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There is increasing evidence that holding a growth-mindset in mathematics, and hence a belief in the capacity for change, pays dividends in terms of mathematical engagement and attainment. However, much mathematics education policy and practice in England is embedded in fixed-trait theories; a belief that some people can do mathematics and some people cannot. Drawing on a wider mixed-methods study involving 284 pupils and 13 teachers in two primary schools, this research used attitudinal questionnaire and interview data to identify pupils' prevailing mindsets in primary mathematics. Pupils were found to hold predominantly fixed-trait theories strongly grounded in a biological discourse. The potential implications of these perceptions are examined.

Keywords: Primary mathematics, ability, growth-mindset, fixed-mindset.

INTRODUCTION AND CONTEXT

Ability-grouping has long been proposed as one answer to concerns over standards in school mathematics. With a controversial history and concerns over equality and diversity, ability-grouping is often central to educational debates. As I write this, England is witnessing ferocious political and media discussion as to whether setting – between-class ability grouping for individual subjects – should be made compulsory in secondary education with its use mandated through the inspection system. Whilst the literature on ability-grouping in secondary mathematics is quite extensive, the literature for primary mathematics is more limited. However, the wider study this report draws on suggests that primary ability-grouping practices and their impacts essentially mirror the literature in secondary mathematics [1], and there is evidence that the use of ability-grouping is currently increasing in primary schools (Hallam & Parsons, 2013).

Underlying ability-grouping practices must be some notion(s) of "ability", yet defining this concept is far from straightforward. Mathematical ability is a pervasive discourse within the English education system. Selection practices, such as ability-grouping, are commonplace, being grounded in 'common sense' fixed-ability thinking where individual potential is thought to be immutable and easily determined (Marks, 2013). The concept of individual boundaries, neatly described as ability, is entrenched in social attitude. A belief in the 'correctness' of this underlies many educational debates. This was vividly illustrated during a television debate on secondary school selection:

> It seems to me that 1000 kids in a comprehensive, sooner or later, the ones who are good at maths will have to be told "you are good at maths" and the ones who aren't, will have to be told "you are not good at maths" and you should be doing your darnedest to break the barriers but you should be learning as a young person that there are limits to what you can do. (Richard D. North, The Big Questions, BBC1, 26.07.2009)

This paper examines how pupils' come to understand themselves and others within this discourse and practices. The paper asks: How do pupils construct themselves as mathematicians within the prevailing discourse of ability in primary mathematics? Understanding this is fundamental in that beliefs about the capacity for change are known to impact on mathematical engagement and attainment (Dweck, 2000). This paper extends previous work, being grounded in primary mathematics, and hence allowing us to examine belief development within the earliest stages of schooling.

THEORY: THE CONCEPT OF ABILITY IN PRIMARY MATHEMATICS

Adopting a socio-cultural approach, learning is taken as a process of participation and enculturation (Kirshner, 2002). In developing an understanding of how pupils construct themselves as mathematicians within the prevailing discourse of ability, mathematics education is taken to extend beyond the classroom, incorporating the wider cultural contexts in which pupils participate. Learning is seen as identity development in which pupils negotiate between themselves and the social context in which "a culturally and personally located social schema" may be "transacted, redefined ... resisted and, like discourse, called upon when the moment is opportune" (Carr, 2001, p. 527). In doing school mathematics, pupils can adopt and adapt available learner and/or mathematical identities and thus become enculturated to the mathematical world. However, this identity 'choice' is both constrained and constraining, with some identities excluding learners from mathematics. It should also be highlighted that, whilst research on affective issues generates considerable interest, exploring pupils' beliefs is complex (Hannula, 2011).

