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► **To cite this version:**

Steven Watson. Revisiting teacher decision making in the mathematics classroom: a multidisciplinary approach. Eleventh Congress of the European Society for Research in Mathematics Education, Utrecht University, Feb 2019, Utrecht, Netherlands. hal-02430233

HAL Id: hal-02430233

<https://hal.science/hal-02430233v1>

Submitted on 7 Jan 2020

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Revisiting teacher decision making in the mathematics classroom: a multidisciplinary approach

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The purpose of this paper is to consider the role of mathematics teachers' thinking and decision making in the classroom. This has been a somewhat neglected area of research since the mid-1980s, but I will argue here that understanding the nature of teachers' thinking and decision making in lessons is important in understanding practice and can inform approaches to initial teacher education and professional development. While mathematics teachers' knowledge and beliefs are important, the decisions they make and the actions they implement in the lesson influence the learning environment, culture and interpretation of tasks and activities. I draw on my own empirical research along with a multidisciplinary account based on developments in cognitive psychology, neuroscience and ontology (e.g., posthumanism) to provide a theoretical account of teacher thinking and decision making and how this influences practice.

Keywords: Teachers' decision making, teaching practices, teaching methods, teachers' knowledge, teachers' beliefs.

There was considerable research into teachers' thinking and decision making during the 1970s and 1980s, but since the mid-1980s this was rather displaced by a surge of interest in teachers' knowledge (Borko, Roberts, & Shavelson, 2008). It is not entirely clear why there was a change in direction, but it is likely that the seminal American Educational Research Association presidential speech by Lee Shulman in 1986 heralded widespread interest in teachers' pedagogic content knowledge (Shulman, 1986). Since then researchers have been more interested in what teachers know in terms of discipline-based pedagogical knowledge than they have been in teachers' thinking. This is not to say, of course, there have been no recent contributions to the field of teacher decision making. Notably, Alan Schoenfeld's book *How We Think* (2011) directly addresses teacher decision making and thinking in the classroom and builds on the earlier research. But there remains further opportunity to revisit and extend the existing research using recent thinking from neuroscience and psychology. My aim here is to argue why, while acknowledging the important contribution of research into teachers' knowledge and beliefs, research into teacher thinking is necessary in order to gain a better understanding of the nature of classroom practice.

The background to this is mine and colleagues' recent research (Watson, Kimber, Major, & Marschall, 2018) into how teachers implement ambitious teaching approaches (Stylianides & Stylianides, 2014) in post-16 (A Level) mathematics classrooms. An intense idiographic inquiry led us to consider how teachers make decisions in the classroom and the nature of the underlying thinking and reasoning processes. We found we could not easily explain, like many researchers before us, why even in the context of supported teaching reforms, a teacher almost naturally tends to a traditional teacher-centred approach in the classroom. And when the teacher is encouraged and supported in implementing ambitious teaching and in giving mathematical authority/authorship (Povey & Burton, 1999) to the students they seem compelled to retain authority/ authorship. This is

not by any means a criticism of teachers, but it is undoubtedly a phenomenon that warrants exploration and a search for further understanding. Our research, building on past research into teacher thinking and recent developments in cognitive psychology, neuroscience and ontological accounts such as posthumanism, suggests that in-the-moment decision making (Schoenfeld, 2011) in the classroom has an important role in this.

It is first necessary to distinguish between teachers' thinking in the lesson as they interact with students and the thinking and decision making that takes place in the planning of and reflecting on lessons. I adopt here the following categorization of teacher thinking developed by Clark and Peterson (1986):

- Teacher planning (preactive and postactive thought);
- Teacher interactive thoughts and decisions;
- Teacher theories and beliefs.

There are qualitative differences between the decisions made in the moment in the lesson and the teacher's thinking about the lesson before and after the lesson. Decisions in the classroom have to be made quickly in a complex and demanding environment. But both interactive, in-the-moment decisions and planning are underscored by a teacher's theories, knowledge and beliefs. The knowledge and perspectives in memory provide the resources that contribute to reasoning processes. The turn to pedagogic content knowledge in the late 1980s tends to privilege the role of teachers' theories and beliefs, I argue here (and following our empirical research) it is the momentary decisions that influence the character of the lesson. That is, in-the-moment decisions can lead to a lesson becoming more traditional and teacher-centred even though the teacher may have the knowledge of and hold beliefs in reform-oriented student-centred approaches (or 'ambitious' teaching)¹.

