Mathematical moments: Autoethnographic excursions with a mathematical outsider sociologist

Michael Corbett[1]

Faculty of Education, University of Tasmania, Australia

ABSTRACT: In this essay I offer some reflections on the field of mathematics education, and particularly the sociopolitical analysis of mathematics education that has emerged in contemporary scholarship. Here I attempt to do two things. First of all I respond to a recent book on "disorder" in mathematics education, identifying some themes and problematics that I find intriguing and generative from my perspective outside the field. Here I reflect on the way that mathematics is positioned in educational discourse generally as a proxy for human capital and general intelligence. Next I relate stories from my life and practice as a primary school teacher in which mathematics, as I understood it, bumped productively against problems in everyday life. Finally, I conclude with a reflection on the productive tension between naïve place-based mathematical understandings and abstract context-bridging mathematical knowledge forms.

Keywords: mathematics education, sociology of education, mathematisation, demathematisation, autoethnography

I. Introduction

To begin with, I read and write into the field of mathematics education as an outsider. As an educational sociologist it seems remarkable to me that what appears to many outside the field as the abstract, orderly, mysterious and esoteric world of mathematics and mathematics education is just as fraught with disorder, ambiguity, uncertainty, and

[1] michael.corbett@utas.edu.au

The Mathematics Enthusiast, **ISSN 1551-3440, vol. 15, nos. 1&2**, pp. 54-77

complexity as any other educational space. In this paper I offer an outsider's reading of what I take to be some key sociopoltical issues in mathematics education as they are articulated in a recent book (Straehler-Pohl, Bohlman & Pais 2017) that takes up the disorderly nature of the field. This argument about disorder seems to me to reflect both the order and disorder introduced into contemporary societies by the application of mathematics in a range of social fields to achieve technical and sociopolitical ends. At the same time, the book offers a critique of the way that mathematics are presented as both a proxy for pure intelligence, and an easily quantifiable human capital-related solution for complex social, economic, and educational problems. Mathematical credentials and understandings have been, it seems clear to me, constructed as a key form of what educational sociologists call deficit framing of particular groups of people as deficient participants in contemporary economies and societies (Gorski 2011, Gutiérrez 2012).

As I read pieces in the edited collection by Straehler-Pohl, Bohlmann and Pais, I am struck by the irony of the mathematization/demathematization paradox that sits in many of the contributions. What I mean by a paradox is the way that two apparently contradictory ideas can simultaneously find support in the messy social spaces in which we currently operate. I have found this idea and the tensions it contains to be highly provocative. Here, mathematics is simultaneously central to the conduct of everyday life while mathematical skills necessary for everyday functioning appear, in many ways, to have diminished as mathematical machines and algorithms operate much of the working surface the most advanced capitalist societies (see e.g. Chevallard 2007, Jablonka & Gellert 2007, Straehler-Pohl 2017). For instance, Chevallard (2007) raises the paradox of a society that requires mathematics to function, but which contains a majority of people who have little or no need for most forms of mathematical knowledge. This has rather obviouc implications for the teaching of mathematics to people whose lives are situated within this paradox.

What use is mathematics today?

So what use is mathematics today? Or more precisely, how can mathematics be useful for individuals and groups differently positioned in social space? How can it stimulate order, how does it promote disorder, and indeed what is the relationship between these seeming polar ideas? The question takes on additional complexity as we move from a consideration of the singular "use" of mathematics to the pluralized idea of multiple situated "uses."

Indeed, it seems to me that mathematics education, has tended to relate to: a) the inherent value study of the subject itself as a formal, orderly system or language and a valued mental exercise which is often used for social sorting and conflated with intelligence itself (Bourdieu 1993), and, b) as a practical tool for getting things done, for example, in the creation of objects and processes, and for the enhancement of capabilities or "human capital" of groups and individuals. Less common is a framing of mathematics in political terms as a means of ordering and dividing the world, for example: 1) in the quantification of human skills, qualities and knowledge, 2) in the comparison and surveillance of individuals and groups for commercial or regulatory purposes, or 3) in medical, health and self-care practices through metrics and mathematically derived procedures. Here we encounter a different sense of the "use" of mathematics as a tool for technical control rather than individual capability formation (Habermas 1972). A further and related question concerns why has mathematics been so successful within the hierarchy of curriculum, but also in the more mundane and functional positioning of numeracy, along with its indispensible side-kick literacy, as an umbrella meta-curricular space to be embedded within all school subjects.

It is not new to suggest that it is not the practicality of mathematics that confers elite curricular status, but precisely the opposite (see e.g. Gates & Vistro-Yu 2003). It can even be argued that at the societal level, contrary to human capital theory and common educational discourse, that poor mathematics results may not be particularly consequential in economic terms. This point was made by Guardian columnist Simon Jenkins (2016) when he argued that languishing in the international league tables in mathematics has not harmed the United States or British economies. The same argument could be made about Germany, Norway, or Australia. This perhaps illustrates one irony of mathematization/demathematization, which is that even most advanced capitalist societies the quotidian utility of mathematical knowledge for most citizens is dubious, and, as Chevallard (2007, p. 56) puts it, "all but a few of their members can and do live a gentle, contented life *without any mathematics whatsoever* (emphasis in original)." It may also be the case that those nations that score highest on established measures of mathematics performance like the PISA and TIMSS are neither economic leaders, innovation trend-setters, nor do they appear to be producing the kinds of creative labour force leading the emerging phase of global economic development. To use Bourdieu's (1984) language, powerful mathematics has become increasingly distant from necessity, at least the necessities faced by most people in an increasingly risky (Beck 1992) and even precarious political economy (Standing 2014; Bauman 2000, 2004). At the level of capital formation and wealth production, the most valuable mathematical knowledge and procedures have become highly specialized tool kits used to build machines, facilitate financialization (Sassen 2014), to form, regulate and surveil populations, and to manage risk.