Ability is a difficult concept that lacks solid definition and is conceptually challenging (Howe, 1997), with these complexities debated in earlier CERME papers (e.g., Brandl, 2011). Despite this complexity, the term ability is in widespread use in education, usually going unquestioned. The dominant view of ability in schools – and perhaps particularly in mathematics – is as a fixed determinant of pupils' future attainment, relatively impervious to change. Through a long history, such beliefs have become elevated to the status of truths through the simple stories they tell and the appeal to a "basic human need to stratify society" (Kulik & Kulik, 1982, p. 619). Within this research, ability is conceived of as an aspect of identity rather than an individual attribute. Ability is co-constructed through discourse within social practices and pupils construct their ability identity in relation to those around them.

METHODS

This research formed part of a wider study into ability in primary mathematics. The aspects of the study presented here sought to ascertain primary pupils' perceptions of their mathematical ability and elicit their views as to what mathematical ability is and the stability of their constructs. The wider study was a longitudinal mixed-methods study conducted over one academic year in two primary schools – Avenue Primary and Parkview Primary – in Greater London. [2] Both schools had similar Contextual Value Added scores (used to measure academic improvement) but employed different degrees of ability-grouping, allowing for a range of experiences. All pupils in Year 4 (ages 8–9) and Year 6 (ages 10–11, the final year of primary schooling in England) were included in the sample for the quantitative aspects of the study, totalling 284 pupils. From this sample, a sub-sample of 24 focal-pupils representing a range of attainment was selected for the in-depth qualitative aspects.

Data collection

Attitudinal questionnaires were conducted with all pupils (n=284) as pre- and post-tests (testing construct stability) in October 2007 and July 2008. This instrument consisted of four sub-scales: motivational orientation, beliefs about the causes of success, perceived ability and enjoyment of mathematics. Reportage is limited to perceived ability. Given widely acknowledged difficulties in measuring affective characteristics, with no 'best test' (Kline, 1990), the instrument used was developed, with permission, from earlier work by goal-theory researchers (Nicholls et al., 1990). This instrument has been widely used, particularly in mathematics education, and favourably acknowledged in reviews. Perceived ability was presented as a one-item scale asking pupils to indicate their perceived standing in mathematics related to their peers. The original instrument had high test-retest reliability (0.83). Pupils were presented with a horizontal line labelled from 'best in maths' to 'worst in maths'. Pupils marked the line to indicate how good they were at mathematics, with piloting interviews suggested that this was easy for the pupils to understand. Questionnaires were administered, following training, by class teachers in lesson time with administration observed in two classes. Data were collated for analysis in SPSS.

Individual and group interviews with the sub-sample of 24 focal pupils were used to "examine individuals' thoughts, feelings, and experiences, which are not easily observed" (Moore, Lapan, & Quartaroli, 2012, p. 251). Individual pupil interviews were semi-structured using tasks adapted from Personal Construct Interviewing techniques. Focal-group interviews were semi-structured with a schedule and tasks – including a discussion of mathematical work – developed from earlier work by the researcher. Follow-up group interviews were used as a form of participant validation developing conversation around themes emerging from early analysis. All pupil interviews were conducted away from the classroom and developed as conversations with themes explored as brought up by the pupils. All interviews were audio-recorded, transcribed and filed with task outcomes.

Data analysis

Following the first administration of the perceived ability scale, the distribution of the data was graphed, then descriptive statistics, Kolmogorov-Smirnov tests of normality, and z-scores for skewness and kurtosis calculated to establish the characteristics of the data and appropriate statistical analysis tests. The first administration produced a distribution that did not differ significantly from a normal distribution, $D(219)=0.06$, $p=0.08$, allowing the use of parametric tests. The data for the post-test did differ significantly from a normal distribution but it was considered that the overall distribution was near normal and that the parametric tests were robust enough for them to be used on the untransformed data.

