

“THE POETRY OF THE UNIVERSE”: NEW MATHEMATICS TEACHERS’ METAPHORIC MEANING-MAKING

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Contemporary metaphor theory here provides a framework for an initial exploration of metaphoric language used by pre-service mathematics teachers to describe mathematical knowledge and learning. Taking metaphoric expressions used by student teachers in early course assignments I begin to consider the affordances and constraints that arise from meanings of mathematics structured by these metaphors and will consider how these might relate to student teachers’ beliefs and impact upon their emerging practice.

INTRODUCTION

Studies in (mathematics) teacher education have questioned the extent to which programmes of initial teacher education can challenge mathematics teachers’ dispositions (Brown & Borke, 1992; Grouws & Schultz, 1996). Social and educational backgrounds have a considerable influence on the emerging teaching dispositions and practice of new teachers (Noyes, 2003) and it is important for student teachers and those involved in their professional development to acknowledge and critique this tendency. In order to expose these influences students are required to submit, in the first week of the PGCE secondary mathematics course, an assignment exploring their ‘starting’ position as teachers. They are expected to write about their experiences of learning and using mathematics - both at school and in their lives more generally, about teaching and about the nature of mathematics itself.

The way that mathematics is taught varies depending upon location, both geographically and culturally; at an international level (for example Stigler & Hiebert, 1999), but also at a national level. Children have different experiences of growing up, of schooling, and of learning mathematics. Consequently, a cohort of forty to fifty student mathematics teachers will have a diverse range of mathematical histories, these being dependent on schooling and the wider social background. The mathematics teacher belief literature reports the complex relationship between beliefs about mathematics and teaching practices. Thompson’s (1992) summary points out that professed beliefs are not always an accurate reflection or indicator of classroom practice but considerable evidence associates beliefs and practices. She commences her work with Hersh’s assertion that:

One’s conception of what mathematics is affects one’s conception of how it should be presented. One’s manner of presenting it is an indication of what one believes to be most essential in it...The issue, then, is not, What is the best way to teach? but, What is mathematics really all about? (Hersh 1986, p13, cited in Thompson, 1992, p127)

Within the aforementioned student' assignments, focused in part on the nature of mathematics, students describe their mathematical histories and beliefs with a great variety of metaphoric expressions. This paper will try to draw some of these together under a few overarching root metaphors. Following contemporary metaphor theory, I contend that the metaphoric expressions used to describe mathematical knowledge and practice relate to individual's personal beliefs about mathematics and thereby probably relate in some way to pedagogic practice. However, this 'think piece' does not seek to validate the claims that it makes but rather proposes further avenues for inquiry.

With this fundamental interrelation between metaphoric systems and knowledge I want to explore the affordances and constraints of the metaphors most commonly found in the students' work. Consider, for example, two of the students' metaphors: if *mathematics is a toolkit* (reflecting an instrumentalist view of mathematics), what meaning of mathematics can and can't be constructed with it, and compare this with where one can or cannot get to if *mathematics is a journey*. The following discussion is necessarily brief but does outline some issues arising from such a topological analysis. At the same time I acknowledge that these metaphors are not mutually exclusive nor do I currently have sufficient data to categorise students or relate their metaphoric expressions to other psycho-social factors or teaching practice.

METAPHOR

Over forty years ago Black (1962, cited in Ortony, 1993) presented an *interaction* view of metaphor in critique of the then prevailing *comparison* view of metaphor. This theoretical shift has since been followed by further developments towards a 'contemporary metaphor theory'. During that period of development Elliot (1984) asserted that education metaphors' "incompleteness makes them flexible instruments for communication, but they lack depth"(p.39). However, this (metaphorically framed) perspective failed to acknowledge the theoretical developments that were taking place at the time. The *depth* that Elliot considered to be missing has in fact been shown to be so fundamental and taken for granted that it often goes unnoticed. More than that, such deeply ingrained metaphoric language is a means of transferring meaning from one context to another. Consider the example *education as market*. The language of markets and economics has seeped into education discourses throughout the world (Apple, 2000; Gewirtz, Ball, & Bowe, 1995). Through the use of such a conceptual metaphoric schema perceptions of the meaning of the education system are changed. This as an example of a generative metaphor (Schön, 1993)one which has power to actually change the way people think about, and consequently act, concerning education. Schön's examples from social policy urge the use of alternative metaphoric frames, which themselves might lead to frame conflict and subsequent restructuring. The same intention is very apparent in Thomson and Comber's (2003) *reframing* of the discourse around disadvantage, and in Sfard's (1998) warning against relying solely on one metaphor to conceptualise learning.