Another notion in play in the Straehler-Pohl et al. collection is the idea that mathematics is a bit of a sinister force in the world because it has been largely co-opted and mobilized to create means of surveillance, control that conceals the exercise of power behind an allegedly innocent and objective veil of data. The data-driven decision-making movement both reflects and formats educational practice. There is also a sense in which the mathematization/demathematization of the world contributes to deskilling many aspects of contemporary life, subsequently making people more vulnerable and perhaps lazy in the bargain. This connects rather nicely with the mathematical dimensions of the problems of alienation and the general capitalist tendency to increase profitability by replacing labour with machines. Today's mechanization is significantly mathematical and algorithmic.

On the other hand, with the advent of big data, mathematics can assume the mantle of a moral democratizing force offering the potential for mass tracking of opinion and preference (without the trouble and messiness of debate!). Rule by plebiscite is now an important conservative policy position, which is not surprising given the power of established interests to manipulate mass opinion. Leaders can now know with some precision the will of the masses on a moment-by-moment basis using data people willingly provide and in turn use this superior knowledge (or even outright lies masquerading as this form of knowledge as Donald Trump routinely does) to manage those same populations. As the capacity of social networking and other informationgathering technologies increases, the strength of the claims that their owners can make about somehow "knowing" the mind of the people advances apace (Hague & Loader 1999, Rudder 2014, Townsend 2013). The new knowledge produced by the analysis of big data have created new ways of holding a mirror up to social processes and have generated new "games", an issue I will return to in the conclusion.

This development suggests that the reason for mathematics' success in the school curriculum as both an important subject, and as a kind of proxy for raw intelligence, as Bourdieu (1994) claimed, has to do with how amenable school mathematics is for creating a disciplined and automatic subject. It is also a useful mechanism for sorting and selecting cadre of highly trained instrumental workers who can create metrics and systems of measurement, comparison and predication which can further the insight and interests of the capitalist class. Mathematics then is sinister because of the ways in which it tends to be mobilized in the service of established interests.

Autoethnography: The experience of mathematics and the mathematics of experience

To return though to the problem of whether or not mathematic is any good to ordinary people in a given social space, I will relate two specific incidents where as a non-mathematician, and indeed as someone who would not really count himself as a mathematical enthusiast, I came to consider mathematics as a social practice rather than as a matter of pure calculation. My account is deliberately disorderly, mirroring what I take to be the messiness of the way I have understood and taught mathematics to primary students achieving only a faint glimmer of the capacity of mathematical thinking to offer an orderly sort of direction to my affairs. To illustrate these brief glimpses of what mathematics could do for me, I offer an autoethnographic (Ellis 2003) account of what I call two "mathematical moments.

Autoethnography is a way of excavating experience through reflexively through the process of writing as a methodology in itself (Green 2015). My own background was working class and like most of my peers I was largely disengaged from secondary school mathematics barely passing my final courses at the end of high school. I now see my performance in school mathematics in terms of the conceptual landscapes opened by

Bourdieu (1984, 1992) and Bernstein (1977, 2000, 2008), which speaks to the differential ability of young people to be able to achieve the point of sight required for success in higher mathematics, and in other areas of advanced school curriculum. For me, mathematics did not address mundane problems and I could not deal well with what I saw as the decontextualized, irrelevant, and what appeared to me at the time as silly symbolic games in mathematics class. Yet even relevance was still not enough to allow me to see the "inside" mathematical thinking behind and beyond automatic calculation.

There were several childhood mathematical moments I might choos where the mathematics I encountered at school became real for me. One began when my father took me to the bank at age 12 after I asked for a bicycle. "Of course you can have a bike if you want one," he replied which came as a bit of a shock. "It's time you learned about credit," he continued. My father then took me to the local Credit Union where I met the manager and a loan was promptly organized for $35 at an annual interest rate of 12%. As the months passed and I slowly repaid the loan from my paper route earnings, I became acutely aware of the importance of percentage.

Another example came when the older brother of a friend showed me how to play chess in the second or third grade. I progressed from mastering the moves of each piece, to seeing geometric patterns on the board, to strategizing several moves ahead by setting up scenarios and traps for my opponent. Baseball pitchers' earned run averages, hitters' batting averages, and ice hockey goalkeepers' goals-against average taught me the nuances of the average and its relation to probability. The geometry and physics of the snooker table and the combinations of rationality and strength involved in carpentry and auto mechanics were also part of the general mathematical education of a working class adolescent in the 1970s in small town Canada. Still, I floundered in mathematics class.

These lessons were indeed real and they made me a wiser consumer, better at DIY, more astute in strategic games, and a more informed sports fan. They brought me into contact with the systematic ordering that mathematics can provide. But they did not cause me to change my mind in the sense of being better prepared, for example, for the inferential statistics I would be required to get my head around in higher degrees in the social sciences. The situations I recount in this narrative relate to specific mathematical moments that caused me to think about the world differently, not because of the neatness and utility of mathematical thinking, but rather because of the disorder introduced to me by mathematical engagement. I wonder here whether the disorder of mathematics is potentially more important than the order it is often purported to represent. Furthermore, I wonder whether or not mathematics education should not be more explicitly oriented toward creating dissonance and uncertainty more than order and rule-following.

