# Being Numerate for Teaching: The Indivisibility of Learning Landscape, Participation and Practice

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Being numerate for teaching involves more than personal numeracy; while the construction and communication of disciplinary knowledge will always be important, so to is the creation of a professional self, capable of appreciating and implementing flexible and dynamic interactional patterns that value diversity and students' idiosyncratic attempts to make sense of experience. New ways-of-being a teacher of numeracy are founded on robust intellectual knowledge, though the learning landscape is constitutive, influencing participation and interactional patterns in the classroom.

A difficult issue currently facing teacher education is the production in the media and policy of an overly simplistic view of the learning to teach process. In relation to numeracy education, stakeholders focus on one element of what is a very complex process and hold it up as the answer to current problems. Arguments are put in commonsense terms such as Rubinstein's (*The Australian*, October 10, 2007) comment on the importance of disciplinary expertise in "well-trained and enthusiastic teachers of mathematics" (p. 33). While this goes without saying, few contributors to the popular press tackle the problem of how teacher education is to produce this expertise when many preservice teachers, especially those in primary and early childhood education, have exited twelve years of schooling with little disciplinary knowledge and even less enthusiasm for mathematics and its teaching. The lack of disciplinary knowledge is a serious problem that has been given a lot of attention, though the lack of enthusiasm impacts just as harshly on preservice teachers' participation and professional learning in teacher education.

In the past it has been assumed that the restoration of disciplinary knowledge would positively impact on preservice teachers' enthusiasm, though this is not necessarily the case. Enthusiasm has been seen from a psychological perspective as a personal attribute that some individuals demonstrate as they construct mathematical knowledge; from a sociocultural perspective its development is seen to be supported in a collaborative way when students discuss alternative solutions and explain their thinking (Vygotsky 1978). However, in this paper we suggest that there may be more to learning to be numerate for teaching than meets the eye; wherever individuals gather there are power relations that are constitutive, affecting participation and practice now and in the future. As Johanna Oksala (2007, p. 15) states: "The subject [preservice teacher] is not an autonomous and transparent source of knowledge, but is constructed in networks of social practices which always incorporate power relations and exclusions". In teacher education, the intellectual knowledge and skills prospective teachers construct are nuanced by an unconscious, constituted *knowing* (Lather, 1991) about mathematics, and about themselves as potentially able to establish some sort of legitimacy as teachers who interact with their students in enthusiastic and generative ways.

Enthusiasm and generative potential for teaching numeracy are constituted in a broad learning landscape, of which teacher education forms a small part. In our day to day teaching we imagine that it is important to conceptualise learning beyond the psychological and the sociocultural, and to consider and work with the constitutive effect of relationships of power in the learning landscape. Traditional epistemologies are useful, though they can

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not tell us, beyond notions of individual deficit, how it is that "the main lesson learned by most school leavers after years of being forced to study mathematics is that they can't do it" (Ellerton & Clements, 1989, p. vii). Our research in teacher education focuses on the complex task of manipulating the learning landscape to better understand this phenomenon, and perhaps go some way at least to turning it around for some of the preservice teachers.

## The Learning Landscape

We teach in an on-line first year numeracy subject, and the learning landscape influencing our students' participation in learning is vast. They come with various levels of disciplinary knowledge and appreciation of mathematics; they have differing dispositions towards mathematics and its teaching. Many of them "lack confidence in [mathematics], do not enjoy or see personal relevance in it and are unlikely to continue its study voluntarily" (Commonwealth of Australia, 2008, p. xii). Our task, from an overarching poststructuralist perspective, incorporating the psychological and sociocultural, is to assist these prospective teachers to establish and recognise themselves as *legitimate* teachers of numeracy in a postmodern world.

There are, of course, some preservice teachers who do sense a certain capability and comfort with/in mathematics; past discourses have fostered their participation and named them as successful. While on the one hand this augurs well for their future teaching, in another it can be problematic if those past discourses operated on outmoded notions of what mathematics is, and of how it should be taught and learned. Although modernist assumptions support the reconstruction or relearning of outmoded views and attitudes in teacher education, poststructuralists assume that this is but a start; for every moment the preservice teachers sat in mathematics lessons at school they were undergoing a process of subjectification, comprising power relations and exclusions that constituted an unconscious knowledge of and about mathematics, of teaching and of how personal deficit leads to failure.

