Investigating the role of positive emotions in secondary mathematics classrooms: Observing play, modelling and storytelling practices of experienced teachers through an Engagement Structures and Positioning Theory perspective

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Abstract

Emotions are an important part of learning mathematics, but until recently have taken second place to cognitive processes within mathematics teaching and learning. Often students complain that they do not enjoy school mathematics, and adults report that they disliked mathematics at school. Yet successful students cite their teachers as a driving factor in choosing to study mathematics to a higher level.

This study explores this and similar mismatches by investigating the existence and role of positive emotions in mathematics classrooms. I examine how teacher emotions 'colour' mathematics teaching, and how teachers actively share their emotional relationship with mathematics with students. To this end, I interviewed a sample of experienced UK mathematics teachers, observed lessons from their normal classroom practice, and used video stimulated post-observational discussion of episodes. I selected episodes by emotional expression in observed lessons in conjunction with evidence from a Galvanic Skin Resistance (GSR) sensor, used as an approximating indicator of internal emotions. In the analysis, I consider two models for examining affect. Engagement Structures (ES) was developed (Goldin, Epstein, Schorr and Warner, 2011) for researching student affect, and Positioning Theory (PT) (Harré and Langenhove, 1999), is used to examine the socially located detail of classroom discourse. I present episodes from classrooms through the lenses of ES and PT, and discuss their adaptation for mathematics teaching.

I argue that teachers who build a positive emotional climate, defined as a climate supportive of positive engagement in learning mathematics, embed emotions within mathematics teaching in myriad unique and connective ways. In particular, teachers embed emotions by socially sharing their pleasure in mathematics, through *play*, by *modelling* enjoying engaging in mathematics, and through *storytelling*. Examining how experienced teachers use emotions within their teaching draws attention to where emotions might be used within teaching to the greatest effect and to some reasons why they might not be used.

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Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
CTO	‘Check This Out’
DDM	‘Don’t Disrespect Me’
ES	Engagement Structures
ESensor	Sensor (ESense Skin Response) from Mindfield Biosystems Ltd.
GSR	Galvanic Skin Response (Resistance)
GJD	‘Get the Job Done’
INF	‘It’s Not Fair’
IRIT	‘I’m Really Into This’
LHSIA	‘Look How Smart I Am’
LMTY	‘Let Me Teach You’
MCK	Mathematical Content Knowledge
PCK	Pedagogical Content Knowledge
PE	‘Pseudo-Engagement’
PT	Positioning Theory
SCOR	Skin Conductance Orienting Response
SCL	Skin Conductance Level
SOOT	‘Stay Out Of Trouble’
T.I.R.E.D	Nardi and Steward (2003) Acronym to stand for student disaffection (Tedium, Isolation, Rote learning, Elitism and Depersonalisation).
UB/LB	Upper Bound and Lower Bound
UEA	University of East Anglia, UK

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Chapter 1: Background and focus of this study

> *"Mathematics is a domain that conspicuously neglects a discourse of emotion."* (Drodge and Reid, 2000, p.249)

If you ask a person about their learning of mathematics, they are likely to answer strongly, and often negatively. Recalling school mathematics generates a visceral response in many, a response associated with the smell or feel of a classroom or emotions connected with boredom or dislike of one particular teacher. Yet certain individuals choose mathematics, and furthermore share their favoured subject through teaching. If we assume such individuals enjoy mathematics, then why might such enjoyment for mathematicians-cum-teachers be apparently invisible to students and the public? Mathematics is commonly seen as a dispassionate, rational activity (McLeod, 1992; Goldin, 2007). In particular it seems that some cultures expect school mathematicians to adopt a somewhat aloof position (Hersh and John-Steiner, 2011). Nevertheless, modern understanding of cognitive processes locates cognition as inseparable from affect (Damasio, 1995). Bibby (2002) sums up this shift,

> *"Traditional views of mathematics are that it is an unemotional subject; however, [...] for many people it is experienced in highly emotional ways – people come to know mathematics through emotions."* (p.706)

There is also growing recognition within neuroscience of the importance of emotion within corporal responses to cognitive processing (Damasio, 1995; Drodge and Reid, 2000; Brown and Reid, 2006; Dalgleish and Power, 1999). It therefore seems an appropriate time to bring more consideration of emotion back into mathematics education debates and to challenge any assumed unemotional identities of secondary mathematics teachers within UK culture.

Most current research around affect within mathematics education focuses on students rather than teachers. This first imbalance is one reason for shifting a research emphasis onto teachers, because a significant factor influencing mathematics learning is the emotional relationship a student has with their teacher (Bibby, 2011, Solomon, 2009). Further,

> *"As an emotional practice, teaching activates, colors and expresses the feelings and actions of teachers and those they influence. Teachers can enthuse their students or bore them, be approachable to or stand-offish with parents, trust their colleagues or be suspicious of them. All teaching is therefore inextricably emotional – by design or default."* (Hargreaves, 2001, p.1057).

Hitherto, affect has predominately appeared in research as part of context for other research questions (Walkerdine, 1998). This is particularly the case for teacher affect (Zan, Brown, Evans & Hannula, 2006; Frade, Roesken & Hannula, 2010). Yet emotions in mathematics classrooms are known to be important (e.g. Cobb, Yackel & Wood, 1989). One reason for comparatively less research for teacher affect might be the known challenge of studying emotions in action. For example, studying the fluidity and the internal nature of emotions can be problematic. Despite these challenges, emotion (as opposed to more stable affective traits such as belief or attitude), has become a productive area of research (McLeod, 1992; Hannula, 2012; Goldin, Epstein, Schorr & Warner, 2011). This research development recognises that learning mathematics is more complex and not only about activating cognitive procedures or learning concepts. For example, Titsworth, McKenna, Mazer & Quinlan (2013) suggest exposure to positive emotions supports recall, whilst Mottet and Beebe (2000) suggest that affect directly determines time spent on a task. The implication for learning of these findings is that teachers should expose students to positive emotions to support recall, and to increase time on task. This reveals a second gap within the literature; that we do not yet know how much or exactly where students are exposed to teacher expression of positive emotions in a mathematics classroom, nor the degree of influence from the use of positive emotions on students.

Within positive affect there are uncomfortable juxtapositions. For example, widespread in western culture, where in neoliberalism individuals should continually feel good (Giddens, 2000, Smith, 2010), affective goals of educators may focus exclusively on making mathematics fun for children (Goldin, 2007). Countering an agenda of making mathematics fun is a popular impression that school mathematics is about disciplined repetitive practice, not intended to be enjoyed (Hargreaves, 2001; Goldin, 2007). Such juxtapositions act to frame classroom interaction.

This study aims to complement active research in mathematics around negative emotions that may block learning if not resolved positively, such as for student anxiety (Evans, 2000), or boredom (Jablonka, 2013). Much less is known about the role of positive emotions, hence this classroom located study focuses on what delights teachers, what evokes a response in their students, and on the qualities of emotive interaction. For example, there is a difference in presenting to students as feeling excited or as serenely confident about mathematics (Pekrun, Elliot and Maier, 2006; Pekrun and Stephens, 2010; Hannula, 2012) that may impact on learning. The research reported in this study sets out from the premise that the study of these differences and variations is central. For example, the distinction between two emotions is often the degree of intensity. Researching intensity is challenging because of the individual and internal nature of emotions, so a third gap within the literature is how to determine the intensity of emotions as they are expressed.

Learning mathematics is a knotty process intricately bound to teachers, who then transfer the strength and effectiveness of their own affect through normalising discourse (Klein, 1998). The impact of normalising discourse cannot be over-rated; norms underpin learning of mathematics (Cobb et al., 1989). Therefore, such behaviours establish which affective dimensions are acceptable to exhibit, and further,

> *"Emotions cannot be seriously studied without attention to the local moral order" (Harré, in van Langenhove, 2010, p138).*

A classroom is a socially determined context, determined by discourse and beliefs, and for this study, teacher beliefs. A teacher acts as gatekeeper to a mathematical community of practice and establishes both norms and 'endorsed narratives' (Ben-Yehuda, Lavy, Linchevski and Sfard; Heyd-Metzuyanim and Sfard, 2012). This role includes acting as emotional and cultural concierge for available discourse. Yet a teacher's available discourse is restricted in part by their own personal understanding of the nature of mathematics (Ernest, 1991). A further restriction forms as a teacher integrates and balances positive and negative emotions, since selecting appropriate valence may determine outcomes of mathematical experiences. A student can choose to resolve natural discomfort or discrepancy in their learning pathway by either rejection or shifting into accepting the challenge (Dewey, 1933). However, not only does shifting into a positive outcome require emotional acceptance by a student, I would suggest that teacher involvement is crucial at such points. Hence examining emotions in context is necessary and this requirement is one that directs the design for this research (Chapter 3).

Developments, such as a shifting within mathematics education research towards social and discursive paradigms (Morgan, Tsatsaroni and Lerman, 2002; Evans, Morgan and Tsatsaroni, 2006; Zembylas, 2005) have potential to address gaps in existing knowledge about teacher affect, such as how different affective dimensions combine when teaching. Such possibilities are considered in Chapter 2, drawing from what the literature suggests as fruitful means of exploration, and in conjunction with the methodology in Chapter 3. There are four focus areas within this study. Firstly, the greater part of school research is on students, despite that neither teaching nor learning exist in isolation. One purpose of this study is to contribute to redressing the balance, to focus on teaching. Secondly, there is a dominance of research investigating transition of new entrants to teaching, as issues such as mathematics teacher retention have topicality. There is less research studying experienced mathematics teachers, so this third element informs my research questions as their experiences have potential to inform less experienced teachers. The fourth element is how much intensity exists and may be appropriate, an area where the research is sparse. The possibilities for impact on learning and the student perspective is identified solely to illustrate connected further study, and offered here to indicate likely future development. For example, questions remain around whether disaffected students perceive mathematics as T.I.R.E.D (Nardi and Steward, 2003) even if a teacher expresses positive emotions, or whether classroom norms mean teachers do not usually show emotions. A primary justification for this study is that firstly we need to know more about the role of the emotions that a teacher shows in a classroom context so that, eventually, teachers can be informed as to where, when and how to use emotions to generate significant impact on learning.

This study takes a fresh look at the role of positive emotions. I focus on affect in secondary mathematics classrooms, with an emphasis on classroom teachers. I centre this study on the teachers, on investigating the role of positive emotions in context, on measuring the intensity of expressed emotions and do this through working with experienced teachers. The impact of teacher affect on student learning, and detailed exploration of student responses to positive emotions, are included where appropriate to indicate how the research is planned to develop in the future.

In Chapter 2, before reviewing the literature to locate this research within what is known about mathematics teacher positive emotions, I introduce working definitions for the key terms used in my study, with an emphasis on positive emotions.

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Chapter 2: Literature review

2.0 Introduction

> *"Researchers know surprisingly little about the role of emotions in learning to teach, how teachers' emotional experiences relate to their teaching practices, and how the sociocultural context of teaching interacts with teachers' emotions."* (Sutton and Wheatley 2003, p.328)

This quote summarises the current state of affective research, the context into which this research fits. In this Chapter, I focus on the literature on affect, exploring, for example, the beliefs a teacher brings to a classroom and what we know from studying classroom interactions from a teacher perspective. Firstly, I establish a working vocabulary (2.1) for the key terms used in this study. In the subsequent four sections (2.2-2.5), I explore research that addresses specific emotions in context, as research on affect is often combined with other agendas such as professional development, beliefs, affect within classroom interaction or teacher identity. I consider how beliefs connect to emotions, how identity can guide classroom practice and what we know about emotions in the classroom. I conclude with a review of intensity of emotion and how intensity might be measured, as this measurement is a known barrier to effective study of emotions. I conclude this Chapter by presenting two models which show potential for examining teacher affect for this study.

Since there is limited research specifically on mathematics teacher affect, I also draw from research on affect for all teachers, and from what we know about affect in the classroom for students where this research directly informs the study of mathematics teacher affect. The review in this Chapter returns attention to the gaps previously identified in Chapter 1; that there is a lack of experienced mathematics teacher research and that we do not know enough about how teachers use emotions, intense or otherwise, whilst teaching.

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2.1 Definitions and terminology: Establishing a working vocabulary

> *"We do not now have a precise, shared language for describing the affective domain, within a theoretical framework that permits its systematic study"* (Goldin, 2004, p.109).

In this section, I define affect, emotion and positive emotion as key terms for this study. I consider what we know of the roles of emotions and how emotions work in the context of learning, paying attention to aspects which apply to a mathematics classroom. I consider meta-affect in relation to how experienced teachers engage with emotions and conclude with a summary of how this section informs and is used within this study.

The quote from Goldin highlights a consistent complaint in affective research (McLeod, 1992; Hannula, 2012; Hannula and Liljedahl, 2016). The lack of precision derives from the evolution of affect research. The common everyday usage of affective language makes definitions variable, whilst influential researchers from different disciplines bring their own language, vagaries and interpretations to affect research. Describing feelings is a basic component of human interaction and communication, generating a long list of everyday affect terms (Mandler, 1989), whilst affective terms are culturally, contextually and socially situated. Graham and Taylor (2014) illustrate this regarding pride, suggesting that Western individual pride and Eastern social pride are recognisably different emotions. Therefore, it seems appropriate to first develop a working relationship with affect and the associated terminology, to come to terms with field's complex nature (Op't Eynde, Corte and Verschaffel, 2006).

I begin with establishing affect, defined here as,

> *"Those aspects of human thought which are other than cold cognition, such as emotions, beliefs, attitudes, motivation, values, moods, norms, feelings and goals"* (Hannula, 2012, p.138).

In this broad definition, Hannula (2012) defines affect as not cognition. Following this definition, I use the term affect both as affect, as an overarching domain, as well as affect as more stable, as representing, on a spectrum, stability in emotions, such as beliefs as well as recall of past emotions. Hannula (2012) uses stable affective *traits* and emotional *states*, following a psychological origin for terminology. This difference forms a second distinguisher used in this study; between affect and emotion. However, there is evidence that historical diversity and fluidity of definitions are converging into a common affect/emotion structure (Hannula and Liljedahl, 2016). A structure that originates with McLeod (1992, 1988) who created an affective framework that linearly moves from stable affect (such as moderate intense and reasonably stable attitude), through to hot and transitory emotions. Kagan (2007) also distinguishes between brief (phasic) reaction to an event for emotions and longer lasting (tonic) states which he characterises as moods. Other terminology used within affective research may benefit from use of such temporal or noun and verb formations to indicate active and static distinctions, such as identity as a disposition formed from positioning. Wagner and Herbel-Eisenmann (2009, p.4) highlight the terms *transcendent* for position and *immanent* for positioning as distinguishers for Positioning Theory. I return to positioning theory later in this Chapter (2.5) and follow this distinguishing, using verb form positioning to indicate fluidity and position for stable traits.

I retain emotion for use 'in-the-moment', as identifying the fluid and transitory nature of emotions. Hannula (2012), drawing on earlier discussions (e.g. Power and Dalgleish, 2007) posits that there is now general agreement that emotions consist of three regulative processes: physiological that regulate the body, subjective experience that regulates behaviour, and expressive processes that regulate social coordination. This conception of emotions reflects motivation for actions (Brown and Reid, 2006), with a role of filtering and switching cognitive processes and energising cognition. Emphasising the intensity of emotions, Lakoff and Johnson (1999) consider emotion is

> *"…better understood as the tension of excitement level produced by the interaction of brain processes of perception, expectation, memory and so forth"* (p.176).

The physical temporality emphasised by this definition is appealing as incorporative of the complexity of emotions. That emotion exists as a tension defines emotion as energy, which means that, as Frade and Meira (2010) suggest, no core, essence or identity exists for emotion. As Lakoff and Johnson (1999), they model emotion as energy that boosts cognitive functioning; energy that moves back and forth between individuals and the social. If we develop the idea further, then not only does emotion exist as communicated energy, then an additional and complementary role within identity is suggested by Zembylas (2005), who suggests that emotions are a

> *"…constant (re)construction of boundaries around the constitution of identity and the self" (p.936).*

The implication for this study is that defining specific emotions becomes less significant. The fact that teachers are using emotions as energy and boundary construction to regulate themselves and their classrooms becomes central. This regulative perspective suggests that discrepancies are needed to evoke emotions. Brown (2011) suggests that if there is a 'bad' fit with cultural specifications, this evokes emotions and physical intensity and energy, which need resolving, rationalising and aligning, closing gaps for an individual between how he/she is [Actual] and how he/she might be [Ideal]. This is a specific perspective on how emotions act to resolve discrepancies (Mandler, 1989), enabling a teacher to function in the classroom through continual processes of resolving need, where need is a driver, as is the case within Engagement Structures as discussed later (2.5).

Zembylas' (2005) establishes the shaping role of emotions in a context such as a classroom, as powerful in either permitting or prohibiting. He calls this combining of personal, cultural, political and historical identity formation '*genealogies of emotions in teaching'*. Zembylas considers what is present or absent in the realisation of emotions within discourse. He also takes the position that people do not 'have' emotions, they cannot be held, they exist simultaneously as object, a subject who does emotions, and as subjects who are subject to emotions and experience them. This definition seems applicable to the dynamic and complex context of classroom teaching. Especially, as Graham and Taylor (2014) note,

> *"Emotions, then, can be a filter through which the perceiver may make rapid judgements in situations where there is much ambiguity" (p.115).*

The implication is that, to study emotions, examination of discourse in context and how discourse shapes the permitted expressions of emotions of a teacher is essential. This position informs my research design, such as how to design the study so that the fluidity of classroom discourse might be considered in relation to emotions. Op't Eynde et al. (2006) talk of emotion characteristics as appraisal, existing as unique and unstable. According to Op't Eynde et al. (2006), an implication is that small differences and changes, a local emphasis, is important as this means research should be on activity and meaning structure rather than emotions themselves, as these can never be objects existing in isolation and hence are not available for study. One can only examine manifestations of emotion and imagine effects on observers, or observe responses of students through discourse, a point returned to in the methodological discussions in Chapter 3.

In social interaction, as in a mathematics classroom, emotions become observable. This is because, whilst emotions are transitory and fluid, some definitions require an object, such as a person, belief or goal, to which to attach the emotion (Mottet and Beebe, 2000; Hagenauer and Volet, 2014b; Dalgleish and Power, 1999; Power and Dalgleish, 2007). Frenzel (2014) considers emotions in relation to goals,

> *"…clearly, teacher goals have a strong affective connotation, and it can be speculated that the goals are systematically linked with emotions, as is the case with students (Pekrun et al., 2006) …. For example, teachers'… mastery goals may be linked to increased enjoyment and decreased anger or boredom" (p.502).*

She adds that, so far, no empirical study seems to have examined such goal-emotion links among teachers, although this exists for students (e.g. Hannula, 2006). Therefore, a third dimension for a working definition of emotions is context, where emotions are observable. Mason (1998) distinguishes between emotions for an individual, in this case the teacher, and socially located emotions that appear in context of a class of students. He comments that,

> *"Teaching is then seen as a process of directing students in the harnessing of their emotions to provide the energy both to train their behaviour and to educate their awareness"* (p.245).

For current purposes, both are important, as a teacher is an individual acting in a social context, holding individual beliefs about self, others and mathematics. This definition aligns with Op't Eynde et al.'s (2006) *'affective aptitudes'*, defined as an individual's unique context constructs within interaction. These constructs form systems, that then make emotions (Scherer, 2000). Some such models discuss emotion as a form of physical activity. For example, Walshaw and Brown (2012) examine emotions by drawing on a physical definition from Spinoza,

> *"By emotion (affectus) I understand the modifications of the body by which the power of action of the body is increased or diminished, aided or restrained, and at the same time the idea of these modifications"* (2000 Ed. Ethics 111, def.3).

This view highlights the role of positive emotions as increasing or aiding modifications, including potential for learning, a disposition towards action.

Mottet and Beebe (2000) break emotion into four activity or setting dimensions that unite the views of emotions previously discussed. Firstly, that emotion only exists through social interaction. Secondly, that a perceived need to meet a desired goal arises. Thirdly, that there is an association with patterned and repetitive place, for example a mathematics classroom which provides limiting conditions for the appropriateness of an emotion. And finally, a recognition that emotions differ and are unique for each person. These four dimensions emphasise a socially patterned contextual location for emotion, accepting that emotion is driven by need and is retentive of individuality. These four dimensions form my working definition of emotion.

2.1.1 Positive emotion

Within emotions, the focus in this study is on positive emotions. Hagenauer and Volet (2014b) suggest that teaching quality relies on teacher emotions. They use the term *“affective relational basis”* (p.241) for teacher and student relationships in terms of emotions. Not only does linking quality with emotions have implications for how teachers perceive the role of emotions in their teaching, the linking suggests that effective use of positive emotions will improve teaching quality. There is a common assumption in the literature, one that is hard to counter, that expressing positive emotions is beneficial (Fredrickson, 2001; Fredrickson and Joiner, 2002). For example, Zan et al. (2006) associate positive attitudes with achievement; that enjoyment, as indicative of experiencing positive emotions automatically implies engagement and hence learning, achievement and success. The benefits of experiencing positive emotions are known within psychology. For example, in a form that resonates with problem solving in mathematics,

> *“…a positive mood is supposed to be associated with divergent, heuristic ways of thinking that enable more flexible and creative approaches [….] The experience of joy broadens one’s action repertoire. According to this theory* [‘Broaden-and-build’] (Fredrickson 2001, Fredrickson and Joiner, 2002), *positive emotions not only indicate success but also produce or promote success by broadening thinking and facilitating the generation of ideas when faced with obstacles”* (Frenzel, 2014, p.509).

Some researchers explore positive emotions simply by distinguishing between the effect of these, the emotional outcome of resolution. For example, Sutton and Wheatley (2003) suggest emotions are

> *“…positive if these involve pleasure or occur when one is making progress towards a goal”* (p.332)

Unfortunately for clarity between affect and emotion, they also determine positive emotion (rather than affect) as happiness or satisfaction. However, the goal element combines the cognitive and the emotional in approach behaviours, since one of the main physiological functions for affect is to guide approach or withdrawal behaviours as a means of survival (Mottet and Beebe, 2002). Approach and withdrawal behaviours are components of Engagement Structures (2.5). Hence, one way to consider positive emotional expression is as a mechanism to support student approach behaviours (Linnenbrink and Pintrich, 2004), a definition which draws attention to the intentions of the teacher. Combining these views, the position taken in this thesis is that engaging in approach behaviours is supportive of learning and contributes to, in Hagenauer and Volet's (2014b) terminology, a positive affective relational basis or, in other words, quality teaching.

Other researchers address specific positive emotions, and explore appropriate defining of these. In this study, if defining in this way, positive is defined as synchronous with favourable, good, pleasing, welcome, promising, encouraging, heartening, propitious and auspicious (OUP, 2016). A notable illustration is enthusiasm, generally accepted as a positive emotion and which is acceptable as a suitable emotion for a teacher to exhibit. In a classroom context, Frenzel (2014) suggests that although enthusiasm as a construct may be inconsistently defined, it may be researched as a motivating feature of classroom teaching, but also as,

> *"…a subjective experience of teachers themselves in terms of the excitement and enthusiasm they feel towards teaching and toward their subject(s)"* (p.501) (See also Kunter, Tsai, Klusmann, Brunner, Krauss and Baumert, 2008; Kunter, Frenzel, Nagy, Baumert and Pekrun, 2011).

Frenzel (2014), as Kunter et al. (2008, 2011), suggests that this definition makes enthusiasm and enjoyment similar to experiencing teaching as enjoyment, adding,

> *"…that it is worthwhile to differentiate between teachers' experiences of enthusiasm (or enjoyment) derived from teaching and enthusiasm (or enjoyment) derived from the subject being taught"* (p.495).

Frenzel suggests enjoyment comes from one of three sources; anticipatory joy, activity related enjoyment and outcome related enjoyment. This implies that a teacher expressing positive emotions is expressing their own enthusiasm derived from both the act of teaching and mathematics.