In the first mathematical narrative shared below, I encountered difficulty with mathematics as a set of pure, context-free calculations. In this situation I was assumed to possess more mathematical skills than others in my working group simply because I was a university student accustomed to "paper work." In the end though, it was one of my railway track-gang colleagues who showed me how to use mathematical principles in a messy world. This instruction in "good enough" mathematics or estimation, allowed me to achieve a workable, approximate solution rather than a theoretically perfect disaster. In other words, I learned to take mathematical abstractions and ground them in a messy lived situations. In the second instance, I describe how one of my elementary school students made the leap in the opposite direction by leaving the concreteness of her corporeal world to enter an imagined, abstract mathematical space. There she met a spectral average person and began the journey that eventually led her to an advanced degree in physics.

II. Ordering a disorderly world: The good enough curve

Through the late 1970s and early 80s, I attended university in fall and winter and worked on railway track crews, or "gangs" through the spring and summer months. I loved the separation of these two parts of my life. In winter I could read and socialize with friends at university and when the weather warmed up in May I would go to work until late August and the end of summer to return once again to university study. The year I turned twenty, I took a job on a "surfacing gang". I worked as a labourer shovelling gravel and spiking railway ties while a group of three machines lifted, surfaced and aligned the track. It was hot, sweaty work involving some manual dexterity, but mostly raw physical strength.

My role was to be part of a crew of labourers who worked alongside the machinery taking care of those inevitable anomalies along the track that foiled the flow of mechanized production. Our job was to keep the machines working steadily and efficiently, clearing obstacles to production. The three machines used by this late 1970s surfacing gang on a marginal rail line in Atlantic Canada are shown in Figures 1-3.

Fig. 1 Torsion beam tamper

First in line is the torsion beam tamper (Fig. 1). This machine raised the track, levelled it, and tamped gravel beneath the ties. The "projection buggy" in front shone a light back at the machine that would regulate how high the tamper should raise the track to make it level. This was done when the black triangular board on the front of the machine raised enough to block the light, which caused the tamper jacks to stop lifting the track.

Fig. 2 Track liner

Next came the track liner (Fig. 2) that aligned the track into neat parallels. By the early 1980s this machine was pretty much obsolete and the only photo I could find is this one. The mechanism on the front drove a large metal pin or "spud" into the ground to stabilized the machine and then hydraulic motors moved the track either left or right in order to straighten it.

Fig. 3 Ballast regulator

Finally, the ballast regulator depicted in Figure 3 distributed the ballast gravel and swept the track bed clean with enormous circular brushes. The end result was smooth, stable, flat-surfaced (no bumps), aligned, and neat railway track.

One day the foreman came to me and said something like this: "Murray got a job up the line." Murray was the "curve plotter" who worked with the middle machine, the track liner. The foreman went on to say something like this: "You're a college boy so you can go work with the track liner graphing curves." I had no idea what Murray did, and neither did the foreman when I asked him. The foreman figured that I could handle the "paperwork" because of my "college" background. I wasn't really given a choice.

I was "trained" by the somewhat taciturn man running the track liner and given a book that contained engineering specifications for each curve on the line. Straight track was easy. I had nothing to do. I brought a novel and sat on a rock as the track line worked away. But when we encountered curves I had to take readings at specific intervals, using an apparatus that measured alignment or lack of alignment of a segment of curved track, and plot the existing curve on graph paper. I was given an instruction manual that had diagrams such as this patent drawing for this procedure to illustrate what I was supposed to do (Figure 4). The dots on he graph paper represented readings taken by the operator indicating the actual position of the track before alignment. The curve on the graph paper represents the best fitting line and my machine would move the track left or right until the track sat exactly on the plotted curve.