Within the learning landscape in teacher education struggles for legitimacy are continuously played out; power relations traverse every point as the preservice teachers and we ourselves struggle to establish and maintain legitimacy as teachers. The preservice teachers' identity is caught up with desperately wanting to be seen, and to see themselves as, legitimate, while we struggle to redefine and reinvent *legitimacy* for them and for ourselves. Although understandings of *being a legitimate teacher of numeracy* vary, we assume that it incorporates three core intersecting and interdependent elements. These elements include a constituted sense of:

a) Mathematics as a powerful structured discipline of pattern and order,
b) Themselves, as legitimate teachers of numeracy in a global learnscape (Brown & Hagel, 2005, cited in Cross, p. 38); and
c) The uncertainty in learning as a window of opportunity.

In this paper we combine psychological, sociocultural and poststructural understandings of the learning process to theorise our teaching and research. We assume that these three together tell a more complete, though more complex, story of the learning to teach process.

### *Appreciating Mathematics as a Science of Pattern and Order*

To our knowledge, no-one has ever suggested that teachers could teach well without knowing the mathematics; as affirmed by the *National Numeracy Review Report* (2008, p.

65): "Teachers need robust content knowledge to enable them to support, direct and guide their students". The content knowledge required for proficiency is delineated by the National Research Council (2001) below, and fostered in our subject, though the final one, the inclination to see mathematics as sensible, useful and worthwhile, is seen to be constituted in discursive practices rather than being a personal ability or characteristic.

- Conceptual understanding: comprehension of mathematical concepts, operations, and relations;
- Procedural fluency: skill in carrying out procedures flexibly, accurately, efficiently, and appropriately;
- Strategic competence: the ability to formulate, represent, and solve mathematical problems;
- Adaptive reasoning: ability for logical thought, reflection, explanation, and justification; and
- Productive disposition: habitual inclination to see mathematics as sensible, useful and worthwhile, coupled with a belief in diligence and one's own efficacy.

The construction of mathematical content knowledge is informed by psychological and sociocultural views of the construction of knowledge; it centres on changing cognitive structures and relies on a notion of the learner as rational and more or less autonomous (Goldin & Shteingold, 2001). Skills, understanding and abilities (as above) are individually acquired as the learner interacts in a linked but separate learning environment. Rogoff (1998, p. 687), for example, makes the point that "individual, interpersonal and cultural processes are not independent entities". Group collaboration is seen to enhance learning where, as Walshaw and Anthony (2008, p. 540) state: "The most productive discourse is that which allows students to access important mathematical concepts and relationships, to investigate mathematical structure, and to use techniques and notations appropriately".

However, while discourse can indeed be mathematically productive in this way, it is simultaneously productive of a student's identity and the sense one has of affinity with, and in, the discourse of mathematics. Student teachers in collaborative engagement with mathematical ideas can sense a deadening hopelessness with respect to how they are positioned within discursive practices. A student struggling to make sense of the mathematics, not able or expected to contribute to the dialogue, senses an alienation that is constitutive, affecting participation and practice. The learning landscape comprises power relations that form, to some extent at least, the numeracy teacher of the future; this is why we take *productive disposition*, as in the final point above, to be constituted rather than constructed as a personal attribute.

### *Becoming Legitimate*

A large part of our students' learning of mathematical content comes from collaborative inquiry; we focus on thinking and reasoning processes and making these explicit, on representation, justification and generalisation as key processes in learning. As made clear in the data below, the students are actively engaged in learning the mathematics in an on-line learning landscape. We draw on Lave & Wenger's (1991, p. 35) notion of communities of practice, and of learning as "an integral part of generative social practice in the lived-in world". But we are circumspect; learning, in the sense of constituted *knowing* (Lather, 1991) is not necessarily generative (at least in the sense we would want), and collaboration does not necessarily make for a quality mathematical experience. In pedagogy, everything is risky, though our aim is to manipulate power relations to the extent that we can to support students in realising themselves as legitimate teachers of numeracy. Walshaw and Anthony (2008, p. 535) mention the importance of positioning in power relations, and its relation to identity, by putting it this way: "The development of thinking depends not so much on the frequency of exchange structures but on the extent to which students are regarded as active epistemic agents. Developing students' thinking also enhances the view that students hold of themselves as mathematics learners and doers". These notions are primary in the analysis and interpretation of data below.