Building on the four-dimensional definition of emotion from Mottet and Beebe (2000), there are some additional dimensions for positive emotions. Firstly, as discussed, positive emotions encourage approach as opposed to avoidance behaviours. Secondly, that observing expression judged to be positive is indicative of the positive emotions experienced by a teacher and students. Thirdly, where positive emotions are evoked in a social context, and have a regulative role as discussed, they are evoked to resolve perceived discrepancies. Hence, the expression of positive emotions is indicative of a perceived need, likely to be met by teacher behaviours that encourage student approach behaviours. For example, creating a positive environment to learn. Finally, teachers need awareness of their own emotions and their effect on students which is a meta level regulative role that appraises the value of investing energy in expressing positive emotions. These four dimensions form the definition of positive emotions as used in this study: that a positive outcome is intended by a teacher making the choice to express positively and that expression of a positive emotion is intended to support learning.

2.1.2 Meta-affect in the mathematics classroom

Much of the discussion so far assumes that teachers will openly display their emotions whilst teaching. This is not necessarily the case, as the role requires a degree of self-regulation. De Corte, Depaepe, Op't Eynde and Verschaffel (2011), whilst discussing self-regulation, provide a definition of meta-emotion as awareness and emotions, which they consider as feelings or thoughts about one's own and other people's emotions. This is a definition of meta-emotions that includes knowledge and awareness as well as emotions. There are other similar distinctions proposed, such as Mottet and Beebe (2000), who divide emotion into first and second orders, Goldin's (2002) meta-affect or Gomez-Chacon's (2013) two levels for affect as local and global. Mottet and Beebe (2000) also talk of meta-emotional skills as,

> *"knowledge of strategies that can be used to control and regulate emotions (e.g. coping strategies) and the competence to consciously and effectively use them" (p.486).*

They suggest that without second order, a person cannot regulate by control or anticipation or make judgement by appraisal. Appraisal in their terms means whether achievable and whether worth investing effort. This aligns with how much intensity a teacher invests, as the investment of effort required for intensity requires an appraisal of the need to express emotions.

I conclude this section by highlighting that, although discussion of terminology will inevitably continue, locating affect as a trait, and emotion as a state, is useful within classroom research. Whilst a pragmatic view of how emotion works in context provides a working basis for discussions within this study. Clarity of terminology seems unlikely, since emotions are complex and any associated language should also be multifaceted. Similarly, explaining multifarious and interactive ideas calls for variations in terminology. To address this complexity, the vocabulary used later in allocating emotions in context uses an emotion wheel (Scherer, 2005) as a source. The wheel organises commonly used labels for emotions by degree of intensity, and by whether generally having a positive or negative effect. Any labelling of observed emotions is included solely to communicate the perceived emotion to a reader who was not in the classroom.

In the literature review that follows, I review studies of affect within mathematics education, noting that there is often inconsistency between authors in terminology use. For example, when determining emotions by retrospective questionnaires, there is a tendency to recall stable rather than fluid affect (Frenzel, 2014; Scherer, 1984).

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2.2 A review of research on affect and emotions in relation to teachers

It seems that the literature is disjointed and that there is a lack of qualitative research on experienced mathematics teacher's emotions as they teach. This study intends to address this, by paying attention to the affective identities (in the trait sense) and expressed emotions (in the state sense) of experienced mathematics teachers. There is however research to draw on that addresses these related parts of affect separately. Most affective research is on colder affective products such as attitude rather than hotter emotional states or processes (as emotions are harder to examine) (McLeod, 1992). Much research has a negative emphasis (e.g. on anxiety) and frequently focuses on all teachers including trainees, especially primary, rather than on secondary mathematics teachers (Frenzel, Pekrun and Goetz, 2007). The majority of mathematics education research still relates to students rather than emotions of teachers (McLeod, 1992), although Mottet and Beebe (2000) examine both using a quantitative methodology. Within mathematics education, mathematical origin determines how affect is examined e.g. processes of problem solving (DeBellis and Goldin, 1997), student attitudes (Hannula, 2002; Asante, 2012) or achievement (e.g. Ma and Nand, 1997; Pekrun, 2006). In 2.2.2 I explore affect research combined with other agendas. There is less research on positive emotions as they appear in the classroom, especially for secondary education. In 2.2.1, I focus on what we know about the affect of mathematics teachers through specific emotions through to social interaction in general (2.2.4), drawing from the research any implications for this study in terms of fluid and interacting emotions as occur in a mathematics classroom.

The predominant area of research on mathematics teachers is belief. Examples of research around beliefs includes from a theoretical position (Ernest, 1991), comparisons to other cultures (Yu, 2009), training (Smith, 2001) and within the primary sector (Holm and Kajander, 2012). Braun (2011) provides an example of physiological research, suggesting that embodiment within affect is a developing field within mathematics education (Thom and Roth, 2011), and may appear as an examination of non-verbal (Mottet and Beebe, 2002), gestures to self (Zurina and

Williams, 2011) or to others (Valenzeno, Alibali and Klatzky, 2003; Yoon, Thomas and Dreyfus, 2011). I therefore consider the place of beliefs within affect research (2.2.3). Affect in relation to a mathematics classroom appears in this section, but in 2.3 the classroom becomes central to the review. The order in 2.2 mirrors that throughout the study of developing the individual into the social.

2.2.1 Studies of specific emotions of teachers

Specifically for teachers' emotions, Hargreaves (2001) summarises research that looks at individual affective characteristics such as passion, thoughtfulness and attentiveness in teachers. These individual emotion studies see traits as self-regulating (Hardy, 2000), a personal disposition or a moral positioning. Examining traits is a continuing research tendency and a prominent subsection of affective research investigates specific emotions, such as enthusiasm, interest or shame, often accessed through motivation-orientated research. A specific emotion foci can inform researching experienced teacher affect, as some research includes teacher views, appearing as teacher views on student affect. For example, Kunter et al. examined students' (2008) and mathematics teachers' (2008, 2011) perceptions of teacher enthusiasm and instruction from a motivation perspective. As for the MCK and PCK classifications of Shulman (1986), Kunter et al. (2008) distinguished teacher enthusiasm for 'mathematics-as-a-subject' from enthusiasm for teaching mathematics, linking teaching enthusiasm to wellbeing, but they found only a moderate link for subject enthusiasm. The connection between teacher enthusiasm and self-assessed student engagement is strongly made in Kunter's research.

Specific emotion research for mathematics teachers is more likely to be on negative emotions. Bibby (2002), from a psychological perspective, writes of teacher shame as part of an emotional response to mathematics, something associated with reactions to perceived criticism, high expectations and related to teaching in an absolutist manner (Ernest, 1991). She does however add that this emotional response is not always negative for teachers, *"There exists a potential for moving on from the lack that engenders shame, for repairing the social bond and (re)developing feelings of connectedness to the subject"* (p.718). This aligns with identifying motivation within Engagement Structures (ES) (2.5) where all ES have a place, even if seemingly unsupportive of learning.

It is common to see specific emotions of teachers examined through quantitative research. An example of this form of emotion research, using self-reported emotions, comes from Frenzel, Goetz, Lüdtke, Pekrun and Sutton (2009). Rather than aggregating affect, Frenzel et al.'s research looks at which unique emotions displayed by a teacher might be influential on students. They concluded that teacher enjoyment was demonstrated through enthusiasm and that such positive displays could make a difference to student enjoyment. This implies that students are aware, consciously or not, of their teacher emotions, a point also made by Sutton and Wheatley (2003). One implication of Frenzel et al.'s (2009) finding is that expressing a positive emotion as enthusiasm is an important teaching strategy.

There is an assumption within the literature that expressing positive emotions is important for engagement in learning. For example, Hagenauer and Volet (2014a) define positive emotions as emotions that support rather than hinder learning. Whilst Csikszentmihayli (1990) suggests that enjoyment is a necessary precondition for positive effective experiences of 'flow', both for an individual and for enjoyment within teaching. This recognition, combined with the importance of the role of a teacher for effective learning, counters the predominantly student-orientated and negative emotion orientated nature of affective research, and has, as discussed later (Chapter 3), guided the empirical direction of my research. The definition of positive emotions used in this study (2.1) is centred on the outcome as suggested by Hagenauer and Volet (2014a), rather than specific identification. Yet without some form of labelling, communicating observed emotions is challenging. How I have addressed this challenge appears in Chapter 3.

2.2.2 Studies of mathematics teacher emotions in conjunction with other agendas

In addition to research on individual emotions, emotionally orientated research in a teaching context appears in combination with other agendas. For example, emotions appear in studies of praxis or patterns of participation, creativity, in research into the professional lives of teachers or research exploring pre-service mathematics teachers.

A rare positively orientated affect paper by Cross and Hong (2012) uses observations of two positive USA primary teachers over time and a series of interviews to examine their regulation of emotions, (defined as 'well-being'). They take conscious and unconscious appraisals as a key part of any emotional experience, and explore how teachers see and use their control and agency to establish and understand their emotions. It seems the main catalysts for these two teachers are deriving joy from students and whole identity alignment as a teacher, with less perceived conflict with other identities. Investment in aligning identity is also identified within empirical research on motivation by Long and Hoy (2006), although not specifically about mathematics teachers.

Studying teacher emotions in regard to change and motivation, Hodgen and Askew (2007) looked at the emotional relationship one primary mathematics specialist had with mathematics, exploring primary teacher motivation to engage in professional learning. This paper illustrates that emotions are inseparable from the professional life of a teacher. Wagner and Foote (2013) explore the relationship between emotion and a second agenda of professional identity, that of praxis. They define praxis in this context, as living and teaching mathematics in a deeply equitable and moral way. Grootenboer (2013) also examines praxis within mathematics teaching. In particular, he explores the limitations regarding decision-making and actions of novice and experienced teachers that may subsequently act to limit or enable mathematical identities. The view adopted in this study, a view that links praxis and affect, is that praxis forms part of stable traits such as happiness or contentment within teaching. It seems reasonable to assume that neither affect or praxis exist independently, as an equitable life reduces potential discord and conflict and, if successful, aligns self with role (Bibby, 2002; Watkins, 2011). These papers address the complexity of studying emotions in the context of decision-making and actions of a teacher, highlighting the challenge of drawing out the role of emotions within dynamic and interweaving classroom relationships.

2.2.3 Studies of teacher beliefs

To date, the largest body of affective orientated research in relation specifically to mathematics teachers is under the umbrella of beliefs. Within belief research, distinctions appear such as general teacher beliefs, comparing espoused to enacted beliefs, or specifically mathematical beliefs. For example, comparing experienced and new entrants to the profession. Other researchers link beliefs of teachers to their knowledge as they become teachers. Holm and Kajander (2012) examined beliefs and knowledge through interviewing teachers during transition into teaching mathematics, whilst Yu (2009) compared teacher beliefs in the different cultures of England and China. Similarly, Smith (2001) looked at how beliefs of student teachers of secondary mathematics changed (or not) as they progressed through teacher training and were subject to a variety of influences. Beliefs interact with and are embedded within affect and vice versa. A point made by Roesken, Pepin and Toerner (2011) who attempt to incorporate or connect affect within the remit of beliefs, through a discussion of significant teacher beliefs in relation to professional development.

The position taken in this study is that beliefs form from repeated emotional experiences, and act to direct as well as stimulating subsequent responses including emotions. Beliefs are therefore an essential dimension of emotion research, albeit temporally distinct. Systems of beliefs are complex. For example, Van der Sandt (2007) investigates teacher knowledge, attitude, views and beliefs as combinatory factors influencing teachers' behaviour, proposing a research framework for teacher behaviour. Teachers bring beliefs into the mathematics classroom, where they interact with emotions, an aspect that Lock and Lee (2001) explored through a literature review by looking at what teachers say, believe and do. They acknowledged the complexity of the undertaking, and addressed complexity by exploring connections between beliefs and actions practically, using Schön's 'theories of action' (Argyris and Schön, 1974, Schön, 1983). Schön's seminal work explored relationships between expert and novice, in a similar way to communities of practice (Wenger, 1998), and is still relevant decades later. Lock and Lee (2001) neatly summarise Schön's (Argyris and Schön, 1974) connection between beliefs and action,

> *"Teachers' espoused theories are composed of the knowledge and beliefs that teachers articulate when they describe their practices, whereas their theories-in-use are the assumptions about themselves, others, and the connections among action, consequence, and situation that govern their classroom practices" (p.305).*

Other research exploring transference of beliefs into practice includes Thompson (1984), who considers affect as belief, although he is writing about mathematics teachers in general, not specifically their experienced emotions. Thompson suggests examining data through the degree of teacher reflection, the degree of interrelatedness and the degree of stability of beliefs as enacted. The focus in Thompson's paper, using case studies, is on differences between espoused and enacted for each teacher. Thompson suggests that teachers react instinctively and intuitively whilst teaching rather than reflectively, and that teaching behaviour patterns act to form teaching, that then becomes established and unquestioned. Hence, responsibility for any failures of integratedness is located with lack of reflectiveness by an individual teacher. In conclusion, Thompson infers a need for emotional stability in order for a teacher to enjoy teaching. Thompson's research also suggests that integratedness, coherence between beliefs and enacted is important. This paper illustrates a commonly held position, as Thompson states,

> *"Examination of the relationship between conceptions and practice showed that the teachers' beliefs, views, and preferences about mathematics and its teaching played a significant, albeit subtle, role in shaping their instructional behaviour"* (1984, p.105).

Yet Skott (2009) partly questions this commonly held view that beliefs can explain classroom practice, that there is a direct link between beliefs and actions, the notion of 'belief-enactment'. Skott (2009) sees this position as an individually located view that does not fit well with more modern research which brings the social to the fore; the 'social turn'. His stance aligns with Goffman (1997), where an identity only ever exists as it interacts with the social.

The value within this study of questioning this location of beliefs, is that their relational position places more importance on interaction; the present rather than on the past and the influence of beliefs on the present. This temporality of affect is a useful perspective. In terms of emotions, such thinking shifts emphasis to emotions rather than affect, the state over trait.

2.2.4 Affect, teachers and social interaction

> *"Contrary to popular opinion, emotions play a positive and central role in mathematics and that it is through social discourse that people come to be mathematicians"* (Drodge and Reid, 2000, p.249).

In this section, given that the focus of my research questions is on classroom interaction, on the relationships between teacher, students and mathematics teaching and learning, I next consider affect research within a social context.

Becker, Frenzel, Goetz and Keller (2012) used a questionnaire with secondary teachers to examine the role of discrete emotions and emotional dissonance (displaying emotions not genuinely felt) in a classroom, but assume that teaching exhausts and the research focuses on negative emotions. They do however examine emotion as transitory experience as well, rather than just stable affect, albeit by self-reporting. They suggest experiences of negative emotions and emotional dissonance depletes resources and can result in emotional exhaustion (Hochschild, 2003). Yet Van Zoest, Breyfogle and Ziebarth (2002) as part of a longitudinal study on how affect translates into practice, found that emotional dissonance can decrease over time, as expertise develops in a secondary mathematics context, as does research from Lock and Lee (2001). They review some literature on theories, knowledge and belief for all teachers from an espoused (Ernest, 1989a) and 'theories-in-use' (Schön, 1983) perspective. They explore what teachers say about their practice and then they look to see what really happens in action, with a view to identifying any inconsistencies.

The 'social turn' of research specifically for teacher belief research in mathematics education includes a contribution from Walshaw and Brown (2012). In a theoretically based work, they draw on Spinoza, who locates affect within cognition, as an integral part of participation in teaching and learning. Similarly, Frade et al. (2010) consider affect in relation to identity for mathematics teacher professional development. The paper forms part of a collection of papers that draws attention to the dichotomy of individual and social within affective research, whilst exploring different dimensions of affect. Together this collection of papers paints a comprehensive and diverse picture of the current state of recent belief research within mathematics education. Significant in reviewing the field, and informing this study, they have common features such as an emphasis on the social location of affect despite theoretical differences.

2.2.5 Summary of 2.2

In Section 2.2 I have explored research involving affect for teachers. I have drawn from wider research areas that influence affective research in mathematics education, through to examples of affective and emotion research for teachers. I have considered beliefs into research on teacher emotions for individuals, which are socially located. The review highlights the complexity and interactive nature of the field. For example, how emotions appear within professional praxis, or how belief research has dominated in affect. There are some key ideas introduced in this chapter that inform this study, specifically the importance of positive emotional expression through teacher enthusiasm. Teacher enjoyment and the communication of their enjoyment in the classroom are important, such as through expressing enthusiasm for mathematics. Whilst it seems the research focus has been on the agenda of student learning, there is room for further research in respect to teacher affect, especially emotions compared to affect as a trait, since most affective research relates to how beliefs appear within classroom interaction.

Gomez-Chacon (2010) remind us that *'affectivity is of fundamental importance...'* (p.1-24) for several related reasons. It is certain that teachers experience intense emotions in a social and cultural context that is associated with cognitions within the activity of teaching, because of the need for continual judgment as previously discussed (2.1). Engaging in mathematics without experiencing emotions is unfeasible, a view which forms one basis for this study. Next, I turn to studies of affect that are mainly located in school classrooms, and attend to how emotions appear within this research.

2.3 Affect research in the mathematics classroom

> *"The task environment that the teacher faces is both complex and dynamic. A teacher faces a classroom of 20 to 30 children, each of whom has unique emotions, motivations, and subject matter competence. He or she must teach in a flexible, responsive, and consistent fashion, balancing responsiveness to student needs with the need to stay on course so material is covered clearly. The resources are the teacher's own knowledge of teaching the subject, knowledge about the particular students, text material, and time. The immediate teaching task is to communicate new information, to review material and assure that the material is accessible, or to assess student knowledge. This task is constrained by the need to keep a group of people active, interested, and engaged in learning-like behaviors and is also subject to environmental constraints such as context and the availability of time and other resources."* (Leinhardt, 1989, p53)

In this research, Leinhardt looked at lessons through three key lesson features, agenda, the role of lesson segments and nature of explanations. The description raises questions for this study as to the role of affect within each of these features. In particular, identifying the role of affect within decisions; checkpoints and flow within agendas; within norms or within lesson segment structures, and the place of affect within teacher explanations or within transmission of subject matter content.

This section, 2.3, explores mathematics and affect, using examples of classroom research on students as well as teachers. Student and teacher affect occurs within a teacher student relationship, which in practice implies a need to look at both sides of teaching and learning. In this study, however, the focus is predominantly on how teacher emotions might be examined in context, on the role they play. There is no intention to examine, as other researchers have done, student self-reported emotions or to examine directly the impact of teacher positive emotion use on student behaviours. As discussed in Chapter 1, examining the effects of positive emotion use by teachers on student engagement remains an area for future research. Given this limitation, there is a wealth of research, primarily centred on school students, which can and does inform teacher-orientated research, such as for classroom specific theoretical constructs around affect. Further, there are models to explore that either inform or are transferrable to researching teachers. I have selected two models from the limited choices available, Engagement Structures from Goldin et al. (2011) from student centred research, and Positioning Theory as presented by Harré and van Langenhove (1999) to evaluate as tools for researching teacher affect (2.5, 3.4.3, 5.4).

Frenzel et al. (2007, 2009) present a series of articles reporting collaborative endeavours centred on exploring emotions in the classroom, initially of students and latterly teachers, where the teachers give their views on student emotions, rather than their own emotions. This quantitative example of researching emotional experiences of students uses a questionnaire on achievement based on four strong frequent emotions of enjoyment, anxiety, anger and boredom, which are grouped for aggregate effects. Yet the findings do not explain causes or roles of indicated emotions, or take variations of context into account, although the research is about classroom environments. Similarly, De Corte et al. (2011) explore self-regulation of students undertaking mathematics. This paper is about students of mathematics not teachers, but as with Goldin et al. (2011) meta-affect, explores affect through the concept of meta-emotion that the authors suggest originates with Gottman, Katz and Hooven (1997). Goldin defines meta-affect as having awareness about ones mathematically associated emotions. De Corte et al. (2011) locates meta-emotion as part of an individual's disposition which allows (or does not allow) coping strategies, as self-regulation. In De Corte et al.'s paper, meta-emotion is in relation to specific challenges, not daily learning of mathematics, with which this study is primarily concerned. The term meta-affect will therefore be adopted. However, like resilience, which is closely associated with coping strategies (Boaler, 2002; 2016; Johnston-Wilder and Lee, 2010), self-regulation of emotions is just as important as self-regulation of cognitive processes. De Corte et al. (2011) suggest (similarly to Op't Eynde et al. (2006)), that continual adjustment and coordination achieves self-regulation. Fluidity within self-regulation has resonance with discussions of how beliefs and stable affect form through local emotional experiences.

De Corte et al. (2011), and Meyer and Turner (2002) both draw on Gottman et al. (1997) who offer three dimensions relating to the role of emotions for students that may equally apply to teachers. These three dimensions make the role of emotions a means to avoid derogation, to access warm interpersonal relations and as a means to access the cognitive as well as emotional scaffolding and praising. If this view of emotions is adopted, as in this study, then specific emotions becomes redundant, and the effect of using emotions takes precedence.

A further option for structuring affect research is through the lens of discourse within participationist theories. For example, affect is approached as identity by Heyd-Metzuyanim (2013), using the commognition framework (Sfard, 2008). Based on emotions of students whilst interacting with a mathematics teacher, this research explores how teachers may, by creating expectations of a student, act to 'disable' a student mathematical identity, where interaction constructs identity into a *'constrained path of learning'* (p.341). Although identity used in this way may not capture the fluidity of classroom interaction, and in this case focusses on the negative, I am intrigued by how emotions might be used to create expectations that enable and are unconstrained.

Identity constructed through interaction has similarities to Goldin et al.'s (2011) Engagement Structures (ES) which temporarily act as enablers or barriers to mathematics learning. There is a close association between identity constructed through interaction and Positioning Theory (PT) (Harré and Langenhove, 1999, p.60) which examines the minutiae of continually shifting and changing interaction, via how a teacher positions a student and vice versa. This is an attractive combination for the purposes of this research and will be discussed further (2.5). Yet although Heyd-Metzuyanim (2013) directly acknowledges the similarities between identity and PT, she rejects identity because of the need for attending to fleeting nature of affect; the very attraction for this study. Heyd-Metzuyanim chooses identifying as opposed to identity because, although fleeting, the model effectively identifies actors and audience. The main difference of this choice, other than those arising from communicational or constructivist epistemology, is a closer focus on the norms of interaction as forming a more fixed interactive structure. This formation process is similar to developing a belief in knowledge of the 'other' that evolves through communication over time. Heyd-Metzuyanim suggests a student, consciously or not, helps form his or her own mathematical identity in relation to learning mathematics. An identity that aligns with the teacher, but that is inseparable from cultural and societal beliefs on learning mathematics which students can buy into. Her paper is located within work on different classroom practices e.g. low sets and top sets who often experience very different presentations of mathematics in addition to the socio-cultural effects (See for example, Ben-Yehuda et al., 2005; Black, 2004; Solomon, 2009). Heyd-Metzuyanim's (2013) paper focuses on disabled mathematics identities through identifying, whereas in this study I explore enabling of mathematical identities. Therefore, the selection of model for this study needs to take enabling into account.

Research where the primary agenda centres on the classroom, but which is wider than researching teachers alone, informs the research design presented in Chapter 3. Within the complex dynamic of a mathematics classroom, I would draw attention to three key points. Firstly, the diversity of approaches possible for classroom study seem to be directing this study towards the use of the models. Secondly, that social discourse, as well as non-verbal communication is central and any selection of models must attend to discourse. These communications form interaction, which can then form mathematical identities, and, particularly for teachers, may develop into meta-affect. Finally, the discussion in 2.1 raises issues regarding the intensity of emotion. Therefore, in 2.4, I discuss intensity further in relation to positive emotions.