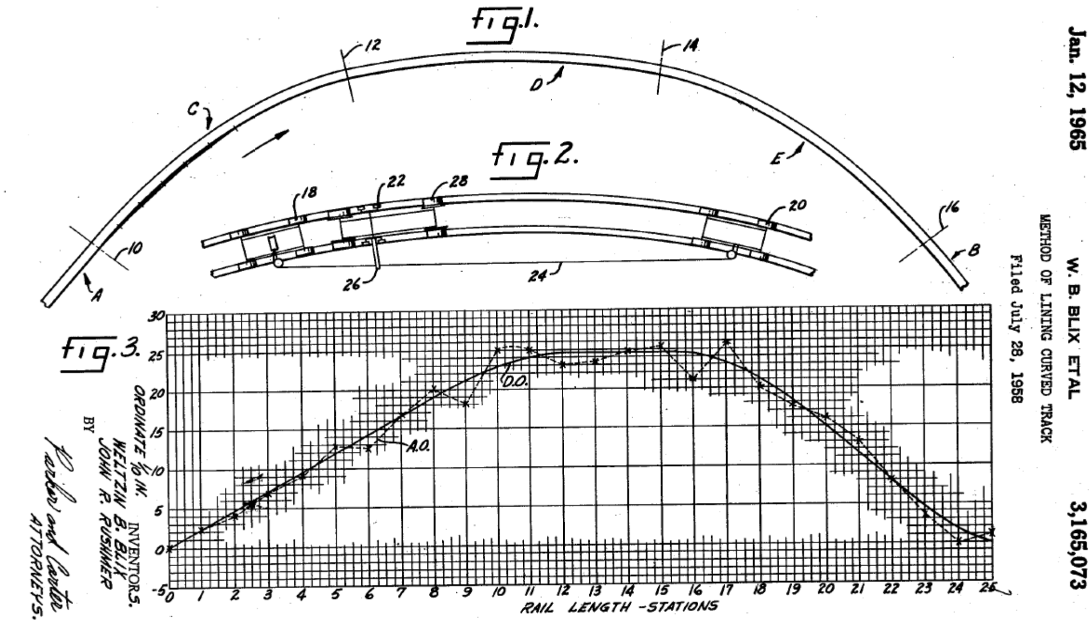

Fig. 4 Patent diagram for railway track alignment

Thus, after plotting the existing curve on graph paper, I then created a best fitting line that would make the curve nicely rounded and match the engineering specifications for how the curve was supposed to look, roughly in accordance with the diagram in Figure 4. The result, for a curve that was not substantially "out of line" would look something like Figure 5.

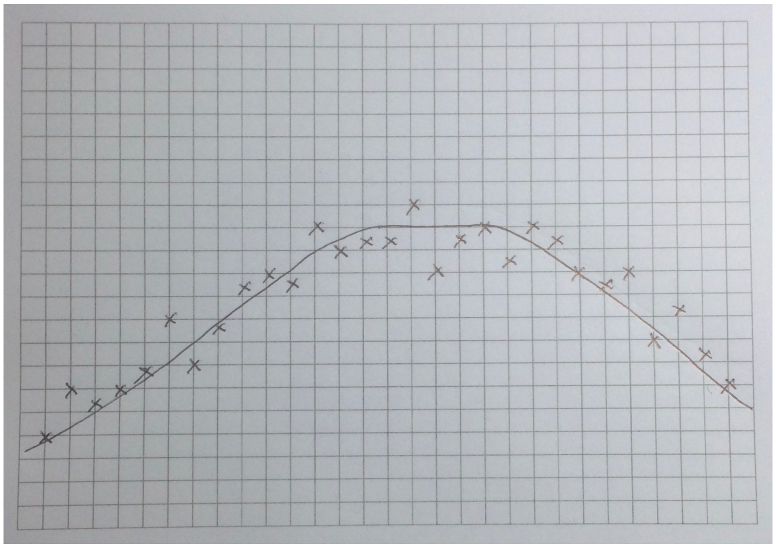

Fig. 5 Best fitting line

My job was then to return with the track-aligning machine to the beginning of the curve, which would pull each errant x (which represented the actual "disordered" position of the track) onto the rounded curve, which represented the desired orderly, "lined" track. This was consequential work. If I did my job poorly, a train could derail. So I dutifully consulted the engineering manual and plotted my curves with great care. For the first couple of curves, things went quite well, but then we moved into an area of wet ground where the track had sunk into the mud and was badly misaligned when the tamper completed its lift and surface. We managed to get the straight track sorted out but the curves were a mess. On my plot, each little x was well away from any nice rounded regulation curve that I could draw. So as we returned to straighten the track, we needed to move the track enormous distances to make it fit my ideal line. After a time we realized that we were pulling the track almost out of the rail bed in order to create the desired curve.

We carried on for a time. The foreman started to get nervous because we were falling behind the tamper and slowing up production. The man who ran the ballast regulator behind us waited patiently in the cab of his dusty machine sometimes emerging to give us advice. Our curve was perfect and orderly. The "math" looked good. The trouble was that my orderly plot did not fit the disorderliness of the existing rail bed, and by moving the track so far we were destabilizing it. Everyone could see that there was a problem. A mechanic and the superintendent were called in. They looked at the track. They looked at my plots. They looked at the engineering manuals. Everything was done according to the rules, but the result was extremely slow progress because we were moving the track back to where it was when the railway was built generations before. I was left to continue on.

Eventually, the tamper operator wandered back to see what we were doing. His machine was so far ahead of ours that he couldn't really carry on further. When he looked at what I was doing he said, "wait a minute, this can't work." He explained to me that when you encounter a curve that is seriously askew as this one was a perfect curve is impossible. Forget the engineering specifications he said. "You aren't building that perfect track, you're fixing this one. Those fools who run this railway don't live in the real world with us." Then he showed me how to make an imperfect curve out of a series of "steps" (Fig. 6). "Them x's are what you have to work with son, not what's in that book," he said.

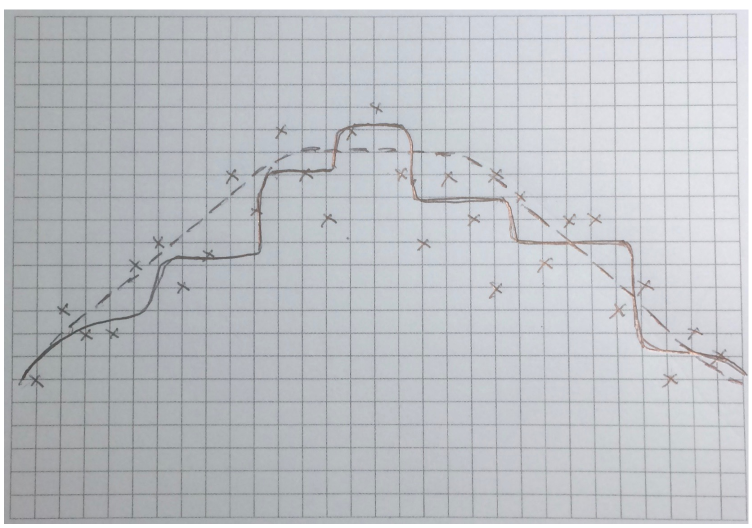

Fig. 6 An imperfect "curve" created in steps

By constructing the curve as a series of stepped line segments (Fig 6), I could create a good-enough functional and safe approximate curve that would look great and take much less time. I carried on this way for the rest of the summer and had lots of time to sit on the rocks amidst the din of the machinery and read my books. The foreman was happy; production had returned to normal.

