and surprising and deep. There is no beginning, no middle, no end, no suspense, no moral, no causes, no effects. What we love in our books are the depths of many marvelous moments seen all at one time. (Vonnegut, 1968, 88)

In my own experience as a mathematics learner, I often experienced frustration that I could not "read" theorems and proofs like a Tralfamadorean novel – all-at-once, rather than over time. For although both theorems and proofs are unfolded over time and space to facilitate communication and learning, there is a sense in which the culture of mathematics insists that the whole story truly exists as a single, elegant point, which in itself contains all its possible ramifications, whether we inadequate humans can perceive them in that form or not.

Mathematical proofs and solutions have an element of the tautological – the conclusions are logically contained in the assumptions. In some sense all mathematical proofs and algebraic calculations are *identities*, in that each line of the work is logically identical to every other line.

I was recently working with a very keen Grade 12 student who was learning trig identities. The student worked one identity, $\tan 2\theta$, through eight different transformations, eventually coming back to the original $\tan 2\theta$.

Ben's work:

$$\begin{aligned} \tan 2\theta &= \frac{2 \tan \theta}{1 - \tan^2 \theta} = \frac{2 \tan \theta}{(1 + \tan \theta)(1 - \tan \theta)} = \frac{2 \sin \theta}{\cos \theta} \cdot \frac{1}{(\cos \theta + \sin \theta)(\cos \theta - \sin \theta)} \\ &= \frac{2 \sin \theta}{\cos \theta} \cdot \frac{\cos^2 \theta}{\cos^2 \theta - \sin^2 \theta} \\ &= \frac{2 \sin \theta \cos \theta}{\cos^2 \theta - \sin^2 \theta} = \frac{2 \sin \theta \cos \theta}{\cos^2 \theta + \sin^2 \theta - 2 \sin^2 \theta} \\ &= \frac{2 \sin \theta \cos \theta}{1 - 2 \sin^2 \theta} = \frac{\sin 2\theta}{\cos 2\theta} \\ &= \tan 2\theta \end{aligned}$$

In frustration he asked me, "What's the use? I just came back to where I started! *What have I done?*" I offered an explanation that he had shown all eight lines to be equivalent, and had created for himself a lexicon of equivalent statements that could be substituted into equations as he pleased.

And yet, I have felt the same frustration – that everything seemed always already to be contained within the original statement, and that the work we perform is merely tautological. This could be said of any working out/ performing of a solution to an algebraic equation or mathematical proof – if it is solvable/ provable, the solution is always already contained within the statement of the problem. It is present "all-at-one-point". The only difficulty is that we are generally unable to experience the gestalt of problem-solution at a single point that has no part – we are constitutionally unable to read the Tralfamadorian novel. We must play it out over the space of a page and the time we take to unravel/ unpack the multiple already-present meanings. So mathematical work involves a performance over space and time, even if that performance is simply the performance of calculations or step-by-step explanations.

What could be meant by the *opposite* of performance in mathematics education? It would not be simply the introverted, quiet, private working out of solutions that has been associated so often with mathematical work, since this is still a matter of performance (albeit a physically restrained one, performed for an audience comprising only oneself). ‘The opposite of performance’ could mean an instantaneous, intuitive grasping of the mathematical implications inherent in a situation, an epiphany, all-at-a-point. These ecstatic, intuitive moments do come to mathematicians, often after long stretches of hard performative work on a problem, and even these require a more public performance in the verbal “unpacking” that enables others to judge the soundness of the intuition.

Varieties of performance

Traditionally, and particularly in the secondary and postsecondary math classes that I have observed, students’ mathematical performance has been limited to a very quiet, private performance using head and hands, pencil, paper and calculator, with the rest of the body held still and quiet, and an audience of one or two (the learner and perhaps the teacher). The teacher’s traditional performance is somewhat more active but just as rigidly circumscribed – lecturing, writing on a board or overhead projector, pacing, asking for occasional short answers from the audience.

Performance studies offers a much broader range of activities that have potential as mathematical performances in education. I will explore three of these, which overlap with one another: ritual, play and improvised theatre.

Ritual in mathematics education

The study of ritual comes to performance studies from anthropology. Ritual performances range broadly in context and purpose, from the liturgical order of religious rituals, to partially codified, partially improvised secular rituals like courtroom trials or the christening and launching of a ship, to private rituals and routines in everyday life which may be considered habitual or even compulsive. All these rituals share the importance of a fixed sequence of behaviour, often using language, rhythm and gesture. Rituals involve repetition and codified actions, which must be performed correctly when called for by tradition or circumstances. (Schechner, 2002, p. 163).

