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**Operant Subjectivity**
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# Meanings of "Mastery" in Mathematics Education: Creation of Concourse for a Research Study

Jennifer Shearman
*Canterbury Christ Church University*

***Abstract***: This article outlines the rationale for and methodological choices made in designing an online Q study. Pre-service and experienced secondary mathematics teachers in the UK use the word "mastery" to describe a specific development programme, a curriculum or a set of teacher or student behaviours; these multiple meanings inspired a Q methodological study to identify types of views held by mathematics teachers. The article details the study's design process, from generation of research question, through concourse and Q sample creation and pilot studies, to the final research design and Q sample. In the UK, changes to teacher practice are often quickly dismissed as fads and fashions, so greater use of Q to evaluate teachers' views on educational initiatives would be a useful tool to uncover and explain that which is valued by teachers.

**Keywords**: concourse, mastery in mathematics, mathematics education, teacher opinions, Q methodology, Q sample

## Introduction to the Problem

### The rapid rise of mastery in mathematics

Few UK mathematics teachers were aware of the term *mastery* in relation to the teaching and learning of their subject before Hattie's (2008) meta-analyses of educational interventions indicated an average 7-month learning gain from mastery learning programmes. In 2012, the Sutton Trust reported mastery learning programmes as "moderate impact for low cost"; this report was incorporated into the Educational Endowment Foundation Toolkit in 2015 and updated in a 2018 report (EEF, 2018). At the same time, mastery was used to describe the teaching approaches in Singapore and Shanghai, which score highly in the PISA and TIMSS mathematical tests[1] (Mullis, Martin, Foy, & Arora, 2012; OECD, 2015). English government spending on mastery is significant; in 2016, £40 million was made available to spread a "Teaching for Mastery" approach to thousands of primary schools (Department for Education, 2016),

[1] The Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) are two large-scale international studies designed to assess school pupil achievement across countries, carried out every three (PISA) or four (TIMSS) years.

Contact author: Jennifer.shearman@canterbury.ac.uk

and a government-funded secondary school Teaching for Mastery programme started in the same year (NCETM, 2017).

## No common definition for mastery

It is perhaps then surprising and troubling that there is currently no commonly agreed upon definition for mastery in the context of secondary mathematics beyond the historic "an explicit philosophy about learning and teaching" in which "under appropriate instructional conditions, virtually all students can learn well" (Block & Burns, 1976, p. 4). Each English mastery programme has its own definition, putting different emphases on whether mastery is about learning, teaching, a curriculum or something else. Published literature in this area skirts a lack of definition by placing "mastery" in inverted commas (ASCL, 2015; Jerrim & Vignoles, 2016; Watson, 2018) or by referring to a specific teacher development programme, such as the National Centre for Excellence in Teaching Mathematics (NCETM)'s Teaching for Mastery programmes (NCETM, 2018). The evaluation by Boylan et al. (2019) of a mathematics teacher exchange highlights how these multiple meanings evolved from different stems of mastery programmes originating in the USA, England, China and Singapore (p. 48).

Most state-funded schools in England teach mathematics as stated in the National Curriculum (Department for Education, 2013), which specifies topics that should have been taught to children during each year or key stage of education, but not how they should be taught. Decisions related to curriculum design and delivery are devolved to bodies who maintain schools (these include local authorities or trusts), who may devolve them further to school leaders and class teachers (Department for Education, 2010). However, the 2019 revised English state schools' inspection framework judges the quality of education by curriculum '"intent" (is it designed for all children?)implementation, (is it delivered effectively to all children?) and impact (do all children make progress?) (Ofsted, 2019).

It is important that the education community and Department for Education have better information about schools, departments or teachers that claim to "do mastery", "teach for mastery" or "have a mastery curriculum" and whether they are speaking with a common language. This will enable individual mastery programmes to be understood or compared, as well as test the trustworthiness of current and future studies claiming to measure the educational benefits of mastery.

Hence, the specific research question for this study is:

What do secondary mathematics teachers consider mastery in mathematics to mean, in relation to their own practice and the learning of their students?

