What to Leave Out When Preservice Mathematics Education goes from Four Years to One: A Poststructural Account

Mary Klein
James Cook University
mary.klein@jcu.edu.au

With one-year teacher education programs for elementary and middle-school teachers becoming popular, teacher educators are put on the spot as to how novice teachers should be prepared for teaching mathematics. In this paper I delineate, and hold up to academic debate, epistemological and ontological assumptions that inform my teaching in a newly introduced Graduate Diploma of Education program. From a poststructuralist perspective the question becomes not one of what to leave out, but of how to vary instructional practices to produce competent, inquiry-oriented teachers of mathematics in less time.

As mathematics educators and researchers we live in confusing times. While there is renewed pressure on us to ensure that teachers exiting teacher education programs are well equipped to teach mathematics, the time given to do this has been considerably shortened. This is accompanied, especially in early childhood and primary teacher education programs, by growing concern at students' low levels of achievement and understanding in mathematics (Department of Education, Science & Training (DEST), 2003; Goulding, Rowland & Barber, 2002). To add fuel to the fire, notions of how mathematics should be taught have changed considerably, making it essential that preservice teachers turn away from a sole focus on transmission-type teaching approaches, to new inquiry based practices of which they have little prior experience, and rarely encounter on practicum rounds in schools. Though many preservice teachers are drawn to new teaching approaches at an intellectual level, in practice this transition is not easily made; students in preservice programs hold on to images of teaching that were formed in their own schooldays, which influence their classroom practice and engagement with other forms of knowledge (Calderhead and Robson, 1991). As Goulding et al. (2002, p. 698) found in their research "prospective teachers evidenced little or no sense of mathematics as an experimental test bed, in which they might confidently respond to an unexpected student question, 'I don't know, let's find out'. Lack of knowledge was accompanied by expressions of inadequacy, fear and even panic".

Yet another difficulty for teacher educators is that we do not have access to well researched and clearly articulated theories of how novice teachers learn to interact in ways that construct mathematics as an "experimental test bed" (Goulding et al., 2002, p. 698). As Adler surmises (in Adler, Ball, Krainer, Lin & Novotna, 2005, p. 378): "We do not understand well enough how mathematics and teaching, as inter-related objects, come to produce and constitute each other in teacher education practice". We neither fully understand what knowledge we should concentrate on, nor how we should relate differently to our students so that they in turn are able to interact in new ways in the classroom. It may be that the theories that have served us so well regarding the teaching and learning of mathematics as a discipline area, are not adequate to inform pedagogical change. For example, confidence is often placed in knowledge reconstruction and the socialisation of novice teachers into investigative or inquiry-based pedagogical practices; researchers speak of preservice teachers' "unlearning" (Ball, 1988) to teach mathematics, and leaving past mathematical "baggage" (Brown, McNamara, Hanley & Jones, 1999) behind them.

However, these notions rely on an intellect quite separate from its human host (in that it can be left behind) and a linear link between pedagogical knowledge and practice (old knowledge, unlearned, will be replaced by new knowledge that will have a direct impact on practice). As mathematics education and the theories and research that attend it front a new millennium, as the pressure to produce more competent, generative and innovative teachers of mathematics, in less time, grows (DEST, 2003), it may be timely to entertain complementary readings of how the teaching practices promulgated and anticipated in teacher education might eventually become more visible in schools.

A Poststructuralist Analysis

A poststructuralist analysis of practice offers an ontological perspective on how it is that one learns to be a different kind of teacher; in this case, one who interacts in investigative, or inquiry based ways in the classroom. Regardless of the mathematical knowledge the preservice teachers did, or did not, manage to construct, at school they were subjected to discursive practices that led to a constituted *knowing* (Lather, 1991) about how mathematics should be taught and learned. Through relations of power, the social world of the classroom inscribed itself on them, establishing teacher and text as dominant and themselves as learners as support or subsidiary to the smooth operation of the school mathematics discourse. A poststructuralist lens focuses on these discursive and regulatory practices and attempts to make visible how they construct and maintain binaries (teacher/student; powerful/powerless; adult/child) by granting rationality or normalcy to the first and dominant term. Although the coupling of the authoritative teacher and the subservient learner did not always operate in the students' best interests, they take up these relative positionings as their own, and see them as highly desirable (Davies and Gannon, 2005). The ways in which preservice teachers make sense of how mathematics is taught are intrusions from past school days, and they "defend them and desire their maintenance" (Davies & Gannon, 2002, p. 319).