The function of ritual is often a repairing or remaking of the world, through “restored behaviour” (Schechner, 2002). The familiarity of ritual is a reassurance that, come what may, a culture has continuity over time. Even as these “restored behaviours” are repeated and recontextualized in changing circumstances, the core elements are preserved through oral tradition and memory. Rituals serve as links across generations and the vagaries of life to reaffirm what is important, mysterious, and central to our cultural knowledge and beliefs. In this way, they fulfil many of the same functions as any formal education system.

In *Finnegans Wake*, James Joyce invoked “history as she is harped, rite words in rote order”, and his pun points out the close relationship between ritual and rote learning, the rightness of certain words in the order they are written or chanted in ritual performances (as in the singing of a culture’s oral histories to the accompaniment of a harp).

Mathematics education, for all its emphasis on logic and rationality, encompasses many rote and ritual elements that lend themselves to performance which may be memorable, playful, even trancelike and hypnotic.

For example, counting itself is first of all a ritual and rote activity. Learning to count initially involves a rhythmic chant of intrinsically meaningless sounds, which are associated first as a sequence (like the names of the letters of the alphabet), and only later with particular quantities or values. Counting initially consists of pointing at objects in a sequence and reciting the elements of the counting chant.

Children often learn to count by twos and by fives playground skipping and clapping games, which involve social interactions, tunes, and rhythms marked by kinesthetic movement:

Cinderella, dressed in yella
How many times did she kiss her fella?
Two, four, six, eight, ten, twelve,
Fourteen, sixteen, eighteen, TWENTY
Two, four, six, eight, THIRTY
Two, four, six, eight, FORTY...

Bluebells, cockle shells
Eavy, ivey, over
Five, ten, fifteen, TWENTY
Twenty-five, THIRTY
Thirty-five, FORTY
Forty-five, FIFTY...

Children's culture is full of number chants that take on the nature of rote learning and ritual. Children engage with these with enthusiasm in playful settings, learning number patterns and the history of counting in the course of play.

Since children engage in counting rituals in their own play, could mathematics educators bring playful rituals to classroom learning? There is a danger in trying to deliberately invent folklore – the result may be stilted or too-precious, and it may be better to research and provide variations on existing ritual traditions. Nonetheless, it can be very interesting to tap into ritual elements for that rote work which is worth “having off by heart”. In order to make a ritual memorable, it must incorporate ritual features of rhythm, gesture, bodily movement, chant, and perhaps rhyme. I still remember the twelve times table off by heart because our Grade Six teacher made us walk across the classroom chanting a number for every step, We practiced this ritual day after day till everyone had got it.

To make a mathematical classroom ritual more memorable, teachers would do well to learn the elements of theatre to add multisensory associations to the ritual performance. Dorothy Heathcote writes about the essential oppositions used to create dramatic effect in all theatrical performances: light versus darkness, movement versus stillness, sound

versus silence. (Wagner, 1989, pp. 153 – 154) I would add to these powerful elements the idea of using the senses of smell, touch and even taste as associations to add to the dramatic elements of ritual. My husband remembers rote learning of the Latin church service as a child associated with the candle-lit darkness of the church, the smell of incense, and the taste of wax and varnish as he gnawed on the back of a pew. Could we find ways to make the rote and rituals of mathematics learning a multi-sensory, dramatic experience?

Play and improvised theatre: Dorothy Heathcote's drama-in-education

Dorothy Heathcote, a British drama educator retired from the University of Newcastle-on-Tyne, is a world-renowned pioneer in using drama as a medium for teaching curriculum in education. The dramatic performances in Heathcote's style of drama-in-education are different from theatrical performances or the production of plays. Heathcote's dramas involve the whole group (students, teachers, and others) performing in role, often over time spans as long as a week of classes. There is no external audience; the group performs for its own satisfaction and learning, not to produce a show for others. Heathcote uses role, decision-making, writing, action, discussion, and particularly a sensitive building of tensions in the dramatic situation to bring learners to fraught moments of dramatic crisis, where learning takes place in a emotionally-charged situation. Heathcote works with fictionalized dramatic situations with which students interact "*as if*" they were real. As in children's play, roles taken on in an imaginative context, even one far from literal truth, create contexts that evoke real emotions. Curricular topics encountered in these dramatic play or performance contexts are no longer treated as drills or exercises, but as vitally important actions within the reality of the drama.

I have participated in or led a number of Heathcote-style whole group improvisations, one with Dorothy Heathcote herself in a school in Gateshead near Newcastle. Two of the dramas that I led were designed to teach mathematics curriculum. The first of these involved undergraduate math education students in role as members of an earthquake preparedness committee, devising escape routes and survival plans for the residents of an apartment building on campus. The other involved high school students on one occasion and preservice elementary teachers on another, in role as resistance fighters after a military coup, hurrying to solve logistical mathematics problems in whispers by candlelight in hot, overcrowded "caves".