At issue here is the truth of the text, in this case the engineering specifications and the ideal mathematics that they imagined. In the end, experience, risk, improvisation and judgment were required to tame the formatting power of the mathematics (Skovsmose, 1994) that was understood to rule the situation. It is perhaps not surprising that none of my superiors could tell me how to dissolve the abstract mathematical order, bend the rules, and fabricate a different mathematics that would create an approximated order and allow the work to proceed. I was shown, by a peer how to juxtapose formal rule-following with estimation and site-specific human judgment necessary to produce a "good enough" railway curve. D. W. Winnicott (1995) developed his concept of the good enough mother to describe a desirable level of parental care. Too much attention will damage the child, as will not enough. There is a sweet spot of good-enoughness that allows the child autonomy but gives enough direction to support development.

How to find that good–enough space is always a matter of estimation and more or less calculated imperfection. In this experience I came to see mathematics as a matter of skilled improvisation, judgment and even creativity. I had to judge the extent to which the actually existing curve could be aligned to approximate the perfect curves inscribed in the engineering diagrams.

By the end of the summer I seldom consulted the technical manual and relied more and more on my ability to construct a smooth but imperfect curve. I had no idea that I had stumbled on a set of ancient mathematical problems that led out of the Pythagorean Theorem, to pi and the calculation of the area of circles, and on to Newton's calculus. This realization took another twenty years and chance encounters with mathematical ideas in narrative form (Ogawa 2009, Ellenberg 2014).

III. A counterintuitive mathematical leap: Imagining someone who isn't there

A fundamental problem in learning mathematics is, in my view, a question of trust that allows the mathematician to navigate and negotiate between the corporeal world and a dimension of thought where sets of relational abstractions operate. These abstractions, powerful as they are, require a certain kind of faith and a leap into the unknown for children. Much mathematical curriculum today seeks to concretize these relational abstractions, but in the end, the goal is to cause the learner to abandon a fixation on the concrete and enter another dimension of relational thought.

In the *Childhood of Jesus*, J. M. Coetzee (2013) creates the character of a child who refuses to either read, write or do the mathematics required of him in school. His particular rationale for not engaging with mathematics is because he finds the basic problem of counting and adding things together to be problematic. One and one do not equal two, because for this child each individual thing is unique and different.

> Put an apple before him and what does he see? An apple; not *one* apple, just *an* apple. Put two apples before him. What does he see? An apple and an apple. Now along comes Señor Leon (Señor Leon is his class teacher) who demands: *How many apples child?* What is the answer? What are apples? What is the singular of which apples is the plural? Three men in a car heading for East blocks: who is the singular of which men is the plural-Eugenio or Simon or our friend the driver whose name I don't know? Are we three, or are we one and one and one? (Coetzee 2013, p. 284 – italics in original)

The child's radical ontology caused him to see the world in terms of discrete things that should not be reduced to comparable classes, and thus, which were impossible to sensibly combine through a simple act of calculation. Without making this fundamental ontological leap required of all school children, is mathematics even possible? It is this leap that we expect students to make. But why should they? Like Coetzee's protagonist, I am not asking this question in a cheeky way, but rather to suggest that one effect of developing a mathematical sensibility is to learn to think in reductionist ways rather than in ways that to recognize subtle differences and attend to nuance. In discussions of research methodology this is not a particularly new conversation and problems of the juxtaposition of classification and rich description are routinely discussed and debated. In curriculum conversations, mathematics education discourse and particularly in the political spaces concerned with boosting test scores and implementing programs, an "attitude" like that Coetzee's protagonist undoubtedly appears dangerous and disorderly, if not sick and disordered. Can we assume though that all children should and will make this ontological leap easily and naturally. And to what extent? A related question concerns how the child in Coetzee's novel might have been taught mathematics in such a way that his formal mathematical skills might have developed.

The second mathematical moment I want to relate came from a teaching experience in rural Nova Scotia (Canada). I was, for nearly a decade, a teacher in a grade 5-6 multigrade classroom in a small school. This was the early 1990s and the NCTM standards were newly embedded in provincial curriculum from primary to grade 12. Primary teachers, myself included, struggled with the expanded scope of what we were expected to do with our students. The established mathematics curriculum focussed primarily on speed and accuracy, for the most part in basic operations algorithms, combined with a very cursory introduction to percentage, fractions, ratio, simple geometry, etc. Prior to reforms in mathematics curriculum of the 1990s, automaticity, speed and accuracy in simple calculations were pretty much all that was required of both primary students and of their teachers. And of course, the struggle over curriculum continues in debates around return to mathematical "basics" which continue in many contexts to be constructed in terms of automatic calculation.

One of the NCTM strands that teachers in my school seemed to be able to grasp most easily was statistics. We worked on sampling and probability through a wide range of experiences and data collection exercises. I spent about three weeks with my class in an attempt to determine whether Black Jack is a fair game. The dealer in our games had to hit until the points totalled 17 and then stop. Players could do what they wanted. We recorded each game played and after several hundred recorded games concluded that overall, the dealer was in a winning position and that Black Jack was not a fair game. It was obvious that the children who were assigned to be dealers had more of our fake currency than those assigned as players. I saw this exercise as one form of childproofing.