This notion of the discursive production of new teachers presents a particular problem for teacher education, evidenced in a number of ways. First, prospective teachers have been constituted through regulatory teacher actions in the classroom; many of them want to be shown the mechanics of teaching mathematics, so that they can take up what they see as their proper position as teacher in the classroom, getting across the knowledge their pupils need to know. Related to this is the preservice teachers' constituted sense that young learners have to be cared for, nurtured and motivated through a 'child centred' teaching approach that focuses on play and physical activity. For example, an early childhood teacher was observed giving a lesson on fractions, where the emphasis was not on the conceptual idea, but on cutting up neatly and the fruit as a 'real world' representation (Gellert, 1999). In my own teaching I am often confronted by student teachers who ignore the mathematics in an effort to make activities supposedly more attractive to pupils; for example, one insisted on using counters of many different colours on the ten-frame, rather than the usual two colours (to represent two addends) — her argument was that it looked 'prettier'. Novice teachers use the positive connotations of prettiness, play and child-centredness to engender motivation: "But they overlook that this is only situation-bound interest focusing on the wrapping and not on the mathematics content" (Gellert, 1999, p. 37). A similar manifestation of constituted knowledge arises in some novice teachers' over-emphasis on having 'fun' in mathematical activities. Because their own experiences of learning mathematics were not entirely fulfilling, they attempt to turn this around for their pupils (Brown et al., 1999); however, in classroom practice, having fun tends to involve lots of competition and games in which pupils need to know the answers before they can participate. Again, such activities involve little depth of mathematical thought, and this goes unchecked when supervising teachers, often consumed by management and other issues, do not even comment on the quality of the mathematics being taught (Brown et al., 1999).

It was Ball (1988, p. 40) who first drew to my notice the fact that "…lack of attention to what teachers bring with them to learning to teach mathematics may help to account for why teacher education is often such a weak intervention — why teachers, in spite of courses and workshops, are most likely to teach math just as they were taught". However, while I agree with the sentiment, poststructuralist proclivities do not allow me to imagine that new instructional practices will evolve from cognitive (re)constructions or 'unlearning' old patterns as Ball (1988) suggests. Rather, new teaching-learning patterns can only grow out of experience in new discursive relations and practices; in teacher education, something is needed that "plugs into the economy of desire" (Venn, 2002, p. 66). That is, novice teachers will work in investigative, inquiry-based ways in the classroom only when they have established an embodied sense that this is how mathematics education should be done. Where once change was sought through discourse (noun), attention now also turns to the operation of the discursive practices (verb) of teacher education.

Teaching in the Graduate Program

2006 is the first year of implementation of a Graduate Diploma of Education (Grad Dip Ed) in the university where I teach. It is undertaken by prospective teachers in one year following a degree in another discipline area. In the program there are 55 students with previous experiences including those of a cartographer, an engineer, a barrister, interpreters and translators and information technology specialists. Graduates of the program are able to teach pupils in Years 1-10. However, curriculum studies are not broken up into eight key learning areas, as in undergraduate programs, but focus on transdisciplinary study across content areas. In ED5223: Curriculum 1, I teach with academics and classroom teachers from science, information and communication technologies and health and physical education with pedagogic inquiry and 'constructivist' learning approaches as a key transdisciplinary tie. The prospective teachers are in schools two days each week over the year long course, and my work with them spans the first six months.

While my teaching seems to proceed along similar lines to that of other academics in the program, mine is informed by a poststructuralist belief in the constitutive force of discursive practice. That is, I assume that while at one level the discursive practices I engage in with students are coercive (I coerce them in to thinking in particular ways about mathematics, and about how it might be taught), at another level these practices are constitutive and need to operate in ways that support students' recognition of themselves as competent and confident teachers, in process. The teaching and learning environment I attempt to set up and maintain comprises three key elements; mathematical and pedagogical content knowledge, relations of power that position prospective teachers as valued participants and initiators of dialogic streams, and a culture of incessant and relentless inquiry regarding taken-for-granted assumptions about learners and learning mathematics (Fig. 1, below). These three elements are intersecting and co-constitutive, and with/in these the students struggle to establish themselves as legitimate and recognisable teachers of mathematics. My aim is not to fill these students with mathematical and pedagogical knowledge, but to encourage them to establish themselves as particular kinds of teachers of mathematics, willing and able to interact with their students in generative ways in the classroom. The diagram below shows the three intersecting elements graphically:

