FEATURE

Investigating teacher beliefs and attitudes on implementing mastery maths with interpretive phenomenological analysis

Suzanne McDonald, suzmcd73@gmail.com

University of Aberdeen, Scotland

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University of Aberdeen, Scotland

Abstract

This study investigates the potential influence of teachers' beliefs and attitudes when implementing a new mathematical reform. Mastery maths has been rolled out across local authorities in Scotland. Originally derived from an Asian method of teaching mathematics, it was favoured following Singapore's poor performance in the subject, particularly in the league tables of the 1980s. Interpretive Phenomenological Analysis (IPA) was adopted to gain a deeper understanding of the teachers' reality influencing beliefs and attitudes around the reform. Four primary school teachers were interviewed. The transcribed interviews revealed three general themes influencing the implementation: confidence, pedagogical understanding and teaching environment. The reform was overshadowed by misconception and future consideration is suggested to focus on precursory growth mindset training and transformative CPD before introducing a mathematical concept from a different culture.

Keywords: mastery maths, teacher beliefs and attitudes, mathematical reform, growth mindset, CPD

Introduction

Several authorities across Scotland's Northern Alliance workstreams introduced mastery maths during 2019 which consisted of six one-hour mandatory training lectures. Mastery maths is influenced by the Asian success in transnational assessments. Since the 1980's when the approach was introduced, it has remained a key strategy utilised by the Singapore Ministry of Education. At the time of data gathering, there was no intention to introduce further CPD in addition to the lectures.

The adopted method of the Asian approach to mathematics has been reproduced in many forms across the UK, with mastery maths being just one version. Due to the potential for misinterpretation and misrepresentation of a substantial paradigm shift in teaching mathematics, this research aims to clarify whether teacher beliefs and attitudes can affect the way the mathematical reform is embraced. The paper argues the complexities of policy borrowing from another culture may not have been fully considered by policy makers.

It is hoped the research will help to identify potential issues which may arise when adopting elements of a teaching pedagogy from a different culture (Clapham and Vickers, 2018). In addition, it is hoped to help inform future professional learning activities CPD, to lead to more successful implementations (Yoon *et al*. 2018).

The origins of mastery maths

For many years, Singapore has topped the rankings for mathematics, Programme for International Student Assessment (PISA) ranking results, while in 2015 the UK struggled in the 23rd place (OECD,

2010; Mullis *et al*., 2012). Across the world, these results were the impetus for concentrated efforts in mathematical reform. Mastery maths was introduced in Scotland following advice within the Scottish Government's report, 'Making Maths Count' (Scottish Government, 2016), to help improve three main areas: raising attainment, transforming public attitudes and improving confidence (National Improvement Framework, 2017). Several authorities across the alliance introduced six one-hour mastery maths training sessions introducing the new reform.

Mastery maths is a concept that aims for pupils to acquire mathematical skills by using procedures which allow for a deep understanding. The concept is influenced by a Singaporean teaching approach, also referred to as the Asian method, with foundations based around the concrete-pictorial-abstract (CPA) heuristic (Hoong *et al*., 2015). The origin of the CPA heuristic was derived from Bruner's (1966, 1991) theory on enactive, iconic, and symbolic modes of representation. Bruner believed any knowledge can be represented in three ways to achieve results: enactive (acting out a scenario), iconic (visualising), and symbolic (abstract, in the form of language). He believed the usual course of intellectual development moves from enactive through iconic to symbolic representation. The labels changed over time to CPA to simplify the language (Ministry of Education, 2012 as cited in Hoong *et al*. 2015).

For students to gain a deep understanding of mathematics the philosophy behind the Asian method involves students using physical objects to add together when learning addition, before moving onto a pictorial representation of the scenario (Witzel, 2005). Lessons may begin with a problem. The initial pupil engagement usually involves conversations around the possible solutions before moving to abstract representations of the problem utilising mathematical symbols and numbers. The adopted method places emphasis on whole class teaching. It distracts and is free from the constraints of ability-focused practices and draws from the concept of transformability (Hart *et al*, 2004). There is an emphasis on connections and discussion which are used as 'scaffolding' to support learning (Bruner,1960); scaffolding enables a child to partake in different activities provided by the teacher or more competent peer. These activities will support the student as they are led through the zone of proximal development (ZPD) where a teacher could provide enough of a boost to achieve a more complex task. (Vygotsky,1978). An abstract finale can be seen as a consolidation of the learning process where the problem is developed in a real-life context and pupils can advance their learning by tackling questions using higher order thinking skills. The formative assessment is based in differentiation of output rather than task (Micklewright *et al*., 2014).