Traditional teacher-centred teaching typically involves teacher exposition or demonstration followed by student practice on routine graduated exercises and might conclude with a whole-class review. In contrast, student-centred² practice involves students in collaborative dialogic problem-solving, inquiry-based or investigative activities in which they construct meaning and conceptual understanding (or 'relational' rather than 'procedural' understanding, see, Skemp, 1976) where the mathematical authority and authorship (Povey & Burton, 1999) is transferred to students. This has been given a catch-all characterization of 'ambitious' teaching (Stylianides & Stylianides, 2014).

From the perspective of cognitive psychology, human reasoning and decision making are characterized as either unconscious and intuitive Type 1 processes or rational and conscious

¹ The implicit assumption here is that the traditional teacher-centred teaching is a default and largely prevalent approach to practice – this is certainly underpinned by evidence from the Office for Standards in Education (Ofsted) in England (Ofsted, 2008, 2012). I contend this to be a justifiable claim for high school and secondary mathematics teaching practice in Europe and the US (see, for example, Cuban, 1993; Stigler & Hiebert, 1999).

² The characterisation of traditional teacher-centred practice and student-centred practice draws on Larry Cuban's historical analysis of classrooms in the USA (Cuban, 1993).

deliberative Type 2 processes (Evans & Stanovich, 2013). Intuitive unconscious reasoning is rapid and is employed in complex and demanding situations where decisions have to be made quickly (Johnson-Laird, 2006). Conscious reasoning uses working memory to construct mental models and assess possibilities prior to making a decision and taking action. Research into teacher decision making in the 1970s and 1980s acknowledged the distinction between unconscious (Type 1) and conscious (Type 2) reasoning and recognized that classroom demands require intuitive Type 1 decisions (Clark & Peterson, 1986; Shavelson & Stern, 1981). At the same time, Clark and Peterson recognized deliberative aspects of teachers' interactive decision making in the classroom. Shavelson and Stern (1981) suggested teachers draw on existing routines and sub-routines to simplify their interactive decision making.

...teachers' interactive teaching may be characterized as carrying out well-established routines. In carrying out the routine, the teacher monitors the classroom, seeking cues, such as student participation, for determining whether the routine is proceeding as planned. This monitoring is probably automatic as long as the cues are within an acceptable tolerance. However, if the teacher judges the cue to be outside tolerance (e.g., student out-of-seat behavior during discussion), the teacher has to decide if immediate action is called for. If so, the teacher has to decide if a routine is available for handling the problem. The teacher may take action based on a routine developed from previous experiences (Shavelson & Stern, 1981, p. 483).

This implies a heuristic approach to decision making that is not entirely intuitive and involves conscious decisions using rehearsed actions and pedagogic routines. The nature of teacher decision making is somewhere between Type 1 and Type 2 reasoning.

Recent research on human reasoning goes beyond a Type 1 and Type 2 dichotomy and offers an intermediate type of reasoning. Stanovich, West and Toplak (2011) propose an algorithmic system. This is a Type 2 conscious process but makes use of heuristics and preestablished routines and processes to reduce the demand on working memory. Algorithmic reasoning draws on knowledge which is "...tightly compiled due to overlearning and practice" (Stanovich et al., 2011, p. 107) and is based on social and cultural knowledge acquired through participation (Stanovich et al., 2011).

In our research (Watson et al., 2018), most of the decision making in the classroom was based on algorithmic reasoning. For example, during the lesson we observed the teacher deciding to stop the class and explain a specific aspect of the mathematics to the whole class. He explained in a stimulated recall interview later that he made the decision to take this action during the lesson. He said that he felt that there were enough student misunderstandings to warrant some remedial action. This heuristic, he said, was learnt during his initial teacher education programme. He explained how he observed that if a teacher found that there were three or more students with a similar question, then it could be assumed that more students were likely to have the same difficulty, then they would stop the class and offer an explanation to the whole class. Based on his explanation of this vicarious learning process, it appeared likely that this heuristic had been supported with some justification from a mentor or experienced teacher. This is an example of algorithmic reasoning, it is a simplified (and almost intuitive) judgement of the situation and the retrieval of rules, procedures and strategies (Stanovich et al., 2011).