2.4 Approaches to measuring intensity of emotion

> *"Expertise is characterized by speed of action, forward-directed solutions, accuracy, enriched explanations, and elaborations of knowledge rich in depth and organizational quality. We know from sports […] that experts "see" an entire scenario or episode before they act. We know that expert teachers run a better class, but the useful, teachable mechanisms of how that is done have been elusive."* (Leinhardt, 1989, p.73)

In this section, I refer to Goldin, Epstein and Schorr's (2007) branch points, interpreted as critical decision points within an affective pathway; points at which a student (the focus in the paper), attempts to resolve some form of anxiety. Emotional intensity is likely at points of potential discord or breaks in expectations on either side during interaction between teacher and student and Goldin et al.'s work draws attention to crucial nodes within processes in problem solving. For example, anxiety can be resolved either positively or negatively, with longer-term consequences for mathematical attitudes,

> *"…branch points occur in archetypal affective structures when someone can act (consciously or otherwise) in one way rather than another, thus experiencing one set of feelings rather than another and evoking one structure rather than another"* (p.262).

It seems branch points can work over a variety of time scales (Sanchez Leal, Brett, Rossman and Seeve, 2013a). They are critical decision points, which can be adjusted rapidly and even overlap within an affective pathway. Goldin et al. (2007) suggest that repeated similar decisions at branch points inform the likelihood of an Engagement Structure (Goldin et al. 2011), or alternatively, the mathematical self-identity of a student. The teacher action (or reaction) at branch points has implications for my research, as I presume an experienced teacher intervenes by instinct to classroom peaks and prickles. This instinct may be part of effortless 'expert' teaching, and the intensity of such an instinctive reaction may be internalised. At a branch point, a teacher might increase their internal engagement, and hence an internal indicator such as skin conductance might show a change, as their emotional intensity increases. At a branch point, effort is required to develop a pathway further, whilst developing a collective positive affective pathway is effortful for teachers. Pesonen and Hannula (2014) use emotion recognition software, on an individual basis, to observe student problem solving, providing an example of researching active emotional states, (states of neutral, sad, happy and angry), rather than recall of emotional states. They consistently observed non-neutral emotional states at decision points, which partially support the proposition. However, this model may only work for stronger visible emotions.

Kahneman (2011) suggests that changing task, and especially rapidly, is effortful. This effort is exactly what is demanded of students and teachers in a mathematics class, as many activities are multi-tasks, requiring integration and resolving of potential discrepancies for several concepts or ideas at once. This view accords with Evans (2000, e.g. p.132) where emotion provides drive within learning as the charge of a goal directed activity. Increasing effort is analogous to 'flooring' the accelerator. In 2.1, I introduced the idea of emotion as energy, which is not a recent idea. Piaget saw affect as an energy supplier, to be like a controlling operator for motivating or hindering action or cognition via a mechanism of emotional intensity. This model of affect requires intensity of emotions to be visible or recognisable. In detailed observational work, despite intensification not being within the study remit, Op't Eynde et al. (2006) found some emotions were frequently observed in an order that is characterised by an intensification of emotional arousal linked to specific interpretation and appraisal processes. In a social context, the degree of energy is significant within the effectiveness of transmission of emotion. Barsade (2002) confirms that stronger emotions are more effective in forming collective emotion, even if negative emotional valence. Higher energy calls more attention to it, by implication leading to more contagion than if expressed with low energy. It is not intensity of emotional and physical reaction that makes a difference, rather whether an emotion is perceived as energising or debilitating. In relation to positive emotions, the valence adds an additional layer of complexity to studying intensity.

It seems reasonable to assume that stronger emotions will have a stronger effect, and rather than the model of repeated positive emotions generating positive affect as beliefs, one intensely experienced event could change views and hence the degree of engagement. It also seems reasonable that this change can occur positively as well as negatively. Liljedahl (2005) when exploring resistance of undergraduate students to mathematics, considered 'everyday' Aha![1] moments from an affective perspective. He asked students to recall such a moment and to describe their emotions, relating their responses to disposition and stability. He concluded that intensity of experience (compared to baseline) has an immediate impact on belief, as well as repeated experiences. He found that it was possible to divide the data into two categories, that of discovering (whoosh, leap) and learning (slower more passive learning). He tells of how students describe pleasure, changes in beliefs and changes in attitude in relation to their 'Aha!' through an associated sense of accomplishment or inspiration. He concludes with suggesting orchestration of teaching to facilitate or provide more opportunities for 'aha!' through talking, big picture, re-creation, time and perseverance. The inference is that 'expert' teachers fluidly judge where and when to act, albeit instinctively, and that intensity of emotional expression required for such orchestration occurs as part of skilful teaching. This skill is a difference between expert and novice also indicated by Leinhardt (1989).

Intensity is part of the dynamic context of teaching. Yet even for temporally significant 'Aha!' moments, student recall of prior experiences dominates the data. For Liljedahl's (2005) research, these are experiences that have left a sufficiently strong impression as to merit writing about them for an assignment. What is emerging is that fluidity of the classroom in terms of affect is under-researched. The multi-levelled nature of studying emotions has implications for whether all emotions are studied within a mathematics classroom, or just teacher emotions in a social interaction. Distinguishing individual emotions (if they exist) seems irrelevant to studying engagement as it occurs. What may be a more appropriate distinguisher in context of a mathematics classroom are categories of self (as teacher), social and mathematical, that combine, intertwine, and are continually interactive. The categories align with perceptions of a person doing mathematics, the context or

[1] Aha! defined as a (sudden) moment of realisation of a mathematical connection or clarity of individual understanding

environment in which they do it and what it is they are doing. The challenge is to explore all three simultaneously in this study.

A further consideration is intensity of emotions in relation to novelty, such as stronger emotions being associated with ‘Ah-ha!’ moments, or when mathematics is presented as non-routine, and how this might change over time because of repeated experiences. Teachers repeat their lessons many times and when repeatedly experienced, an individual may not continue to show the same emotions. Novelty and repetition can represent the valence of emotions, such as positively through an ‘Ah-ha!’ moment, or through negative outcomes to frustration pathways.

Ideally, a means to study teacher emotions would include all these considerations, yet also be specific to mathematics teachers. Dealing with fluidity and complexity seems central. One model from within Mathematics Education that draws from other disciplines and is designed for affect research situated in mathematics classrooms is Engagement Structures (ES) (Goldin et al., 2011), a model that incorporates beliefs as well as being potentially usable in a dynamic changing context. In the next section (2.5) I describe ES and in explore why this choice suits the RQ’s and the identified gaps in the literature. I follow this with the story of how the initial data analysis with ES revealed a new need to address the detail of classroom discourse, resulting in the introduction of a second model, Positioning Theory (PT). In 2.5 I introduce both models, and some implications of use for the research design.

2.5 Two models for researching teacher affect

2.5.1 Engagement Structures (ES)

> *"Briefly, an engagement structure is an idealization involving a characteristic motivating desire or goal, actions including social behaviors toward fulfilling the desire, supporting beliefs, ''self-talk,'' sequences of emotional states, meta-affect, strategies, and possible outcomes - a kind of behavioural /affective /social constellation situated in the person, becoming active in social contexts."* (Goldin et al., 2011, p.548)

Goldin (2007) frames ES within a meta-level structure built from mathematical intimacy, integrity and personal identities. His prolific work on systems of affective representation (e.g. DeBellis and Goldin, 1997; Goldin, 1998; Goldin, 2000; De-Bellis and Goldin, 2006, Goldin et al., 2007; Schorr and Goldin, 2008; Goldin 2009; Goldin et al., 2011) evolves from mapping individual emotional journeys (affective pathways) in mathematical problem solving. Originally, it was set in an American inner city context, one rife with disaffection but is used globally by other researchers (e.g. Lewis, 2013; Verner, Massarwe and Bshouty, 2013). Developed as a practical model, there are 9 suggested positions situated in individuals and adopted in social situations when following mathematical affective pathways. ES are by no means fixed, nor static, instead emerging from common observable characteristics. Students can dip in and out, sometimes showing characteristics of several ES, although at any one moment there is a dominant emotionally directive one. Each structure is empirically derived from observable, simultaneous and interactive components. The components for each structure include characteristic patterns of behaviour, possible individual affective pathways, signification or meanings, 'self-talk' in response to and evoking feelings and strategies and heuristics. Structures also show patterns in interactions with individual's beliefs and values, with individual's self-identity, integrity, and intimacy and with meta-affect (Goldin, 2002; DeBellis and Goldin, 2006; Schlöglmann, 2006). Finally, there are characteristics of external expressions of emotions, such as facial expressions, body language, exclamations etc. The components (strands) are shown in Fig.3.2 on p.87.

Subsequently, researchers have tested and evaluated the model for analysing affect. Weber (2008) used Goldin's taxonomy (Goldin, 2000) to apply ES to coded transcripts. He looked at the mathematical transformation of one student through identifying prominent emotions along a courses' learning pathway. Weber found that restoring a positive pathway needed one event, rather than repeated events as Goldin suggests, a finding that tallies with Liljedahl (2005) for the changing potential of 'Ah-ha!' moments (2.4). Yet Weber's (2008) research collected data by occasional interview over several months and therefore reveals more about longer term affect. Lewis (2013) in a student study focusing on understanding disaffection, attempts to validate ES in the UK by comparing them to Reversal Theory (Apter, 1989). Lewis uses eight switching dichotomies of reversal theory, which in Apter's model are ways to gain satisfaction and are associated with particular primary emotions. Verner et al. (2013) also examined emotions of Israeli students from several different cultures and backgrounds, using ES, although not directly for learning mathematics. They suggest adding a new wider Structure of 'Respect my Culture' which could be a religious culture or on an individual cultural level. Such applications in new contexts suggest that Goldin's model is useful when examining classroom transactions in new yet similar contexts, such as the transference to UK and from students to teachers, to support, for example, the examination of the establishment of traits through observation of state, and further that a problem-solving context is not necessary.

One intention within this study is to adapt Goldin et al. (2011)'s model for mathematics teachers. This approach means contextual examination becomes possible. For example, mapping how interacting ES facilitate or block positive emotions that are supportive of engagement within 'ways of being' (Schutz, Hong, Cross and Osbon, 2006). The original nine structures are summarised in section 4.0 (p.99-107) and discussed further in Chapter 3. The original model as proposed in 2011 may need modifying for teacher affective engagement in two ways. Firstly, I need to consider the model's potential as applicable to a UK secondary mathematics environment, although Lewis (2013) has already demonstrated a degree of portability in this respect and Goldin acknowledges the universal nature of the model, *"We see them as universally or near-universally present in individuals."* (p.554). Secondly, since the wider aim is to explore mapping of emotions between teacher and student, the model may require creating a similarly constructed ES model for teachers. It may be that the existing model applies to teachers, but there may also prove to be significant differences in what positions are available within accessible mathematics teacher identities.

2.5.2 Bridging between individual ES and the fluidity of classroom discourse

Placing affect research in a social context entwines affect with identity as a research area. For this study, I draw attention to identity in relation to the personal images of the ideal, since emotions play a major role in negotiating the match between the existing and the ideal identity. In relation to affect in mathematics education, Krzywacki and Hannula (2010) extend the idea of an existing and an ideal self which act to form identity, suggesting that there is always a gap, of different degrees, between an individual's present identity and their ideal. Further, that identity, as for affect, splits into stable beliefs and fluid emotional states. The authors suggest that these identity classifications evoke needs that then inform actions. This approach to affect highlights how temporary positions can act as a form of fluid identity, one that bridges between identity (as formed of beliefs), and emotions (as forming beliefs). Horn, Nolen, Ward and Campbell (2008) undertook a longitudinal study into identity of new-into-practice secondary teachers (half the sample were mathematics teachers) using Holland's (1998) *'figured worlds'* to inform their conceptual framework of teacher identity. They explore what trainee teachers consider a 'good' teacher in relation to himself or herself, as key in identity formation. The paper concludes that they found Holland's (1998) concepts of *identification* and *negotiation*[2] of most value. I would suggest that these values would be the same for experienced teachers but with a differing balance. I return to the idea of identity, and what makes a 'good' teacher in Chapters 4 and 5 using the data from experienced teachers. Identity is important within the role of a teacher, but may not capture the transitory nature of emotions. Similar to identity is positioning theory, a model that

[2] Similar to Wenger's (1998) constructs of *identification* and *negotiability* as two components of identity that are in tension. Identification refers to ways of belonging as part of identity e.g. 'mathematics teacher' or 'secondary'. Negotiability refers to being a particular *kind* of mathematics teacher or secondary. Both are taken up and modified by individuals over time.

does seem suitable for capturing the fluidity of classroom discourse, and that complements Engagement Structures.

2.5.3 Positioning theory (PT)

The term *position* is common in social and psychological research. Harré and van Langenhove (1999) use *position* in a specific sense, as a means to understand social interaction (p.1). PT is intended to support detailed examination of discourse to show how language and interaction serve to *position* and act to *position* oneself in a social context. *Positioning* refers to the way people are using action and speech to arrange social structures, using words and actions to draw on existing storylines and pre-adopted *positions* (dispositions). Analysis of *positions* available within discourses therefore displays ways of meaning, acting and feeling available to participants (Evans et al., 2006). According to positioning theory, an interlocutor can be complicit with a proffered *position or positioning*, negotiate or resist (reject) it (Wagner and Herbel-Eisenmann, 2009, p.3). These three possible responses give *PT* a dynamic facet that incorporates both self-positioning and positioning by others, and gives a focus on how change can occur, such as of beliefs through *repositioning*. One assumption within the model is that *positions* inform discourse and that *positioning* occurs within (not after) discourse that marks at least one difference between *position* and role (Goffman, 1997). PT can be used to examine stable beliefs through examining the *transcendent* via interview discourse, as used in studying emotion of adults in Mathematics Education by Evans (2000). Evans et al. (2006) make the point that it is *positioning* that can be examined to find emotions,

> *"…the positions available, and possible spaces and roles for emotion within a discourse […] how positions are occupied, how opportunities arise for emotionally charged meanings…" (p.213).*

The term position can be viewed as established, *position* or as emerging, *positioning,* subject to external influences. This specific use of terminology matches affect as fixed and emotion as fluid since beliefs are often seen as more fixed in nature; an established *position*, whilst vacillating *positionings* relate to emotions attached to social interaction in context, where positive or negative emotional valence over time act to form beliefs. In *PT* terms, interaction over time tends to *'orient to commonality'* (Carbaugh, 1999, p.162) which becomes the norm. Carbaugh (1999) uses PT for researching cultural identity and suggests that positive emotions act to reduce oscillation of vacillating positions. I see this tendency as convergence, achieved by compliance and negotiation, rather than potentially emotional divergence, which tends to result from resisting a *position*. If we think about learning as a form of continuous *repositioning,* then *PT* becomes attractive as a model to support research on activity in teaching and learning.

PT fits this research design and questions, and complements the use of ES (Goldin et al., 2011). In particular, *positioning* as context specific can provide a mapping of emotional shifts that may be missed by a lens that views from the bigger picture. The two analysis methods become complementary funnels; one from collected data to a summation or characterisation of the complex traits of a teacher, the other generated from the detail of classroom interaction. The ES approach is quite categorical and therefore subject to bias from being archetypal. PT counters this limitation of ES, if indeed archetypes are considered negative. Examining *positionings* in relation to events where positive experiences are expressed, or physically felt by a teacher, may help examine the role of positive emotions in the classroom.

In the uses and discussions of PT in education (e.g. Davies and Hunt, 1994; Evans et al., 2006; Wagner and Herbel-Eisenmann, 2008; Anderson, 2009; Wagner and Herbel-Eisenmann, 2009; Barnes, 2004; Black, 2004; Tsatsaroni, Evans and Morgan, 2007; Allen and Wiles, 2013; Tait-McCutcheon, 2014; Vanassche and Kelchtermans, 2014), one unifying element is that PT applies to specific contexts. The process is peculiarly located within a culture, and acknowledges the historical grounding and institutional influences. The theory appears to address,

> *"(t)he need for a theory that provided opportunities for understanding interactions from a flexible, changeable, and unpredictable perspective"* (Tait-McCutcheon, 2014, p65).

The use of PT for affect emerges from there being more than one available position or positioning for an individual, either within one discourse or within several competing discourses, where potential for conflict between positions may spawn emotionally charged positionings. Additionally, given that positions are associated with differing degrees of power in relation to others, and with differing values within discourse, this interplay of values and power creates spaces within which emotion may arise (Tsatsaroni et al., 2007). Social interaction aimed at producing change must have an affective dimension. This suggests that the role of positive affect is to provide a charge of energy, supportive of receiving message positively and effecting intended change. For example, *'I want you to'* (positively charged) gets a positive reception and compliant action, a form of collusion in both task and emotion. The opposite is resistance. However, on another level, the teacher is also resisting and complying through using positive emotions. Positive emotions therefore play a role in forming the constraints and affordances of positions.

Evans et al. (2006, p.213) provides a useful list of indicators that help identify how others position participants or how participants seek to position themselves, as well as how they, and their contributions, are valued within the discourse. This list overlaps with the *strands* (Fig. 3.3, p.90) described by Goldin et al. (2011), but is applicable only to fluid interaction. The indicators include references that reveal values and what statuses are valued, or are indicative, such as speech references to self and others or pronoun use. To illustrate, indicators might be a person aligning with a textbook, or with Mathematicians rather than mathematics teachers. Alternatively, there might be a revealing reference to what is believed to be a 'correct' view. These indicators include direct verbal expression, e.g. *'I feel anxious',* but also include exhibiting (consciously or unconsciously) emotion by use of particular metaphors, e.g. claiming to be 'coasting' (Evans et al., 2006, p.214), emphasis by words, gesture, intonation, or repetition, indicating strong (or chronic) feelings, and 'body language', facial expression or blushing. Evans et al. also suggest examining data for psychoanalytical insights such as *identification*, whereby pupils seek to take on characteristics or behaviours of a favourite teacher or admired classmate.

Research on teacher positions in mathematics classrooms already exists (e.g. Tait-McCutcheon, 2014). PT is often used with students and with emotion, although not, as yet, teachers and emotions together. Hence, there is a synthesis to explore further. A benefit of the model for classroom analysis is through examining details of positive emotions as expressed by teachers, including examining how a teacher uses positive emotion to focus attention and close unwanted deviations, as such use supports establishing classroom norms. Alternatively, positive emotion use might alter pace, or add a deviation to either shift focus or to distract or to reduce stress. Based on the data, I can establish positions and positionings of a teacher as positive emotions are expressed, within the context of the discussion in the classroom, and use this to explore the roles of positive emotions in context.

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2.6 Implications for the design of this study

> *"Emotions give meaning to thoughts, actions and relations by drawing upon what has been experienced, is being experienced and is anticipated."* (Meyer, 2014, p.458)

The implications of the literature review for the focus and design of this study (Chapter 2) are that negatively resolved emotions act counter to engagement and hence to learning. Teachers may not always express emotions in the classroom, or may restrict positive expression to milder forms such as smiling rather than laughing, whilst expressing strong negative emotions such as anger or impatience run counter to supportive learning environments, and are frowned upon for a professional. The literature in the review places emotions as central to engagement, and hence to learning. By implication, emotions may be an under-used tool for effective teaching of mathematics. The awareness of emotions (meta-affect or meta-emotions) is potentially a means to attract student interest through a teacher knowing where to locate emotional intensity. Mandler (1989) discusses emotions associated with error when teaching mathematics, that teacher use of and modelling of emotional responses to errors can inculcate a tolerance for error that potentially benefits learning mathematics. To support subsequent discussion, I review more specific literature on how emotions are used after presenting the analysis. The divisions of self, social and mathematical seem to offer a suitable framing for examination of teacher positive emotions, and with this in mind, in Chapter 3, I turn to discussing a suitable research method with potential to address my research questions, which, in light of this Chapter and the next, have become:

RQ1 Do teachers use positive emotions in their mathematics teaching? If so, how? Are positive emotions used to support the teaching of mathematics, to communicate mathematically? If so, how?

RQ2 What are the risks and benefits within how participating teachers make use of positive emotions?

RQ3 What implications emerge from how participating experienced teachers use positive emotions whilst teaching?

RQ4 Does combining modified Engagement Structures (ES) with Positioning Theory (PT) support examination of emotions in the dynamic context of the mathematics classroom? If so, how?

Chapter 3: Research design, data collection and data analysis

3.0 Introduction

In this Chapter, I briefly consider research design before considering the context specific practicalities and possibilities for data collection (3.1). I then present the chosen method (3.2). With any research, the planned process changes as it proceeds, therefore section 3.3 discusses some implications of modifications to the data collection as it progressed. In section 3.4, I describe the interconnected analysis phases: firstly, selection of episodes based on observable expressions of positive emotions, as defined in 2.1; secondly, revisiting ES and PT as analysis tools, (as introduced in section 2.5). I conclude the Chapter with ethical issues for data collection and analysis that have further directed my research possibilities (3.5).

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3.1 The design of the data collection: Drawing from research designs within (Mathematics) Education & affect research

In this section, I consider how other researchers have designed their research, and what I can learn from their choices. For example, how they have addressed the challenges within observations of emotions or methodological issues around accessing emotions of teachers. Drawing on work from other researchers, I construct a pathway from least to most applicable design options and I consider how emotions per se may be researched before addressing researching emotions during classroom interaction. Ordering from the least to the most applicable, I consider some promising methods such as case studies, before drawing such possibilities into the final design (3.2). To show the developing of my reasoning behind the final choices, I begin with data collection through questionnaires. These are rare for positive affect research, although Kunter et al. (2011, 2008) used questionnaires to examine a large sample of student views of teacher enthusiasm. The research findings support the importance of researching positive emotions such as enthusiasm.

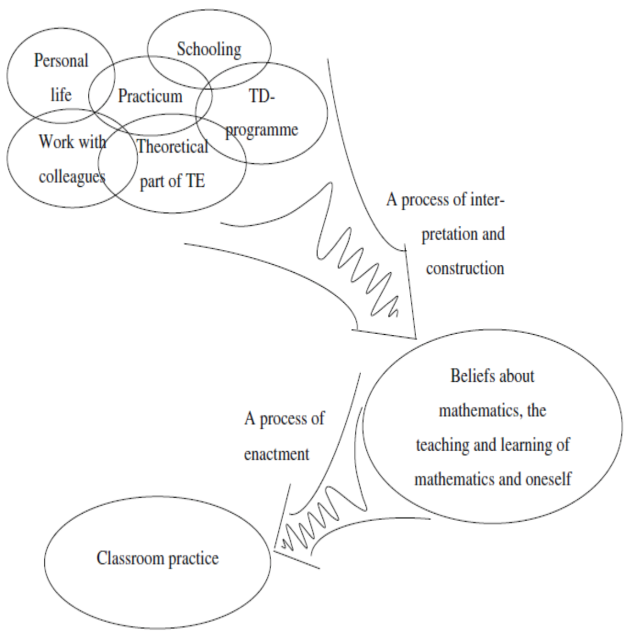

Figure 3.1: Beliefs in mainstream belief research; a link between experience and practice (Skott, 2013, p.549)

Yet such research does not identify what a teacher does that gives students the impression of enthusiasm. Nor do questionnaires provide a holistic view of classroom practice.

A holistic study of classroom practice involves three interactive phases. A first phase examines what a teacher and students bring to the teaching before the event (as in Fig. 3.1). This paper from Skott (2013) shows the intricacies of the first dimension (Fig. 3.1) and hence the need to design a methodology, using multiple methods, that addresses such complexity. Skott (2013) looks at how teacher beliefs appear in practice, firstly considering shifts from beliefs as espoused (before interaction) to enacted. The second phase is during teaching, and the third, after interaction with students, is reflection. Looking at all three incorporates past, present and future dimensions (Clandinin and Connolly, 2000).

Multiple methods can be seen in a paper from Hagenauer and Hascher (2010), who looked at student learning enjoyment, using diaries alongside questionnaires. Teachers have busy lives and I wanted to be as unobtrusive into their lives as possible, whilst maximising the data. To ask teachers to write diaries was, I felt, demanding of time, and knowing of this demand might have meant teachers would be less willing to participate. Hence, I sought further than diaries or questionnaires for options that might effectively provide data to address the research questions.