Many schools across the UK are also adopting mastery approaches influenced by the Asian method with successful results. In order to understand the effects of an implementation of a new mathematical policy from a different culture, a government programme was launched: in 2014-15, the Mathematics Teacher Exchange (MTE) funded by the National Centre for Excellence on the Teaching of Mathematics (NCETM) involved teachers from Shanghai exchanging with teachers in 48 selected schools in England for one or two weeks as part of a CPD programme. Findings of the programme suggested while some components of the mastery practice had the potential to improve pupil attainment the complete mastery pedagogy policy may be too ambitious as it originates from a different culture

(Boylan *et al*. 2018). Component practices were identified from the study and went on to become the genesis for 'Teaching for Mastery' (NCETM, 2020). Conversely, NCETM do not mention the underpinning CPA concept within their 'Teaching for Mastery', diagram or within their five big ideas which underpin the teacher for mastery programme in England. Clapham and Vickers (2018) investigated policy borrowing with teachers working in England who were implementing 'Mathematics Mastery'. They found 'cultural baggage' was affecting the implementation as comparatively, the two education systems, English and Asian, were significantly different.

In addition to the research presented by NCETM, the 'Maths No Problem' (2019) scheme was researched by Boyd and Ash (2018) who found teachers were successfully applying the new pedagogy. What is more, they suggested that the introduction of the Asian approach may have played a role in changing teacher beliefs around mathematics. Teachers may be seeing mathematics as more of a deeper collaborative process rather than a speed and calculation race.

Around the same period, in 2015, 'Inspire Maths' was launched by Oxford University Press (OUP, 2020). This whole school textbook programme was translated from Singapore, 'My Pals are Here'. The textbooks are only part of the picture designed to introduce the concept along with a CPA approach, scaffolded sessions and, 'how to' training modules. Hall, Lindorff, and Sammons (2016) conducted an evaluation of 'Inspire Maths' and found significant positive effects on students' maths attainment after two terms. While Oxford University welcomed the findings from 'Inspire Maths', they suggested that for teachers in the UK to deliver a similar regime, they would require a change of mindset (OUP, 2020).

Growth mindset

Across Asia, growth mindset for students, parents, and teachers, is a major driver of student performance (Chen *et al*. 2017). While most original components of the Asian pedagogy remain within the adaptation in the Scottish rollout, growth mindset training was omitted from many of Scottish and English adaptations.

The term growth mindset was derived from innovative research by Dweck (1999), who believes changing beliefs can have a positive impact for learning. Dweck (2008) found mindsets can predict math/science achievement and that mindset interventions can also increase achievement. In our culture, having mathematical ability is often portrayed as being innate, and the brain is believed to be fixed. The myth that some of us are 'maths people' is prominent within western culture and suggests if we are not 'a maths person' then we will never be able to achieve a higher-level knowledge in mathematics (Boaler, 2013). In order to abolish this myth, a growth mindset can be adopted.

The necessary change in mindset required before implementing a change in reform, from another culture, was the impetus for a year-long US study by Anderson, Boaler, and Dieckman (2018). The study investigated the effect on teacher learning, change in beliefs and pupil attainment after introducing a mathematical mindset approach (MMA) consisting of an online training course supported by face-to-face meetings. The professional development was the focus of the research. The approach was intended to eradicate the myth and fixed perception that some of us are 'maths people' and some are not. Their research found teachers were actively making changes within their teaching practice in terms

of adopting growth mindset which positively affected teacher and student beliefs and, as a result, increased attainment. These results, along with the underpinning research from Dweck on the effects of growth mindset intervention, highlight the importance of paying attention to all component parts of a new mathematical reform.