Conflicting metaphoric frames could be utilised in a similar way to challenge (new) teachers' already well-established beliefs.

Lakoff and Johnson's (1980) early work in this field demonstrated how language employs metaphorical constructs to build meaning on the basis of prior conceptual understandings. Through a series of detailed studies of English' root metaphors they demonstrated how all meaning making sits upon a foundation of metaphor. That pioneering work was supported by Reddy's (1993) exploration of the *language as conduit* metaphor, with its critique of the damage caused by such an all pervasive, unproblematised metaphoric language system. Lakoff's (1993) later work reports a thorough account of metaphoric systems in everyday thought and language.

Metaphors (i.e. the root metaphors, for example *life is a journey*) are not primarily linguistic tools but are conceptual mappings. He describes three main types of metaphor image schemas: "containers, paths and force-images" (p. 228) and it will be useful to see how these relate to what I consider to be the root metaphors in the students' narratives concerning mathematics.

A METAPHORIC FRAMEWORK

The range of metaphoric statements used by student teachers is extensive but themed under what I have already described as the key or root metaphors. I take each of these root metaphors and explore them in some detail, using the students' own scripts as exemplification. I have brought together these metaphorical descriptions under four headings: mathematics as structure, language, toolkit and journey. The metaphors of, and associated with, mathematics as toolkit and as language are predominant in the student narratives.

Mathematics as language

That mathematics is considered to be a language is evident in a large number of students' scripts. Moreover, as a language it is considered to have properties of internal logic and is useful for describing and communicating. Indeed, with regards the latter the students variously consider mathematics to be "the international language":

What is most important to me is how it is universally understood by all across the globe. Mathematics is...a language in its own right. (PC)

For me Mathematics is the poetry of the universe... To put Mathematics in context with other disciplines: maths is the poetry of everything, or the language with which everything communicates with everything and how it relates to everything. (SE)

There is a strong sense of the pre-existence of this language, and when described as *the language of the universe* it appears to have a self-existence, embodied in nature itself. This positivistic pantheism, elevating mathematical language to an almost divinic status (e.g. "God is mathematics" (IR)) mirrors Lerman's (1990) description of mathematics as "the last bastion of absolutism":

Whether people like it or not maths is everywhere. (AB)

Mathematics can exist without real life situations, maybe even without people to invent it. It certainly is argued that mathematics is discovered like a truth about the universe, rather than invented like a language ... (maths is) a mystical world of its own. (JG)

This self-existent quality of mathematics means that it can act almost like a teacher itself:

Mathematics has made me a logical thinker. (BC)

Mathematics teaches clear and logical thinking. (SY)

So for many of these students mathematics is not simply a pre-existent language but it seems to be able to speak for itself. They explain that this language is useful for describing the world and is a means of interpreting the world around us. However, there is still the sense in this usage that the world can be interpreted using mathematics because mathematics is itself ‘the language of the universe’, and so the process of coming to know mathematics is akin to ‘tuning in’ to the voice of nature.

As “the last bastion of absolutism”, such positivistic assertions concerning mathematics could lead to a sense of superiority. If it is *the* language of the universe; the ultimate means of description and understanding, then those who can understand and speak this language are in a privileged position. If it is merely another humanly constructed language of description and communication then it has different relative importance in the field of knowledge. Furthermore, if it is a language to be learned, then how should it be learned, through use or through study of its grammatical structure?

