Disposition towards engagement in mathematics

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This is the first part of a project to explore the factors influencing life-long engagement in mathematical activity. In preparation for the first phase, involving semi-structured interviews, I propose a draft version of a construct for 'disposition' with four components; beliefs / values / identities; affect / emotion; behavioural intent / motivation; needs. I discuss this in the following brief account, which also draws upon the discussion from the conference session which highlighted the need for clarity and specificity in the use of terms such as 'attitude', 'disposition' and 'motivation'.

Keywords: affect, attitude, beliefs, construct, disposition, engagement, identity, needs, self-efficacy, values.

Introduction

The importance of promoting a mathematically engaged society has long been recognised and is reflected in prominent educational initiatives to increase attainment in school examinations. Less attention has been given to the factors which may influence the degree of an individual's engagement in mathematical activity. My interest is in exploring the factors which have had a bearing upon the extent of adults' engagement in mathematical activity, in order to cast some light on how our approaches to teaching mathematics at school may affect this life-long engagement. I have considered a number of factors, including attitude, affect, motivation, disposition, self-efficacy, beliefs, values etc. with a view to developing an operational construct which can, as far as possible, be related to our approaches to teaching mathematics in school.

Attitudes to mathematics – a changing view

Models of attitude to mathematics have evolved steadily during the 20th century, from a single dimensional construct, a "simplistic like-dislike model" (Ruffell, Mason and Allen 1998, 13), to a multi-dimensional construct, one where attitude is seen as "a constellation of impulses vying for cognitive attention and triggering physiological and hence emotional responses" (ibid., 13). There have been significant developments since the 1970s. Although not addressing mathematics specifically, Fishbein and Ajzen's (1975 and 1980) Theory of Reasoned Action addressed belief, attitude, intention and behaviour. Mandler (1989) and McLeod's (1989) cognitive-constructivist model of emotional experience is described by Zan et al. (2006): this model has some parallels with cognitive conflict. They identify three elements (ibid., 115):

- a discrepancy between events and expectations, causing
- physiological arousal and an evaluation resulting in the construction of an emotional response and

- a "reduction in conscious capacity available for problem-solving".

McLeod (1989, 1992, 1994) explored factors underlying affect in mathematics. In particular he addressed beliefs, attitudes and emotions, "ranged along a dimension of increasing stability and decreasing intensity - with emotions as the most intense / least stable, beliefs as most stable / least intense and attitude in between" (Zan et al. 2006 115-116). Ruffell, Mason and Allen. (1998, 13) departed from a single-dimensional model and posited a "multi-dimensional construct with three interwoven components":

- 'cognitive': to do with beliefs,
- 'affective': to do with feelings and
- 'conative': to do with behavioural intent.

Affective / behavioural / cognitive models of attitude as posited at the end of the 20th century might be broadly described as psychological in origin. In recent years, social-scientific approaches have led to related factors such as beliefs, values and identities being explored (DeBellis and Goldin 2006, DiMartino and Zan 2001, Goldin 2002, Leder, Pehnkonen and Törner 2002, Leder and Forgasz 2006, Maaß and Schlöglmann 2009, Mendick 2006). Bandura's (1997) construct of self-efficacy (an individual's belief in their own capacity to be successful) has been adopted by social-scientists. Akinsola (2009) has explored how teachers' beliefs about self-efficacy contribute to pupils' affective responses to mathematics.

Zan et al. (2006) note two approaches to investigating attitude. The constructs described above were addressed theoretically, however much of the research on attitude in the last forty years has been statistical. During the 1970s and 1980s there was a growing awareness of issues relating to gender in society The Fennema-Sherman Attitude Scale (FS scale) (1976) was developed with a focus on exploring research into gender differences in mathematical engagement and consists of nine sub-scales

- Attitudes towards success in mathematics
- Mathematics as a male domain
- Confidence in learning mathematics
- Effectance motivation in mathematics
- Usefulness of mathematics
- Father (concerning the father's perceived opinions / beliefs / attitudes)
- Mother (concerning the mother's perceived opinions / beliefs / attitudes)
- Teacher (concerning the teacher's perceived opinions / beliefs / attitudes)
- Mathematics anxiety.

Although this scale is now more than thirty years old, it still has significant influence, many of the attitudes items in current use are very similar to those in the FS scale.