## Mastery and Q methodology

The previous section illustrates the necessity of understanding the different meanings of mastery held by groups of secondary school mathematics teachers who are responsible for planning, teaching and assessment practices within secondary mathematics departments. Since teacher professional development involves development in behaviour, attitudes and intellect, all asymmetrically influenced by school environments and performance management objectives (Evans, 2011), investigating teachers' precise understanding of mastery requires a methodology where participants' views are revealed in a way that systematically facilitates broader discussion about future mastery practice and policy development. Q methodology's ability to reveal shared opinions of particular groups (such as teachers) which generalises concepts, categories, theoretical propositions and models of practice beyond a single study is thus an effective methodology for this investigation.

The nature of educational research this century has followed the paradigm shifts predicted by Durning (1999), moving from favouring the subjective to the objective and back again. Q methodology, underutilised in UK education research, is an important addition to the quantitative world of randomised controlled trials and the rich but narrow conclusions made by qualitative research.

## Method of Collecting the Concourse

The creation of a concourse, including mapping these multiple meanings of mastery, is a critical component to the overall success of this research study.

This study claims "epistemic rationality" through a delicate balance of maximising true beliefs whilst minimising false beliefs (Pritchard, 2013). Truth is revealed by abduction through pursuit of explanation, rather than description or verification (Watts & Stenner, 2012). On an individual basis, opinions of mastery are variable and unpredictable, but reliability of the conclusions as "systematic subjectivity" (Brown, 2008) is claimed through the revealing of distinct categories of opinion and thus a truth as consensus (Bridges, 1999). The material used to select the concourse ultimately dictates its fitness for purpose and the security of the later claims made; it is the responsibility of the researcher to capture the essence of "the stuff of life" (Brown, 1993, p. 93).

### First concourse creation

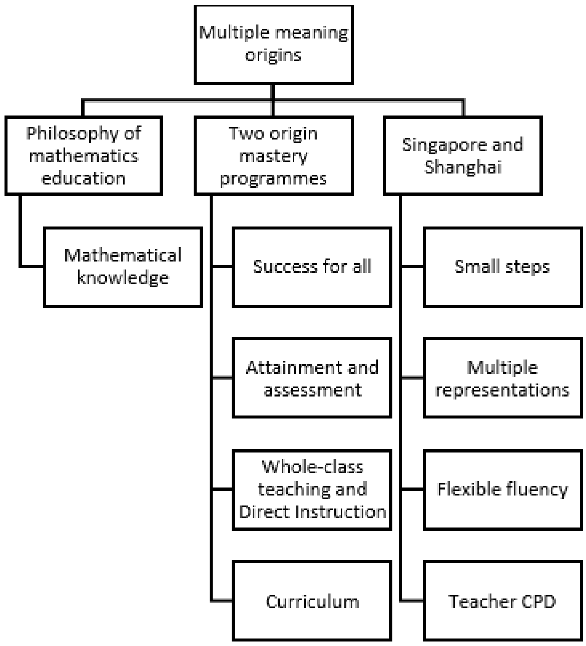
No previous Q study had been undertaken on this topic, nor was there a single pre-existing framework classification of mastery learning. Therefore, the researcher was responsible for creating the concourse of knowledge of mastery in mathematics in a robust and replicable manner to ensure the complete range of opinion was included (Watts & Stenner, 2012). Concourse development is acknowledged as "more of an art than a science" (Brown, 1980, p. 186) and there is no one accepted method for generating the concourse. Kenward's (2019) review of concourse development in nursing reported that approximately half of the reviewed studies had no obvious theme or structure to their concourses and the remaining studies used researcher-generated themes, a researcher-generated framework or pre-existing frameworks.

After establishing that there were no existing frameworks, concourse development in this study began with a review of published literature that included a definition, explanation or example of mastery, limited to those previously known to the researcher (whose professional expertise is in mathematics education) and those articles available on the researcher's university database. On reviewing the literature, the researcher recorded mentions of mastery in relation to its definition or where the term was exemplified in relation to learning or teaching. These yielded over 200 statements with no uniformity in length, language or theme.