We also did a number of surveys, some of which included investigations of student opinion on aspects of school policy such as how to divide the playground amongst different age groups. Very quickly my grades 5 and 6 students who were the eldest in the school learned to manipulate their surveys, at first by over-sampling children in their classes and then by manipulating younger students to give the answers they wanted. All of this led to discussions about sampling and the ethics of consent and indeed about power and persuasion.

When it came to calculating central tendency in data using mean, the median and mode, we did a fairly standard exercise with the height and weight of students in the class. When it came to the average weight and height of the children in the class, the result failed to match the results for any particular person. I think I must have been using the terms normal, average, and mean interchangeably because one student made the remark that there is no one in the class who is normal. I don't have the verbatim transcript but it went something like this:

Student 1: Normal weight in this class is 96 lbs. But nobody is 96 lbs.

Teacher: That's right.

Student 2: That means that none of us are normal (laughter and snide comments).

Teacher: The mean is a concept, it means the middle.

Student 3: The middle of what?

Teacher: Well, the middle of the group.

Student 1: Like when we all lined up from the shortest to the tallest there was someone in the middle.

Teacher: (Attempting humor) Yes, that is the mean person … you're not laughing. Actually this is the median person.

Student 1: But the math is wrong because there is nobody in the middle for weight.

Student 3: What do you mean?

Student 1: Nobody is 96 lbs., so nobody is in the middle.

Teacher: Nobody has to be in the middle. They might be, but in this case nobody was.

Student 2: So the math is wrong.

Teacher: No, the math is right but nobody fits exactly in the middle.

Student 1: So who is the mean?

Teacher: Nobody. It's an idea.

Student 1: Not a person?

Teacher: That's right.

Student 1: So they expect us to imagine a person who isn't there.

This is an exchange that betrays my own lack of attention to the distinctions between statistical and social norms or between mathematical and value-laden ethical language. This raises the question as to why I used the term "normal" at all knowing full well its value-laden implications it held for my students. I have no answer to this question other than to suggest that my linguistic carelessness with mathematical language is probably not unusual, and that it is indicative of the relatively disorderly way I approached the teaching of mathematics.

There are a number of other things I remember from this exchange. Student 1 was struggling to get her head around a disembodied concept. We went on to establish a persona for the "mean boy" and "mean girl," the shadowy character who sat in the middle of things and who was perfectly "normal" but who was invisible, malicious, and couldn't be trusted. Using the mechanism of the person who wasn't there, some students were able to embrace and play with the ideas of central tendency and data itself as an abstraction drawn from living beings. But at the same time, my blurring of normative and descriptive mathematical terminology probably created additional confusion. This illustrates how as a teacher, I inelegantly used the relatively disorderly ethical normative language to promote an orderly understanding of a mathematical relationship.

Student 1 shows particular creativity and insight, in part because she found a space in which to play between order and disorder. She asked a provocative mathematical question when she wondered about the identity of the mean itself. Who is in the middle of a data set, or who is normal? In doing so she illustrated her ability to abstract or in effect, to be wiling to make an ontological leap and see what isn't there categorizing things and beings based upon characteristics operationalized as variables. She may or may not have confused statistical and social uses of the term normal, but the core feature of this shift is to move from seeing concrete individuals to seeing variables and categories, i.e. things that are not really there. This ability to extrapolate the invisible out of the visible is, in important respects, the sort of ontological move necessary for participation in formal mathematical learning. In a sense, one must be able to see what is not there, move beyond context-bound perception, and trust in an abstract vision. Was my student developing a foundational sense of the larger notion of inference and was she, as a result of her playful questioning about an absent presence, on the way to powerful mathematical thinking in the sense of Michael Young's (2007) conception of "powerful knowledge" as non context-dependent, systematic and specialized? Of course, I can never know for certain.

IV. Back into context: Social class, formatting and power

One way to think about the problem of the invisible being in the middle of a group of people who are reduced to data points is to consider how classification has been found to operate amongst differently positioned social actors. What I am trying to suggest above is that it is not the instances in which mathematics came to seem real and useful to me (as important as they were) that were most important to the refinement of what I would now see as a more developed mathematical sensibility that can help me see what is not obviously there.

The general findings associated with the work of Bernstein (1977), for instance, advance the claim that middle class students are more likely to use general classification strategies to group objects while working class students are more likely to generate classifications that are more specific to their personal lives (Bernstein 2000, Cooper 1998, Holland 1981, Walkerdine 1988). This is the ability to appropriately use what Bernstein (2000, p. 31) called "recognition rules" or the inclination to understand the particularities of the context from another point of sight and the power relations in play within the context. The capacity to do this in school tasks is, following Bernstein, unevenly distributed amongst the social classes with people positioned more marginally tending to think in ways that relate intimately to an immediate, experiential locale. As Cooper (1998) points out, this is not a question of concrete or abstract thinking, but rather one that is more or less attuned to presence and absence and the immediacy of the lifeworld, and I would argue, family, mobility and literacy practices. What academic study requires is what I have described elsewhere as a kind of mobile sensibility that is able to transcend place (Corbett 2005, 2009).