Beliefs and attitudes

Growth mindset attitude, enthusiasm and self-efficacy have been seen to be adopted in classrooms where the mastery approach would be more favoured (Lazarides, Bucholz, and Ribroch, 2018). Attitudes towards teaching can be internal constructs based on beliefs and values from the school's culture and teacher past experiences (OECD, 2009). In terms of the former, Rokeach (1960) spent years researching the organisation of belief systems in teachers with a focus on intolerance, authoritarianism, and discriminations. Rokeach researched the role attitudes and values play on belief systems by demonstrating how dogmatism impedes decision making, negatively affecting the teacher's belief system and thus augmenting a fixed mindset attitude. In terms of teacher experiences, during the past two decades, researchers have explored the relationships between positive teacher experiences, student achievement and teaching styles (Wayne and Youngs, 2003) finding teachers having a positive experience has a positive impact on the quality of mathematical education (McLeod, 1992). Considering beliefs and attitudes while encouraging a growth mindset are key components found to be harmonious with research evidence in Asian professional development (Boylan *et al*, 2018). This research draws on the lived experiences of four individuals to ascertain whether their beliefs and experiences are indicative towards a growth mindset attitude thus influencing the overall success of the implementation.

Continuing professional development CPD

While teacher beliefs can be difficult to navigate, professional development for teachers may be an essential lifeline leading to changes in teaching practice and improvement in school performance (Hargreaves, 1994). According to Kennedy (2005), continuing professional development models can be sorted into three categories :transmissive, transitional, and transformative. Transformative practice and professional autonomy are suggested to be ideal conditions required for successful execution, where teachers can associate the proposed agenda with their own teaching practice (Fraser *et al*., 2007). The transmissive model, most frequently used for many years (Little, 1994), would be delivered by a lecturer from a specialist where knowledge is passed on; the teacher here would be the passive learner. Transitional sits in the middle with the capacity to align with each model. It may include coaching and mentoring. Coaching, when coupled with transformative practice, can have a significant impact on follow up CPD. Likewise, Nolan and Molla (2017) suggest mentoring programmes and tailored CPD programmes are the key to help improve confidence.

Overall, Singapore's PISA results were the impetus for concentrated efforts in mathematical reform across the world and gave rise to many interpretations of the Asian approach. Within the UK, many adaptations have surfaced with some key elements missed resulting in barriers towards implementation. In particular, literature suggests that teacher beliefs and attitudes, CPD opportunities and school culture might affect the implementation of the Asian method. However, the impact of these

elements may be unclear in the Scottish context. As such, this research focuses on the following questions:

1. How are teacher beliefs and attitudes influencing the implementation of Mastery maths?
2. How is CPD training an influence on the implementation of the approach?
3. To what extent are beliefs and attitudes towards the approach influenced by school experiences?

Research design

Due to the complex and varying nature of teachers' beliefs and attitudes, the research follows a qualitative design. An Interpretive Phenomenological Analysis (IPA) was favoured over other forms of analysis due to its value in exploring topics which are complex and sometimes difficult to articulate (Creswell, 2013). IPA can be used to access underlying cognitions of the participant (Smith, 1996) because it is concerned with what the participant thinks about the situation. Thematic analysis was disregarded as an alternative due to the potential pitfall of replicating the study and producing weak (Boyatzis, 1998) or unconvincing analysis (Braun and Clarke, 2006) as it is sometimes viewed as the easier and more flexible option in qualitative research less robust analytical work may be undertaken or avoided (Javaid and Zarea, 2016).

Four participants were selected on the basis that they could provide access to the phenomena in question (Creswell, 2013). This is because all participants had completed their first Mastery Math training session. The table below shows respective experience in primary education and primary level taught.

Table 1: participant background

Participants	*Experience in Years*	*Primary*
Marie	*20+*	*P7*
Rosalind	*10+*	*P1*
Lise	*25+*	*P4*
Brian	*4+*	*P5*

Semi-structured interviews were elected as the optimum practice for extracting information due to the flexibility of questioning and availability of the participants (Willig, 2009). This research complies with all processes and standards as detailed within Aberdeen University's Policy on Research (Aberdeen University, 2017).

Five phases of analysis were adapted in part from healthcare research produced by Biggerstaff and Thompson (2008).

Phase 1 – acquiring the initial knowledge base by reading the transcripts.

Phase 2 – a close line by line analysis was initially undertaken after reading and re-reading the text.

Phase 3 – patterning the data and generating themes.

Phase 4 – participants were cross referenced.

Phase 5 – testing understanding of the emergent and main themes. Current theory was identified to gain synthesis.

During the analysis of the transcribed interviews, the researcher has acknowledged their own preconceptions. The findings are therefore co-constructed with participants dialogue and the researchers' inferences throughout. Findlay (2008) uses the analogy to 'dance' between reduction and reflexivity when describing the process.