Intervention as a research method is common in research into education, as one purpose of education is to effect change by engagement in learning. In terms of affect, intervention can either be about how affective state changes whilst engaging in learning (e.g. Maloney, Schaeffer and Beilock, 2013), or during change periods such as teacher training (e.g. Collins, 1978), or curriculum change (e.g. Nolder, 1992). Efklides and Petkaki (2005) examined student ‘mood’ around the process of solving mathematics problems by invoking in students a positive, neutral (students were asked to think about brushing teeth) or negative mood. The students then did problems and self-assessed their mood through before and after questionnaires. Efklides and Petkaki found no significant effect of mood on problem solving. There are examples of intervention as a method for affect research in Mathematics Education involving teachers, but these studies are rare, and often involve trainee teachers. Blanco, Barona and Carrasco (2013) when researching primary mathematics prospective teachers, examined affective change during problem solving. The researchers used open and closed questionnaires, diaries and forums in combination with audio and video-recorded sessions, observing both students and teachers, accompanied by field notes. Although my agenda is not to change teacher practice, I take forward from these affect orientated illustrations of intervention research, how multiple methods can draw a fuller picture of context and participant actions, creating a useful rich description. Rich descriptions that are integral to ethnographic research.

Ethnographic studies in Mathematics Education (e.g. Eisenhart, 1988; Kelley and Lesh, 2000), expect researchers to be fully immersed into the lives of participants, although a partial immersion is possible. In terms of research into emotions within a teaching context, Harden (2012) studied the emotional regulation of primary children, exploring the construction and negotiation of emotions in context through an ethnographic study. Smith (2010) provides an example of exploration of student happiness, that may also be applicable to studying teachers. Her method is ethnographic as the partially immersive data is collected over time, and is multiple method, using emails, questionnaires, interviews and observations. It seems from these examples that to explore emotions in depth, a small number of case studies might support constructing a rich description.

The potential for conjunction between ethnography and case study is illustrated by Hannula (2002) who suggests a framework for researching affect in Mathematics Education, using an ethnographic case study of one student to illustrate the framework. Case studies within mathematics education are numerous, possibly as a more practical, time efficient model as compared to ethnography. For example, Cross and Hong (2012) looked at two primary teachers, examining their emotions as case studies. Hodgen and Askew (2007) looked at emotions when forming a teaching mathematics identity in primary education through a case study. A case study can potentially bridge the three temporal phases of teaching, before, during and after interacting with students, thereby addressing a further methodological concern about how to bring in affect alongside collecting emotion data from the classroom.

It seems then that case studies can support researching complex contexts, and in particular studying emotions. To summarise, this account of the development of my thinking led to the method presented next. Approaches such as questionnaires and interventions gave way to methods that access a richer description, one designed to address the research questions.

3.2 The data collection plan

The research design is exploratory, intended firstly to establish the existence of positive emotions as a phenomenon within the specific context, followed by development of propositions to address the uniqueness of each participant. Participants are considered individually in this research, with comparison between participants restricted to exploring summary patterns of commonalities and differences. There is no intent to seek to draw some more widely applicable conclusions from research involving 8 teachers in Norfolk. Although I recognise that there will inevitably be a degree of speculation and *moderatum* generalisation, defined as the basis for deductive reasoning by Williams (2000). The following point about discussing the implications of the study and any emerging strategies for other teachers in terms of negative emotion use being the most pertinent; *"The implication being that strategies to discourage such practices must arise from a consideration of its heterogeity"* (p.212).

In this study, the methodology needs to align with the layered nature of classroom interaction and the multiple lives of mathematics teachers, yet at the same time, prioritising participant interpretation through giving a voice to participants. What is truly worth examining is what attracts the interest and attention of participants sufficiently to be expressed (Cohen, Manion and Morrison, 2007). Therefore, an appropriate design for this study seeks teacher expressions of interest and attention, both in and out of the mathematics classroom.

The reality presented in this research is a contextual snapshot. One aiming to provide a rich description (Lincoln and Guba, 1985) of the examined context and a sense of the whole (Connelly and Clandinin, 1990), supporting readers in understanding the meaning of the research (Kelliher, 2005); a report 'grounded in examples' (Sharma, 2013).

A suitable data collection method for this study supports exploration of positive emotions in context. There are many possible inter-related reasons, overt and hidden, determining the presentation of emotions in a mathematics classroom. Therefore, the design builds two levels onto Skott's model (Fig. 3.1), thus incorporating not only what teachers bring to the classroom, but also what happens during interaction and how teachers perceive the interaction. The data collected needs to support analysis of each teacher's affective relationships with mathematics, facilitate examination of how a teacher's espoused views interact with the enacted, support explore positive emotion use when teaching mathematics, and consider self-regulation and its effect on classroom interactions for teachers. I also need a means of gauging or measuring intensity of emotions whilst teaching (2.4).

This research is concerned with the individual teacher in a social context and explores the professional life of a specialist who interacts with their students in relative isolation, despite being part of a community of mathematics teachers. Yet, as in any interactions, historical, social and cultural constraints are still in play. These constraints act to control classroom interactions, despite the apparent power of being a teacher (Hardy, 2000). I need a research design that can incorporate this individual and social context, as well as a method that mirrors and captures teachers as individuals, located within classroom interaction. In addition to addressing how emotions might be interpreted, they are also transitory, depending entirely on context and evocation, so any method must acknowledge this. Finally, the method needs to support examining whether teacher affective interpretations match my observer perceptions of the lesson. With these considerations in mind, I use a three-part model to explore interpretations, one that incorporates temporality through past, present and future through reflection.

The method

The design minimises taking a teacher's time and the impact on classroom activities. Teachers are busy people and access to classrooms could potentially be difficult without prior attention to a design that teachers can both visualise and incorporate within their demanding role. There are three parts to the design (A, B, C), and two elements form the second part (B1, B2). These parts are:

A. Eliciting teacher narratives as the past dimension, representing what teachers bring to the classroom
B. B1. Observing teaching and
   B2. The use of a physiological measure, Galvanic Skin Response (GSR),

as present dimensions

C. Engaging in stimulated post observation discussion as the future orientated and reflective dimension

Part A: Story-telling interviews

There are few examples of storytelling or narrative research (as an open form of data collection) specifically for experienced secondary mathematics teachers, especially for researching affect. In terms of education research, storytelling for data collection is not new. Blumer (1969) used storytelling in his study on change and episodic encounters, similarly Watson (1976) used narrative to explore individual teacher ideas about pedagogy. Beijaard, Meijer and Verloop (2004) reviewed the literature on teacher beliefs, including a review of research using teacher narrative and stories, with an emphasis on research applicable to experienced teachers rather than newly qualified or prospective teachers. Similarly, Day and Leitch (2001) used narrative to explore teacher emotions within their professional lives, presenting some case studies as a series of vignettes. Kelchtermans (1993) researched career stories of primary teachers in order to explore professional development providing an example of a narrative biographical approach which appears to have advantages in terms of indirectly accessing the emotions of teachers. A point also made by Bibby (e.g. 2002), who examined teacher stories for examples of shame. Although focussing on negative emotions, and located in primary school, Bibby's storytelling approach seems effective at drawing out useful data. Di Martino and Zan (2011) also used storytelling in mathematics, in this case with students. Intriguingly, they used an essay form to produce data, entitled '*me and maths'*. Similarly, Klein (1998) also used stories, in this case with trainee teachers, to explore their experiences of mathematics prior to teacher training from the perspective of change and transition.

By telling a story, a person reveals a great deal about themselves, both explicitly through their choice in what to articulate, but also much of what underlies their identities (Beijaard, Verloop and Vermunt, 2000; Kelchtermans, 2005). The limitations identified, such as time and the need to identify emotions for an individual without necessarily being explicit, guided my design towards informal discussion. Rather than using structured interview questions, I asked teachers to explain how they had evolved into the mathematics teacher identity as at the point of interview. I also gave each teacher a large sheet of paper and colouring pens, to encourage production of a visual mapping of their life stories. This open-ended approach allowed teacher ownership of discussion. For example, they could direct the conversation and be comfortable in what they chose to reveal. The teachers could tell me what they felt was important out of many stories that could be told, a research position that, given that I was a researcher entering their classroom domain by permission, seemed equitable. Further, a 'good' model for exploring teacher emotions requires using ways to strengthen credibility for any inherent subjectivity, whilst acknowledging both participant and researcher as sources of bias. This form of storytelling interview meets these criteria.

Part B1 Observation (Video)

Historically, research using videoed lessons uses pre-assigned classifications. For example, Buff et al. (2011) initially appears to be simply mathematics lesson observation, but looking closely, the research method is a pre-set classification by trained observers seeking characteristics relating to the degree of control by the teacher. In contrast, the aim of this part of my research is to explore positive emotions as they appear, a dimension of teaching that may be restricted by using pre-set classification. Van Zoest et al. (2002) used an observational template in a longitudinal study of changes in teacher practice, looking at how change affected their espoused and enacted views of mathematics. However, I felt that video directing and simultaneously completing a template would be challenging for a single observer.

Video or audio-taping of students discussing mathematics is now common. For example, Elliott, Hudson and O'Reilly (2001) explored aspects of communities of practice using audio recorded discussion from three mathematics students. Similarly, Escudero and Sanchez (2008) used video, with a camera located at the back of a classroom and following the teacher. They combined video data with pre-observation and post-observation semi-structured interviews with secondary mathematics teachers who were experiencing change. Their description of camera use influenced and supported my decision to film the class simply by pointing the camera at the teacher. This is a similar design to my study in many respects, but without video stimulation in post-observation interview. Schorr and Goldin (2008) gathered video data from mathematics classes, empirically constructing ES for problem solving students (2.5). Their data was collected using one camera to video, and they took notes. The children only appear when they are within the video shot. This choice addresses some ethical concerns around videoing children (3.5), and supports establishing acceptable conditions of access to school classrooms. As Buff, Reusser, Rakoczy and Pauli (2011), Schorr and Goldin (2008) had a prior list of emotions to look for in the video data,

> *“The variety of emotions that we sought to infer included curiosity, puzzlement, bewilderment or confusion, anticipation, frustration, annoyance, anger, fear or a sense of threat, defensiveness, suspicion, pleasure, elation, and satisfaction”* (p.140).

Schorr and Goldin (2008) examined video for ‘key affective events’ (p.135), subsequently presenting the data as vignettes. This seems to be an approach suited to the current purposes. Adapting this method for positive emotions would mean looking for episodes of pleasure, elation or satisfaction, (and possibly anticipation, if there is also an expectation of a positive outcome).

The method of pre-setting by setting codes, although supportive of analysis, seems inflexible, and is primarily for quantitative categorisation or standardising multiple observers when comparing teachers, or useful when interested in the frequency of different pre-determined engagements in the classroom, and the emotions attached to each. However, I do need a means of establishing emotions. Scherer (2005) used an emotion wheel to categorise expressed and observed emotions. Similarly Stipek, Givvin, Salmon and MacGyvers (1998) used a coding system to characterise mathematics teacher practices whilst exploring reforming teaching methods, intervening by training teachers on motivation. The researchers linked where emotions appear to their location within practice, rating each teacher using video on a scale 1-5. One advantage is that video can be watched repeatedly, and ratings given by each assessor compared. Although the repeated watching is useful, as for other earlier methods, such ratings do not address the why? Similarly, Frenzel, Becker-Kurz, Pekrun and Goetz (2015) assessed emotional state at points in time as *'experience sampling'* or *'ecological momentary assessment'*. The associated risk of experience sampling is discontinuity of context, and interrupting in this way is potentially intrusive for teachers. One of my aims within the design is to reduce intrusion. Observing, unobtrusively located in one place with the camera, whilst taking minimal notes, potentially misses one-to-one discussions. Therefore, I asked each teacher to carry a voice recorder. A further concern is whether to observe or participate in lessons. This consideration is particularly pertinent as I am a qualified secondary mathematics teacher. It felt judicious just to observe, as being a participant could interrupt exchanges of information, interrupt routines normal to that space and introduce additional bias. My aim was to focus on affective relationships, and to try to access the meanings of participants, the motivation, beliefs and intention of the teacher as experienced by students. The attention of an observer depends on their observation skills, resulting in interpretations with distortion, bias or selective observation that affect the accuracy of the analysis. Using video to revisit an episode, and paying attention to different characteristics helps reduce such bias. A further influence in making observational decisions was whether to observe normal daily practice or unusual emotional events. Ideally, I wanted to experience both, but realistically expected the former and the design reflects this expectation.

Part B2 Observation (Physiological measures)

Emotions within education research are mostly evaluative judgements, but some methods aim to be closer mirrors of experienced emotions. For example, Brown and Reid (2006) examine classroom decision making, incorporating positive emotions as a feeling of 'rightness' for both teacher and student, a subjective position,

> *"emphasising, in our research, the non-conscious nature of most decision-making, guided by somatic markers, we add an alternative perspective to research that uses professed beliefs and values (determined through surveys and interviews, for example) to explain behaviour"* (p183).

I too wanted some meaningful way of accessing emotions, to avoid the usual method of using post event self-reporting as the sole form of data (Di Martino and

Sabena 2010). Yet I was doubtful that I would be able to identify rapid changes in emotion through observation alone. I sought additional means to study invisible emotions, some way of incorporating dealing with emotional invisibility into my research design, especially as classroom interactions are so fluid and dynamic.

Emotions have an additional dimension of intensity (See 2.4) that my research design aims to capture. Research by Hobbs (2012) takes the lens of studying aspects of the positive emotion of passion, hence examining a more intense positive emotion. Exploring professional passion for teachers, she used two case studies of secondary science or mathematics teachers, teaching out of their usual discipline, with a focus on the aesthetical dimensions of teaching. The methodology uses video with a focus group, as part of larger scale research,

> *"The final reflective interview was a two-step process where teachers were interviewed prior to viewing their videos for their explanations for intentions and purposes associated with the lessons observed. Teachers were asked to annotate a written description of the lesson, which I had prepared. The reflective interview that followed viewing of the video asked teachers to reflect on what they had noticed"* (Hobbs, 2012, p721).

Incorporating one or more physiological measures could address this need, especially as a growing area within Mathematics Education research is engaged in studying attention, such as through eye tracking (Andrá, Arzarello, Ferrara, Holmqvist, Lindström, Robutti and Sabena, 2009; Inglis and Alcock, 2012). In addition, there have been studies of undertaking Mathematical tasks whilst being measured for heart rate and temperature, although, as yet, under laboratory conditions (e.g. Hughes, 2001).

One such alternative is to explore the use of skin conductance, (usually referred to as Galvanic Skin Response, GSR), which is known to be useful in measuring both anxiety and excitement. Whilst,

> *"skin conductance is still often used as a proxy for neural and brain activity because it is relatively cheap and can be measured unobtrusively and reliably"* (Figner and Murphy, 2011).

GSR measures small changes in skin humidity. Skin humidity is one indicator of either stress or excitement in the body. Measuring GSR is less intrusive than heart rate because the measuring device usually attaches to the hand. Since emotions are connected to visceral responses, as indicative of emotions, GSR seemed appropriate, providing a means to focus on intensity whilst engaged in teaching.

Until recently, the use of GSR in active contexts was sparse, usually taking place as study of individuals under laboratory conditions. However, the potential range of uses is mostly in the context of laboratory research. For example, within biological psychology, use of skin conductance is common, with studies ranging from ADHD in boys (Herpertz, 2001) to antisocial and violent behaviour. The value in this field appears to be in early identification and potential for intervention, as many studies involve children (Isen, Raine, Baker, Dawson, Bezdjian and Lozano, 2010; Raine, 2002). Skin conductance has also been included within twin studies that can help identify inherited traits. Tuvblad, Gao, Isen, Botwick, Raine and Baker (2012) used a 'skin conductance orienting response (SCOR)' to determine the genetically influenced variance between twins during late childhood and adolescence. SCOR,

> *"[I]s an autonomic response to novel stimuli and indirectly reflects how much a person attends to and processes novel stimuli in the environment"* (Tuvblad et al., 2012, p.47).

It is known that psychotics have distinctive patterns in skin conductance (Glenn, Raine, Venables and Mendick (2007), and laboratory research (Dindo and Fowles, 2011) looked at whether students identified, by a personality inventory, as being at risk of psychopathy, had the same distinctive patterns. They found that skin conductance was reduced when participants were exposed to adverse noise, which the researchers associated with a weak defence system and increased when participants were exposed to a speech about one's faults.

Yet application is wider than the sciences, but still suggestive of an emotional response. For example, D'Mello, Dale and Graesser (2011) looked at GSR in relation to disequilibrium in the mind and disharmony in the body whilst Oxley, Smith, Alford, Hibbing, Miller, Scalora and Hibbing (2008) suggest that political views have a biological basis. The physiological measures used in their research included measuring change in skin conductance whilst participants were exposed to threatening and non-threatening images. They found that, for participants with strong political views, lower physical sensitivities correlated with participants being more,

> *"likely to support foreign aid, liberal immigration policies, pacifism, and gun control, whereas individuals displaying measurably higher physiological reactions to those same stimuli were more likely to favor defense* [Author's spelling] *spending, capital punishment, patriotism, and the Iraq War"* (Oxley et al., 2008 p.1667).

Additionally, skin conductance is used within risk analysis research. For example, when given a card game task (Classic IOWA gambling task), it appears that skin conductance levels (SCL) increase before selection of bad decks i.e. a risky choice, but that this only applies to successful performers (Crone, Somsen, Van Beek and Van Der Molen, 2004). There is interest in GSR within media, involving identifying an emotional response such as responses to films or disturbing images (Brown, James, Henderson and Macefield, 2012). In the last decade, there has been a proliferation of contextual research reporting uses of GSR across a wide range of disciplines. Doberenz, Roth, Wollburg, Maslowski and Kim (2011) recorded skin conductance of people following normal daily routines over a 24-hour period, and summarised by suggesting technology has become feasible for use outside the lab with some concerns, such as time delay and rapid changes in responses as discussed later. There is also potential for use in active medical practice, although it appears that skin conductance fluctuations correlate poorly with post-operative self-report pain measures in school-aged children (Ledowski, Bromilow, Paech, Storm, Hacking and Schug, 2006). Now GSR technology is better and cheaper there is growing interest in longer term monitoring, such as for patients who cannot communicate well, where raised GSR indications are useful indicators. For example, epileptic fits, or where a patient has a panic disorder or even when emotional disclosure is involved. However, there also seems to be medical research interest in evaluating GSR for monitoring either in ambulances (Doberenz et al., 2011), or for recovery in post-operative context (Ledowski et al., 2006). There is increasing use of physiological responses across a wide range of disciplines, and understanding GSR responses is improving. Yet not, as yet, examples of use of GSR specifically for education or for mathematics education.

For the purpose of this study, I found a basic portable sensor designed to measure Galvanic Skin Response (GSR). The ESensor® (Mindfield Biosystems Ltd, 2013) is a portable device which attaches to a mobile phone and which has been previously been used in studies on excitement, anxiety and stress. The ESensor® records bodily response, either positive or negative, and quickly produces data to convert into an intensity graph. Differences in skin response activity is greatest on the palms or soles of the feet. However, for practical purposes, where fingertip measurement (distal phalanges) is not possible, as for a teacher who needs to use their hands to write or gesture, researchers recommended using the intermediate phalanges on the first and second fingers of the non-dominant hand (Crone et al., 2004; Lykken and Venables, 1971; Van Dooren, de Vries and Janssen, 2012). Recording from the non-dominant hand, (usually left) means that the participant is not using this hand as much, so recording is less likely to be interrupted by loosening of sensor fastenings or similar.

This option seemed to provide a suitable and unique approach to classroom observation, combining qualitative and quantitative. The unobtrusiveness was an important point within my research design. Each teacher was to wear the sensor whilst teaching, so whilst observing, I could note points when I felt intensity from the teacher. I could use the device to corroborate what I, as observer, experienced as I was sitting with students. I felt I would be able to approximate what they experienced, despite expected individual differences in reception and interest.

Issues include that some researchers suggest delay between experiencing and recording by the sensor of up to 10 seconds (Oxley et al., 2008), but other studies suggest delay varies from around 0.5 sec. to 5 sec. (Figner and Murphy, 2011). Therefore, using video recordings that surround an episode of interest is crucial to provide collaborative data, raising the importance of teacher interpretation of the data. Only the teacher can suggest why or what stimulated any observed changed in GSR at any point. Teachers also need a prompt to recall a selected point in sessions, consequently, using video extracts with teachers becomes essential. There is an issue of reliability for measuring skin conductance and some risk in using new technology.

In regard to data analysis, no comparisons can be made between teachers other than central tendencies and distributions. The individual distributions will appear in the presentation of data in Chapter 4 as box plots. As Lykken and Venables (1971) point out,

> *"The conclusion is inescapable that a substantial proportion of the variance in any distribution across [Subjects] of SCL[3] or SCR[4] values must be attributable to physiological differences which are essentially unrelated to the psychological processes in which we are primarily interested. That is, both the maximum and minimum SCL of which a given S [Subject] is capable must be determined by structural, physiological, and biochemical factors which themselves differ widely from one individual to another; it is the variation within these limits which is normally of psychological interest"* (p.666).

My research, as experimental in this regard, uses a relatively simple portable sensor aimed at the stress reduction market, and I acknowledge the potential limitation of the ESensor's reliability to provide indications that are relevant and meaningful to my study.

Part C: Post-observation discussions

The idea of participants reflecting on their experienced emotions was highly influential on my study. Sanchez Leal et al. (2013a) used stimulated recall, although the selection of episode was by chosen by identifying a typical teacher response to student difficulty. I have incorporated stimulated recall into my method as the final

[3] Skin conductance level
[4] Skin conductance response

dimension of a holistic and temporal (before, during and after) design, forming the final piece of the bricolage; a methodology based around case studies using interviews, observation and stimulated recall discussion.

Since the final method phase is for participants to discuss the lesson, the study design includes sharing of the resulting GSR graph, a discussion centred on an extract of video data and interpretation of graphical results by the participant. I also used the GSR sensor to guide the selection of extracts from a teaching session, focussing on where intensity is indicated. However, the selection is additionally determined by my observation notes and my own response to the teacher. The post-observation discussions were designed to enable each teacher to talk about their thoughts and emotions during the videoed lesson, using clips of their teaching as a prompt. Skott (2013), who also used post-observation discussion, makes the point that,

> *"(t)he present study does not use observations and stimulated recall interviews to provide better access to the 'true' character of the teachers' beliefs. Rather, the intention is to allow teachers to elaborate on their views of school Mathematics while referring to immediate classroom practices"* (p.33).

Using stimulated video recall is not new, but as with physiological measuring, modern technology makes the process simpler. Thompson (1984) examined the relationship between teacher beliefs and practice through a case study approach. After observing teachers, the researchers used video to stimulate discussion to elicit their conceptions of mathematics through six tasks and a bi-polar questionnaire, to establish Mathematical beliefs. These cases were analysed for differences between espoused and enacted. This approach is appealing as does not require comparison of individual teachers. In Mathematics Education, stimulated recall has also been used when researching children:

> *"In particular, we have adopted in our continuing research the technique used by Op't Eynde and Hannula (2006) of conducting retrospective, visually stimulated recall interviews with "focus children," as a way of obtaining an account in each student's voice of*

the emotional feelings remembered as having occurred during key affective events" (Schorr and Goldin, 2008, p.146).

Darby (2009) used a similar video led recall process for mathematics and science teachers, whilst Hunter (2010) looked at student Mathematical identities using lesson video to stimulate discussion with students about boredom. Both these papers highlight a need for rapid recall, if possible. For example, Op't Eynde and Hannula (2006) debriefed students immediately. This urgency for post observation discussion is not always feasible, but remains an ideal. They suggest that, ideally, the post-observation discussions should be audio recorded and discussion guided by both video clip and participant.