I think this mathematical sensibility may also involve a way of thinking about the world that takes too seriously spectral presences found in manufactured mathematical space. Today, there is growing concern about the algorithms that make choices for us and that structure the way we are governed and targeted for marketing. Some of the best minds of the emerging generation of capitalists owe their fortunes not to making objects or finding and processing resources, but rather, to having advanced mathematical skills combined with business acumen and foresight relating to the creation of nonmaterial objects. The fact that Mark Zuckerberg, Bill Gates, Steve Jobs, Elon Musk and

Tasmania's David Walsh are mathematicians or at least mathematical enthusiasts whose products are essentially ideas, creates fuel for the myth that mathematics paves the road to prosperity. Like many myths, this one contains truth. As I suggest above though, there seems to be evidence that the societies that seem to produce the best results collectively on international assessments of mathematics may not be leading the world in economic and social innovation. But the myth of mathematics as the engine of growth and development also contains a core conservative kernel, which is that the game itself is what is important rather than the algorithms and assumptions that make the game work. It also assumes that understanding the game itself, and becoming an efficient and effective player, rather than challenging or questioning the way it is constituted is more fundamental to education. All games though have cultural, social and political roots and they contain foundational assumptions that format and organize play and perception.

I offer one final story that is now more than 20 years old. When my son was a small boy, he was fascinated with computers and gaming. One of the first computer games we played was *Sim City*. My son enjoyed playing this game and he quickly learned how to get his cities to grow to a great size in a peaceable and prosperous way. On the other hand, my cities would often descend into chaos and fail to grow. So one day I asked him how he managed to grow such vibrant and prosperous cities. "Simple," he said. "Two things you need to keep in mind. First of all, keep the taxes below 7%. Secondly make sure you have lots of police stations." He showed me both how to prosper in the game but also how the assumptions built into the algorithm were subtly training gamers to think conservatively.

Mathematics is intimately involved in political spaces, and the ways in which hidden mathematics structures social space, the mathematization of the world, is a topic that ought to be foregrounded in contemporary curriculum. Often though it appears that there is more public and political interest in teaching primary school students how to code than there is in teaching them how to think about the way that their experience in real and imagined space is coded. Could it be, all of the rhetoric about how STEM education is crucial for future economic prosperity, that there is more money to be made by teaching children to do as they are told? While there seems to be less interest today in automaticity and speed and more interest in analytic thought to meet the human resource needs of contemporary capital, the ideal mathematics student imagined in contemporary curriculum may be no more engaged than I was in my 1960s and 70s school mathematics classes.

It is also still the case that highly divergent mathematical content is offered to young people differently positioned in social space (Schmidt, Burroughs, Zoido & Houang 2015). It is encouraging that there is work in mathematics education that helps young people understand how math is a tool that can be used to illuminate situations of social injustice and oppression, which is important as well (Gutstein 2003, Moses & Cobb 2002, Skovsmose 1994a). There is no avoiding how mathematics is intimately bound up in the intricacies of a messy world, power differentials, unequal access to resoruces, and diverse forms of social practice. Indeed mathematics itself is social practice that is unevenly distributed and differentially taught along the lines of contemporary social divisions such as social class, race, ethnicity and gender. This leads me to the conclusion that there is good evidence to support the idea that for some, even for most people, the demathematization of everyday life will only deepen even as mathematics becomes more central to the way life is organized.

What this comes around to is the relationship between identity and mathematics, which is why I chose narrative to illustrate my argument. First of all, as my story of the good enough curve illustrates, the mathematical understandings I have acquired have come to me through experience. I wonder if my notion of narrative "mathematical moments" might have value in mathematics education? Can we help our students find and tell mathematical stories from their lives? Secondly, mathematics must take place somewhere, which is the point of the first story; but it must also take place nowhere, which is the point of the second story. In the two stories, the problem of visibility and invisibility, tangibility and intangibility, order and disorder illustrate how what I understand to be powerful mathematics learning occurs in the thirdspace in-between. The examples I used foreground the importance of those moments in which school mathematics became "real". Much mathematics curriculum today is properly focussed on the experiential hooks that ought to be present in good math learning. Nevertheless, what mattered more were those biographical situations that involved an integration of order and disorder.

Thirdly, my last story raises political questions about the formatting power of mathematics and questions of power more generally in mathematics and in mathematics education. Extending the problem of power and the extrapolation of powerful learning from local contexts remains a problem upon which we have not made significant progress in decades of educational research. In a recent analysis of AERA presidential addresses relating to what we know about learning, Carol Lee (2016) concludes that most of what educational research has discovered is tempered by how little we still understand about the all important influence of context. Following Bernstein's (1977) lead, the relationship between different knowledge forms and the places and spaces in which they are enacted and valued remains the most difficult and intractable of educational problems.

References

Bauman, Z. (2000). *Liquid modernity*. Cambridge: Polity Press.

Bauman, Z. (2004). *Wasted lives: Modernity and its outcasts*. Cambridge: Polity Press.

Beck, U. (1992). *Risk Society: Towards a New Modernity*. Thousand Oaks: SAGE.

Bernstein, B. (1977). *Class, Codes and Control, Vol. 3: Towards a Theory of Educational Transmissions*. London: Routledge & Kegan Paul.

Bernstein, B. (2000). *Pedagogy, Symbolic Control, and Identity*. Lanham, Md: Rowman & Littlefield Publishers.

Bernstein, B. (2008). *The Structuring of Pedagogic Discourse*. New York and London: Routledge.

Bourdieu, P. (1984). *Distinction: A Social Critique of the Judgement of Taste* (1 edition). Cambridge Massachusetts: Harvard University Press.

Bourdieu. (1992). *The Logic of Practice*. (R. Nice, Trans.). Stanford, Calif.: Stanford University Press.