Mathematics as toolkit

The idea that mathematics is a toolkit, or set of skills, is the predominant discourse of student’ conceptions of what mathematics is. Mathematics has utility!

It is perfectly reasonable to view mathematics as a toolkit, a bag of rules, methods and conventions that we can use to model, interpret or change the world around us. (SA)

As well as being useful these tools can be “powerful” (DP) which reflects the measure of status afforded to mathematics in the previous section. In order to be able to use these tools correctly children are described as needing to practice their use. There is a standard set of *tools* that are introduced to children and then they need to develop expertise in a) tool use and b) tool selection. Children who achieve technical mastery with this tool set will be able to move on to use more dangerous tools, or perhaps specialise their *trade* with a particular subset of the mathematical toolkit. The student teachers do not explain how these tools came to be or whether children can invent new tools to do a better job.

This metaphor is used much more in the context of solving problems, as an odd-job tool kit, rather than the way in which an artisan might create something new with tools. So mathematics is described by these students as being the tools themselves rather than the artefacts created by the use of the tools.

These instrumentalist perspectives betray an attitude to mathematics that is necessarily useful and has to be relevant to real life problems. Very many applicants to the PGCE course find the idea that maths *is useful for everyday life* a difficult concept to defend, critique, or convince children of. For many student teachers this metaphor indicates that teaching (children how to use) mathematics is an apprenticeship where they, as the expert tool user, will pass on their trade secrets to children, jealously guarding the traditional ways.

Mathematics as journey

This root metaphor, which might more accurately be ‘learning mathematics is a journey’, is not as common in the students’ descriptions of mathematics as the previous two metaphors but it tries to explain the process of mathematical learning. There is some overlap with the structure metaphor (below), particularly with regards the fallibilist (Ernest, 1991; Lerman, 1990) conception of historically constructed mathematical knowledge structures. Here, journey is a process that includes places and timings, obstacles and short cuts, dead ends and all too often, going around in circles. Some learners are understood to progress more quickly than others, some get stuck or are hindered, and others never get through to reach the desired destination. Many of the teachers’ personal stories contain references to getting ahead, or going faster, on this journey and relate this to their emerging liking for the subject during childhood. For the majority of new teachers the route is pre-planned as in this example:

Mathematics is a journey, understanding one step leads to another, and each step relies on the existence of the previous one. This journey, for me, is what Mathematics is all about...How far each individual chooses to travel is up to him or her, but all must take the same initial steps. At a later stage the path begins to split as different areas of mathematics become more defined but again the first steps must have been taken for travel to continue...The purpose of mathematics as a school subject is to demonstrate to pupils the significance of all of these paths and to invite them on the journey. It is then our job to make the journey exciting and eventful and each destination a memorable achievement. (CF)

So what is important here is not how one travels or which route one takes but “how far” individuals travel. The advent of the UK National Curriculum in the late eighties, and more recently the Framework for Teaching Mathematics, has made the official route much clearer. These official documents mark the way for journeying school mathematicians. Many of our student teachers completed their secondary mathematics education with the influence of such maps and route plans. In this respect there is some conflict between their tutors’ perspectives, who were much more mathematical explorers and pioneers. When the student teachers complete their school placements they discover that oftentimes tutors’ tales of mathematical explorations are a far cry from the well-worn track that they now so often have to follow.

A related image is that of climbing a ladder; children learning mathematics go up the hierarchical ladder rungs only moving up to the next rung when they are firmly

positioned on the previous one. To go down to a previous mathematical idea is negative and acceptable attainment at the end of compulsory schooling is rung X. Such a conception of the hierarchical nature of mathematical knowledge is of course the language of National Curriculum levels, a fiction themselves. However, as part of a generative metaphoric structure they have created meaning and are part of a frame that needs continued critique and restructuring.

Mathematics as structure

Again, like the above metaphor, the *mathematics as structure* metaphor is not seen in its root form but many related metaphoric expressions can be seen in the students' work. Mathematics is described as a building; a network; a framework; as branched; as a fabric, and so on. Some of the references are concerned with the mathematical ontology itself whilst others are more concerned with the epistemology of coming to know.