To operate with any sort of legitimacy, participants have to be accorded a real *presence* in the relevant discourse; they should be respected and valued for their participation and their contribution to the dialogue and other discursive practices. Active engagement involves power relations which regulate who gets to speak with authority, who is able to initiate discursive threads and make sense of experience in a personally meaningful way. Key to participation in numeracy education is that preservice teachers, in struggling to sense legitimacy in teaching, are supported in authoring or initiating a personally meaningful learning process. For the preservice teacher, the future as a legitimate participant of the teaching community, is made imaginable in the present.

### *Living With and Appreciating Uncertainty*

In this postmodern era, mathematics education is still largely informed by psychological understandings of the learner and the learning process; learning has a sense of certainty about it and only positive connotations, as does its corollary, teaching. Each presupposes a more or less autonomous individual, able to think rationally, make decisions and act accordingly. The learning context or environment is separate from the individual who, in some cases, (as in the case of a teacher) can supposedly manipulate it to produce more robust outcomes. This is a convenient reading of learners and teachers in context, as where there is a problem it can be sheeted home to an individual who is in some way deficient, mandating remedial intervention.

Poststructuralism displaces the rational humanist learner of positivist thought, positing instead one who is buffeted and/or aided in establishing oneself as a legitimate active participant in a discourse or intersecting discourses (such as those of mathematics and education). Whatever the discursive practices of teacher education, it is important in this postmodern era that strategies are chosen that uplift and empower prospective teachers, rather than exclude them from purposeful participation as previous mathematics education discourses may have done. To this end, in our first year numeracy education subject we prioritise the mathematics, while also paying careful attention to how well our interactions and teaching strategies support a developing sense of legitimacy as teachers of numeracy.

A component of this legitimacy, as previously mentioned, is that novice teachers take nothing for granted in respect to teaching and learning mathematics. Indeed, since participation and identity are constituted in discursive practice, it is to discursive practices they should turn (rather than blaming the individual) when learning outcomes are not met. Poststructuralist thought informs the ontological, the ways-of-being a teacher, and it seems important that a circumspect outlook in relation to what is learned and how should be constituted in teacher education. However, this is no mean feat as the preservice teachers tend to search for the *right* way to teach and the *correct* thinking process (Schuck, 1996).

## The Indivisibility of Learning Landscape and Participation

As previously mentioned, one important component of the learning landscape is the mathematical content knowledge we talk about, help students construct, discuss and display in daily interaction. We hope that our students will engage with this mathematics, and the tasks we set, as foundational to establishing themselves as teachers. As the students learn the mathematics they establish a presence in the discursive threads, and our task is to maximise participation, drawing in as many of the students as possible and ensuring that a respectful tone in interaction dominates. Some examples from the on-line discussion board include:

> Once again I am just determining if my explanations are on the right track.
>
> We had a chocolate bar. Sam has eaten 1/3 of it and Lucy took 2/9 home. How much of the chocolate bar is gone? (I know if it was my chocolate bar the whole lot would be gone, haha).
>
> We need to find a common denominator and what is done to the denominator must be done to the numerator also. So, 9 goes into both numbers so we multiply 1x3 and 3x3 as the 3 from the 1/3 goes into 9 three times and we multiply the 2x1 and 9x1 as 9 goes into the 9 from 2/9 one time. Our answer becomes 3/9 and 2/9 then we add the numerators to determine how much of the total chocolate bar has been eaten which is 3+2=5 so 5/9 has gone, or 5 pieces of chocolate from the 9 pieced chocolate bar have gone.
>
> Any feedback would be appreciated…
>
> H, you have it right. I have also just gone over this. Lucy took 2/9 home and Sam ate 1/3. 1/3 is 3/9 (as you worked out). So 2/9 + 3/9 = 5/9. Therefore, 5/9 of the chocolate bar have gone with 4/9 remaining. 4/9 + 5/9 = 9/9 or one whole chocolate bar.
>
> Speaking of chocolate, it must be time for some now. Keeps me going.