Transcripts from interviews were imported into a single NVivo project allowing for consistent coding and analysis. Interview analysis was conducted using constructivist grounded theory, the more theory-driven approach developed by Charmaz (2000) in response to criticisms of grounded theory as narrowly empiricist and atheoretical. In this approach, analytical categories (codes) were derived from reading the data alongside existing theoretical analyses. Codes were structured into trees prior to axial-coding. Mirroring Hamilton's (2002) secondary-school work on ability constructions, analysis was split into internal beliefs and external references. From the corpus of data appended to each theme, extracts, often critical incidences, were selected which best illustrated the area under discussion.

Reliability and validity were key considerations throughout the data collection, analysis and presentation processes. Where possible, established instruments with known reliability and validity were used; in all cases instruments were extensively piloted. Across the analysis, quantitative and qualitative data were linked using methodological triangulation (Denzin, 1997) where data types were compared to determine if there was convergence, difference, or some combination. Participant validation and inter-researcher scrutiny of coding use and application provided a proxy for the validity of the themes drawn from the data (Kurasaki, 2000).

RESULTS: PUPILS' PERCEPTIONS OF MATHEMATICAL ABILITY

The data suggest pupils tend to perceive ability as an internal construct, determined biologically and relatively impervious to change. Self-perceptions of ability appear to remain fairly stable. There is a tendency towards positive self-perceptions but this is accompanied by a long tail of pupils holding weak self-perceptions.

Primary pupils' perceptions of ability: Questionnaire analysis

The self-perception of ability scores for the post-test covered the range of available scores from 0–100 with a median of 68.5. These are illustrated in the boxplot in Figure 1. These data are significantly non-normal, $D(239)=0.09$, $p<0.0001$, being negatively skewed ($Z_{skewness}=-4.73$). A median of 68.5 suggests a tendency towards more positive self-perceptions. However, there is a long tail of weak self-perceptions with outliers representing pupils holding very low perceptions. Change in ability-perception scores were calculated (post- minus pre-test scores) ($M=3.2$, $SE=1.4$, $sd=20.3$) with scores ranging from -44.0 to +96.0. On average, there was a small increase in self-perceptions between the pre- ($M=61.4$, $SE=1.6$, $sd=23.0$) and the post-test ($M=64.6$, $SE=1.5$, $sd=20.9$). This difference was not significant $t(396)=-1.46$, $p=0.15$. Overall, pupils' perceptions remained fairly stable over the year.

Primary pupils' perceptions of ability: Interview analysis

Of note, when conducting the interviews – both individual and group – no pupil struggled to place themselves or peers on the perceived ability line. As Howe (1997, p. 2) suggests is the case with the wider population where "people today have so little hesitation about ranking individuals as being more or less intelligent", many pupils appeared enthusiastic in positioning their peers. Pupils regularly talked about ranking and had no difficulty in labelling how 'good' or 'bad' they were or of categorising other pupils into a dichotomy of the 'top' and the 'others'. Whilst all avail-

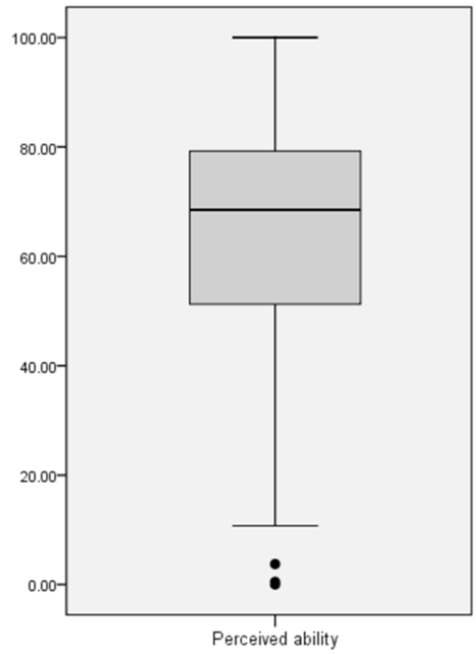

Figure 1: Pupils' perceived ability – full dataset

able evidence points towards a continuum of attainment (i.e., there are no distinct high or low attaining groups) and shows that learning trajectories are not fixed (Brown et al., 2008), the mathematical identities dominating pupils' talk seemed to be predicated on a notion that some are, and some are not, mathematical.