Mathematics teaching and teaching more generally is replete with pedagogical routines and strategies. Indeed, Alexander's (2001) analysis of primary classrooms observed complex hierarchical and temporal systems of routines and rituals. Leinhardt characterizes teachers' knowledge as "...highly proceduralized and automatic and in which a highly efficient collection of heuristics exist for the solution of specific problems in teaching" (Leinhardt, 1988, p. 146).

As a secondary mathematics teacher, my own practice featured automated, proceduralized routines and heuristics. For example, I had a routine for teaching how to solve simultaneous equations. It was highly procedural, I would refer to it as a 'recipe'. And as an experienced mathematics teacher, I did not have to think, in the moment, about the pedagogical process in too much detail. I had learnt it from other teachers and used it on many occasions. If students were having difficulty solving simultaneous equations I could quickly stop the class and invoke this routine. I knew that if students were becoming anxious (and potentially disruptive) I could quickly and authoritatively provide this well-rehearsed explanation and give the students some routine practice questions, and this would provide reassurance and calm the situation.

It is widely acknowledged in the literature that a major preoccupation for all teachers is the management of the classroom and the management of student behaviour (Martin, Sass, & Schmitt, 2012). Shavelson and Stern explain the main aim of the teacher is to "maintain the flow of activity" (Shavelson & Stern, 1981, p. 484) and that decisions are made when there is an indication of a "potential problem or unexpected event" (p. 484). At these points teachers become "aware of reality" and their attention focuses on student behaviour (Shavelson & Stern, 1981). Therefore, what prompts a teacher to make an in-the-moment or interactive decision is strongly influenced by the affective system, that is the senses, the autonomic system and physiology. While Schoenfeld offers a highly rationalistic account of goal-oriented in-the-moment decision making based on his previous research on mathematical problem solving, he acknowledges the importance of affect. He advocates for future research in decision making to work toward a "rapprochement of the physiological and psychological" (Schoenfeld, 2011, p. 195).

Indeed, this rapprochement can be observed in posthuman accounts of practice and potentially provides a compelling interdisciplinary account of thought, experience, affect and behaviour in the context of classroom practice. A posthuman³ critique of teacher thinking represent a departure from the Cartesian mind/body duality (Strom, 2015); posthumanism emphasizes the physical, the material, the experiential and the embodied nature of cognition (Braidotti, 2013). The posthuman classroom is not populated by discrete individuals but is "...an assemblage of multiple human and non-human elements that are all connected and work together to jointly produce teaching and learning activity" (Strom, Mills, Abrams, & Dacey, 2018, p. 144). A feeling or sensitivity to the environment is processed by the amygdala, which is reciprocally connected with the brain cortex and the thalamus. The amygdala is often associated with 'fight or flight' responses. Effectively it

³ Posthumanism is not a rejection of humanity but a counter to humanism, as an anthropocentric project and a challenge to Enlightenment rationality that privileges the mind as a conscious and rational system as the primary mechanism for solving individual and collective problems.

helps us decide whether a response should be intuitive and reactive or conscious and deliberative. Importantly it draws on episodic memories which have affective and emotional signatures to quickly make sense of the situation (Markowitsch & Staniloiu, 2011). In contemporary liberal society human responses are much more nuanced than simply ‘fight or flight’: in any critical situation then the amygdala is involved in the following processes, do we have to react quickly or intuitively with deeply embedded culturally and evolutionarily compiled behaviours? Is there time to invoke socially learned and culturally embedded heuristics, strategies, routines and processes (the algorithmic mind)? Or is there time to reflect and construct and mentally evaluate alternative hypothetical courses of action and use logical processes? (see, for example, Janak & Tye, 2015; Markowitsch & Staniloiu, 2011; Pessoa, 2017; Phelps, 2006).

Much human behaviour is intuitive, we respond to the context with culturally and evolutionarily compiled behaviours, like, for example, the fight or flight response. Algorithmic responses are invoked where simple decisions and well-practised responses are required, and these have been the focus of the research I have referred to in this paper (Watson et al., 2018). Reflective Type 2 thinking might take place in the planning and evaluation of lessons, or in the work of research and scholarship, for example.