At this point, the decision was made to limit the concourse items to text statements; the inclusion of graphs, diagrams, equations or other pictorial representations was considered but ultimately rejected. Whilst there was a practical element to this decision (many online Q-sort programmes do not facilitate this), without a framework it was felt that a text-only selection would be more likely to result in a set of items that elicit an equal emotional or self-referential response in the participant (Stephenson, 1953). Inclusion of, for instance an equation, might lead a participant familiar or favourable to equations to respond more (or less) strongly to someone who is averse to equations. In addition, a possible definition for mastery includes the use of multiple representations within mathematics so whilst it was tempting to incorporate this within the concourse, the possibility for the participants to be confused about the meaning of the cards, (are they sorting the concept of multiple representations or the representations themselves?) was deemed too much of a risk.

This initial review identified a number of distinct categories that multiple studies used to distinguish mastery from other methods of learning and teaching, specifically attitudes regarding attainment, knowledge, curriculum and pedagogy, and approaches to teacher professional development (ASCL, 2015; Boylan et al., 2019; Boylan & Townsend, 2018; Drury, 2018; NCETM, 2016). The author sub-classified these themes to nine: *types of knowledge, attainment and assessment, curriculum, success for all, whole-class teaching and direct instruction, small steps and variation, multiple representations, flexible fluency, and teacher professional development.* Figure 1 illustrates how three categories for the initial diversification of mastery further developed into the nine themes. Within Q, it is permissible for structures to be both imposed on the concourse, or to emerge from it (Brown, 1980); for this study there were elements of both processes. All existing statements could be categorised into a theme leaving none outside, and so the concourse generation could continue by further focusing on these themes.

***Figure 1: Initial generation of themes***




The establishment of these categories preceded a second review of literature, now including search terms related to "mathematics", "mastery" and key words related to each theme. This review included peer-reviewed journals, mathematics education publications, government reports and mathematics education professional development and teaching materials. Since the research question specifically seeks to elicit perceptions of mastery in relation to teaching and learning, care was taken to ensure all aspects of these were covered and irrelevant literature rejected, and notably the latter was more complex. Statements were put into the theme that the researcher deemed the best fit.

A greater number of statements increases the sample size, thus theoretically strengthening the rigour and verification aspects of the research, but too many statements will reduce the participation and accuracy of the judgements. At this point the 200-statement concourse was much higher than the "house standard of 40-80 items" in a Q sample recommended by Watts and Stenner (Watts & Stenner, 2012, p.61), so the statements were reviewed. The researcher studied each theme in turn, removed obvious duplicates, and selected the six statements in each of the categories that best fully represented the theme containing all meanings of mastery by identifying statements that expressed the limits of different types of teaching or learning within that category (two of the categories did at this point contain seven statements). This approach has similarities to a "balanced block" design consistent with Fisher's design principles (Stephenson, 1993). These statements were the Q sample for the first pilot study.

## First pilot study

The final Q sort was to be administered online, with teachers recruited through electronic advertisements and social media. The rarity of Q methodology within education research means few teachers will have completed a Q sort before, and they may need to be encouraged and motivated to take part for this reason (Nazariadli, Morais, Supak, Baran, & Bunds, 2019). Teachers are under a great deal of time pressure, and an option of completing educational research in their own time and place, using a computer, tablet or phone, widens the pool of potential participants and increases the response rate. However, an online method means that the information gained within "the silence of the Q sort" is lost, and although teachers may have more time to reflect deeply on their choices, they may not in fact choose to do so.

The aim of this first pilot was to elicit feedback about how Q participant novices understand the principles of what they have been asked to do (so contributing to the condition of instruction and administration of the final study). It also gave the researcher a chance to observe the "dynamics of subjectivity" (Brown, 1980, p. 196) and obtain a degree of insight into the statements that participants found more or less difficult to place and a sense of the overall time it would take to complete the sort. Twelve final-year undergraduate education students undertook the Q sort face-to-face. None had any previous experience of Q methodology and as non-mathematics specialists, they may have had a very limited understanding of mastery in mathematics, so it was not an intention that they should take part in the final study.

The 56 statements included in these Q sample elicited opinions about mastery learning and mastery teaching. The group were undergraduates in education studies, not mathematicians; however, the only card that they asked for clarification on the meaning was "Mathematics is reducible to a series of topics". The participants did however comment that fifty-six statements were too many and that they struggled to remain focused by the end; they suggested halving the number of statements.