Using Hamilton's (2002) internal beliefs and external references dichotomy for coding, there was a discernible bias in where pupils perceived mathematical ability to be located. Across the data set, pupils made 121 references to ability being an internal construct (biologically determined) and 52 references to mathematical ability being driven by external factors (such as age and experience). 81% of pupils' references at Avenue Primary, which employed strong ability-grouping, located mathematical ability internally, compared with 54% of the total references made by pupils at Parkview Primary which employed weak ability-grouping structures.

Many pupils constructed mathematical ability, mirroring societal conceptions, as something real and located within the individual rather than being an aspect of a person's developing and changeable identity. When asked what caused high or low mathematical ability pupils tended to recourse to natural variation and neurological and genetic differences. Of all pupils experiencing setting for mathematics, pupils in top sets made 80% of these links suggesting they held a stronger belief than pupils in lower groups in a biological explanation for individual differences in mathematical ability. Pupils expressed a belief that differences in mathematical ability were apparent from birth "because you are born with an ability" (Victoria, Avenue Primary, Year 4, Top Set). When asked, individually, what made someone good, or otherwise, at mathematics, pupils repeatedly talked about those who were good at mathematics as being born to be good at mathematics and vice versa:

Wynne: Their brain's bigger. And they're cleverer and better [...] I don't know, it just happens. They were born like that. They were born clever.
Zackary: Some people are just not born clever.
Yolanda: Some people are really good at maths and some people aren't that good at maths. Probably it sometimes runs in the family.
(Avenue Primary pupils, Year 4, Bottom Set)

Talking about ability differences was a natural discourse to the pupils and strong links emerged between this and the ability-grouping practices they experienced:

Uma: Cause it's like the erm, ability of what you can do, so there's like a high, there's like a top maths group, then a middle maths group then a bottom maths group
Victoria: And then you know which one is which
Uma: Because if you are like in one big maths group and you're all different abilities then there might be something too hard for like the people that need to do easy questions, and the people that need to do it hard, it would be too easy for those people
(Avenue Primary, Year 4, Top Set)

In interview, the pupils introduced the language of ability themselves; in the extract above the pupils brought the terminology in at the beginning of the interview in response to being asked to describe what happens in their mathematics lessons. For these pupils, ability, and the practices of ability, are important constituents of what mathematics is. The extract, in common with many pupil interviews, carries an unquestioned assumption that there are different types of people in terms of ability levels and these can be clearly demarcated into groups. Based on this belief in clear groups, pupils voiced an acceptance that "some people are more clever than other people" (Catherine, Parkview Primary, Year 6, Top Set). People are seen as different, with, as in society more generally, ability providing a simple explanation for individual success and failure. Pupils accepted that this was right without question. These beliefs may be influenced by ability practices:

> Natalie: Well some people are just, you know, cleverer than other children, that's what decided our groups in year 3 and it hasn't changed.
> (Avenue Primary, Year 6, Top Set)

Pupils construct an explanation that fits what they see. They hold the belief that individual differences lead directly to group placement and that group placement has not changed as differences are innate and unchangeable. Holding a fixed-ability belief appears to be self-perpetuating with pupils viewing mathematical ability as an internal force that drives, and limits, what they can do. External factors are seen as relatively inconsequential to outcomes with a belief that individuals can only take their attainment to a maximum level determined by internal limits.