Synthesis of research questions and themes

The table below identifies themes revealed from Phase 5 of the analysis. Each theme developed from the language synthesised under the umbrella of a semi-structured interview therefore there is an element of overlap between themes and research questions. The research questions drove the following transcription analysis which is synthesised with the general and sub themes. Given that this project is ongoing, the current feature focuses on the findings related to the second and third research questions.

Table 2: research questions and themes

Research Question	General Themes	Sub Themes
How are teacher beliefs and attitudes influencing the implementation of mastery maths?		
How is CPD training an influence on the implementation of the approach?	**Confidence**	Years of teaching experience
	Pedagogical Understanding	
To what extent are beliefs and attitudes towards the mastery approach influenced by school experiences?	**Teaching Environment**	
		Negative perceptions
		Time
		Enormity of task

How is CPD training an influence on the implementation of the approach?

Confidence, Pedagogical Understanding and sub theme: Years of Teaching Experience

The general theme '*confidence*' is prevalent throughout the findings and overlaps with ''*pedagogical understanding* and sub theme, '*years of teaching experience*'. It appears that experience provides a distinct advantage for the adoption of the reform. Having the confidence to try something new was related to the participants who had more years' experience supporting what was potentially lacking in the CPD training package. In support of this, Marie states:

> And I think it is actually just saying, 'no wait a minute, I've got the resources. It's just a slight change in attitude or a slight change in approach', but em, so maybe that makes it easier but then I've got 10 years' experience. So that also will help with it and It's always been the way I've taught. My maths has always been quite flexible in that respect.

The participants were asked how mastery maths fits in with the curriculum and the school's framework. The subtheme, '*years of teaching experience'*, in this case, accounts for knowing and visualising the curriculum and therefore the framework is not required. Marie reluctantly suggests the framework is there but not used.

> I've been just picking up and doing, you know, how many grams…… then I know where they are. I just know because I've had so much experience. It's not for any other reason than after 20 years I have a pretty good idea of what I should be covering.

The '*confidence'* theme was highlighted again after a question was asked about how their first mastery maths lesson ran. Marie answered with immense pride showing belief and high regard for the pedagogical approach repeating how amazing it is to them:

> I'm so bought into it. I think it's amazing. I think it's amazing…. It's not you you know we've all been doing bits and pieces of it, but I think the fact that the children are not, the children are not put into groups right from the start of the way it's done. I think it's amazing. I really really buy into it.

The sub theme, '*years of teaching experience'* and associated '*confidence'*, enabled teachers to mould the new concepts around their developed teaching style. It was also associated with high amounts of self-belief and of benefit when planning from having the ability to visualise the curriculum.

The theme '*pedagogical understanding'* has both positive and negative outcomes from the participants. Some participants seemed to demonstrate confusion and uncertainty. Most participants agreed to using whole class teaching, CPA, and mixed ability groupings on initial trials of mastery maths which are components covered within the weekly training sessions. Nevertheless, the transcribed data suggests confusion as to how mastery maths should be implemented. There is an undertone of uncertainty which the participants were all aware of.

> Most of my lessons are, if not, erm I have adapted the approach. I don't feel as though I've really followed the approach directly step by step. But I think that makes it, as a professional teacher you've got to take on concepts and adapt them to your style of teaching because otherwise it just doesn't work.

> I'd kind of, been trying to look at it as components.

> It's not you you know we've all been doing bits and pieces of it.

> I quite often feel that I'm having to do something for the first time and then someone comes along and says, 'you have to do this all differently' and I'm like, I'd just like to know how to do it at-all, never mind do it differently.

Following the theme on '*pedagogical understanding',* the following statement comes near the end of the interview and is perhaps an afterthought and a cause for concern.

It can fit around any program because it's not a programme of learning, It's an approach to teaching. You know, and that's so important. I don't know if a lot of people just quite understand that.

Trusting in skills and abilities reinforces self-belief building a greater foundation of confidence (Nolan and Molla, 2017). This trust in skills can be reinforced by transformative CPD as transformative practice and professional autonomy are ideal conditions for fostering collaborative practice (Fraser *et al*. 2007). The participants' uncertainty may suggest there is a lack of appropriate CPD to help with the overall transition.

To what extent are beliefs and attitudes towards the Mastery approach influenced by school experiences?

Teaching Environment and sub themes: Negative perceptions, Enormity of Task and Time Factor

The general theme '*teaching environment'* was identified from the data on how school experiences has influenced the approach. In addition, three overlapping sub themes will also be discussed.