In both dramas, the most remarkable feature was the willingness and excitement participants had in working on mathematical problem solving in role, with a *purpose*. There was no distinction between "real-life" purposes of an actual, serious adult world and the fictional purposes of the imaginative worlds we had created. The consciously theatrical use of space, time, narrative and character built belief and tension in an imaginary world "as if" it existed. Although these participants were adults and older teenagers, the world of play was immediately accessible to all. The physical and imaginative engagement with this style of drama-in-education took us from the *burden* of seemingly purposeless exercises to a sense of the emotional, human necessity of the work we were doing, and to a desire to become better at it.

Provocative ideas on configuring time and space from performance studies:

(1) Liminal spaces

Performance traditions of all kinds reconfigure our perceptions of time and space, creating places for play and transformation and disturbing the conventional order of things. Within performance studies, one of the most distinctive qualities of performance is seen to be the *liminal, protocultural* space it claims and creates.

The term “liminal” was introduced by Victor Turner, who came to performance theory from anthropology (Turner, 1982). Turner was looking at anthropological accounts of rites of passage within a variety of cultures, and saw these transitional rituals in the life cycle as occurring in an “in-between” or liminal space, between sites of more conventional cultural activity.

Richard Schechner, a key performance theorist with a background in both anthropology and theatre, develops the idea of liminal *cultural* space as a quality of the actual *physical* spaces where performances are enacted:

A limen is a threshold or sill, a thin strip neither inside nor outside a building or room linking one space to another, a passageway between places rather than a place in itself. In ritual and aesthetic performances, the thin space of the limen is expanded into a wide space both actually and conceptually. What usually is just a “go between” becomes the site of the action. And yet this action remains, to use Turner’s phrase, “betwixt and between”. It is enlarged in time and space yet retains its peculiar quality of passageway or temporariness [...] An empty theatre space is liminal, open to all kinds of possibilities – that space by means of performing could become anywhere [...] The spaces of film, television, and computer monitors [...] apparently full of real things and people, are actually empty screens, populated by shadows or pixels.
(Schechner, 2002, 58 – 61)

A classroom can be a liminal space – a space of possibility, a passageway, an expanded marginal space with room for play. Classrooms are designed to allow for flexible spatial arrangements; if we are willing to work in the space of the culturally liminal, a classroom can be as mutable as a theatre space.

Brian Sutton-Smith elaborates on the uses of liminal spaces as the source of innovation in a culture. He writes that liminal spaces provide a place to experiment and create new structures which may later be adopted by mainstream culture:

[...] The “antistructure” represents the latent system of potential alternatives from which novelty will arise when contingencies in the normative system require it. We might more correctly call this second system the *protocultural* system because it is the precursor of innovative normative forms. It is the source of new culture.
(Sutton-Smith, 1972, quoted in Carlson, 1996, p. 23)

In considering mathematics education as performance, we are opening up the concept of schooling as a space for protocultural experimentation and invention, rather than (or as well as) cultural transmission, and rediscovery and exploration of what has gone before. Elementary and secondary schools are rarely viewed as hotbeds of new cultural forms and ideas. Is it possible to treat schools as the sites for culture-creating performance? Certainly the concept of digital performance, which I will discuss at the end of this paper, holds promise for cultural innovations initiated by young people.

(2) Sacred spaces

In all kinds of performances (including sports, religious rituals, theatre and ceremonies), there is a demarcation of a special kind of space. A specially marked performance space begins to take on sacred or magical qualities. There are restrictions about who may enter the space and in what manner, what preparations consecrate the space for its special uses, and how a person must behave in and towards that space. There are performance spaces where one must bow or remove one's shoes or cover one's head on entering (for instance, a karate dojo, or a temple or church). Some performance spaces require that special words be spoken on entering, or that a person enters silently. Sometimes only the elect may enter the space (athletes on a field, priests at an altar, actors on a stage). The geometric shape of the performance space may have symbolic as well as practical significance.

It is rare that we consider the aspects of sacred space or consciously play with these parameters in the mathematics classroom, even though every class does establish tacit conventions and rituals around space.

