

TEACHER CHANGE IN POST-16 MATHEMATICS: A MULTIPLE CASE ANALYSIS OF TEACHERS IN THE ZONE OF ENACTMENT

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This research focuses on the use of teaching resources that support an ambitious student-centred approach to learning mathematics. A multiple case study involving three teachers of post-16 mathematics is presented to develop new insights into the process of teacher change. Data sources include classroom observations in addition to teacher and student interviews. Using the concept of Zone of Enactment (ZoE) as a theoretical framework this research reveals the importance of teachers being aware of, and able to reflect on, the ZoE. The role of teacher confidence in meeting the challenges inherent in the ZoE is also highlighted.

INTRODUCTION

This paper explores the implementation of an ambitious approach to teaching mathematics in the context of post-16 mathematics (A-level) in England. *Ambitious teaching* is conceptualized here as providing rich learning environments in which students are required to use their powers of reasoning and problem-solving; there is a strong component of dialogue and the teacher is responsive and adaptive to the learning process (Stylianides & Stylianides, 2014). Research involving three teachers is presented to examine how practitioners respond to, and enact, an approach designed to encourage ambitious teaching. Using the concept of Zone of Enactment (ZoE) as a theoretical framework particular attention is paid to the process of teacher change.

This research is motivated by the need to investigate the use of resources (tasks and teacher support materials) developed by the Cambridge Mathematics Education Project (CMEP). Since 2012, CMEP has been developing resources to support and inspire more ambitious teaching of A-level mathematics. Through an investigation of classroom practices, this work aims to improve understanding of teachers' experiences using CMEP resources and make a broader contribution to knowledge on classroom instruction.

BACKGROUND

The General Certificate of Education Advanced Level (A-level) is an established two-year course taken predominantly by 16–19-year-olds in England, Wales and Northern Ireland. Funded by the UK Department for Education for an initial period of 3.5 years, CMEP aims to enhance A-level mathematics education through the development of resources (tasks and teacher support materials) that help make A-level mathematics a rich, coherent and stimulating experience for students and teachers. This research forms part of an applied research and development sub-project of CMEP, involving the iterative analysis and refinement of support materials to promote the faithful implementation of tasks developed by the CMEP team (see Major, Watson, & Kimber, 2015). By developing a deeper understanding of teachers' experience using CMEP tasks and support materials we aim to develop ways to encourage teachers to embed CMEP pedagogy in their practice.

Theoretical framework

We use Spillane's notion of a *Zone of Enactment* (ZoE) as a framework for teacher change (Spillane, 1999). This acknowledges the existence of patterns of practice in mathematics teaching, where teachers adopt and individualise historically- and culturally-developed classroom practices. ZoE is an adaptation of Vygotsky's *Zone of Proximal Development* (ZPD; Vygotsky, 1978) which describes the progress that can be made by an individual acting on their own, compared with the progress that can be made by the individual working with a knowledgeable other. In terms of teaching reform, ZoE means the extent to which a teacher will engage with (and commit to) a change in practice, given that there is support to do this and the extent of the change is not so large that it represents too radical a departure from existing practice.

We analyse teachers' attempts to change their approach, from traditional or teacher-centred practice to the ambitious approach suggested by the CMEP materials. This we characterise as within their ZoE; there is an invitation to try out new approaches but with guidance using support materials (which have been designed to make crossing the ZoE achievable and not too distant from existing practice). By undertaking an exploratory case study, we can better understand what is happening in the ZoE in order to develop and enhance the support and guidance that accompanies CMEP tasks. It is important to note that when we refer to *teacher-centred* teaching this is more than simply chalk, talk and textbook exercises. While such lessons might include groupwork and investigations, the feature that makes them teacher-centred is that the teacher attempts to reduce the cognitive demand in the lesson so that students can progress easily through the tasks. In contrast, the aim of the CMEP tasks is to offer higher levels of demand so that students have to think deeply about the mathematics and, as such, we characterise this as *student-centred* (Watson, Major & Kimber, in preparation).

METHODOLOGY

A multiple case study was undertaken to ask:

How do different teachers experience using materials to promote ambitious teaching of A-level mathematics?
What happens in the Zone of Enactment?

A case study was considered suitable as this facilitates systematic research that investigates real-world occurrences in their real-world settings (Robson, 2011). Three teachers were involved - *Kay*, *Amy* and *Irvin*. Kay and Irvin teach in 11-18 comprehensive schools, while Amy teaches in a selective 16-19 college. All have at least five years' experience of teaching A-level mathematics. This research complies with the British Educational Research Association's ethical guidelines.

'Two-way functions' and associated teacher support materials

The same CMEP task, 'Two-way functions' (available online: rich.maths.org/11301), was used by each teacher. This task is designed to develop ideas about the properties of functions and to expand the set of functions students can work with. Students can use a combination of algebraic and graphical representations to attempt the task. Teacher support materials place the main CMEP task in the context of a sequence of preliminary, main and follow-up tasks designed to be used during three separate (but not necessarily successive) lessons. Guidance includes a suggested way of using the task, descriptions of mathematical behaviour to look out for and questions to prompt student reflection. Details of overarching mathematical ideas, connections that students might make, common issues and misconceptions are given. Teacher prompts/questions are also suggested.