Following this pilot, the reviewer considered whether and how to reduce the number of statements without fundamentally changing the holistic structure of the Q sample. Upon reflecting on Figure 1, the decision was made to remove the mathematical knowledge category from the Q sample, and instead incorporate this into the pre-sort questionnaire. Whilst this would will remove a layer of understanding about the kinds of mathematical knowledge that are assumed by mastery, this could be explored in the eventual analysis of the factors emerging in the final study; for example, whether teachers who have a particular mathematical philosophy load highly on any one factor. Removal of this category also added some balance to the remaining eight themes; four of which stem from the original mastery programmes, and four that stem from pedagogical approaches in East Asia. The design of the statement framework for the second pilot (unchanged in the final Q sample) can be seen in Table 1.

***Table 1: Q-Sample Framework***

*Final design of themes and types*

| Theme | Type 1 | Type 2 | Type 3 |
|---|---|---|---|
| Attainment and assessment | Continual vs. periodical | Uniform vs. graduated | Grouping vs. mixed |
| Mindset and Differentiation | Whole group vs. personalised | Keep up vs. catch up | Same vs. differentiated |
| Curriculum | Compartmentalised vs. connected | Equal vs. weighted | Faster vs. slower |
| Teaching methods | Teaching vs. understanding | Student vs. teacher | Teacher vs. mentor |
| Small steps and variation | Content vs. stretching | Student vs. teacher | Student vs. teacher |
| Multiple representations | Variable vs. fixed | Hierarchical vs. non-hierarchical | Student vs. teacher |
| Flexible fluency | Necessary vs. unnecessary | Similar vs. variety | Compartmentalised vs. connected |
| Teacher CPD | Subject vs. pedagogy | Within school vs. into school | Research vs. improvement |

## Second pilot study

At this point, the researcher was confident about the structure of the study, the balance of the Q statements within and across the themes and how the Q sort fitted within the whole data gathering process. The second pilot elicited expert feedback about whether the Q sample did indeed capture the full range of views on mastery, the language of the statements, and whether the Q sort could successfully be conducted online. Six mathematics education or online learning experts who were practicing teachers or university academics completed this pilot following a direct email invitation including an online link. They were given a small amount of information about the study and the aims of the pilot. They then moved straight to the Q sort. Following the sorting (a two-step process of sorting the cards into agree/ neutral/ disagree before placing the cards into a forced normal distribution with the continuum "most disagree" to "most agree", with "neutral" in the middle) they were asked three questions:

1) In your opinion, do the statements represent a comprehensive range of views in relation to mastery? If not, what is missing?
2) In your opinion, does the number of statements provide enough variety without being too tedious for the participant? If not, should the number be increased
3) Is the online platform sufficiently easy to use and compatible with your device? If not, what are the major pitfalls?

This second pilot group completed the study anonymously online using QsorTouch (Pruneddu, 2016), with an opportunity to correspond by email if they wished.

All the participants agreed the wording of the statements was a good representation of the range of perspectives on mastery, providing a degree of confidence to the concourse selection process, researcher-designed framework, and Q sample. Most of the participants also expressed the view that the number of statements (reduced to 48) was comprehensive without being onerous, though one found the number of items "overwhelming" and another found the "two-step" process overly long.

The main area of negative feedback participants gave related to the shape and labelling of the distribution. Two of the participants questioned the forced normal distribution shape, one reporting they found it "constraining". Some participants questioned the combination of agree/neutral/disagree for the first stage of the sort with the "most disagree-most agree" continuum of the second stage, one saying "I felt that by the forced placement of [some of the cards in stage two] my initial opinion of disagree was being disregarded".

The reviews of QsorTouch were positive, though the two participants who completed the sort using a mobile device found the small screen created difficulty, and one participant reported compatibility issues with their computer operating system.

An unexpected bonus of conducting this pilot was that all participants offered to promote the invitation to participate in the final study with their own teacher contacts.

## Resulting Selection of the Q Sample

The pilot studies were an invaluable complement to the concourse generation and statement selection process in reaching the study's final Q sample (see Appendix). In addition, they also contributed to refining the "condition of instruction" (Watts & Stenner, 2012), Q-sort administration and accompanying processes, which are detailed below.