The teaching environment consists of colleague's attitudes, beliefs and their teaching practices. Although most teachers seemed confident with their practice, the interviews identified that one participant at times alluded to having a closed mindset. Brian has more reservations on the mastery concept. This may be related to how mastery maths is implemented in their schools and how flexible it is for teachers to adapt it in their classroom. For Brian the initial implementation created a negative perception, as he refused to implement any component part of the mastery approach without peer reviewed evidence and suggested it's a "golden bullet kind of thing":

Or does it have any evidence? Or is it just been introduced as this package that has a golden bullet kind of thing. I feel that mastery maths kind of has that kind of thing.

Brian has a sceptical view and emphasised doubts as to its foundations alluding to some of the components of mastery maths being, "*educational gimmicks*" which may have been influenced by dogmatic colleagues. Brian's teaching environment seems to be influencing his discourse and at times he alluded to the influence of colleagues with a closed mindset.

I think with a lot of the staff meetings, the usual chat afterwards is you know, 'who's got time to actually go away and think about all that and apply it in their own context?

None of them would have adopted the whole approach.

In addition to dogmatic peers, uncertainty when planning could have a knock-on effect on attitude. Brian makes a statement suggesting planning is done as a whole school with little flexibility and he is not experienced enough to break free from following the framework.

We never really plan from the E's and O's directly. It's always kind of following the framework to the letter almost. I'm still not sure if that's how they were designed to be used or not.

Furthermore, the participants spoke about the '*enormity of task and time factor'*. Teachers may find it difficult to keep up to date with current theory and recommended practice due to time constraints (Walia, 2015). Aligning with this, Marie suggested the following:

> We don't get the luxury of that time, stuff starts, and you've not been given time but that's the nature of the beast.

All the teachers surrender to the belief that the reform will change before it has time to make a difference in the classroom. There is a lack of confidence with the speed of change stemming from historical government reforms adopted from different cultures and the potential for more to supersede the current concept. Rosalind states:

> Ideally you would like it to be embedded throughout, but we will move on to something else. Sorry, that's the cynic in me.

This statement may contribute to evidence of superficial adoption creating a barrier to successful implementation. Teachers may be confused due to the lack of transformative practice, historical speed of change and a misconception of the original mathematical concept. The analysis identifies a misconception that mastery maths is being promoted as a sequential package of concepts that cannot be unpicked and that it is a direct replication the Asian approach:

> They're doing it in Singapore and Shanghai, and they've got great PISA results therefore if we do mastery maths, we'll get great results too. I'm slightly sceptical of that reasoning and think there's a lot of other factors that are creating the Asian results. Erm, and so I'm, I'd would rather than sort of adopt mastery maths the whole package and sort of do a policy importation from East Asia. I'd kind of, been trying to look at it as components. (Brian)

Conclusion

Several conclusions emerge from this analysis. First, results at this early stage of implementation show a similarity to the research on teachers' beliefs by Boyd and Ash (2018) where teachers were challenged by the new approach but overall positive about the possibilities. Conversely, the in-depth IPA analysis has uncovered misconceptions and fear around the implementation with one teacher appearing to be influenced by dogmatic colleagues.

Second, although research demonstrates that by implementing mastery maths teachers have reported feelings of increased autonomy, the way CPD has been delivered may have had a negative impact on how it is has been received and implemented. At the same time as teachers needed to be proactive in identifying how the suggested reform fits in with their own teaching practice, the reform was overshadowed by misconception. Most participants broke the concept down into components rather than adopting the whole package.

Third, when conducting research on the MTE Boylan *et al*. (2018) also found some components had potential to improve pupil attainment but the whole policy may have been too ambitious. Educational reforms in both Scotland and England follow a trend of evidence based informed policy and teaching. Nevertheless, evidence sourced from research in policy making can be used selectively. It is therefore

imperative that evidence supporting policy innovations are analysed. The Scottish Government may appear to be making use of PISA results to inform policy and reform, yet there are dangers of adopting practices from other parts of the world without paying attention to cultural differences. Considering beliefs and attitudes while encouraging a growth mindset are key components found to be harmonious with research evidence on Asian professional development, yet it seemed to be omitted from the adaptation of the Asian concept.

Overall, the results here highlight the importance of various factors in teachers' perceptions about implementing borrowed policies. Future research is recommended to help magnify these issues, with a focus on the structure of CPD, the compounding nature of the teaching environment and influential cultural differences.

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