Mathematics is a building block. (EB)

Mathematics is taught because it underpins a great many other subjects that are taught at school and beyond. (JP)

In addition students describe mathematical tools as keys, keys that presumably open up this building of knowledge. The students' ascription of priority and significance can be seen again here in the notions of foundations or underpinning. The claim that mathematics 'underpins all of life' is fantastical as all of life is not compatible with a foundation that mathematics could provide. This echoes the 'maths is *useful* for everyday life' myth that seems to permeate student teachers discourse.

Similar notions are envisaged in the idea of mathematics as a framework, it is something upon which a more substantial construction can be built. The difference in this image is the reduction of hierarchy and the increased inter-linking. It differs from the notion of network in that a framework is something that is built upon or extended/expanded whereas a network describes a more self-contained structure:

The fact that mathematics is a vast network of ideas to explore remains one of my favourite aspects of the subject and I found the teachers who used exploration and discovery to bring the subject alive were among the best I was taught by. (VN)

This usage was unusual (as was the idea of exploration). Interestingly, VN is perhaps the most highly qualified student on the course and her initial ideas about teaching mathematics show how, at least in theory, her beliefs seen through this metaphor relate both to her experience, personal philosophy and notions about good teaching. The image in this network of mathematical knowledge is that the links are as valuable as the nodes, i.e. knowledge is as much contained in the linkages of the network as it is in the separate ideas.

One more thing to include within this section, although it could perhaps be situated within the *mathematics as language* section, is the notion of the aesthetic value of

mathematics. Many students describe mathematical structures as beautiful, which is arguably an image is not associated with a *mathematics as toolkit* metaphor:

And its nature is elegant and beautiful. (RO)

However my interest in mathematics is not only because of its applications and its power, I think it has a beauty and fascination of its own. (CS)

These two quotes reflect the self-existence of mathematics described above.

CONCLUDING COMMENTS

Of the four groups of metaphoric expressions discussed above, Lakoff's three image schemas can be seen: the *structure* metaphor is a 'container', whilst the *journey* is a 'path' and 'force' is represented in the metaphor of *toolkit*. The first metaphor I presented was that of language and I would suggest that this fits more with the former and latter of Lakoff's categories. Reddy's analysis of language as a conduit is similar to the notion of mathematical language as a container of mathematical concepts. Also language has power in the same way that the students' consider mathematics to have power or pre-eminence.

Why these metaphors? Why not other path metaphors? For example, why does the notion of journey appear more commonly than that of exploration for these UK pre-service mathematics teachers? Why is the *mathematics as toolkit* metaphor so predominant, and to what extent is that subject to cultural variation? As I have shown within each of these root metaphors there are a range of metaphoric expressions and different meaning arise from their various uses, for example *journey* or *exploration*, *network* or *foundation*. Conceptual shifts within these metaphoric spaces might lead to changes in belief and an associated self-critique of student teachers' developing classroom practice.

That mathematics is seen to be a toolkit fits with teacher belief research, where an instrumentalist view of mathematics and mathematics teaching is acknowledged to be prevalent amongst new trainees. Platonist absolutist beliefs can also be seen threaded through these metaphorical tropes. However, a number of questions arise from this brief examination. How have these metaphoric systems developed and can they be changed? If, through the use of alternate generative metaphors, teacher educators can create conflict situations that might shift meanings of mathematics, how might this affect the conceptual positioning of new teachers and their subsequent teaching? How strong are official discourses in the promulgation of the current metaphors and can they be countered (NC levels are such an example)?

Liston and Zeichner (1991) urge teacher educators to engage new trainees in critical reflection of their beliefs and the social conditions in which they are developing as teachers. A critical examination of the metaphoric construction of their beliefs, as theorised by the contemporary theory of metaphor, provides another means of challenging teachers during their early socialisation into (mathematics) teaching.

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