Any change in teacher behaviour because of observation nerves is relevant to emotions, as there may be correlation between emotions and importance, unfamiliarity, or excitement. The presence of another person is sufficient to alter the classroom interaction dynamics, and the camera exacerbates any such alteration. There has to be some allowance in method and flexibility for unforeseen themes, ideas that emerge as data collection matures, and a will from a researcher to adapt or modify plans in light of new discoveries and contributions from participants.

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3.3 The data collection plan in action

[This section is adapted from a SAGE Research Methods Case, (Lake, 2015c)]

The collection period had to be matched to the UK academic year (September to July). It took time for the required gatekeepers to allow access, so visits took place between October 2013 and May 2014. One implication is that by the time I was observing classes much of the crucial norm setting that takes place at the start of a new academic year in September was in place, so I observed normal daily practice rather than norm establishment.

Constraints on how data can be collected include geographical, time, opportunity, access and purpose. Geographically, my research is located in a relatively rural part of the UK where schools are geographically disparate. The population from which to draw participants is defined as teachers qualified (QTS) to teach mathematics at secondary level. Geographically, the local selection was restricted to a 50-mile radius of UEA, and limited to non-selective public schools in Norfolk LEA. 50 miles extends into the county of Suffolk that historically has differences in school organisation. I limited selection of teachers to those with a least 3 years' experience, in order to limit the influence of extremes of emotions associated with novice change processes.

I wrote to all 44 secondary state high schools in Norfolk, sending letters to Head Teachers, as appropriate first gatekeepers. None of the schools were independent, nor any of the state schools selective. I sent letters in batches of 4-6 so that they would be staggered, to spread out meetings and observations over a school year. The time between sending letters and visiting each teacher varied enormously from a few days to several months, and impacted on the number of teachers I was able to visit. Schools vary in size, although most have at least five mathematics teachers, either full-time or part-time, so my local population was approximately 300 teachers. High School teachers are busy and I was asking to video their practice and their children, which potentially may make them feel vulnerable. Therefore, I am extremely grateful to those teachers who have willingly given their time. Yet recruiting in this way engenders bias, as all my participants were happy to be seen teaching and may already be interested in research.

I observed and interviewed eight teachers, all those who agreed to participate, and modified the design to include revisiting one teacher (Adam) on several occasions with the same children. I visited the other seven teachers either once or twice. The cases of all eight teachers are presented in Chapter 4. I sent a template letter to each teacher in advance of observation, so that they could use school systems to inform parents about the research. The parental consent was by exception, if parents approved, there was no need to reply to the letter. I think my position as a local ex-mathematics teacher also supported access.

When I arrived at school to interview the first teacher, armed with drawing equipment and voice recorder, I thought I was prepared. However, I found it difficult to listen passively to each teacher. I felt the desire to ‘give back’ by acknowledgement and confirmation, as in a discussion. Subsequently, I found narrative inquiry (Clandinin and Connelly, 1986), which positions myself as researcher in a more relational way; one where the interviewer and interviewee are co-composing each aspect as we ‘live’ the inquiry. This led to a small shift in design, one with which I felt more comfortable. I began to manage the storytelling element of the data collection as discussion rather than interview. I also felt this shift to be necessary as participants did not need to enculturate me into their ways because I am a teacher. However, I still encouraged each participant to speak freely without interruption, unless there was a need to refocus or clarify.

I encountered interruptions from other staff, or noise from children outside that interfered with audio recording quality. Since I draw and map ideas, and often use flow diagrams and illustrations to coordinate my thoughts, I assumed the teachers would do the same. Only two teachers used the proffered drawing materials (Debbie and Freddie, (See 4.1D (Fig. 4.20) and 4.1F (Fig. 4.32)). The teachers talked, openly and freely about their lives and their subject. I also did not expect tears, which occurred twice, yet perhaps I should have, given research on what triggers teacher tears by Watkins (2011).

Fortunately, I was transcribing as I collected data, so I could modify mistakes before the end of data collection. In an early recording, I have the teacher talking on the video, and simultaneously, the teacher talking about the clip, so that where either the teacher has a quieter voice or the volume is too loud on the video clip, the voices are indistinguishable. There is also a reduction in the depth of data as much was expressed in the post observation discussion by expression and gesture, none of which is retained through audio recording. With hindsight, videoing the post observation discussions would have added depth.

3.3.1. Using the ESensor in real life

The ESensor device was initially used within a seminar and university lecture context prior to using the device in a school classroom. It did not always work, and therefore the design was modified to place less reliance on the device. Each teacher wore the sensor whilst teaching, so whilst I was observing, I made notes of when, as experiencing the lesson, I felt intensity from the teacher. This enabled me to use the device to corroborate what I experienced.

Occasionally, the ESensor device failed to work, ending the recording mid lesson, so where possible another visit was arranged. Fortunately, the device worked on each second visit, providing additional observational and audio data. Similarly, on two occasions, teachers pulled out connections which then stopped the device. I introduced a belt pouch for phone and voice recorder, (unless the teacher had pockets), although there were still trailing wires. Interpreting the data in preparation for part C discussion required rapid examination of the video, as I preferred to conduct the post-observation discussions as soon after lessons as possible, in most cases the following day. Other modifications included placing more emphasis on my own experiencing of emotions of varying intensity, rather than on the GSR recording due to the unreliability. However, I would do the same again, partly because of the excitement and interest engendered by the device. It has novelty, even if it is occasionally unreliable. Once I had sufficient data, I began the process of analysis.

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3.4 Data Analysis

As for the data collection, I begin with some principles which guided my analysis choices through examining the role of the researcher (3.4.1). This is followed by some analysis options within affective research (3.4.2) which led to the selection of Engagement Structures and Positioning Theory (3.4.3). The Chapter then concludes with ethical considerations (3.5).

3.4.1 The role of the researcher

Patton (2002) argues that validity of analysis is largely dependent on the skill, competence and rigour of the researcher. ‘Bracketing out’ (Charmaz, 2006), separating the researcher from the research, is never possible. The researcher position ideally supports commonality, minimises risks such as ‘Hollywood smoothing’, and addresses differing agendas when communicating with potential readers.

Acknowledging commonalities can add resonance for an audience. Any researcher is attempting to translate, to understand and represent another way of life. Yet the dilemma is that researchers will always have a set of values partially alien to the setting being studied, despite commonalities which may suggest an ‘adequate’ translation. In this case, my interpretation is guided by my role of teacher as well as researcher, as in this research both interviewer and interviewee are teachers. In addition, I now work as a teacher educator, and this new position must inevitably impact on interpretation. Yet the existence of strong commonalities is an advantage, as interpreting the teachers is mediated by an overlapping community of practice.

A risk within analysis is what Connelly and Clandinin (1990) call ‘Hollywood smoothing’, where everything works out well in the end. It is inevitable that choices are made within analysis, but these choices can be presented with reasons discussed and any research difficulties, bumps included, to give readers affinity with the process and to support an empathic response to the research. The data collection plan in action illustrates some of the encountered difficulties.

An author’s critical role requires a continual re-reading of data in context with different agendas in mind, including at design stage, to guard against potential subversion of either design or text (Connelly and Clandinin, 1990). The research story needs to be presented in a way that acknowledges that both the generation and interpretation of data is subject to inquirer bias and that potential unequal power balances between participants and researcher exist in any context (LeCompte, 2000). One way of addressing this need is through the researcher examining the data from a variety of lenses, as discussed in 3.4.2.

The data of interview, (A) video and ESensor recordings (B) and post observation discussion (C) together tell one possible story of each teacher and their affective professional life. In the following section, incorporating a discussion of some choices suggested by other researchers, I discuss how this data was analysed. The intention is to explore possibilities and choose analysis methods that best address these points.

3.4.2 The data analysis methods used for pre-observation interviews, observations and post-observation discussions

Constructing a unique and experimental analysis methodology is a challenging part of research design. There are many suggested methods from the literature for analysis, although few for affect, and fewer for emotions in context. Part A and C, the interviews and post-observation discussion include emotions appearing in the transcript supported by the audio recordings. A common analysis method used to analyse transcript data is thematic analysis, either taking a grounded theory starting point or using an existing theoretical frame and classifying data accordingly (e.g. Evans, Harvey, Buckley and Yan, 2009; Hobbs, 2012). I have chosen to initially analyse the transcripts (A and C) for incidences or references to positive emotions. This filtering then forms the illustrative data used to build Engagement Structures and, alongside the graphs produced from the ESensor data, guided the selection of episodes for the Positioning Theory analysis.

The physiological measure in B2 results in numerical data. I can use statistical analysis methods to summarise the data and graphs as required. The primary purpose of B2 in terms of analysis is to select episodes from the observed lessons by potential intensity within the limitations described in the data collection plan in action (3.3). The ESensor data supports exploration of emotions of teachers whilst engaging in teaching, and proved useful in selecting extracts of teaching to discuss with participants. The analysis in Chapter 4 includes graphs and summary box plots for each lesson, adding to the emotional portraits for each teacher. Fig. 3.2, (p.87) shows how the selection of episodes connects the data collection and analysis.

The means of analysing the classroom data of video derived in Part B1 is necessarily more complex. From options available, I briefly consider cluster analysis and one form of discourse analysis before resolving into a preliminary form of thematic analysis, directed by the appearance of affect in the data, which then acts to guide my choices for the ES and PT analysis.

Harvey, Bimler, Evans, Kirkland and Pechtel (2012) used cluster analysis to map emotions of teachers. They used a sorting exercise using statements that participants either identified with or rejected and constructed emotional clusters around three dimensions. Six teacher emotional profiles emerge from the research, ranging from *'empathic but minimises emotion'* to *'structured but distant'* and *'teacher led'* classifications. Although this analysis method seems useful, clustering in this way relies on commonality of language and seems applicable to larger samples than available for this research.

An alternative from an affective context is to use a detailed discourse analysis, such as that suggested by Heyd-Metzuyanim (2013) and Heyd-Metzuyanim and Sfard (2012). These papers explore teacher student interactions in mathematics from a perspective of identity formation enablers and barriers. Whilst studying students as small groups from a 'fine-grained' Mathematical discourse perspective, Heyd-Metzuyanim and Sfard (2012) relate affect to discourse through the labelling of student transcripts with descriptive affect. The labelling of transcripts in this way seems not only useful for my purposes, but also aligns with Positioning Theory (See 2.5, 3.4.3), by placing an emphasis on discourse which is becoming more important in affect in Mathematics Education (Op't Eynde and Hannula, 2006; Zan et al., 2006),

> "[c]*onsiderable progress has been made recently in the "fine-grained" study of mathematical affect, focusing on individual interviews of children or teachers"* (Schorr and Goldin, 2008, p132).

In particular, Heyd-Metzuyanim and Sfard (2012) consider the idea of '*emotional hue'*, how emotions of both teacher and student *'colour'* interactions in the classroom by labelling conversation with observer-interpreted emotions. Given that my primary concern is with teacher emotions, I have chosen to identify emotional episodes first, and then interpret specific emotions within identified episodes in the form of a pathway though an episode. The pathways for each episode appear in Chapter 4, in conjunction with the analysed transcripts (4.1A to 4.1H).

I was influenced by the papers in the 2006 Special issue of Educational Studies in Mathematics, within which different researchers examined the case of Frank using a range of affect analysis methods (Op't Eynde and Hannula, 2006). These papers suggest new possibilities for creative methodologies and the many interactive ways by which the same data can be analysed. This flexible comparative approach influenced my choice to analyse the selected data with two complementary lenses of Engagement Structures and Positioning Theory. In particular, the case of Frank as examined by Op't Eynde and Hannula (2006) maps visible emotions of students in an episode of problem solving and provides a graphical representation of observed emotions. The visual nature of representation reveals the importance of interpreted intensity for each emotion. It is the temporality used in this analysis that I wish to capture.

3.4.3 The conceptual framework of the data analysis: ES and PT

I have selected two approaches to combine in analysis and discussion. Both are tools from the affective domain used by researchers to access classroom interaction, providing different lenses and a means of revealing teacher emotions in context. Both are tools developed for an environment conditioned by teacher affective stimulations and by reactions to student emotions, efforts or actions. The first of these approaches is a global categorising analysis which is developed into characteristic ES based on research by Goldin et al. (2011). The second is complementary as it pays especial attention to temporal details of interaction, is Harré and van Langenhove's (1999) Positioning Theory (PT).

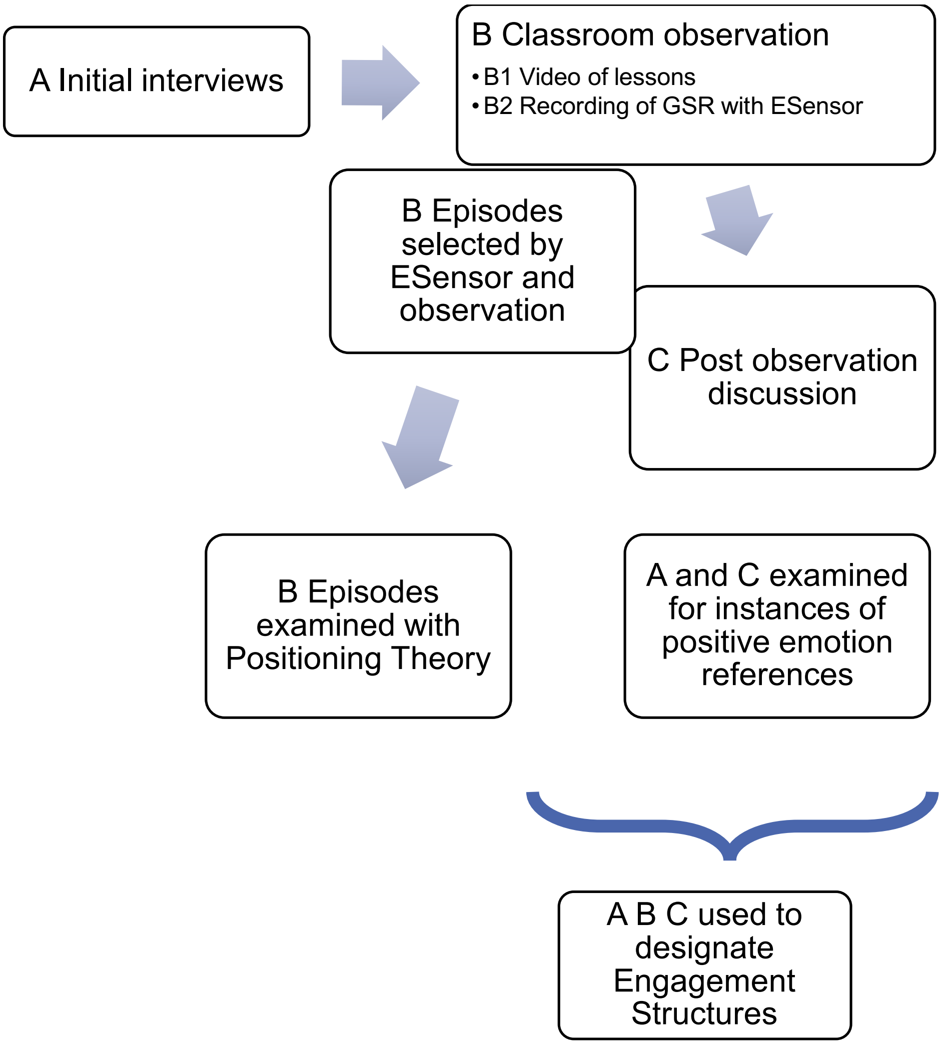

Figure 3.2 Summary of data collection and analysis

'Engagement Structures' (ES) as a means of analysis

In Chapter 2 (2.5), I introduced ES as proposed by Goldin et al. (2011) for use with studying students in mathematics classrooms, along with an aim to explore the applicability of ES with teachers. The model incorporates dynamic classroom interaction into overarching structures with varying dominance, and provides a potentially useful summary, as shown by Goldin et al. (ibid.) for students, and here for each teacher. The ES analysis in this study uses all three transcribed narrative sources of interview transcripts (A), transcripts of extracts from teaching observations (B) and post observation discussion transcripts (C). I have developed a process that summarises primary collected data through to archetypal ES. The example of Debbie (Lake, 2014) illustrates and exemplifies this process. The process is to:

P1. Annotate transcripts for each teacher for affective and emotive elements (ABC)
P2. Re-watch video and replay audio recordings to re-establish connection with the data
P3. Extract quotes from annotated data (P1) and make notes on affect and emotions
P4. Highlight connections or repeating themes related to affect for further discussion
P5. Use Goldin et al. (2011)'s interacting *strands* (Fig. 3.3, p.90) to identify characteristics and examples
P6. Use interacting *strands* to build a mapping of which ES (4.0, p.99-107) apply by degree of dominance for each teacher
P7. Build exemplars for each applicable ES

In Chapter 4, I present the results of this process for each teacher. The first teacher discussed, Carol, provides a fuller description of the process, whilst the others are summarised. Much of the process (P1- P7) was completed by hand since the data sample is small, an approach that is recommended for keeping close contact with data (Cohen et al. 2007, Lincoln and Guba, 1985). This closeness is supported by continual revisiting of video and audio data (P2) since much affective information is lost through transcription. Although still subjective, this option seems to be the best possible approach. The next stage (P3) is a modified thematic analysis, extracting quotes, accompanied by notes. Most of my notes for this process are either about extract selection and its location within transcripts, to retain context, or are my emerging thoughts. The themes used to organise the discussion in Chapter 5 emerged from this stage of the analysis.

Primarily however, I use highlighted themes (P4) to focus on aligning examples to Goldin et al.'s (2011) *strands* (Fig. 3.3, p.90) to show connections between the interconnecting *strands,* from which ES are formed (P5). The final stages of analysis (P6/P7) maps which ES apply to each teacher. Sanchez Leal, Schorr and Warner (2013b) used codes to represent ES so that they are not confused with the *strands*; these codes also appear in the Abbreviations and in 4.2.1. The nine student ES (See 4.0, p.99-107) are,

'Don't Disrespect Me' (DDM)

'Stay Out Of Trouble' (SOOT)

'Pseudo-Engagement' (PE)

'It's Not Fair' (INF)

'Get the Job Done' (GJD)

'Look How Smart I Am' (LHSIA)

'Check This Out' (CTO)

'Let Me Teach You' (LMTY)

'I'm Really Into This' (IRIT)

Looking at ES in this way, with the same classification as for students, begins to explore what ES a teacher in the study might adopt, and how adoption might either enable or restrict the available dominating ES's for students..

(1) a characteristic goal or motivating desire,

(2) characteristic patterns of behavior including social interactions oriented toward fulfilling the desire,

(3) a characteristic affective pathway experienced by the individual,

(4) external expressions of affect,

(5) meanings encoded by emotional feelings,

(6) meta-affect pertaining to emotional states,

(7) characteristic self-talk or inner speech,

(8) interactions with systems of beliefs and values,

(9) interactions with longer-term traits, characteristics, and orientations, and

(10) interactions with characteristic problem-solving strategies and heuristics.

Figure 3.3: Goldin et al.'s (2011) strands, p.549

ES are designed for students, but the generic nature, as discussed in Chapter 2 (p.50) and discussed by Goldin et al. (2011), supports transference to teachers. I have maintained the classifications as established by Goldin to support the transference. However, there may arise some issues in respect to transferring from students to teachers. The intention is to retain the model as presented for students, and to subsequently review the process. This evaluation is presented in Chapter 5.

Classroom interactions and teacher roles are complex, but so is affect, and analysis choices should reflect this. In terms of analysis, despite the incorporation of both affective and emotive within the components which form ES (Fig. 3.3, p.90), what may be missed by using the data in this way, due to the focus on the individual, is the temporality and interactivity of the classroom. The dominant ES of any individual are formed as a constellation of experiences, both past and present, but are appearing within social classroom interaction. Firstly, the model does not appear to sufficiently attend to how ES come to be formed, nor how they become likely to be dominant for an individual. Secondly, emotions as discussed in Chapter 2 are fluid and often transitory, and capturing their role is important for this study. This gap became evident with preliminary analysis using ES, as the mechanism of construction seemed elusive, and the subtleties of classroom interaction, especially as the emotions as they connect with the discourse, did not seem sufficiently well captured. The emphasis emerging from the preliminary analysis was weighted on traits and espoused affect. A third concern was the level of analysis. ES is proposed as addressing,

> *"the need for a ''mid-level'' construct, centered in the affective domain, which describe rich details of students' in-the- moment mathematical behavior and permit characterization of possible mechanisms through which beliefs influence classroom engagement." (p.558).*

In this respect, I felt that an additional level of analysis closer to the social dimensions of the 'in-the-moment' would add depth to the presentation of the data. Hence, I sought another complementary means of analysing the detail of classroom interaction in terms of emotions. The result is the incorporation of Positioning Theory (PT) as a complementary and overlapping analysis approach to access the minutiae detail of mathematics classroom interaction (beyond the affective pathways of an individual), in terms of emotions. PT alone does not capture the complexity as ES does, and together they capture the temporal nature as well as the individual in the social.

Positioning Theory as a means of analysis

The process of applying PT to a sample of data considers positions and positioning in relation to data for episodes shared with teachers after observation of their lesson.

As discussed in 2.5.3,

> *"The act of positioning thus refers to the assignment of fluid `parts' or `roles' to speakers in the discursive construction of personal stories that make a person's actions intelligible and relatively determinate as*

> *social acts. For example, in a conversation between a teacher and a pupil, rights to make certain kinds of remarks will be differentially distributed between the conversants."* (van Langenhove, 2010, p.219).

When ascribing positions to an individual, this means examining prior and post speech, listening for clues in the audio recording and video and subjectively ascribing one interpreted position at any one moment. Within positioning theory, the emphasis is firstly on pronoun use, which reveals positioning of self and others, and secondly on the student or teacher responses of accepting, negotiating or rejecting the fluid and changing proffered positionings within any discourse as discussed in Chapter 2. In Chapter 4, I annotate the episodes from each lesson with a column entitled Interpretation (Positioning) where these emphases are noted. For some episodes, where the teacher talks directly about the episode, I have comments to collaborate interpretations of teacher positions. It is likely that some of the characteristics (strands) of ES will overlap with the positioning annotations, potentially adding to the strength of the combined model. For example, strand (4), external expression of affect will also appear in the discourse notes and inform both lenses. This is despite the difference between examining the teacher as an individual (ES lens) and the teacher when interacting with students (PT lens). However, this anticipated overlap may increase the value of the whole when combining these two lenses. To draw further attention to the emotions in each episode, and as Heyd-Metzuyanim and Sfard (2012), (in their analysis, labelling is referred to as 'emotional hue'), I use pathway labelling of interpreted dominant emotions to show how teacher emotions shift during an episode. These researchers omit labels if emotionally neutral, but I label neutral for completeness. These labels accompany the annotated transcripts presented in Chapter 4.

Using both ES and PT seems to facilitate a fuller sense of what is happening in the classroom. From a detailed local lens using PT, through to a general sense of dominant ES. It seems possible that PT will act as a lens that reveals the mechanism by which ES are constructed. I discuss this further in 5.4 when evaluating the models.

The research design uses small episodes of data to allow scrutiny and to consider the process as a construction of multiple stories. This partially addresses issues from the complexity of the process, the degree of interpretation required, as well as recognising Engagement Structures and associated positions from amongst many possibilities. It must be acknowledged that this research presents just one of many stories, in the same way that identifying characteristics is representative of one view of an identity. However, attention is on how a teacher represents themselves to students in that time and context, and how I as observer, am interpreting this presentation as witness. What we therefore have is a snapshot of teacher interaction with students, one which can be used in conjunction with ES and PT.