Richard Schechner writes about the ways he establishes the sense of a demarcated sacred performance space in theatre workshops:

Because rituals take place in special, often sequestered places, the very act of entering the "sacred space" has an impact on participants. In such spaces, special behaviour is required [...] Ordinary secular spaces can be made temporarily special by means of ritual action [...] When I lead a performance workshop I insist that participants wear no street clothes, shoes, watches, or jewelry for the duration of the workshop. No one has a watch, so time is defined by our mutual experience. Each session begins with a careful sweeping and mopping of the floor. Such simple actions as sweeping and mopping in silence transport the workshopers to a different place mentally and emotionally. These ritualized procedures help create a feeling of *communitas* even before the exercises begin. (Schechner, 2002, 63)

Simple rituals for marking off a performance space are available to mathematics educators if we want to engage in mathematical performances. If we are willing to set aside a Platonic disdain for physical, sensory modes of knowing, we can use tools borrowed from theatre to create an atmosphere of anticipation and set-apartness that facilitates affective performance.

(3) Performance time

Schechner considers three variations on the treatment of time in performance:

1. *Event time*, when the activity itself has a set sequence and all the steps of that sequence must be completed no matter how long (or short) the elapsed clock time. *Examples:* baseball, racing, hopscotch; rituals where a “response” or a “state” is sought, such as rain dances, shamanistic cures, revival meetings; scripted theatrical performances taken as a whole.
2. *Set time*, where an arbitrary time pattern is imposed on events – they begin and end at certain moments whether or not they have been “completed”. Here there is an agonistic contest between the activity and the clock. *Examples:* football, basketball, games structured on “how many” or “how much” can you do in x time.
3. *Symbolic time*, when the span of the activity represents another (longer or shorter) span of clock time. Or where time is considered differently, as in Christian notions of “the end of time”, the Aborigine “Dreamtime”, or Zen’s goal of the “ever present”. *Examples:* theatre, rituals that reactivate events or abolish time, make-believe play and games. (Schechner, 2003, p. 8)

Of these, the second, *set time*, is the most familiar in schooling. Teachers complain about racing against the clock and against the calendar, in an agonistic contest to fit in the maximum mandated curricular content into an impossibly short span. Students experience the race against the clock in the rush to complete exams and assignments before the bell rings or the deadline arrives. In other *set time* situations, students may be rooting for the clock in the contest between a dull or indecipherable lesson and the bell that ends it on time. *Set time* carries with it suspense and a potential for comedy, as protagonists race against the inexorable ticking of the clock.

In Dorothy Heathcote’s dramas, *event time* prevails; within some very broad limits, the events of the drama take as long as they need to unfold. Heathcote also talks about slowing the pace of drama to provide pressure for a deeper experience of its central themes, a “drop to the universal” (Wagner, 1989, p. 79). This slowing down of the experience of time within the performance is an evocation of *symbolic time*, the most powerfully emotive and spiritual use of time in performance.

What if we played with time as an element of mathematical performance in schooling? When time is structured with a consciousness of its effects on perception and involvement, it can become an important element in developing drama and ritual. It is a challenge to those developing math performances, as it is to other performance artists, to make choices about time that will enhance the qualities of a performance.

Digital performance: moving fluidly among worlds

Finally, I would like to consider the digital aspect of “digital mathematical performance”. I would like to propose a view of digital mathematical performance that creates a liminal space – a passageway between worlds where boundaries are deliberately blurry: boundaries including disciplinary boundaries (math vs. applied skills, music, art or drama, for example), distinctions between “teacher as knower” and “student as listener”

(already challenged by the use of computer networks in schools), the differentiation between performers and audience, boundaries among the virtual, imagined and real, and mind/ body boundaries that have long played a central role in shaping the image of mathematics.

We live in a world where these and other fixed borderlines are dissolving in the new environments created by rapid technocultural change. Young people in particular are accustomed to moving easily, and sometimes living simultaneously in physically present embodied worlds, virtually embodied online worlds, and abstract conceptual worlds. They are very comfortable moving among websites, computers games, digital music and photography, cell phone calls, text messages, email, video filmmaking, engaging in many of these virtual worlds at the same time as they are playing a pickup game of basketball, walking or skateboarding with friends, riding on a bus, eating – or going to class. Multitasking and bricolage are dominant features of our culture. Schooling must meet kids where they live if education is to be a living dialogue.

The digital math performances I imagine would not be solely digital, but would move easily between online, onscreen experiences, physically-present, kinesthetic embodied experiences with other people in a variety of spaces, and quietly conceptual individual imagining, working and thinking. Students and teachers would use resources to address purposeful *design* problems – not exercise problems with ready answers, but complex, open-ended design questions that require skills, research, imagination, humour, aesthetics and judgement. If mathematical concepts and skills were at the heart of these performances, their uses would be immediately apparent as “digital performers” used them as elements of the design of (for example) songs, games, videos, three-dimensional sculptures, robots, paintings, animations, inventions, furniture, gardens, playground equipment... The liminal spaces of computer processors, interfaces and networks would flow seamlessly to and from other kinds of performance spaces. In the interplay of these spaces, schooling could become a source of new culture.

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