1. The participants' invitation to participate, which would normally arrive by email or social media, would contain a very short introduction about the study and contain a link to the QsorTouch online study.

2. Participants would arrive at a landing page that had more information about the study (including giving consent) and about Q methodology.

3. Participants would answer a pre-sort questionnaire (consisting of some yes/no and some Likert questions) to determine information about their professional background and pedagogical preferences (including questions about their personal philosophy of mathematics).

4. Participants would complete their sort.

    a. The Q sample remained at 48 statements. The removal of the more general questions about pedagogy and philosophy had already reduced the sub-themes to eight from the original nine. A final review of the statements following pilot feedback against the original concourse helped the reviewer conclude that reducing the statements further would lose a "dimension" of the concourse. A sentence on the landing page explaining the importance of the study, and the contribution that each teacher was making to educational research, might increase the incentive for each teacher to maintain focus during the sort.

b. The term "fixed normal distribution" has been removed from the instructions in favour of "place your statements in this grid". The distribution categories would not be numbered, there would only be a continuum labelled "most agree with" and "most disagree with".

## Summary

The construction of the concourse and Q sample for this study is shown diagrammatically in Figure 2.

***Figure 2: Q sample creation and reduction process***

The researcher followed these steps:

1. The *concourse creation process* began by an initial review of literature narrowly focused on exploration of mastery definitions and explanations, in order to create the themes that the statements would be sorted into, as well as generating a large number of statements (Figure 1).

2. The *concourse creation process* was completed by an expanded literature review that included the identified themes, then allocating all the statements to the themes. Each theme was further separated into "types" of teaching and learning within the theme (Table 1). The concourse was then reduced to 56 statements by examining each theme in turn, removing duplicates and refining the language so that the range of each type was maximised within the theme, analogous to a balanced-block design.

3. The first pilot facilitated the *Q sample creation* from the concourse through participant observation and feedback that enabled further statement selection and refinement (Figure 2).

4. The second pilot refined the Q sample creation through expert review of statements in relation to concourse coverage and ensuring that conditions of instruction and Q-sort administration appropriately facilitate a successful participant sort (Table 2).

In the absence of previous Q studies on the topic, each stage in the process added an element of confidence that the final Q sample was representative of the mastery concourse, which was itself representative of the population of statements related to mastery in math education in the UK. An unexpected outcome of the process was that it focused the researcher on the contribution of the "whole participation experience" to the quality of the Q sample as well as to the consideration paid to the (in this case) online instructions and usability.

## Conclusion

This article has identified the various decisions made in generating a concourse and Q sample for a study on a topic previously unexplored through Q methodology. It uncovered the freedoms that Q researchers have in choosing a method for concourse gathering whilst highlighting the multi-layered approach needed to justify their methodological decisions at each stage. More discussion of this important facet of a Q study within mainstream research papers would both increase the academic credibility of each individual paper and make a valuable contribution to the increased understanding of Q methodology as a rigorous and effective research methodology.

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## Appendix
## Statements used for the Second Pilot Study

| Number | Category | Statement |
|---|---|---|
| 1 | A and A | In mastery lessons all students should be assessed every lesson |
| 2 | A and A | In mastery lessons assessments should only be used at the beginning and end of topics |
| 3 | A and A | All students are capable of achieving a mastery level of attainment |
| 4 | A and A | In general, 1/3 of students will achieve a mastery standard, 1/3 of students will achieve an average standard, and 1/3 of students will achieve a low standard of attainment |
| 5 | A and A | Mastery will be easier to attain if children are taught in groups of similar prior attainment |
| 6 | A and A | Mastery will be easier to attain if children are taught in groups of mixed prior attainment |