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3.5 Ethics

The participants were aware that my research explores teacher emotions, and of my former role as a secondary mathematics teacher in schools in the same geographical area. This inevitably influenced the interviews, affecting the degree of trust, commonality of language or via shared understanding of context. Teachers may be more open in discussion with someone with experience of their professional role, even though some omissions of context setting usual between researcher and participant may occur. The teachers and students were aware that they were research participants within the context of normal classroom practice. This position has consequences over and beyond responses aimed at pleasing the researcher, in that the more knowledge participants have about the research, the less naturally they behave (Cohen et al., 2007). In this case, the need for willing informed participants took precedence. My loyalty is primarily to their interests as teachers, and I have identified minimal risk to them from participation such as embarrassment or loss of trust. No actual names are used and all data is anonymous and untraceable, other than recognisable to each participant. I have used cartoonised images in Chapter 4 and 5 to ensure anonymity. The EDU REC approved this research, and it meets the requirements of the UK Data Protection Act (1998).

One identified risk is that of embarrassment of teachers because of the novelty for their students and a change in routine, as well as the presence of an observer who is videoing and recording. Wearing an ESensor device whilst teaching may unintentionally affect classroom interaction, so the teachers wore the device in earlier sessions, without recording, until they felt comfortable. I informally practiced with the device in university seminars, and within a few minutes, wearers behave as normal and report forgetting about the recording and, although aware of the device, there is no apparent change in their observable behaviour. The output is a graph solely for selecting points of intensity. Software for video editing (Microsoft moviemaker) extracted clips to share on a laptop with teachers. Codes (letters A to H, with associated pseudonyms) identified participants and pseudonyms (with aliases or numbers depending on the degree of identifiability) for students.

The GSR device may reveal more than a teacher wishes to share, as what triggers emotional reactions can be deeply personal and is often hidden other than on an unconscious level. Therefore, the recordings and subsequent discussions are confidential between researcher and participant. I took care that participants were aware of, and were happy with this risk. I also provided a link to external teacher support on the teacher information sheet. In each school, I sought consent hierarchically (accounting for preparatory approaches to known mathematics teaching colleagues), initially to the Head teacher, Head of Department and then any participatory Teachers. Some schools ask for additional parental consents for videoing students, and I prepared a letter to address additional consent if required. I was only working with students in the presence of their mathematics Teacher. However, I asked students to consent to being videoed through a register that then remained with the teacher.

There was no compulsion to participate, even if line managers gave consent, and the voluntary nature was made clear to participants both verbally and in writing. Any declining or objections from students and recording would not take place in that lesson. Withdrawal for teachers expires on completion of data collection and analysis. Since the data includes visual and aural identification, it was made clear throughout that data would not be shared with line managers in schools and the researcher would not discuss an identifiable teacher or lesson with anyone else in school or elsewhere. Interviews and discussion took place in a private space within school to protect participant confidentiality.

In this Chapter, the choices have been guided by the logistical considerations of gathering data from schools such as minimising the time required of teachers to participate. I have considered some analysis choices from current methodologies within affect in Mathematics Education and selected an applicable method. These choices have shaped my analysis method, where identification of emotions in interview and observation informs the use of ES for analysis and uses the lens of PT to highlight details within classroom episodes. Chapter 4 reports the data and the PT/ES analysis for each participant. In Chapter 5, I discuss themes that emerge from this analysis and I evaluate the combination of these lenses as tools for future research in mathematics classrooms.

Chapter 4: Analysis

In this Chapter, after providing a summary of the ES in tabular form (section 4.0), I introduce the participants and begin the analysis. I begin with Carol, and for this case, provide a full description of the data and initial analysis. The subsequent accounts are summarised, and presented in alphabetical order following the structure for Carol. The Chapter concludes with an ES summary table for all the participant teachers (Table 4.16, p.231). Chapter 4 leads into subsequent discussions in Chapter 5 of self (5.0), play (5.1), modelling (5.2) and storytelling (5.3) before evaluating Engagement Structures for mathematics teachers in conjunction with Positioning Theory (5.4).

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4.0 Goldin et al.'s (2011) Engagement Structures as used in this study

The nine tables presented here, in no particular order, are formed from the text in Goldin et al. (2011), and show how the strands connect together to form each Engagement structure (ES).

ES	Applicable Strands	Description	Additional information
Get The Job Done (GJD)	Desire	To complete an assigned mathematical task correctly, following given instructions, thus fulfilling an implied obligation. *"The motivating desire for task completion in GJD may evoke more procedural, time-efficient strategies or algorithms."*	Belief that Mathematics is mainly procedural, answer orientated and rule governed, requiring thoroughness, with given directions from an authority. Meeting expectations and compliance are valued.
	Need	What Murray (1938) calls deference: *"to yield to the influence of an allied other"* (p.154).	GJD allows a person with such beliefs to use his knowledge to complete the task procedurally, to ask for step-by-step help, and to detach from further cognitive engagement, without calling his beliefs into question. One may set out to GJD, but notice along the way that he understands something another person does not. Initially, LMTY becomes active in task completion. The imparting of understanding becomes the major motivating desire, with the goal of simply completing the assigned task no longer salient: GJD has branched into LMTY.
	Evoked by	Being given directions	
	Behaviour	Orientated toward straightforwardly carrying out the work. In group work, others may be enlisted in this goal.	
	Emotional satisfaction	From fulfilling the obligation through task completion, not necessarily from mathematical learning. Different ES may evoke different meta-affective responses. For example, when GJD is active, frustration is likely to be experienced negatively, signifying barriers to fulfilling the motivating desire.	

ES	Applicable Strands	Description	Additional information
Don't Disrespect Me (DDM)	Desire	The motivating desire is to meet a perceived challenge or threat to dignity, status, or sense of self-respect and well-being	Correctness of answers or reasoning is important to status, which is highly valued. The self-concept includes capability of assertiveness and entitlement to respect.
	Need	The likely underlying need is termed by Murray's infravoidance: *"to avoid conditions which may lead to belittlement"* (p.192).	As a person defends their ideas, however, they may come to feel sufficiently secure that they begin to take seriously the arguments of the challenger. If something in those comments suggests a possible payoff-e.g. by offering a new perspective to the problem- a subsequent response may be more consistent with CTO, with DDM no longer active. Affective pathways associated with DDM involve emotions of resentment or anger, and pride. Self-talk or inner speech occurs in response to and is evocative of the person's emotions, beliefs, and motivating desire. We hypothesize patterns of self-talk associated with the activation of each ES, facilitating the internal organisation of the ES. For example, 'He has no right to talk to me that way,' and 'I'm not going to let him get away with it,' may characterize activation of the structure DDM.
	Evoked by	The social context may be a challenge perceived as belittling or insulting to the expression of a mathematical idea. For instance, a challenge to mathematical work can elicit DDM.	
	Behaviour	Resistance to the challenge- defending oneself to the point of unwillingness to consider the reasoning of the other – raises the conflict to a new level. "Saving face" can override the issue of understanding the math, as the context becomes a highly charged discussion or argument. Subsequent comments are construed as 'attacks' on her mathematical or social identity.	
	Emotional satisfaction	From successful defence of mathematical ideas	

ES	Applicable Strands	Description	Additional information
I'm Really Into This (IRIT)	Desire	Here the desire is to experience the very activity of addressing the task, ideally in 'flow' (Csikszentmihalyi, 1990). One is intrigued by the mathematics or the problem-solving process, 'tuning out' other elements of the environment.	Math, mathematical representation, and/or problem solving intrigues, as it has internal logic and coherence. The self-concept is as an effective problem solver, serious, an engaged thinker. Problem-solving or learning activity is valued for its own sake.
	Need	Behind this desire (in the case of mathematics) may be the need Murray calls understanding: *"to represent in symbols the order of nature"* (p. 224).	In context, it may express a mastery goal orientation. *"Some of the specific motivating desires described here can be understood as 'counterparts' to longer-term goal orientations: thus, the motivating desire for I'm Really Into This seems more like a mastery-approach goal."* *"In the context of I'm Really Into This, frustration is more likely to be experienced positively, signifying challenge and heightening intrinsic mathematical interest in the problem."*
	Evoked by	The opportunity presents itself with social support for deep engagement in a challenging problem.	
	Behaviour	Apparent task absorption	
	Emotional satisfaction	Satisfaction derives from achieving mathematical understanding, solving a difficult problem, or simply experiencing fascination.	

ES	Applicable Strands	Description	Additional information
Stay Out Of Trouble (SOOT)	Desire	A desire to avoid interactions that may lead to conflict (e.g. a fight) or distress (e.g. embarrassment, humiliation or anger) involving peers or someone in authority. Alternatively, they may want to be left alone due to personal circumstances involving some emotional vulnerability.	Mathematics or class activity can be dangerous or strewn with pitfalls. The self-concept includes low capability of self-defence if challenged, or low emotional or intellectual self-efficacy beliefs. Conflict avoidance is highly valued. SOOT is like a performance-avoidance goal, performance avoid goals are maladaptive and related negatively to many valued educational outcomes. SOOT involves emotions of apprehension or fear, and relief.*
	Need	Murray describes the need for harm-avoidance: *"to take precautionary measures"* (p.197)	
	Evoked by	The social context suggests to the person possible trouble with others.	
	Behaviour	Avoidance behaviour, including striving not to be noticed, may supersede addressing the task's mathematical content.	
	Emotional satisfaction	A sense of relief rewards success.	

* See also 'resigned acceptance' (disaffection) (Nardi &Steward, 2003, p.346)

ES	Applicable Strands	Description	Additional information
It’s not fair (INF)	Desire	The motivating desire is to redress a perceived inequity.	School activity entails implicit rules of fairness in division of work and bestowal of acknowledgement. Bias exists in recognising individuals’ or groups’ abilities, contributions, and rights. Equality of treatment and sharing fairly are highly valued.
	Need	Underlying it may be the need Murray terms succorance: *“to have one’s needs gratified by an allied other”* (p.182).	
	Evoked by	Perception of some unfairness in a group problem-solving effort evokes the desire e.g. with the level of participation by others, the role accorded to the person, or recognition from others.	
	Behaviour	Behaviour ensues toward redressing the inequity, with likely disinvestment in the task itself.	
	Emotional satisfaction	Satisfaction, if it occurs, can derive from restoring fairness, or else just ‘getting it over and done with.’	

ES	Applicable Strands	Description	Additional information
Let Me Teach You (LMTY)	Desire	To help another understand or solve the problem.	Mathematics has an understandable internal logic, and the person has high self-efficacy beliefs. Understanding and helping others are both valued. As one person attempts to teach another, the other may not regard him as especially knowledgeable or smart ad reject the help. LMTY may branch into LHSIA, as the first person tries to impress with knowledge and ability. The latter, accessed initially in service of LMTY, may come to govern the engagement.
	Need	The need Murray identifies as nurturance includes: *"to gratify the needs of a mentally confused person"* (p.184).	
	Evoked by	The social situation evocative of this desire is one where a person who has an insight or relevant knowledge to share becomes aware of someone who does not understand.	
	Behaviour	Behaviour includes trying to help by explaining or demonstrating.	
	Emotional satisfaction	Satisfaction derives from the other person learning and/or appreciating the help.	

ES	Applicable Strands	Description	Additional information
Pseudo-Engagement (PE)	Desire	The motivating desire is to look good to the teacher or to peers by seeming to be engaged while avoiding genuine participation.	Mathematics is difficult and/or inaccessible, boring, or too easy. The teacher attends to or values mainly outward signs of engagement and compliance. The person may have low self-efficacy beliefs, or possibly, high but unwarranted self-concept. Values the satisfactory opinions of others, or avoidance of low opinions. PE can function constructively in a classroom, allowing the painfully bored or alienated person to engage non-disruptively with something other than the task in hand.
	Need	The underlying need is termed by Murray as blame avoidance: *“to avoid blame or rejection”* (p.187).	
	Evoked by	The desire arises when real mathematical participation is not perceived as possible r satisfying, but overt disengagement might evoke disapproval.	
	Behaviour	Behaviour includes trying to look busy or pretending to listen.	
	Emotional satisfaction	Relief occurs as the activity ends without detachment being noticed.	

ES	Applicable Strands	Description	Additional information
Look How Smart I Am (LHSIA)	Desire	To impress others (or possibly himself) with his/her mathematical knowledge, or genius.	Mathematics requires high innate ability or genius, and others think so too. The person holds high self-efficacy beliefs and values mathematical ability.
	Need	In Murray terms, achievement: *“to increase self-regard by the exercise of talent”* (p.164).	In context, it may be expressive of a performance goal orientation. *“Whilst acknowledging the importance of longer-term goal orientations and their relationship to learning mathematics, we highlight here the great variability of in-the-moment goals”* […] that for LHSIA is *“like a performance-approach goal”.*
	Evoked by	Evoking the desire may be a potentially admiring audience, or possibly the presence of ‘rivals’ for high regard.	
	Behaviour	Can be competitive, including ‘showing off’ by tring to be fast or claiming one’s own solution to be better than others.	
	Emotional satisfaction	Accompanies achievement of recognition, if it occurs.	

ES	Applicable Strands	Description	Additional information
Check This Out (CTO)	Desire	To obtain a reward or 'payoff' – immediately or in the future. To function as a reward, something must have value to a person. One may distinguish a task's intrinsic value (how interesting or enjoyable it is) from it's utility value (how useful). The motivating desire for CTO may be based on intrinsic or utility value.	Mathematics has internal logic, inherent interest , some valuable areas of application, and/or is useful to achieve other goals. The belief is that s/he can achieve a perceived reward by working on the problem, valuing the reward, and possibly doing conscientious work. *"The motivating desire for an intrinsic payoff in CTO may preferentially evoke exploratory problem-solving strategies".*
	Need	The need behind the desire can vary with the nature of the reward.	
	Evoked by	The desire is evoked in a situation by perception of the payoff possibility	
	Behaviour	Behaviour includes increased attention to the task in pursuit of the payoff	
	Emotional satisfaction	Fulfilling the desire may increase (intrinsic) interest in similar tasks or heighten (extrinsic) interest associating the mathematics with the reward.	

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4.1 Introducing the participants

There were 4 males and 4 female participants, representing a wide range of teaching experience, from 3 to over 30 years in the classroom. Six taught in state schools in rural market towns and two in relatively urban state schools. None of the schools were independent, nor any of the state schools selective. The teacher roles within schools varied from head of mathematics department to full time classroom teacher.

Carol (4.1C) has a pastoral role in addition to teaching mathematics. She has taught in one other school, and has been in a secondary teaching post for 11 years. She works in a rural school with a good reputation teaching across the 11 to 18 age range. She has a degree in mathematics and a secondary PGCE.

Adam (4.1A) is a head of department. He has been teaching 8 years. He pursued a different career after qualifying, before returning to teaching and moving into his current role.

Bertha (4.1B) has been teaching for more than 7 years, after moving into teaching after having a family. Her degree is in mathematics and teaching combined (B.Ed.), specialising in middle years (Ages 8 to 14).

Debbie (4.1D) has the least experience: She is second in department in a rural school with a good reputation. She is in her third year of teaching.

Edward (4.1E) entered the profession through supporting non-mainstream learners. He has travelled widely and is now in his fourth year of teaching.

Freddie (4.1F) teaches in a larger urban school. This is his fourth year of teaching, and he has recently taken on additional pastoral role. His degree is in mathematics and physics. He has a secondary PGCE in mathematics and teaches ages 11 to 18.

Gus (4.1G) is the most experienced teacher. He has been teaching for over 30 years, the majority teaching in one school, and he retired in 2014. I observed him as head of department and he taught ICT for many years, as well as being a senior manager.

Helen (4.1H) has had a varied career path, having also taught primary and her degree is in accountancy. She has a secondary PGCE in mathematics. She has taught in various schools and has been teaching for 14 years, across the 11 to 16 age group in mathematics. She is now a classroom teacher in a well-regarded rural school.

The data set includes interviews of up to an hour, during which teachers talk about becoming and being a teacher. These interviews precede audio recorded and videoed observations, which are followed by post observational discussions based on an episode of teaching, selected using GSR data where available. The matching of ES with each teacher is an iterative and subjective process and the alignment varies, so I have ordered the ES according to the strength of the supporting evidence. The most likely ES to be activated are designated as dominant and supportive, with partial for less well aligning ES, but ones which still can be evidenced. These are shown by lighter to darker (most likely) shading. The *strands,* introduced in Chapter 3 (Fig. 3.3, p.90), appear in this Chapter in **bold type**. Locating an expression of positive emotion as central in each episode is not always practicable, especially if negative emotions dominate. Where the emotional expression is not interpreted as positive emotion or central to the episode, this is discussed within the cases.

The structure for Carol and the other seven teachers (A, B, D-H) is presented in the same format. Each account begins with a summary and preliminary analysis of the interview and post-observational discussion data that refers to emotions (1). I then present a summary of the lesson and justification for the selected episode (2). The GSR data is presented as graphs, the selected episode as analysis of the transcript in table form and includes the emotional pathway associated with the episode. I then summarise the positioning analysis for the selected episode (3). The presentation of each teacher concludes with result and the process (via engaging with the strands) of assigning dominant Engagement Structures based on the interview and selected episode (4). For Carol only, the process is presented in full (all the ES can be found for reference at the end of Chapter 3), and concludes with Table 4.2 which summarises the aligning of ES for Carol.

Carol (4.1C)

1 Carol: Emotions and affect in interview and post observation discussion

I interviewed Carol twice, before and after the observation. Carol and I discussed her teaching prompted by the selected episode. This resulted in both a general discussion of her teaching and the following extract. After transcribing, I examined the interview recordings for affective indications such as emotive words or non-verbal indications such as laughter. These indications form the basis for describing Carol's affect.

In the initial interview, Carol chose to tell the story of an early experience of mathematics. As a child, she expressed pleasure in recalling a magic square competition, indicating an interest in puzzle solving that was encouraged by her family,

> *"He [Dad] recognised that I had an interest, and he sort of perhaps pushed that and promoted that a little bit."*

Carol talks of communication in mathematics. She went pink in the face as she told a story from a recent experience,

> *"...they couldn't do it... I sort of then showed them, and they clapped me...I didn't expect it... it was just sort of "Oh well done miss". And in interview, "...at the end of primary school there was a competition...we [Dad and I] won a bar of chocolate [laughs], two things I like, maths and chocolate" [Laughs].*

The interviews add a valuable perspective, as she showed emotions more openly in interview than she did in interaction with students. I could describe her emotion in the observed lessons as 'gently positive', modelling learning of mathematics as pensiveness and interest which indicates that learning mathematics is a serious business, yet not unemotional.

The discussion reveals what is important to her,

> *"...I was saying on Friday to my husband that I didn't really feel excited about maths, we were talking about the emotion of it... and perhaps I'm not conveying it because a lot of it is the day to day of it, I've done it 20 times, 50 times, 100 times..."*

Perhaps Carol shows a semblance of emotions to students, reconstructing interest for their benefit, acting rather than real (Goffman, 1997). Mason (1998) suggests that,

> *"if a teacher cannot re-enter a semblance of the state of fascination of wonder which accompanies a discovery, then students are likely to conclude that there is no place for personal creativity in mathematics"* (p.253).

Carol's valuing of communication and helping appears in the post observation discussion,

> [I was] "*more comfortable talking to that group...cos they are weaker, so I feel I can help them more. They engage better".*

To summarise, affective related themes emerging from this data include Carol self-reflecting on impatience and guilt, through to a need to model enthusiasm and some perceived challenges to her comfort zone. Objects associated with expressing emotions include boredom from repetition, perceived emotional pressures and expectations of effort that she sees as characteristics of a good teacher. Overall, Carol commented in general and not specifically about the selected episode.

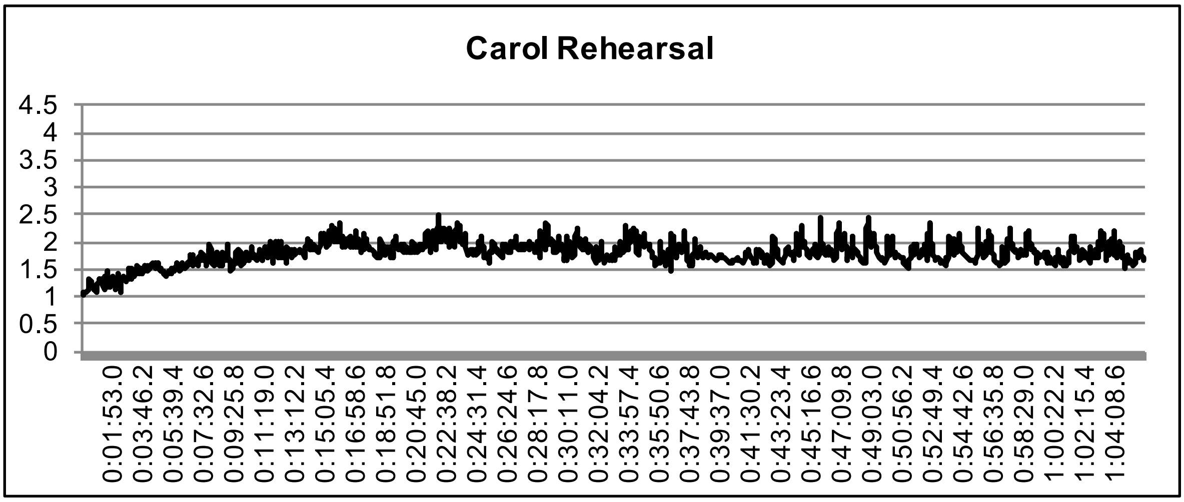
2 Carol's lesson and the selected episode

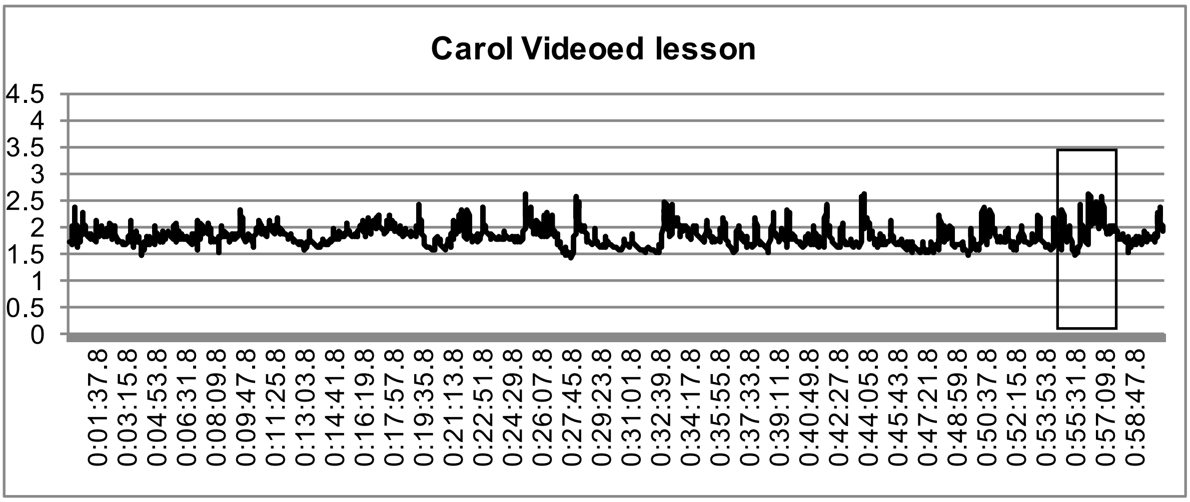
I observed two classes chosen by Carol. Firstly, for practice, a year 11 class (ages 15 to 16). This was followed immediately by a year 10 class (ages 14 to 15). I used audio recording for both classes and video with year 10. Carol's classroom allowed up to six students to sit at each block of tables; there were five blocks. The room was bright and displayed student work in a colourful way. In the videoed lesson, there were 19 students present, of mixed gender. My observing position was at one side towards the back, behind a group of students.