Large scale international research also took account of the affective domain. The First and Second International Mathematics Studies conducted by the International Association for the Evaluation of Educational Achievement in the 1960s and 1970s respectively (IAE 2011a, 2011b) included items addressing students' attitudes to mathematics. The IAE's third international survey, Trends In Mathematics and Science Study (TIMSS), first run by the IEA in 1995 (IAE 2011c), is repeated every four years (the last completed survey was in 2007). The 2007

survey had two clusters of attitudinal items addressing liking mathematics (seven items) and valuing mathematics (five items). As indicated above, the items used in TIMSS 2007 are similar to items used in the FS scale. It is interesting to note that the earlier versions of TIMSS contained more attitudinal items, distributed over more clusters. For example, in TIMSS 1995 (Keys, Harris and Fernandes 1997) there were 18 items in the following clusters:

- Students' perceived ability in mathematics
- Qualities required to do well in mathematics
- The importance of doing well in mathematics
- Reasons for doing well in mathematics.

More recently, the Programme for International Student Assessment (PISA) has reported on international attitudes to mathematics (Organisation for Economic Cooperation and Development, OECD 2004), having used similar items to those in the FS scale in the following clusters:

- Interest and enjoyment in mathematics
- Instrumental motivation in mathematics
- Anxiety in mathematics
- Self-confidence in mathematics
- Self-efficacy in mathematics

A construct for disposition

I have considered a number of names for the combination of factors that promote or militate against individuals' engagement in mathematical activity throughout their lives, including attitude, affective response, behavioural intent, disposition, motivation, self-efficacy etc. Ruffell, Mason and Allen (1998) have identified the confusion associated with different understandings of notions of attitude and affect, contrasting popular notions of 'mental orientation' with the "cognitive, affective and enactive aspects of the psyche" (ibid., 2). All of the possible names I have considered have similar potential for confusion, this was one of the themes in the discussion during the conference session. I finally chose to use disposition, as its common usage as tendency to behave in a particular way was consistent with my interest in engagement in mathematical activity (despite the possibility of confusion with popular notions of pre-disposition).

The reports from PISA 2003 (OECD 2004) noted that only 38% of students did mathematics because they enjoyed it (ibid., 115), "students' interest and enjoyment of mathematics have on average no clear association with performance" (ibid., 148) and that good results can be matched by low enjoyment (ibid., 119), In their analysis of TIMSS 2007, Sturman, Ruddock and Burge (2008, 10) observe "England's profile, of high performance but relatively low enjoyment, was common in other high scoring countries and that "pupils generally valued their learning in mathematics, despite their relative lack of enjoyment of it; they clearly recognise that it can be useful to them". This suggests that individuals may be disposed to engage in mathematics, despite attitudes / affective responses that would appear to militate against this engagement. I have used Maslow's (1970) hierarchy of needs (a hierarchy of human needs starting with the most fundamental, concerning survival and welfare, progressing through social and emotional needs, with the highest levels concerned with expressions of one's own individuality) to attempt to address this contributory factor influencing disposition.

In the longer term, I wish to identify how a disposition to life-long engagement in mathematics can be promoted more positively in school. This is my initial attempt at developing a construct for such a disposition. I have tried to use components that can be broken down further in a way that may help to identify how (and whether) they may be addressed. For example, an exclusive notion of the identity of a mathematician may be a deterrent to some pupils and will be redressed differently from a belief that mathematics is not relevant to an individual. I am currently using the following components.

- Beliefs / values / identities
- Affect / emotions
- Behavioural intent / motivation
- Needs: relating to Maslow's hierarchy

Review

The discussion during the conference session raised two issues that I have referred to in this account. The first was related to terminology and how terms such as attitude and motivation need to be used carefully. A word may be in common use, but this does not necessarily guarantee that, when used in a specific context, its meaning will also be shared commonly. The use of the term disposition to describe the construct was queried, and other terms such as motivation, resilience (and, unsurprisingly, attitude) were offered as better alternatives. I have reviewed the description of the components of the construct to reflect this, however I have retained the term disposition to describe the construct (as I describe above). The second issue related to the need for such a construct at all. It was suggested that the adaptation and use of existing attitude scales (especially those based on affective / behavioural / cognitive models) was adequate and preferable for addressing the notion of disposition of adults. Whilst accepting the value of established constructs and scales, I hope to develop a model of enquiry that allows general inferences to be drawn about how schooling affects adult actions. Many of the established scales (such as the FS scale and those used in TIMSS and PISA) use items that are designed specifically for school children, rather than adults. Although those aspects of disposition that I address through the components drawn from a social, rather than psychological, perspective (beliefs, values, identities and needs) may be addressed within an affective / behavioural / cognitive model, I find the latter approach less specific. For example, one individual's motivation to develop a high level of mathematical skills in order to support career choices could be clearly identified under the needs component of the proposed construct, whereas its situation within the affective / behavioural / cognitive model is less clear (cognitive was suggested).

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