Bourdieu, P. (1993). *Sociology in question*. Thousand Oaks: Sage.

Chevallard, Y. (2007). Implicit mathematics. In U. Gellert & E. Jablonka (Eds.), *Mathematisation and Demathematisation. Social, Philosophical and Educational Ramifications* (pp. 57-66). Rotterdam: Sense. (Orig. pub. 1989).

Coetzee, J. M. (2014). *The Childhood of Jesus: A Novel* (Reprint edition). New York: Penguin Books.

Cooper, B. (1998). Using Bernstein and Bourdieu to understand children's difficulties with "realistic" mathematics testing: An exploratory study. *International Journal of Qualitative Studies in Education*, *11*(4), 511–532.

Corbett, M. (2005). Rural education and out-migration: The case of a coastal community. *Canadian Journal of Education/Revue Canadienne de L'education*, 52–72.

Corbett, M. (2009). Rural Schooling in Mobile Modernity: Returning to the Places I've Been. *Journal of Research in Rural Education*, *24*(7), 1–13.

Ellenberg, J. (2014). *How Not to Be Wrong: The Power of Mathematical Thinking*. New York: Penguin Books.

Ellis, C. (2003). *The Ethnographic I: A Methodological Novel about Autoethnography*. Walnut Creek, CA: AltaMira Press.

Gorski, P. C. (2011). Unlearning Deficit Ideology and the Scornful Gaze: Thoughts on Authenticating the Class Discourse in Education. *Counterpoints*, *402*, 152–173.

Green, B. (2015). Research, Practice, Emergence; or, Emergent Methodologies in Cultural Inquiry and Educational Research. *Fusion*, 1–12.

Gutiérrez, R. (2012). Context Matters: How Should We Conceptualize Equity in Mathematics Education? In B. Herbel-Eisenmann, J. Choppin, D. Wagner, & D. Pimm (Eds.), *Equity in Discourse for Mathematics Education* (pp. 17–33). The Netherlands: Springer.

Gutstein, E. (2003). Teaching and Learning Mathematics for Social Justice in an Urban, Latino School. *Journal for Research in Mathematics Education*, *34*(1), 37–73.

Habermas, J. (1972). *Knowledge & Human Interests*. (J. J. Shapiro, Trans.). Boston: Beacon Press.

Jenkins, S. (2016, March 10). Our fixation with maths doesn't add up: Politicians tell us it is the pre-eminent subject. Nonsense. They're just obsessed with measuring, targetry and control. *The Guardian*, Retrieved May 26, 2016, from http://www.theguardian.com/commentisfree/2016/mar/10/fixation-maths-doesnt-add-up-targets

Hague, B. N., & Loader, B. (1999). *Digital Democracy: Discourse and Decision Making in the Information Age*. New York: Psychology Press.

Jablonka, E., & Gellert, U. (2007). Mathematisation - Demathematisation. In U. Gellert & E. Jablonka (Eds.), *Mathematisation and Demathematisation. Social, Philosophical and Educational Ramifications* (pp. 1-18). Rotterdam: Sense.

Lee, C. D. (2016). Examining Conceptions of How People Learn Over the Decades Through AERA Presidential Addresses Diversity and Equity as Persistent Conundrums. *Educational Researcher*, *45*(2), 73–82.

Moses, R., & Cobb, C. E. (2002). *Radical Equations: Civil Rights from Mississippi to the Algebra Project*. Boston: Beacon Press.

Ogawa, Y. (2009). *The Housekeeper and the Professor*. (S. Snyder, Trans.) (Original edition). New York: Picador.

Rudder, C. (2014). *Dataclysm: Who We Are*. New York: Crown.

Schmidt, W. H., Burroughs, N. A., Zoido, P., & Houang, R. T. (2015). The Role of Schooling in Perpetuating Educational Inequality An International Perspective. *Educational Researcher*, *44*(7), 371–386.

Sassen, S. (2014). *Expulsions: Brutality and Complexity in the Global Economy*. Cambridge, Massachusetts: Belknap Press.

Skovsmose, O. (1994a). Mathematics — A Formatting Power? In *Towards a Philosophy of Critical Mathematics Education* (pp. 42–58). Dordrecht: Springer Science & Business Media.

Skovsmose, O. (1994b). *Towards a Philosophy of Critical Mathematics Education*. Dordrecht: Springer Science & Business Media.

Standing, G. (2014). *The Precariat: The New Dangerous Class* (Reprint edition). London: Bloomsbury Academic.

Straehler-Pohl, H., Bohlmann, N., & A. Pais (Eds) (2017), *The Disorder of Mathematics Education. Challenging the Socio-Political Dimensions of Research*. New York: Springer.

Straehler-Pohl, H. (2017). Delmathematisation and Ideology in Times of Capitalism: Recovering Critical Distance. In H. Straehler-Pohl, N. Bohlmann, & A. Pais (Eds.) *The Disorder of*

Mathematics Education. Challenging the Sociopolitical Dimensions of Research (pp. 35-52). New York: Springer.

Townsend, A. M. (2013). *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*. New York: W. W. Norton & Company.

Walkerdine, V. (1988). *The Mastery of Reason: Cognitive Development and the Production of Rationality*. London ; New York: Routledge.

Winnicott, D. W. (1982). *Playing and Reality*. New York: Tavistock.

Young, M. (2007). *Bringing Knowledge Back In: From Social Constructivism to Social Realism in the Sociology of Education*. New York and London: Routledge.