While it might be argued that the goal of teachers’ decisions is to optimize student learning (see Schoenfeld, 2011) and this might be possible in the planning and design of lessons, tasks and activities, in interactive decision making, in the classroom, decisions have to be more immediate. The primary aim, in the moment, is to manage the social situation, as Cuban observes:

... teachers have learned to ration their time and energy to cope with conflicting and multiple societal and political demands by using certain teaching practices that have proved over time to be simple, resilient, and efficient solutions in dealing with large numbers in a small space for extended periods of time (Cuban, 2009, pp. 10–11).

The algorithmic mind quickly accesses routines and procedures that are learnt through participation and provide well-rehearsed and culturally-embedded approaches to respond to situations in the classroom. The mainstay of these established cultural scripts (Stigler & Hiebert, 1999) correspond to traditional teacher-centred approaches. Moments of doubt, pressure and uncertainty in a classroom are likely to result in an almost automatic response with teacher-centred routines, as we found in our research (Watson et al., 2018). This shifts the mathematical authority/ authorship back to the teacher. Research into mathematics teachers’ beliefs has shown that there is frequently a misalignment between teachers’ espoused and enacted beliefs (Thompson, 1984; Wilson & Cooney, 2002), teachers may profess beliefs in reform-oriented student-centred ambitious teaching, yet their teaching is largely traditional and teacher-centred. Cuban refers to teacher-centred progressivism (Cuban, 2009), where there are many surface features of reform and student-centred practice but fundamentally the pedagogy is teacher-centred – the mathematical authority/ authorship remains with the teacher. The classic illustration of this is Cohen’s case of Mrs Oublier (Cohen, 1990). The difference between espoused and enacted beliefs, and the manifestation of teacher-centred progressivism can be explained by considering the momentary interactive decisions and algorithmic

reasoning that leads to teachers implementing culturally established and embedded teacher-centred routines and scripts, as Leinhardt (1988) observes:

[The] resistance to change on the part of the teacher should not be perceived as a form of stubborn ignorance or authoritarian rigidity but as a response to consistency of the total situation and a desire to continue to employ expert-like solutions (Leinhardt, 1988, p. 146).

The “expert-like solutions” represent the momentary intuitive judgements that draw on the teacher’s established knowledge – the essence of practical reason in Aristotelian terms⁴.

In this paper, I have considered the nature of teachers’ decision making in the classroom. Drawing on multidisciplinary approach, I have argued how important momentary interactive decisions are in the classroom, how they can shape the character of the lesson and influence the nature of students’ learning experiences. It seems as important as ever to research this decision making further, to better understand the affective dimensions, the culturally embedded routines and strategies that teachers acquire through participation in the professional community (and vicariously as a student, see, Lortie, 2002; Stigler & Hiebert, 1999, for example). An improved understanding of mathematics teachers’ interactive decisions would also inform the design of reform-oriented professional development and initial teacher education.

I suggest the main implication for future research is to give greater attention to teachers’ decision making from a multidisciplinary perspective while using techniques such as stimulated recall. What I have presented here prepares the way for a model of teacher thinking that integrates cognition, affect and the social setting. Further research could develop and test the model.

Acknowledgements

I would like to pay tribute to the late Professor Malcolm Swan, my PhD supervisor, with whom I did not always agree but always respected his profound insight into mathematics education. It was within the Shell Centre milieu that this line of thinking was born. I also thank Dr Matthew Inglis (Mathematics Education Centre, Loughborough University) who introduced me to the ideas of Type 1 and 2 reasoning, the work of Philip Johnson-Laird and Jonathan Evans on human reasoning from a cognitive perspective. Finally, to my colleagues in the Mathematics Education Research Group and the Culture, Politics and Global Justice cluster in the Faculty of Education, University of Cambridge who have provided helpful formative criticism from hugely diverse disciplinary, philosophical and theoretical perspectives.

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⁴ The Nicomachean Ethics (Aristotle, 1998) alludes to effective practical wisdom in terms of a harmony of conscious reasoning, intuition and affect.

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