**Transformation of Learning Capacity seen as organisation and extension of spaces of learning**

Anne Watson

*Using the metaphor 'space of learning' developed by Ference Marton and his colleagues, I present a way of thinking about learning that offers tools to transform the intellectual activity of learners.*

Mathematics is a system of quantitative and spatial relationships and generalities. Such relationships and generalities themselves become objects with properties which relate further to other objects. Hierarchies of ideas develop, both historically and in learners’ understanding. The communication of these relationships and properties is through examples from which learners form generalities, and through general statements which learners experience through examples. Thus a learners’ mathematical understanding is both enabled and limited by the range of examples they have experienced, and the generalities that are named and described to them, or by them.

Marton’s view of learning is that it involves the discernment of variation in what we perceive, and that different aspects of an ‘object of learning’ are experienced because of different decisions about variation. In mathematics, for example, the collection of straight line graphs given by: y = x + 1; y = x + 2; y = x + 3; y = x + 4 would be perceived to vary in position, whereas the collection y = x; y = 2x ; y = 3x; y = 4x would be perceived to vary in slope. The first set does not afford learning about gradient, the second set does not afford learning about intercept. Marton calls the ‘space of learning’ the nature and amount of variation offered to learners, and of course this includes aspects which are invariant as well as aspects that vary, and also much irrelevant information which the learner has to recognize as such.

This idea of ‘space of learning’ as something a teacher can construct is very helpful when thinking about how to help students to learn mathematics. Obviously there are many features of classroom life, interaction strategies, social and emotional framing, and motivational devices that can make a difference to learning, but at the heart of a mathematics lesson is the need to learn new relationships, generalities and abstractions. Teachers’ choices in the questions they ask, the examples they choose, the aspects they draw attention to frame the space of learning for the student. It is therefore possible for a teacher to construct more extensive, or more limited, spaces than the students’ existing experience. Sometimes it is more useful to limit the space, such as in the graphs above, in order to focus on distinct features; sometimes it is more useful to extend the space, in order to introduce new possibilities. Whatever the decision, the structure of the space (the way that individual examples relate to each other through variation) is critical. If every example learners see is different from the one before in several aspects, there will be nothing to observe about structure, but if examples are too similar (such as all squares sitting parallel to the page edges) then learners will make irrelevant associations about generality.

In my work as PGCE tutor the idea that learning is limited by what is offered to learners, and what is expected of them, runs through every taught session. Typically we start with some mathematics to do, presented in a form which is usable in school, and then discuss the affordances and limitations of the approach in terms of what sense learners might make of it. Evidence that this approach can empower new teachers to make a difference can be seen in many of the mathematics lessons we observe, even though our students often have difficulty fitting their ideas into school’s expectations.

A recent story is especially powerful. East, one of our students, was introduced to the unit in his placement school which is the ‘last chance’ for pupils before exclusion. He was sure that his mathematical knowledge would be of some use and volunteered to give them two hours a week and work with two year 11 students who were coming up to GCSE. These two knew that, as far as getting a ‘pass’ grade in maths was concerned they were (to quote) ‘f\*\*\*\*d’. East thought differently and started by trying to relate GCSE topics to things they were interested. This is a typical method used to convince students that mathematics is intrinsically useful, but East managed to keep this going for a while using data and situations from the trade and working lives to which the students aspired. It turned out that this was only necessary as a way to build relationships and get them to see that they were far from hopeless. Very soon East managed to abandon the contextual approach, because he had found, as others have before him, that even students from ‘bottom’ sets can think mathematically. For example, they had to know now to multiply fractions, so he used a rectangular array to show how to ‘see’ two-fifths of three-quarters, and before long they were telling him why you have to multiply the denominators. What is more, they were excited by being able to ‘see’ this and justify it for themselves.

East therefore continued in this way, acting as if they were cognising, sentient beings (and not nagging them about their language), and presenting them with carefully devised examples from which they could deduce mathematical behaviour. In this way he led them way beyond their current knowledge. For example, by seeing several examples they were able to deduce the laws for calculating with and combining indices. He then offered them; 10x x 10x and asked what x would be if the answer to this is 10. From ‘their’ laws (note the sense of ownership) they worked out that x had to be ½, and that this implied that the power of a half was ‘the same as’ square roots’.

Sadly, not many class teachers have the time to do this kind of rescue task, nor do all teachers of ‘low’ sets have the mathematical knowledge to construct spaces of examples which can lead young minds towards these insights.

East has certainly transformed learning capacity for these two students. Of course I cannot claim to have directly influenced this, but do claim that the idea of structuring example spaces in which minds can act mathematically is an important one.