| Number | Category | Statement |
|---|---|---|
| 7 | M and D | Learners should move through a mastery curriculum at their own pace, moving on once they reach the expected level of attainment |
| 8 | M and D | Learners should move through a mastery curriculum as a group, only moving on once all students have reached the expected level of attainment |
| 9 | M and D | Teaching for mastery increases the rate of learning for lower-achieving students so they can catch up |
| 10 | M and D | Teaching for mastery involves students keeping up, not catching up |
| 11 | M and D | To achieve mastery, in mathematics lessons all students should be working on the same problems at the same time |
| 12 | M and D | To achieve mastery, in mathematics lessons students should all be working on different problems |
| 13 | Curriculum | In a mastery curriculum students will understand the structure of number before applying it to other topics |
| 14 | Curriculum | In a mastery curriculum students will develop an understanding of the structure of number through applying it to other topics |
| 15 | Curriculum | A curriculum for mastery should give equal priority to number, algebra, geometry and data handling |
| 16 | Curriculum | A curriculum for mastery should give greater priority to number and algebra |
| 17 | Curriculum | Planning mastery lessons is quicker because there are no differentiated resources to create |
| 18 | Curriculum | Planning mastery lessons is slower because it takes a long time to craft the small-steps teaching and pupil exercises |
| 19 | Methods | To achieve mastery, students should be explicitly taught mathematical laws (for instance the commutative, distributive and associative laws), including their formal names |
| 20 | Methods | To achieve mastery, students should understand mathematical laws (for instance the commutative, distributive and associative laws) but do not need them to be explicitly taught |
| 21 | Methods | A student is more likely to achieve mastery if a teacher uses a specific pedagogy |
| 22 | Methods | Mastering mathematics is unconnected with specific teacher pedagogies |
| 23 | Methods | Teaching associated with mastery assumes a 'novice-expert' relationship between teacher and student |
| 24 | Methods | Teaching associated with mastery assumes a 'mentor-mentee' relationship between teacher and student |
| 25 | SS and Var | In mastery lessons, a question should be set that a student could only answer if they have learnt something beyond what has been explicitly taught |
| 26 | SS and Var | In mastery lessons, all questions set should reflect only what has been explicitly taught |
| 27 | SS and Var | In mastery lessons, complex problems should be reduced by the teacher into a series of steps |
| 28 | SS and Var | In mastery lessons, complex problems should be reduced by the students into a series of small steps |
| 29 | SS and Var | Teaching for mastery aims to minimise lecturing and maximise student participation |

| Number | Category | Statement |
|---|---|---|
| 30 | SS and Var | Teaching for mastery aims to maximise the opportunity for teachers to impart their knowledge to students |
| 31 | MR | Mastery lessons should incorporate multiple representations of a concept |
| 32 | MR | To master mathematics is to understand mathematics using concrete, pictorial and abstract representations |
| 33 | MR | Multiple representations are always needed in secondary school teaching for mastery |
| 34 | MR | A goal of mastery is to understand mathematics without needing a concrete or pictorial representation |
| 35 | MR | In mastery lessons, learning is constructed by the teacher's careful explanation and selection of problems |
| 36 | MR | In mastery lessons, learning is constructed by the students noticing similarities and differences in the mathematics they are doing |
| 37 | FF | Rote-learning is incompatible with mastery learning |
| 38 | FF | Rote-learning is an inevitable part of mastery learning |
| 39 | FF | Practising similar problems is part of developing a mastery understanding of mathematics |
| 40 | FF | Practising a variety of problems is part of developing a mastery understanding of mathematics |
| 41 | FF | In mastery lessons problem-solving is developed through exercises which combine topics |
| 42 | FF | In mastery lessons problem-solving is developed by ensuring each separate topic is fully understood |
| 43 | CPD | Mastery professional development activities should include a high degree of teacher subject knowledge development |
| 44 | CPD | Mastery professional development activities should include a high degree of specific pedagogy development |
| 45 | CPD | Teaching for mastery pedagogy is mainly learnt through external professional development |
| 46 | CPD | Teaching for mastery pedagogy is mainly learnt through collaborative in-school professional development with colleagues |
| 47 | CPD | Reading, and taking part in, educational research is an important aspect of teaching for mastery |
| 48 | CPD | Teaching for mastery is vital in UK secondary schools to improve standards and close achievement gaps |

*Note: category codes stand for Attainment and Assessment, Mindset and Differentiation, Curriculum, Teaching methods, Small Steps and Variation, Multiple Representations, Flexible fluency and Teacher CPD*