Carol chose for observation an experiential learning lesson, an approach associated with conceptual understanding. The lesson was on data collection and representation, presented to students as an investigation. Following a starter, assessing earlier learning on a different topic, the students used dice and coins to estimate probabilities in a noisy and active exploration. Each table of 3 to 4 students had a different activity, but with a similar potential outcome in terms of graphical representation. My impression as an observer was of a positive atmosphere, as students appeared engaged and attentive. The students were seated as mixed gender groups chosen by the teacher as students entered the room. Carol used an interactive whiteboard in the middle of the 60-minute lesson to demonstrate how the graph students were creating might appear. She mostly circulated between groups of students during the activity. There was no discussion of findings, as this was planned for the following lesson, which I did not observe.

Selecting the episode

I selected the episode for post observation discussion which took place after school the following week, using the ESensor graph produced. In this case, I centred the episode around the highest recorded value. The ESensor GSR graphs for the rehearsal with year 11 (R) and the videoed year 10 lesson are shown in Figs. 4.1. The distributions of the GSR readings for Carol (Figs. 4.2R and 4.2) are shown as box plots. There is no intention to compare teacher GSR readings, but the distributions give an indication of whether readings are consistent, and the range over a lesson.





Figures 4.1R and 4.1: ESensor recordings as graphs for Carol (The box indicates the selected episode).

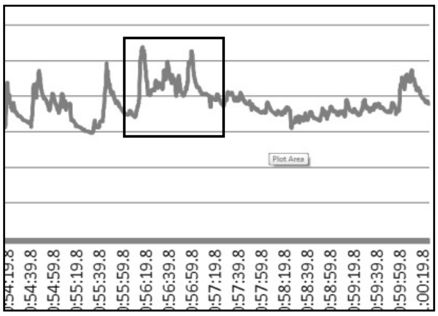


Figure 4.1(Episode): Expanded graph showing the selected episode

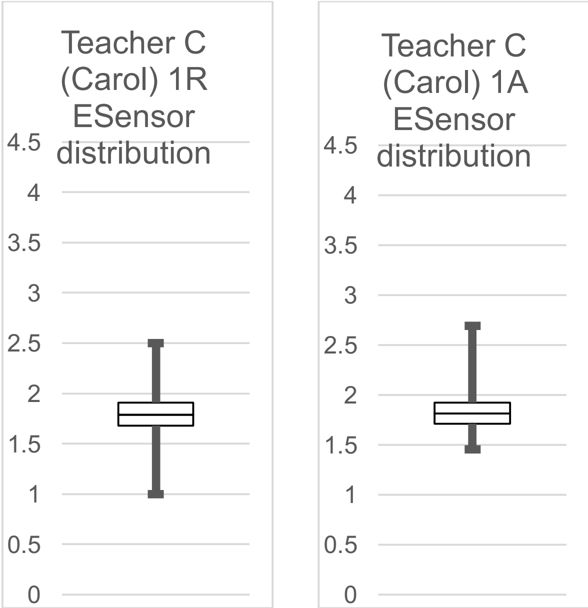


Figure 4.2R and 4.2: Distribution pattern for Carol, Rehearsal (R) and Lesson C1

There seems to be little variation between rehearsal and the videoed lesson, the distributions being consistent with an increased negative skew for the actual. Some variation may be due to lower readings at the start of rehearsal. There are slightly higher readings (over 2.5) for the videoed lesson compared to rehearsal, and frequent lower range readings for rehearsal. Interpreting this, just being filmed may make a difference, although temperature is not considered by the manufacturers to be a factor, differences may be accountable to any classroom becoming noticeably warmer over the course of a day.

Presenting the selected episode: Correcting a group constructed graphical representation

The selected episode centred on one group of three students, two boys, one girl, who were collecting data empirically using dice, recording the number of times each dice value occurred. The selected episode, taking place towards the lesson end, shows the teacher revisiting each group as they were beginning to construct a theoretical frequency graph for their data (Fig. 4.3a). The camera points just at the teacher, so one girl, with whom most eye contact is made, is not shown. After some discussion relating to constructing their graph (Fig. 4.3b), the teacher fetches a textbook and shares the relevant part, explaining how the book shows how the graph might be constructed (Fig. 4.3c).

Figures 4.3a, 4.3b, and 4.3c: Snapshots from the selected episode

Carol's emotional pathway (Fig. 4.4) for the selected episode is shown in conjunction with the transcript (Table 4.1). The selected episode from Carol's teaching gives an insight into her communication of mathematics 'in-the-moment' and facilitates looking in detail at Carol's positioning. The selected episode provides evidence, in addition to interview, to support determining dominant ES for Carol.

T= Teacher
S1-Sn = Students in the class
Sx = Student not identifiable

	Transcript	**Assigned emotion**	**Interpretation (Observer notes)**	**Interpretation (Positioning)**
T	*Ok, so you need to show me that then...*	neutral	[Nodding, making eye contact, appearing to pay close attention]	Seeker of knowledge
T	*So how can you show me?*	neutral	Students positioned by 'how' as possessors of knowledge which needs communicating. That mathematics has many ways/choices for demonstrating knowledge	Elicitor of information I am interested
	[Inaudible]			
T	*Yep*			
S2	[Inaudible]		Possibly the student says, 'put it on another piece of paper'	
T	*Put a percentage sign in...* [Waits]	Slight Impatience	Gives the impression that doing this should be obvious	I am knowledgeable
	That's right.		[Waits and watches, head turned to one side]	I am interested
		Puzzlement, confusion	Fig. 4.3a [Change in facial expression at this point may reveal that she has realised	I am confused

			they are doing it wrong e.g. bites lip and head from side to side	
T	*Can I stop you after this one for a minute?*	Doubt	[SENSOR PEAK] Sharing problem identification	I need to sort this out.
	How many goes have you had?	Interested	Pensive facial expression	I am interested Questioner
Sx	[Inaudible]		[Sits down with students at their table, Fig. 4.3b]	
T	*So are you stopping every....*	Interested	[Waits expecting student answer]	Elicitor of information. I want to know...
Sx	[Inaudible]			
T	*Right. So, we've got to be careful because what I have asked you to try to record it as it is progressing.*	Neutral	Shifts language pronoun use from you, me to we and then back to me, you. [Hand gestures marking intervals from left to right] Modelling	I understand the task Collaborator in mathematics task (mediator) Demonstrator
S1	[Inaudible]			
Sx	[Inaudible]			
T	*Yeah. So, you've done 16's as lots?*	Neutral		Elicitor/ confirmation seeking
T	*So, I need you to try and stop every 16* [Across hand movement showing blocks] *Cos what I want to see on the graph...*	Stronger interest	Attention at this point appears to be on addressing student misunderstanding	Instructor and restorer. I am expecting...
T	*Let me show you what I mean.*	Interested	[Gets up and fetches book] Is she seeking further strategies to use at this point?	Sharer of expert information Positioned with textbook authors I am knowledgeable
T	*So, although I wanted you to find some of the patterns yourself, I don't want you to be completely confused.*	Neutral	[Finds page in book, takes time using index] Reveals a view of learning mathematics	Resolver of confusion. I understand your difficulties Positions students as capable but in need of scaffolding

Sx	[Inaudible, possibly '*Do you mean like do 16, and then another 16?'*]			
S1	[To another student out of camera shot] *You silly woman* (shaking head). [Possibly adding] *I told you that was not how we should draw the graph* (smiles)		Comment ignored completely by teacher Student aligning with teacher but also with other students through playful humour	Student attempt to reposition, rejected by teacher
T	*So, you can see how it is progressing.*	neutral	Finding page in text book. Use of 'it' labels task as 'other'. Looking at book.	Sharer of authoritative information We are doing this together.
Sx	*Maybe I should just put some dots on?*			
S1	*How about we do it every 56 seconds from now on?*		[Addressed to other student, does not appear as serious comment]	Ignored (rejected by teacher)
T	*This is what we are looking for.* [Shows graph in book to students]	Interested	Uses wide hand gestures on book page (Fig. 4.3c). Making eye contact with students out of camera shot	Helper to solution We are doing this together
T	*Right, here is a graph,* ***they*** *have put frequency up the side. They've gone for decimals, with the number of trials along the bottom. Ok. So, they have marked it every hundred, really, ok,*	Interested, both in text and in student responses	Emphasised '**they**' in this context are unknown other mathematicians as in textbook writers [Uses hands to show detailed parts of graph in text book]	Aligning with students using 'they' as an authoritative other I am mediator between text and you
T	*Although you have not got time to do that.*	Mild frustration	Looks at S1 and shakes head at him [Underlying message might be 'get on with this you are wasting time'] Acknowledges earlier attempts to negotiate, and confirms rejection	Understanding of student task issues Aligning with lack of time for classroom tasks I know you need time
T	*So, I was hoping you would go up at perhaps, every 16, 32...*	Interested [Head nodding	Positioning of students in relation to text	Hopeful of student success at task

	[Nods head to show continues] *and then every time you have done a chunk then stop and see what you have got.*	and eye contact to each student in turn]	Reading of body language of students to assess understanding? Expecting nods back?	Clarifier of task/understanding
S1	*Fine*			
T	*Yeah?*	Neutral		Confirmer I know you understand now
T	*So, go back to this point where you knew how many you had of each. OK.*	Satisfied	[Moves away from this group as speaking] [END 2.00 min]	Back to instructor mode I know you will do this right now

Table 4.1 Selected episode transcript and commentary for Carol

Neutral → slight impatience → puzzlement/confusion → doubt → interested → neutral → stronger interest → interested → neutral → interested → mild frustration →interested → neutral → satisfied

Figure 4.4: Carol's emotional pathway

In the selected episode, shown by the emotional pathway in Figure 4.4, Carol exhibits characteristics of mild frustration or puzzlement in a predominantly positive lesson. In the selected episode, Carol modelled a careful assessment of the situation before acting, as well as patience and thoughtfulness when doing mathematics. She encouraged explanation from students with her head on one side, with expectant body posture and interested face. Finally, within the selected episode, we have emotional uncertainty or doubt. One student in the group is unknown to her, and she later expresses concern that she does not have a strong relationship with him. This unknown factor could potentially shift her out of her comfort zone and may account for the higher ESensor measurement (Figs. 4.1).

3 Carol: Positioning within the selected episode

The selected episode has three phases as described, and Carol's physical positioning moves with these phases; from standing (ready to move on quickly to the next group if all is well) (Fig. 4.3a), to sitting with students (to resolve) (Fig. 4.3b), to demonstrating (Fig. 4.3c). The first phase shows Carol checking progress and understanding. In the second phase, she sits with students and seeks further clarification. In the third phase, she fetches a textbook and shows the relevant page to the group. Whilst modelling a three-part interaction process, Carol's language models that it is important to take care when doing mathematics, such as,

> *"Right. So we've got to be careful…"*

This is emphasised by subtle shifts in pronoun use, shifts indicative of positioning students and self within a discussion (Table 4.1). She models process in learning mathematics, and mathematics as social problem solving, as in,

> *"So, although I wanted you to find some of the patterns yourselves, I don't want you to be completely confused".*

Carol chose to be observed doing group work, which reflects her social orientation. In the selected episode, although she does not smile, she uses voice, stance and body positioning to progress positively through the phases. It was a pleasure as both observer and teacher, to see such efficiency in action. Her facial expressions are indicators of her emotions in this example, and there is further evidence from her subsequent account. Her words at this point also position students as being able to align with the same external textbook authority, whilst her use of pronouns positions herself as with students even when referring to the text, whilst standing aligns her with the book as knowledgeable teacher. Her positioning appears to be as mediator between mathematics and student learning. It is an example of where interpreting positioning directly links to mathematics learning, rather than a relationship emphasis that emerged from discussions with this teacher. I would suggest the selected episode, analysed with Positioning Theory, provides a lens to examine how closely Carol's espoused and enacted behaviours align. Carol is experienced, so her practice may have moved beyond conscious decision-making and positioning reveals her instinctive behaviours. Considering immanent positions as affective traits and transcendent positioning as emotional states, there are similarities between these, as might be expected as a teacher becomes more experienced in the role.

4 Carol: Analysis of interviews and the selected episode using ES

The dominant ES for Carol are LMTY as the primary driver (dominant) and IRIT (used as a teaching strategy), supported by CTO. Table 4.2 summarises the ES analysis for Carol, from least to most applicable ES. The shading indicates the degree. Light shading for partially evidenced ES (None for Carol), medium shading for supportive ES (CTO), and darkest shading for the strongest supporting evidence (most likely to be dominant ES) (IRIT, LMTY). This ranking by shading is applied consistently across the teachers. For Carol only, I include justifications for all possible ES, but for subsequent teachers I focus attention on those that are most likely to be activated (partial, supportive and dominant). I draw evidence for assigning applicability from the ES *strands* for all the teachers. Further details for ES *strands* and beliefs as appear elsewhere (3.5, Fig. 3.3, p.90), whilst applicability and modifications for teachers are considered in 5.3, where Carol's unique LMTY is discussed. In Table 4.2, the strands as discussed are summarised for each ES in relation to Carol.

Evidencing each Engagement Structure	
DDM Don't disrespect me	Carol's identified threats to her self-beliefs appear as intrinsic guilt or doubt and relate to how others see her, so not, as for DDM, related to dignity or status. There is no evidence of defending oneself, or teaching as a conflict. Status for this teacher comes from successful interactions rather than correct mathematics. An unlikely ES for Carol
SOOT Stay out of trouble	In her discourse, Carol does not emphasise conflicts with peers or authority. She shows some characteristics of emotional vulnerability, yet not with associated avoidance behaviours usually attached to this ES. If we consider this teacher's beliefs, then there are no alignments with the beliefs associated with this ES. An unlikely ES to be dominant for Carol.
LHSIA Look how smart I am	I have no evidence of any desire to impress others in the way described by this ES, suggesting Carol has little interest in admiring audiences or in teaching as performance. Competition for herself was mentioned in interviews, but not in the observed lessons. If she seeks recognition, it is as socially caring. Her role as a supportive teacher indicates a belief that mathematical ability is negative, even a threat. This ES is unlike to dominate for Carol.
PE Pseudo-engagement	There are no indications that this teacher is not fully engaged, she appears absorbed in the task of teaching. There is no evidence of avoidance or blaming others, or failing to take responsibility, and she seeks real participation from her students. Her espoused values are for deeper learning, not overt compliance either for herself or for her students and she seeks for more than just being satisfactory. Not an ES likely to dominate for Carol.
GJD	The motivating desire for this ES is completing the task correctly and fulfilling perceived obligations. Carol's perceived obligations are socially

Get the job done	orientated, uncharacteristic of GJD. She seeks social alliance, but authority for her is socially interactive and not, as for GJD, goal orientated. Her interest seems to be more in the processes of learning. Tasks for her are interesting problems requiring thoroughness, not especially emotively associated. This procedural and outcome orientated ES does not align with her socially located beliefs.
INF It's not fair	This ES requires a belief in implicit rules about fairness in mathematics. Although Carol places emphasis on fair reward, the inequities are for others not self. Supporting students who are challenged by mathematics seems to be a source of emotional satisfaction, rather than redressing balance, as described for this ES. An ES that may become active for others rather than self.
CTO Check this out	This ES requires an articulation of future desires, such as evidence of ambition, which is not characteristic for Carol. Although she has a career path, her current role is, I think, satisfying, even if there are identified negatives. Carol's sought reward of social recognition and student appreciation shows values that do not align with this ES. Carol's motivation comes from both interest and enjoyment, and her engagement is directed towards situationally located social reward from her students. Carol describes her pleasure at being a mathematics teacher, whilst she refers to mathematics having an internal logic and interest. But this belief is inapplicable to her mathematics classroom in that she does not expect students to follow her thinking. Yet she exhibits the conscientiousness associated with this ES. This ES may be dominant on occasion, so identified as a supportive ES for Carol.
IRIT I'm really into this	The characteristics of this ES appear within the data. For example, in terms of beliefs, she says she finds mathematics and its representations and problems intriguing. She refers, on several occasions, to the logic and coherence of mathematics, which I would infer is one of the appeals for her. She values efficiency both for herself and for her students. Being serious about mathematics, being an engaged thinker and the value of solving problems for their own sake aligns with a process orientated way of thinking. In terms of beliefs, a strong match. She flows round the classroom in continual interaction, rarely positioned as separate from students. In terms of pedagogic mastery, she places emphasis on the social and encourages deeper engagement through use of extending questions and through modelling. Her satisfaction is for self in terms of mathematical understanding, yet in this case it seems deeper. She is perhaps seeking mathematical understanding on the level of a socially engaged mathematics teacher; seeking understanding of the motives and beliefs of her students.
LMTY Let me teach you	LMTY is likely to be a dominant ES for Carol. She talks of a strong desire to help others understand and solve problems, and nurturance is characteristic. She talks of resolving confusion, seeing need and meeting it, and places a strong emphasis on explaining and demonstrating. Her primary reward is recognition or appreciation of help, or that students learn. The beliefs associated with this ES align well with the evidence, including that mathematics has an understandable internal logic, that high self-efficacy is important, and helping others is of high value.

Table 4.2: Aligning Carol's ES, from least to most applicable ES

In what follows, I discuss the construction of Table 4.2 using the interviews and selected episode. I first identify the *strands* which determine the dominant and supportive ES for Carol. This is primarily through identification of the desire, need, evocation, behaviour and perceived reward as described by Goldin et al. (2011) and summarised in Chapter 4 (4.0, p.99-107). I then explain how the strands develop into and indicate the dominant and supportive ES for Carol.

Carol: Building ES using Goldin et al.'s (2011) strands

The intermediate step between the data and ES are described by Goldin et al. (2011) as *strands* (Fig.3.3, p.90), which together form ES as described in 2.5.1 and 3.4.3. *Strands* are indicated in bold type in what follows. I draw from both interviews and the selected episode to illustrate how the strands direct the dominance of the ES. The process considers the data for each strand before drawing the characteristics together into ES.

Following Goldin et al. (2011), I begin with the *strand* of **motivating desires**, moving through the *strands*, whilst recognising that the *strands* are continuously interweaving and overlapping. According to Goldin et al. (2011), *"The components or strands are regarded as simultaneously present and dynamically interacting."* Later adding that, *"The first seven describe in-the-moment, changing or changeable aspects of the student's state; the latter three pertain to interactions with longer-term attributes or more ''global'' structures"* (p.549). The evocation of Carol's **motivating desires** within a social context are emphasised in her interview comments. There is evidence of affective pleasures and discomfort as activating **motivating desires**, such as her discomfort at not being always excited about mathematics. Her reflection appears throughout the data and there is evidence of activity towards seeking satisfaction through helping students. From these activations, I would suggest that her **characteristic goals** and **motivating desires** are orientated towards pleasing others such as being of service to those perceived as weaker.

The result is supportive **behaviour** in the classroom. She places emphasis on clarity of explanation and resolution of confusion,

> *"…but they got themselves in such a muddle with it"*

When her students were stuck, she could resolve their confusion. Her **behaviours** in class include presenting herself as a supporter of students, possibly over the requirements of a mathematics teacher role,

> *"And so, rather than standing there, I'm the teacher telling them what to do, I was trying to get down on their level and having more of a conversation..."*

This shows how she positions herself in relation to her model of a 'good' teacher (2.2.5). Her conversation includes examples of what is not perceived as good teacher behaviour, including her concern that she may be seen as *'grumpy'*, *'fed up'* or *'impatient'*, all socially negative emotions. In some ways, such a position is inevitable given her dual role in school as both classroom teacher and pastoral manager. Reasons for such **behaviour** given in discussion of the observed lesson, and my own observations and recordings, centre on encouraging self-belief for students, such as,

> *"I knew they should be able to do it…" and "...because they've tried it themselves, so they understand."*

My impression is that she places conversation and discussion above telling or imparting of knowledge. In Ernest (1989b) terms, she presents as fallibilist both in discourse and from enactment, and that she values conceptual understanding. The selected episode used for post observation discussion illustrates a **characteristic engagement pathway** (Fig.4.4) for Carol, an element returned to in Chapter 5.

In the selected episode, Carol expects three students to understand and to be engaged in the task. Prior to the selected episode, she has checked their progress several times. She first expresses surprise at both misunderstanding and perceived lack of engagement, expressing this verbally as lack of normal engagement,

> *"... I was a bit surprised that they hadn't managed to get more out of what they were doing."*

She then moves onto doubt; visually expressed as biting her lip and putting her head on one side and then the other, and articulated later as apprehension,

"... because I knew they should be able to do it [Draw the graph], but they weren't giving me anything back".

In post observation discussion, she assigns this doubt to either lack of understanding or to the group dynamic. Her **behavioural** response, both observed and subsequently explained is to shift from instructional mode to conversational level. Accordingly, she sits down with the group. She explains this action as,

"…trying to get down on their level and having more of a conversation"

To support her own understanding of the perceived problem. Her **pathway** then moves to assigning a reason for her understanding of the context. In this case guilt, because she was responsible for assigning them to groups, but then she shifts to resolution as she discovers a resolvable misunderstanding. She resolves verbally, by gesture and by reference to an example in a textbook, additionally emphasising the cumulative nature of the graphical task, which was the identified group misconception.

Carol's **external expressions of affect** are regulated to support learning and engagement. In interview, she smiled and laughed, but such positive expressions were rare within the observed lesson, where I would interpret her predominant expressions as serious engagement. Her voice and persona presented as calm and relaxed when engaging with students. Carol is constantly evaluating, both within context and for meaning. For example, during the selected episode, upon experiencing uncertainty, she quickly assigned alternative likely meanings to the situation, and acted to establish which one appears the most suitable. I would suggest she achieves resolution by imagining possibilities and seeks collaboration through discourse. In terms of **meta-affect**, repeated use of such **strategies** would be likely to establish the use of **meanings** and continual evaluation as stable **strategies**, associated with experience.

There is evidence of **self-talk**, as personal self-regulation and evaluation, as in the reflection previously mentioned, but also in relation to her **beliefs and values**. The strongest of these **beliefs** are relationships and social appreciation, both as individual doubts, but also in relation to others, located more within her comfort zone. This interpretation of her **beliefs** is supported by how she talks of her family influences and significant others. Her conversation also exchanges between the ‘good’ social teacher, and the ‘bad’ knowledge imparter and her degree of control of this dichotomy. Linked to her dichotomies is an emphasis on how she and her students should engage in mathematics, revealing a philosophical position, based on the appeal of internal logic and interest of mathematics that is firmly fixed within her practice. I would suggest that her identity combines both mathematics as a subject, as a pedagogy and as social, and that, for Carol, these components are inseparable. Finally, the data illustrates Carol’s **long term traits, characteristics and orientations.** This dimension includes her **goal orientation**. In these terms, she is positioned as mastery combined with approach.

The consideration of the strands leads into assigning ES as dominant, supportive and partially evidenced for Carol as shown in Table 4.2. This process is repeated for Adam to Helen. Modifications appear for multiple episodes for the same teacher, for Adam, Bertha, Edward and Freddie.

Allocating possible positions to the transcript provided useful supportive evidence for not only assigning ES for Carol, and for the other teachers, the allocation supported identifying the fluid dimensions of Carols teaching, a lens on the data that reveals more than looking at ES alone. For example, the importance of being interested through Carol’s discourse, and how her positioning shows shifts over a few minutes within her LMTY ES. There are also indications of how she implements behaviour for learning in the class, which may inhibit or encourage particular ES for the students. This is outside the remit of this current study, but shows how ES and PT might be used in the future. Similarly, how Carol mediates between the students and mathematics, in this case by realigning position with text as authority, merits further discussion and investigation.

Adam (4.1A)

[An explorative paper on using Goldin et al. (2011) ES, with the data collected for Adam, appears in PME38 proceedings (Lake and Nardi, 2014)]

1 Adam: Emotions and affect in interview and post observation discussion

I interviewed Adam in November 2013. I then observed four lessons with the same year 10 class, chosen by Adam. All lessons were audio recorded, three were videoed. As well as general discussion, other parts of lessons were referred to by Adam in post-observation discussion. Together, these form the basis for describing Adam's affect.