Kerry is aware of power relations in the immediate learning landscape and defers to the whole group before coming in; she values the reasoning process through which the preservice teachers hone their mathematical knowledge and perhaps glimpse legitimacy (Walshaw & Anthony, 2008) as future teachers. However, her students demonstrate diverse positioning in the discourse, at least in relation to the mathematics:

> Hi Kerry
>
> I am a bit confused because the question asked you to throw 2 dice and add the 2 numbers. If you add 2 odd numbers you get even, if you add 2 even numbers you get even and if you add 1 odd and 1 even you get an odd number. So wouldn't you be more likely to get 'even' as 2 odds equals even and 2 evens equal even?
>
> Confused

A student answers:

> The way I thought about it was that each die has 6 possibilities – 1,2,3,4,5 or 6. So 2 dice with 6 possibilities each = 6 (possibilities of die number 1) x 6 (possibilities of die number 2). Therefore, 6x6=36 complete possibilities. Don't forget, each step that you've shown on your representation has a reverse possibility ie 1+2 has another possibility, 2+1. If you draw a table (6 across, 6 down), then colour either odd or even, it becomes clear. I think the question was probably a bit misleading, as it hasn't qualified that you need to find *every* possibility, however it was probably worded that way to test our process of thought and depth of understanding. If you think about it in both representational (ie the table) & mathematical (ie the logic that 6x6=36), the light goes on. I'm probably a bit 'anal' in that I like to double check my results using an alternative method "just to be sure". This sometimes helps deepen my understanding & clear up any misconceptions an individual line of thought might create.
>
> Hope this helps…

Another feature of the on-line learning landscape is that it facilitates just in time learning, rather than just in case (Brown & Hagel, cited in Cross, 2007, p. 39); that is, students are able to access the knowledge they need when they need it. Deferring to the uncertainty surrounding learning, we embrace all sorts of instructional interactions that could help students access information how and when they need it. Intervention from peers is just one of the many avenues to which our students can turn in the learning landscape, and it is valued for the sense of community it fosters. A student (L) asks how multiplication and division of fractions can relate to *real world* examples and another student answers:

> This is how I've been tackling them which helps me:
>
> Multiplication of fractions: $^1/_3$ x ¼
>
> First step I do is to say it out loud and write it in word form. ONE THIRD OF ONE QUARTER
>
> The quarter represents a part of a whole and I need to find $^1/_3$ of the ¼. What is the whole?
>
> Representing ¼ shaded in of a whole (say pizza or pie) then allows me to divide that ¼ into thirds. Dividing all the other three quarters of the pizza or pie into thirds shows that I have 12 pieces altogether. Therefore the $^1/_3$ of the ¼ is actually $^1/_{12}$ of the whole pizza or pie.
>
> Mathematically, you then show your students that $^1/_3$ x ¼ = $^1/_{12}$ or (1x1) / (3x4)
>
> Multiplying a whole number by a fraction: $^4/_5$ x 20
>
> Say it out loud: FOUR FIFTHS OF 20. In this example you could represent the whole as a long chocolate bar, that has been partitioned into 20 pieces. We want to know how many pieces make $^4/_5$ of the bar. We know that $^5/_5$ (five fifths) also represents the whole bar which is the same as the 20 smaller pieces of the bar. Then by evenly dividing the 20 pieces into 5 even bits will show that $^4/_5$ equals 16 smaller pieces.
>
> Mathematically you can multiply both the numerator and denominators of $^4/_5$ by 4 = $^{16}/_{20}$. In this example you are working with equivalent fractions.
>
> Division by a fraction: 6 ÷ $^1/_3$
>
> Say it out loud: 6 DIVIDED BY $^1/_3$. We have 6 whole things that need to be divided into thirds. You could represent it by pies or chocolate bars. The result is that you will have a total of 18 pieces.
>
> Hope this helps
>
> Cheers
>
> E.