Given that limits to attainment appeared to feature strongly in pupils' constructs, I asked pupils if they felt they could improve upon their current position. The responses across schools, ability-groups and year-groups were consistent and stark:

> Zackary: I think I would not move. I think I would normally stay in the same place. I don't think there's anything I could do to make myself better.
> (Avenue Primary, Year 4, Bottom Set)
> Megan: I think I could move a few centimetres further up the line, not far.
> (Avenue Primary, Year 6, Top Set)
> Peter: Just about here, not a huge way, well because you can only do so much can't you, it's quite hard.
> (Avenue Primary, Year 6, Bottom Set)

Most pupils suggested limited room for improvement. They positioned themselves within a hierarchy seen as normal and accepted the place they, their teachers and others gave them, believing they simply did not 'have' something that others did which might have allowed them to achieve more highly in mathematics. Peter's statement was not made as a question, but as an acceptance coupled with an assumed shared understanding with myself as the interviewer. Other pupils made similar comments. Whilst there were some positive statements from pupils who felt that some improvement could be made through teaching and learning in mathematics, this was tempered by the consistent underpinning theme of immutable limits:

> Researcher: Could anything help you to improve?
> Uma: Yes, if we had something like, Mr Iverson, if he explained it out a couple of times and actually came up to me in the lesson and talked it through then I would understand it a bit better.
> Researcher: Could that make you move up higher?
> Uma: No, because I have some trouble on a lot of sums with carrying over. I'm way past there in history though, but not in maths, there's this bit [≈ the top 20% of the perceived ability line] I can't get.
> (Avenue Primary, Year 4, Top Set)

Although Uma suggests that intervention from her teacher could lead to improvement, she does not see this as having an impact on her ability, which she constructs as fixed and internal. She talked about a part she would never be able to attain, even with teaching, suggesting a belief in upper boundaries. Extending this, pupils suggested that effort cannot overcome predestined limits:

> Natalie: I don't think all children can do really well in maths though
> Megan: Even if they tried really hard, even if they tried really hard
> Natalie: If they tried really hard their best might not be a 5A, but if you have lots of ability and you tried your best then you would do very well in maths. So not all children can do well. [...] If you're determined you might be better but I don't think all children, I don't think, all children can't be, well they could be okay at maths but not really brilliant, because...
> Megan: Well you could have people who had lots of ability but they just weren't trying hard enough so they were considered to be not as good but then when they try

> hard they are really good, but they have to have lots of ability.
>
> (Avenue Primary, Year 6, Top Set)

Natalie and Megan suggest that you can have ability and not use it but that you cannot move beyond innate ability limits; effort alone is not enough to achieve success. Such persistent fixed-ability beliefs hold implications for mathematics education.

IMPLICATIONS FOR MATHEMATICS EDUCATION

This paper is significant for those working in mathematics education, illustrating how the pupils were, as Boaler (2000) suggests, not only learning mathematics, but also learning to be a mathematician. Understanding these pupils' constructs has important implications for future research, as these foundations cannot be ignored when looking at any intervention aimed at increasing engagement or attainment.

From early on in their mathematics careers, pupils are engaged in producing understandings of mathematical-ability that are likely to be carried forward into and beyond secondary mathematics. These productions are strong in Year 4 and particularly salient in Year 6, mirroring the "evolving sense of ability identity" found in Hamilton's (2002, p. 601) secondary school study. Pupils' models of ability portray a stable concept with little plasticity. These models can be complex, drawing on multiple ways of thinking including internal and external references. However, the overriding view of mathematical-ability is as an innate, biologically determined quantity, residing within individuals in specific quantities, with limited possibility for change. Few pupils suggested they could move in terms of their mathematical attainment and those that believed they could move placed boundaries on this.

It is perhaps not surprising that pupils are holding entity-theories of mathematical ability given the clear and consistent messages to this effect they receive from teachers, parents, and the media. Previous writing has suggested that primary teachers are engaged in reproducing their own relationships with mathematics in their language and practices (Hodgen & Marks, 2009). As such it is imperative that spaces and opportunities are provided for primary teachers to engage with their perceptions of mathematical ability and disrupt 'common-sense' practices which may set-up, or perpetuate, the limits pupils impose through their constructions.

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ENDNOTES

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2. All names in this paper are pseudonyms.