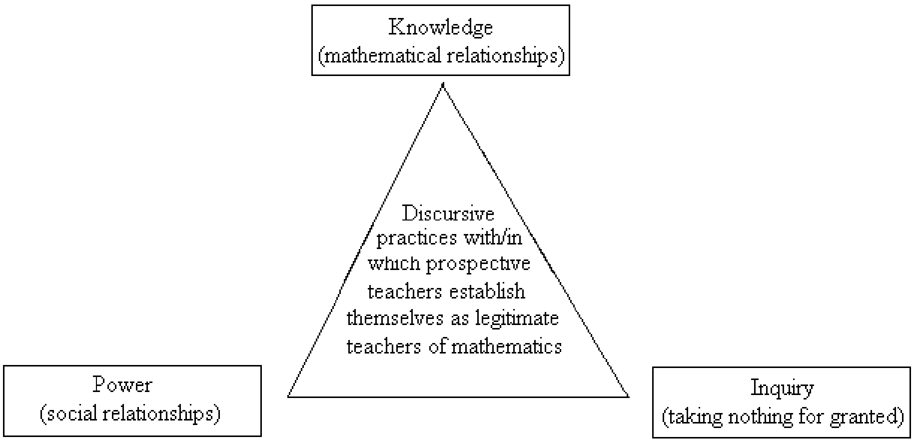

Fig 1: Intersecting elements of classroom practice

Knowledge

For prospective teachers to accomplish themselves as legitimate members of the teaching profession, they must have a mathematical (in this case) and pedagogical knowledge base. However, as soon as one attempts to make suggestions regarding the nature of this foundational knowledge, all sorts of problems present themselves. For example, many of the graduate students already have a strong formal mathematics background, while others do not. As well, what they have learned would probably have been done through instructional techniques now considered inappropriate. Then there is the perplexing problem of whether what is discursively produced as quality teaching of mathematics in the academic setting is similarly regarded in schools; the preservice teachers run the risk of having to develop dual identities to serve different masters. Added to all of this, of course, is that the time to do anything at all is limited.

What I have decided to do with the little time I have with the students is to concentrate on the order, structure and relationships of mathematics; the knowledge that is centred is the recognition, understanding and explicit teaching of mathematical relationships. While I will discuss *how* the workshops proceed in the following section, my reasoning behind this decision bears further elaboration and consideration. First, mathematical relationships are seen to be key in policy and curriculum documents, published by the educational authority under whose auspices most of the prospective teachers will work. On one hand it was thought that this would give what was to be studied some credibility, and on the other, it could potentially serve as a focus for classroom practice on teaching rounds. While many of the novice teachers would be quite adept at using the structural properties of mathematics in their day-to-day activities, they would be less certain of teaching interventions to make these explicit for their pupils. Second, there was the hope that a growing recognition of the power and regularity of mathematical thought would facilitate engagement by the intending teachers, who might come to see the learning and teaching of mathematics as a worthwhile endeavour. However, as previously mentioned, many have had experiences of learning mathematics that have not been entirely satisfying, and this *knowing* about mathematics (Lather, 1991) will no doubt influence engagement. Third, the focus on pattern and relationships would give the preservice teachers something to teach…something relevant to the classroom and perhaps something of which they know as much as the classroom teacher. My hope, in planning the program, was that they would be able to grab on to something to teach, and sow seeds of the structure, regularity and generality of mathematics in primary and middle schools. But as Goulding et al. (2002, p. 702) caution:

> This will only happen if the teacher appreciates how these ideas underpin the regularity of the number system, flexible methods for number operations and patterns in sequences. Mathematical proof is based on rationality and reasoning: it is about convincing mathematical argument, with roots in questions such as 'will that always work?', 'why is that?' and 'Can you explain that to someone else?' If students do not experience these enquiries themselves, how can they hope to encourage mathematical questioning in pupils?

Social Relationships

This quote (immediately above) leads then to consideration of the constituted *knowing* (Lather, 1999) about mathematics and themselves that informs how novice teachers are able to interact with students in classrooms. My sense is that in teacher education they need to experience new notions of what it means to teach and learn mathematics, based on social-constructivist approaches. However, this has been tried before (Foss & Kleinsesser, 1996) and can not be relied upon to ensure changed classroom practice. In this program, rather than trying to implement or emulate a particular teaching method, emphasis is placed on getting the previously documented elements (Fig.1) of the learning environment working together to support the students' professional and mathematical knowledge growth. From a poststructuralist perspective, *how* one interacts with preservice teachers is seen to matter (as it is constitutive), and I attempt to bring together new notions of what mathematics is, and how it might be taught and learned, in an environment that respects and values the new teachers (in process) as equal participants. The aim, of course, is to have them recognise themselves as generative and insightful beginning teachers, comfortable with new, investigative ways of working with learners in classrooms.