Kerry attempts to keep the conversations alive through being responsive rather than directive in her support, though the response below is an example and does not follow on from the comment directly above:

> …Let's think about this carefully. You have raised some real concerns here and if my child was feeling the consequences of confusing mathematical experiences I would be concerned too. Let's look at what the literature is saying first…

## The Indivisibility of Participation and Practice

From the data above one can get a sense of how participation fosters the construction of mathematical knowledge; some students are explaining, others are at the receiving end, though all are participants in the discourse. One might expect that the *explainers* are better positioned than the *receivers*, though this is not to be taken for granted as the latter clearly felt comfortable enough to ask. There are some problems with the language, one example is where H says 9 goes into both numbers (3, and 9); the pedantic educator would want to clarify this, though one would prefer a peer to ask another question for clarification. As teacher educators in what we see as a broad learnscape (Cross, 2007) we are not adverse to correcting or clarifying to enhance understanding, though we are always wary of *how* we go about it, as all learning experiences have a constitutive effect that influences the sense one has of legitimacy in a discourse.

On many occasions this developing sense of legitimacy is demonstrated as the preservice teachers talk personal relevance into their mathematical investigations:

> Thanks for your feedback, Kerry – what I'm enjoying about this subject (apart from the fact that maths is finally making sense to me!) is being able to apply the theory to real life situations (such as my children's education). What you've said makes a lot of sense and her teacher has likely introduced this method with the intention of retaining their understanding of place value, but when Candy tried to calculate 46+66 this way, she got totally confused with where to put all the numbers. I think what this might highlight is that she's not quite ready for this method yet, and needs some more practice with place value so she can grasp it in a meaningful way. Her teacher is very open to suggestions so I might approach her about how we can check …her level of understanding place value.

> Really appreciate everyone's thoughts on this – I don't know about everyone else, but I find I learn so much better when I apply the subject material to real life situations, and it gives me reason to really reflect on what I'm reading/learning and how best to apply it.

The students overall are happy with the quality of the learning experience, rate it highly in student evaluations of teaching (SFS), and thank Kerry for her facilitative role:

> Thank you for your invaluable time and the dedication you have put into this subject. I've had to relearn many ideas, but in doing so have learned that the world of mathematics is truly amazing. I'm grateful for having this opportunity to learn using the on-line facility.

## Conclusion

A poststructuralist analysis of pedagogical practice, for example the teaching of mathematics for numeracy, concentrates on two key concepts: power relations or positioning, and identity. These concepts are central because it is assumed that power relations unconsciously play out on preservice teachers' identity formation, which influences participation and their later teaching practice. While in this case feelings were positive regarding the preservice teachers' learning in the teaching for numeracy subject, we have to be circumspect. Foucault, for example, once remarked: "People know what they do; they frequently know why they do what they do; but what they don't know is what they do does" (cited in Foucault and Deleuze, 1972, p. 208).

We need to be cautious, because we know we can not fully pin down the effect of our pedagogical interactions with the student teachers. Learning to be numerate for teaching, especially given the past experiences of many of the preservice teachers, is a highly complex business. Certainly the students have been engaged in some rigorous mathematics; they have undertaken a lot of thinking and reasoning which has been made visible on discussion boards and in assessment projects. Their learning and engagement has been facilitated by Kerry who spent her own time chasing up students who did not demonstrate high levels of, and quality in, participation. The assessment process was labour intensive, with Kerry responding to student thinking daily on-line, and every three weeks to pieces of submitted work. It may be that the labour intensive nature of a subject such as this will ultimately make it unsustainable; technological advances are useful in their own way, though in first year subjects such as this it would seem they cannot compensate for a teacher who expects high levels of participation, who supports you all the way being constantly there for help and reassurance.

We are also cautious in taking anything for granted in relation to how our students will later interact with their pupils. As previously stated, we would want them to interact in ways sensitive to the uncertainty surrounding learning and the efficiency of teaching strategies; we would want them to nurture diversity in the many ways of making sense of mathematics and of all experience. We acknowledge the poststructuralist assumption that power relations in the learning landscape affect participation and later practice, but these students are in teacher education for such a short time in relation to schooling. Our only hope is that participation in teacher education evokes a blended sense of compulsion, challenge, pleasure and being worthwhile, such that these prospective teachers will work to reproduce it for their students.

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