Data collection and analysis

Multiple sources of data are used: (1) semi-structured teacher interviews (5-20 minutes) before and following lessons; (2) focus groups (4-6 students, approx 15 minutes) to establish students' opinions; (3) classroom observations (stationary and tracking cameras; audio from teacher lapel mics and recorders on students' desks); (4) discussions with teachers videoed during later CMEP workshops. The analytical process centred on observed lessons and involved the project team reviewing the video of the lesson together with associated transcripts. The formation of a case description for lessons, using a theoretical proposition, was iteratively tested. Data triangulation was then effected by developing and elaborating explanations from interview transcripts.

FINDINGS

Kay's response characterised her ZoE experience in terms of the difference between teaching pre- and post-16 classes, describing how CMEP lessons felt more like those she would teach at Key Stage 3 (students aged 11-14, when there is generally greater opportunity for investigative work and open-ended problem-solving). Of the three teachers, the way in which Kay presented the lesson was most consistent with the approach suggested in the CMEP support materials. This is evident by Kay using many of the questions or prompts suggested. As a result, Kay is considered to have used the support materials to assist her in crossing the ZoE. Students corroborated that the approach in the CMEP lesson was different from usual, commenting, "*...we usually just work through with Miss, get the understanding and then go on to questions at the end so it was different*". The design of the task was also noted as helping students to resolve the complexity in the task for themselves:

"... going along the rows and seeing that the numerator was telling them the roots, whereas the denominators were telling them the asymptotes... usually they would have a whole series of questions to do individually..."

Amy did not use the support materials beyond choosing a preliminary task, instead adapting the ideas into her usual approach to teaching. She expressed concern about the level of challenge, and wanted to make the experience using the task similar to that expected in a more traditional lesson:

"...saying that the x axis is an asymptote and finding something that passes through the origin, is quite a big ask for a group like that... Quite a few times I was going 'shall we just change that bit?'"

When questioned if there were any challenges in using the resources, Amy commented:

"Not really. I think the main thing would be not really realising how long the activities are going to last for a class and so ways of dealing with that, either with ways of getting them to engage more deeply, or other things to look at which I think I sort of did"

When some students completed the task in a way that Amy judged to be superficial, she asked the groups to swap their work to compare approaches and prompt a more sophisticated response. Amy attributed this technique to CMEP workshops, although it is suggested in the support materials. In a later interview, Amy acknowledged she hadn't read the teacher support materials in detail:

"I wish I'd read this document [teacher support materials] slightly more carefully before I did it. Things like, allow individual thinking time at the start of the activity, I didn't do that..."

Irvin used the support materials and followed the guidance much more closely than Amy. While concerned about the attainment and confidence of his class, Irvin was surprised about the level of mathematical discussion that took place during the preliminary task:

“... there is a sizable minority in there who will have just failed their AS-level [the first component of a full A-level] and yet, the level of discussion they were able to keep going with that work with each other, and the outcomes [of the discussion] that I could see on the whiteboards was quite impressive”

Despite being pleased with the resilience shown by some students, Irvin noted that many used tables of values to help them sketch graphs rather than thinking about behaviour of functions. Additionally, despite being impressed with how the students had tackled the preliminary task, half-way through the main task lesson Irvin commented to the observer, “...it’s like this group [points to group of students] has taken... six months step backwards”. Irvin also described the task as being “a little more scary” and wanting to “get them used to that”.

DISCUSSION

Kay showed an awareness of the existence of the ZoE, and was able to reflect upon it. It is this awareness that allowed Kay to bridge, to a certain degree, the difference between her existing A-level teaching approach and that proposed by CMEP. Amy, in contrast, showed little or no awareness of a ZoE as she integrated the CMEP tasks into her existing practice with the lesson being more teacher-centred and thus traditional. The fact that she did not fully engage with the support material supports the view that Amy interpreted the required pedagogical approach as somewhat different than that suggested by the support materials. Irvin was aware of a ZoE and recognised the differences in pedagogy and teaching approach required. He found the experience of using CMEP tasks, however, challenging. Indeed, Irvin was concerned with both the effectiveness of student collaborative work and the challenges of formative and summative assessment.

We conclude that the ZoE is an important concept in the analysis of teacher change and propose that teachers’ awareness of the ZoE, in the context of their teaching, is a necessary condition for them to be able to change their approach. If teachers do not recognise the ZoE, then it is likely that they will not use the support available to them. We also suggest that teachers need to have the confidence to bridge the gap between their existing teaching approaches and ambitious teaching. Through our ongoing research into how teachers use the support materials we will continue to pay close attention to the mechanisms, processes and responses at the site of individual teacher change. Using ZoE has provided a useful conceptual framework for theorising teacher change and will help to inform the design and formative evaluation of teacher support materials in the future.

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