However, many of the students have little knowledge of flexible, self-generated methods of computation, and lack competence and confidence in the use and power of mathematical patterns and relationships in the construction of understanding. As previously mentioned, this is the knowledge I intend to focus on, as I attempt to have the students bring new notions of teaching and learning mathematics together. Practically speaking, workshops begin with students working for 10 minutes or so, in small groups, on an investigation. They attempt the inquiry from "what they think a 10-year old (or any age up to Year 10) might be able to produce". The investigations are simply worded, and vicarious, in that the preservice teachers are to answer in terms of what they imagine a student of theirs might do; in this way, any shortcoming in relation to the mathematics is not so obvious and can be interpreted in terms of a lack of knowledge of developmental levels. In this ten minutes (the time varies), there is no input from the lecturer, and s/he does not comment on the findings they share after the investigation. The students ask each other questions about the conclusions they report, and may indicate disagreement in some cases; this is accepted and there is no arbitration. Whether or not this will have a positive impact on their teaching of mathematics is yet to be determined, but from a poststructuralist perspective, it is assumed that these experiences give the students some sense of what mathematical and pedagogical inquiry looks and feels like.

After the investigation or inquiry, there is an analysis of the work the preservice teachers have produced. At this stage, the lecturer has more input, and works with them to determine the mathematics that has been constructed, and to discuss pedagogical interventions that might extend and deepen understanding (this may be of a particular pupil or the class). In this program, emphasis is on making explicit how the mathematics produced demonstrates the order, regularity and generalisability of mathematics. The use of models and other activities are suggested to extend and deepen this understanding. The preservice teachers engage in some of these activities, and attempt to make connections to other mathematical ideas and 'real world' applications. Askew et al. (1997, p. 3) found that teachers who had "knowledge and awareness of conceptual connections" tended to produce the highest numeracy gains in pupils.

It is also important that assessment procedures in this program do not stifle inquiry and the students' avid construction of pedagogical and mathematical knowledge. An emphasis on auditing knowledge could have a demotivating effect (Goulding et al., 2002). In this case the assessment is the compilation of an e-portfolio through which the students have to demonstrate their accomplishment of the Professional Teaching Standards. The standards whose criteria are met in ED5223 are that graduates of the program will:

- Possess and be able to apply professional and disciplinary knowledge bases, and
- Exhibit the skills to create supportive and intellectually challenging learning environments to engage all learners.

In this way, the students are able to choose any work they have done in schools, the community or at university to demonstrate that they have met the various outcomes delineated under each criterion. This knowledge is revealed to a panel of educators at the end of the semester.

The Inquiry

As previously mentioned, I have a sense that we need to understand much more about how intending teachers, constituted through discursive practices of teacher authority and the transmission of knowledge, can come to interact in inquiry-based ways with pupils in classrooms. From a poststructutalist perspective, we can not assume a direct link between preservice teachers 'doing investigations' in teacher education and the implementation of an investigative culture in schools. The latter involves a measure of autonomy or agency that can not be taken for granted, since it is influenced by far too many intervening variables, not least of which are preservice teachers' romanticised notions of learners and regulatory ideas of what learning mathematics entails. Added to this is the fact that although 'doing investigations' in teacher education has an intended intellectual purpose, the process itself comprises relationships of power (teacher/student binaries) similar to those experienced in learning mathematics in school. Although the preservice teachers construct new mathematical and pedagogical ideas, they are subject to relations of power that maintain the teacher/student; knowledgeable/lacking knowledge binaries. To the extent that these relative positionings are formative or constitutive of the mathematics educators of the future, old authority relations endure and novice teachers will probably continue to transmit the knowledge they imagine their pupils need to know.

However, there may be a small window of opportunity for teacher education to accomplish something quite different from what has been attempted in the past. Professional identities and practices are not set in stone, and are amenable to influence by all manner of discursive practices. New mathematics educators are produced in social spaces where power and knowledge circulate unpredictably and where identities are always tenuous, in process, vulnerable (Davies & Gannon, 2005). As Butler (1997, p. 14) suggests:

> As a subject of power (where 'of' connotes both 'belonging to' and 'wielding'), the subject eclipses the conditions of its own emergence; it eclipses power with power…the subject emerges both as the effect of a prior power and as the condition of possibility for a radically conditioned form of agency.

New teaching-learning patterns grow out of new discursive relations and practices, with interesting and challenging implications for teacher education. Our task becomes not only epistemological, but also ontological in making it possible for preservice teachers to acquit themselves as particular kinds of teachers in schools; teachers who prioritise investigative processes of thinking and reasoning mathematically, over procedure. A poststructuralist assumption is that such teachers are produced in discursive relations founded on incessant questioning and inquiry as to the taken-for-granted of teaching (mathematics). Preservice teachers want to know the facts about how teaching should be done, and the facts are that there are many ways of ensuring pupils in schools have a rich experience of learning (mathematics); to this end uncertainty enters the equation, as only out of uncertainty can new possibilities and practices arise. Such a cultural change is not expected to be easily achieved nor is it likely to be particularly welcome in teacher education; however, in mathematics education the rigour and structure of the mathematics (epistemological) as a disciplinary field need not be reflected in the pedagogy (ontological). Second, for intending teachers to value the learning process (over procedure) they must recognise its productive (constitutive) potential; that is, they should come to appreciate how in discursive relations mathematical and professional identities are born. Preservice teachers could begin to sense the constitutive force of discourse by recognising their own constitution as historically specific and socially regulated, and thus able to be called into question (Davies & Gannon, 2005). They could ponder and share how particular ways of being a teacher of mathematics are convincing and compelling, and others not. As they become aware of the constitutive force of previous and current discourses, and strive to become recognisable (to themselves and others) as teachers of mathematics, they may sense the vulnerability of learners denied an energetic and active presence in learning mathematics.

Conclusion

From the research that has been done in mathematics education we do have a good sense of what 'quality' in classroom based teaching looks like; what we do not know is how such teaching might become commonplace in schools. It is here that poststructuralist theorisations of the constitutive force of discursive (pedagogical) practices can make a contribution. My teaching is based on two core assumptions: one is the importance of having novice teachers explicitly recognise the order, structure and relationships of mathematics (epistemological). A second assumption (ontological) has to do with social relationships and suggests that preservice teachers' ways of interacting with students in classrooms, ways-of-being a teacher of mathematics, have less to do with theory and policy than their previous (and current) experiences of institutionalised teaching and learning. This latter, poststructuralist belief in the constitutive force of discursive practices, causes me to think not only about *what* knowledge is important, but also about *how* to engender a change towards inquiry-based, investigative teaching practices in the new, classroom based mathematics educator. I surmise that the only thing that can be left out of my practice is any sort of certainty that contemporary theories and research in mathematics education adequately inform this change.

References

Adler, J., Ball, D., Krainer, K., Lin, F-L., & Novotna, J. (2005). Reflections on an emerging field: Researching mathematics teacher education. *Educational Studies in Mathematics*, 60, 359-381.

Askew, M., Brown, M., Rhodes, V., Johnson, D., & William, D. (1997). *Effective teachers of numeracy*. London: King's College.

Ball, D. (1988). Unlearning to teach mathematics. *For the Learning of Mathematics*, 8, 40-48.

Brown, T., McNamara, O., Hanley, U., & Jones, L. (1999). Primary student teachers' understanding of mathematics and its teaching. *British Educational Research Journal*, 25(3), 299-322.

Butler, J. (1977). The psychic life of power. Stanford, California: Stanford University Press.

Calderhead, J. & Robson, M. (1991). Images of teaching: Student teachers' early conceptions of classroom practice. *Teaching and Teacher Education*, 7, 1-8.

Davies, B., & Gannon, S. (2005). Feminism/Poststructuralism. In B. Somekh & C. Lewin (Eds.), *Research methods in the social sciences* (pp. 318-325). London: Sage.

Department of Education, Science & Training (DEST) (2003). *Australia's teachers: Australia's future: Advancing innovation, science, technology and mathematics.* Canberra: Department of Education, Science and Training.

Foss, D., & Kleinsasser, R. (1996). Preservice elementary teachers' views of pedagogical and mathematical content knowledge. *Teaching and Teacher Education*, 12(4), 429-442.

Gellert, U. (1999). Prospective elementary teachers' comprehension of mathematics instruction. *Educational Studies in Mathematics*, 37, 23-42.

Goulding, M., Rowland, T., & Barber, P. (2002). Does it matter? Primary teacher trainees' subject knowledge in mathematics. *British Educational Research Journal*, 28(5), 689-704.

Lather, P. (1991). *Getting smart*. London: Routledge.

Venn, C. (2002). Refiguring subjectivity after modernity. In V. Walkerdine (Ed.), *Challenging subjects* (pp. 51-71). Houndmills: Palgrave.