Adam talks mainly about his teaching, yet he tells a story about when his school was short of mathematics specialists at one point. In this he indicates his unease with just getting the job done (GJD), and what gives him pleasure in his teaching,

> *"Um...so you kind of lose some of the nice bits of the job, all the perks, all the nice feeling, you are just trying to get the job done."*

He talked about his experiences at university, placing an emphasis on competitiveness. He talks of losing some of his faith in mathematics, exactly when he was challenged at university and could not perform highly enough to meet the demands of this competitiveness. His response was to seek a different, more satisfying career pathway, which was teaching. He appears to find personal satisfaction in his own success. This is evidenced when Adam talks about his own achievements in the interview. I noted the frequent use of a contented 'hmm' when recalling a positive experience. Other examples include his statement that students liking mathematics because they also like him is rewarding,

> *"I think um...students I teach get that enthusiasm from me, and they like the subject."*

2 Adam's lessons and the four selected episodes

Lesson A1 selected episode: Teacher error whilst teaching upper and lower bounds

Lesson A2 selected episode: Student explanation of stem and leaf diagrams

Lesson A3/1: Nominating within questioning on sequences

Lesson A3/2: The shepherd story within teaching linear sequences

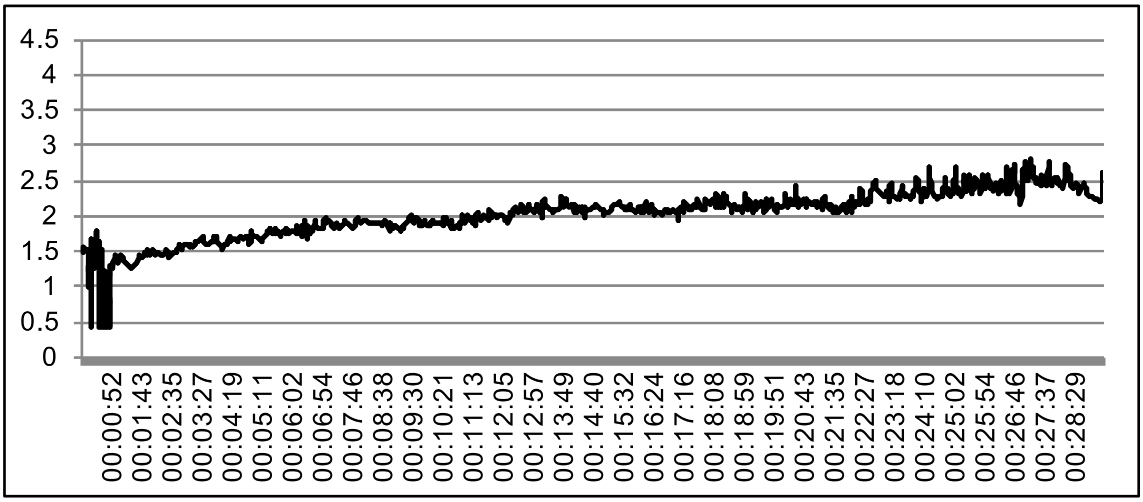
After the rehearsal lesson, I observed three classes with the same students and selected four episodes. The year 10 class of 14 students engaged in three topics within the GCSE mathematics syllabus. These were upper and lower bounds (Lesson A1), stem and leaf diagrams (Lesson A2) and linear sequences (Lesson A3). Adam has arranged his desks in pairs facing an interactive whiteboard. The teacher's desk was centre front facing students, just to one side of the whiteboard. The room displayed students work, and many idiosyncratic items such as images of Dr Who, Rubik cubes, Stars Wars items and other eclectic objects. I observed from the back of the room.

For Adam, I present the results of the ESensor recordings together, before introducing the four selected episodes. The ESensor graphs and distributions for Adam are shown in Fig. 4.5 and Fig. 4.6. There were three post observation discussions for each videoed lesson using the selected episodes from each observed lesson as a basis for discussion. In the selected episode from lesson A2 Adam talked specifically about the selected episode, and this commentary is included in the table.

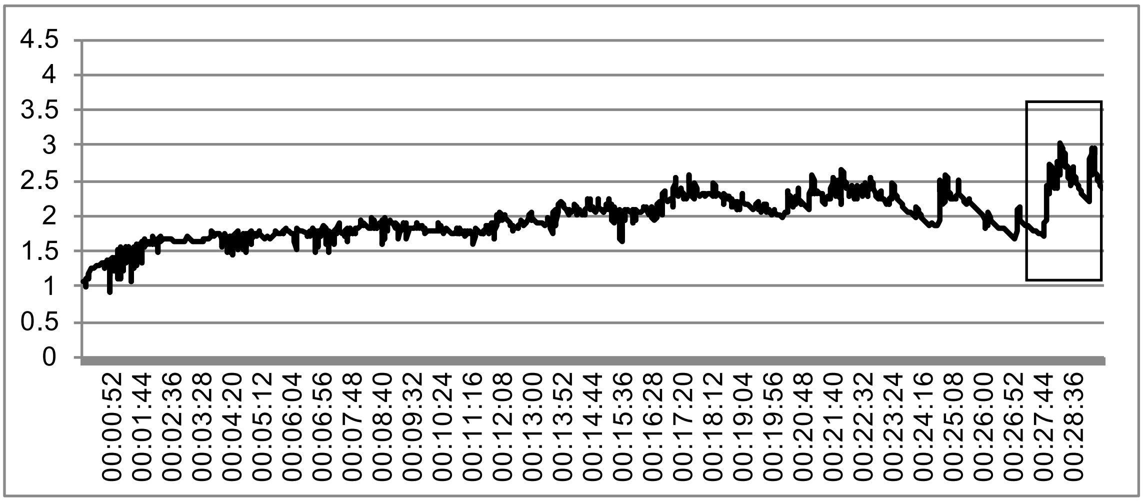
Selecting the episode

I selected episodes based on ESensor indications (Fig.4.5), using the highest recorded value(s) in each case and the two highest recordings for A3 since these both had string expressions of observed positive emotions. The significant dip shown in A3 occurred after the lesson conclusion and cannot be included.

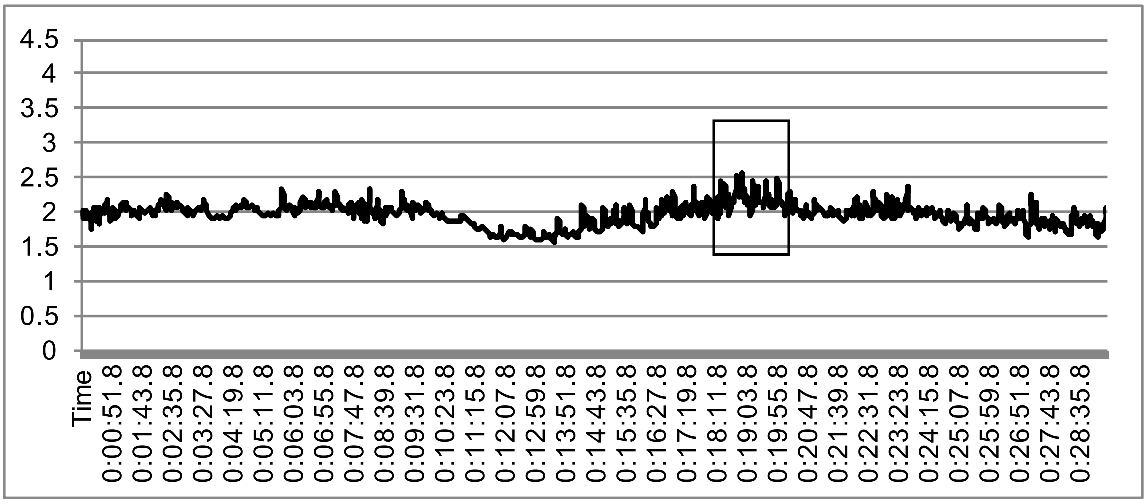
Adam Rehearsal



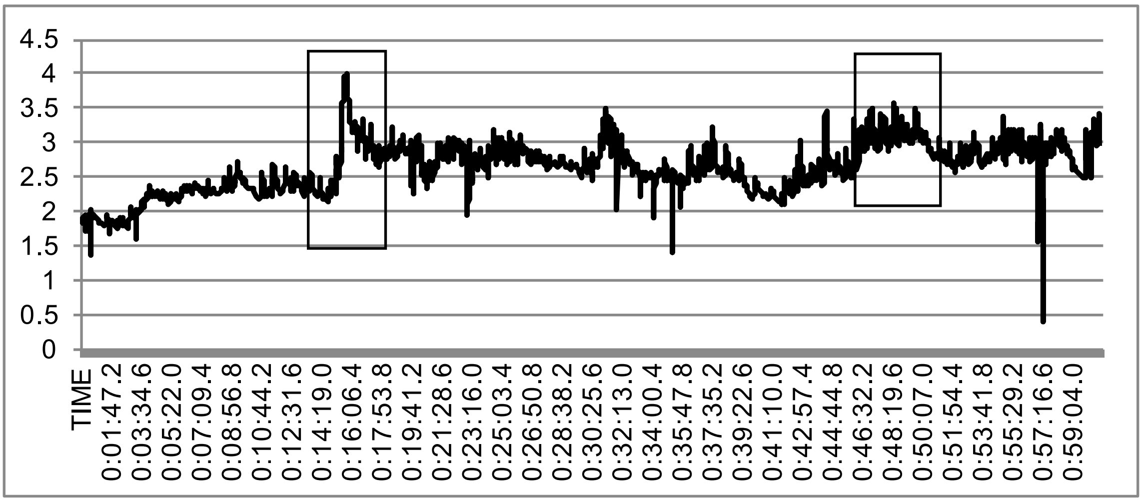
Adam Lesson A1, the box indicates the selected episode



Adam Lesson A2, the box indicates the selected episode



Adam Lesson A3 (with 2 boxes indicating the selected episodes A3/1 and A3/2)



Figures 4.5: ESensor recording as graphs for Adam (From Rehearsal and Lessons A1, A2, and A3 respectively)

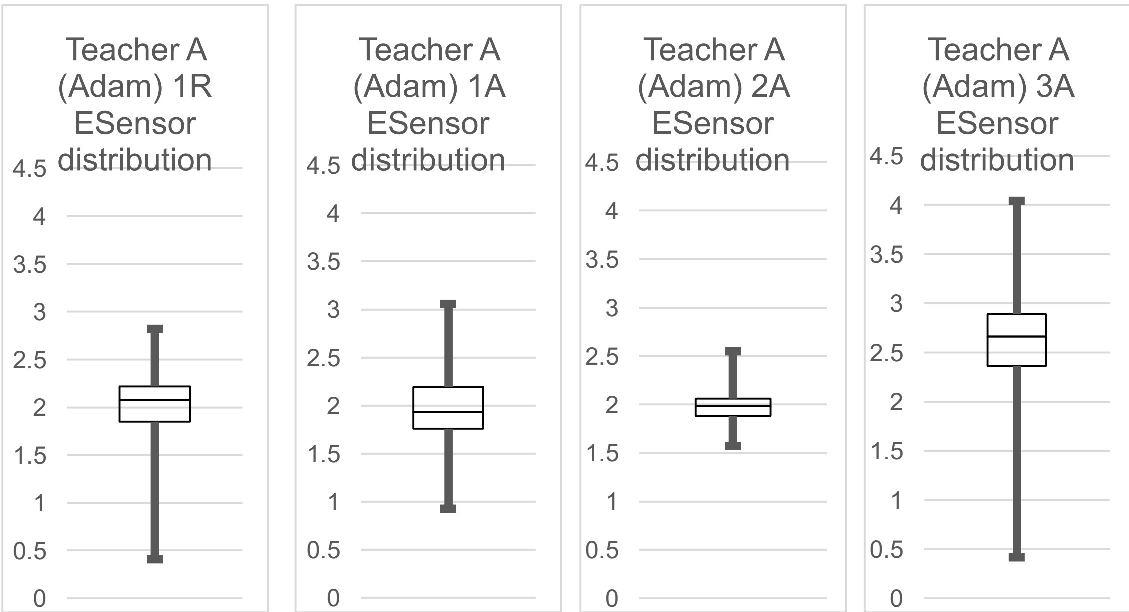
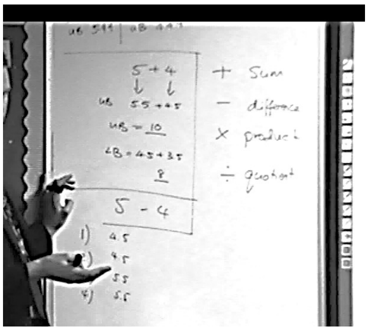


Figure 4.6 ESensor recording as box plots for Adam (Rehearsal, Lessons A1, A2, and A3)

The box plots vary more than might be expected for the same teacher. In the first three distributions the median is relatively consistent, but in lesson A3 the recording indicates a wider range, with more higher values. This was the ‘shepherd’ episode. Accounting for this variation is not possible with a small sample, however the lesson was later in the school day which may be significant. The first selected episode has a noticeable peak, and the dip after the end of the lesson skews the data.

Presenting the selected episode from Lesson A1: Teacher error in teaching upper and lower bounds

5-4
1) 4.5
2) 4.5
3) 5.5
4) 5.5



Figures 4.7a, 4.7b: Board image at the start of the selected episode

In this episode (Table 4.3), selected as the highest ESensor recording, Adam had just considered upper and lower bounds for 5+4=9 as a whole-class discussion. He had talked through the topic, writing notes on the board and asking questions. The students were independently taking notes with an occasional prompt of *'write this down'*. The images show Adam starting to complete possibilities for 5-4, after giving students time to work on the task of finding the upper and lower bounds of 5-4 themselves. As the selected episode begins, the board shows Figs.4.7a and Fig.4.7b. By the end of the selected episode, Figs.4.8a and Fig.4.8b are showing.

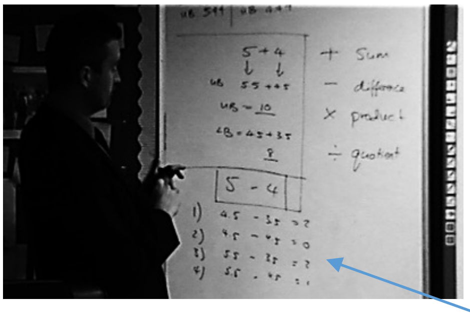
5-4

1) 5.5-4.5 =1

2) 5.5-3.5=2 UB (max. value)

3) 4.5-4.5=0 LB (min. value)

4) 4.5-3.5=1



Figures 4.8a, 4.8b: Board image at the end of the selected episode

The error
4.5-3.5 ≠ 2

In the video, Adam notices an error. The screen shot (Fig.4.8a, 4.8b) was taken as he pauses, looks at the board and asks whether anyone has spotted the error. The emotional pathway through the selected episode moves from pleased through to a degree of unease through to satisfaction (Fig. 4.9).

	Transcript	Assigned emotion	Interpretation (Observer notes)	Interpretation (Positioning)
T	*Right guys.*	Confident Assertive	Heads up shift indicator Homogeneous group identifier ('guys' – you plural)	Organiser Students positioned as collaborators ('guys')
	Pause on what you are doing.	Neutral	Switch to talking as to individuals ('you' singular)	Instructor (Do this)
	I'll show you something quickly to help tie this together.	Confident Neutral	'tie this together' – physical analogy and objectifying of topic – Mathematics as subject	Problem solver Demonstrator (I'll show you) Intermediary between 'this' and 'you'
	*There are **4** different combinations of these you can do.*	Confident	Mathematics exists first and is not negotiable, 'There are' These are the rules. This is certain **Shift** to students choosing to own it? 'you can do' Breaking down of task/ method of finding answer.	Mathematics expert (I Know how) Instructor ('you can do') Intermediary/ mediator between mathematics as certain and students' choice to follow rules, 'you can…' Positioned as problem solver Positions students as able
	*For the number **4**, the two options are... **3**.5 and 4.5.*	Confident	Factual knowledge imparting Emphasis (Bold type) is where potential errors occur and on mathematical understanding of task [Writing as speaking]	Mathematics expert
	Shh.	Neutral	Reminder should be listening, but without breaking flow of speech to do so. Undirected instruction to be quiet	Manager of behaviour This mathematics is important

	*You can either do for **5**..., 4.5 or 5.5, they're your two options, because that's the lower and the upper bound.*	Confident	Ownership Perhaps 'the' is used where there is no negotiation? [Writing as speaking]	Instructor Mediator Imparter of factual knowledge
	*So, what I have written out on the board is **all four different combinations** of what can happen.*		Repeated comment, this time with emphasis [Indicates degree of importance] Including relevant terminology e.g. 'combinations' No ownership of mathematics, so mathematics exists. Asserting there are choices in doing mathematics	Mediator between mathematics and students Explainer
	Ok.	Uneasy	[Pauses – he is staring intently at the board] Modelling reflection?	
	I'm going to work out all of them. *So, I am going to get* *2, 0, 2, 1.* Error [NOTE the first 2 is incorrect, it should be 1]		**Shift** from mathematics as an object and you to ME associated with the solution Out loud thinking – modelling? Use of the personal (I am doing mathematics) 'them' – potential objectifying forming of process/answer- a transitory form	Modeller of doing mathematics, in writing and verbal Self-positioning as able to do this Positions students as passive audience or expert novice model (Schön)
S1	*Blast-off…*		Student attempt to position as class clown? Ignored by teacher	Implies deviation from formal mathematics script is condoned (Evidence from elsewhere in the lesson indicates this is a likely interpretation)

<table>
<tr><td>S2</td><td>It should be 1.5</td><td></td><td>Also ignored, perhaps as wrong answer as well.

‘It’ – the answer, student is also objectifying mathematics in a similar way to the teacher</td><td>Implies former positioning as questioner of teacher answers is condoned by the teacher (this is supported by post observation teacher comments)</td></tr>
<tr><td>T</td><td>Right, think about this. [Pauses]</td><td>Confused</td><td>No subject. It is not clear who should be doing the thinking. It could be self, due to the error, or that students (plural) should be thinking.

It could show valuing of thinking?

Interpreting this pause could be part of modelling, but I have taken it as doubt, possibly unconscious, which then acts to instigate resolution</td><td>Both or either positioned as reflective depending on whether this is interpreted as instructional, directed at self or encouraging of reflection</td></tr>
<tr><td></td><td>The question was saying upper bound, the upper bound for 5 minus 4.

That number is going to be as big as possible. [Emphasis and shift in pace into regular time beat]

<table><tr><td>as</td><td>big</td><td>as</td><td>Pos-si-ble</td></tr></table>
1- and-2- and-3- and-4-</td><td>Changing into certainty

Interested</td><td>The emphasis is on key mathematical terminology.

[Uses hand positioned to show distance between forefinger and thumb, digits touching for smallest, but shaking hand for both]

It is interesting that re-establishing of certainty comes before and not after resolution

As before dissociated from the question. ‘The question was saying’ (not the teacher was saying)

Further example of objectifying?</td><td>Clarifier of requirement of task

Teacher role of drawing attention to pertinent points</td></tr>
<tr><td></td><td>Hm. [Pause with pen ready, his head moves as</td><td>Doubt

Uncertain</td><td>No pronouns used

He may be rechecking the question, responding to a</td><td>Modelling interest?</td></tr>
</table>

	scans writing and then steps back] *Looks like 2.* [Pause] *Which 2 is it going to be?* *Well here...* [Pauses again, this is in a quieter voice]	Pensive	niggle of doubt, and using thinking out loud as a resolution that also supports learning **[ESensor peak]** He is becoming more aware that there is an inconsistency	Thoughtful problem solver?
	Oh, that's right, I've done that wrong, that should be 1, uhh, [Faster pace resumed]	Visibly happier Satisfied	[Resolution] Ownership of error, modelling Modelling ok to make mistakes 'uhh' sound interpreted as never mind	Modeller of dealing with error positively
	Who picked up on that? [Hands up] *Chris? Gold star* [Smiling]	Pleased	Re-establishing authority Social reward for correction of error Recognition for him from students? (you- plural) Error becomes object unassigned, and then into a positive outcome (you-individual) It felt almost like he was pinning the error somewhere distant from self OR… he was including students in his happiness at finding the error, and hence was rewarded	Positioned as audience All re-positioned as collaborators in error resolution This student is positioned as knowledgeable Student accepts position (by hand up)
S2	*How about me? Oh. Uh!*		Ignored comment	Attempted to position as knowledgeable as well. Rejected on these grounds
T	*Uh!*	Humorous	Mimicry as playful banter Restorative of relationship which the comment above	Positioning student back into group as acknowledged member, but

			indicates was potentially threatened. [Reinforced by body and positive facial expression e.g. smiling]	not knowledgeable other Recognition of contribution only
S2	*Uh! I said one though sir*		Bouncing back mimicry and banter	Accepting position in relationship Attempt to retake knowledge-able position
T	*Sorry, that's a 1.* *The biggest number is 2.*	Confident	Clarification of resolution A further example of objectifying mathematics	Rejected S2 bid by ignoring it Position of clarifier Position of instructor
	How did I get 2?	Neutral	Rhetorical question, but possible attempt to model student thinking and guiding students as to how they could be thinking, articulated self-talk Return to 'I' Modelling of doing of mathematics	Problem solver Collaborator
	*I took the **biggest** number possible here for 5, but the **smallest** number possible for 4.* *That made the **difference-as-big-as-possible**.* [As before, emphasis and shift in pace into one staccato word]	Confident	Repeat - uses hand positioned to show distance between forefinger and thumb, digits touching for smallest, but shaking hand rapidly for both – [See image on repetition] Intensity is both by repetition but also by verbal emphasis on key mathematical learning point for the topic	Explainer Emphasiser Chooser of what is important mathematically Mediator between mathematics and students
	2. [Firmly stated] Upper *bound.*			
Sx	*I got 1 for the lower bound*		Ignored (correct) comment	Rejected attempt by Sx to position as

				knowledgeable (as was the previous student)
T	*To get the **lower** bound, it is going to be the **smallest** possible difference, which is actually zero.*		Repeated hand gestures associated with emphasis on mathematical words A further example of no I, you or we pronoun, which has the effect of distancing from mathematics	Instructor
	What happened there?		Further rhetorical question Refocus of student attention	Questioner – self or students?
	I minimised the difference. *I made this* [Pointing] *as **small** as possible... 4.5.* *This* [Pointing] *as **big** as possible... 4.5.* *And that made the difference between the number as small as possible...0* [Hand gestures as earlier]	Pleased	SHIFT from abstract to doing Third repetition of key points Associating with the action of solving the problem, rather than with mathematics As earlier modelling problem solver following a rhetorical question	Instructor Mediator (local) between task and students – Re-formulator of mathematics for students
Amy	*But that's not using… you can't use the upper bound and the lower bound and put them together*		This relevant question is responded to. Limited? Although phrased as fact then you, the 'you' is ambiguous, it could be you (specifically the teacher) or you (all people solving this kind of problem)	Student positions self as not knowledgeable

T	*You can, because we are talking about the upper bound of the* ***difference****, the lower bound of the* ***difference****.*		This is a repeated hand gesture for difference, this time more emphatic, shaking his hand rapidly.  Repeated emphasis on key mathematical words. This is the only occurrence in this episode of you and we positioned like this	Teacher accepts position, I understand and responds as instructor and clarifier of mathematics
Amy	My mind is fried			
T	*Good, that means you have been thinking a lot Amy.*	Pleased, almost laughing	Praise relating to value of thinking for oneself You as individual But also very skilful blocking of a question potentially developing further, very subtle	Student positioned as appropriately behaving/ management
	[Summation of lesson] *This guys is where it's going to stretch…* [Twisty fingers to show minute distinction]... *A onto A** *The complexity of a kind of exam question, an A* exam question, will involve all of these elements.*	Enthu-siastic Confident	SHIFT in pace, faster and task focussed SHIFT from local problem solving, question specific into a global purpose for the topic. Aligns to exam as purpose, aligns to expectations of students You (plural) NOTE – it is confidence building as not really an A* question! Mathematics de-personified Contextualising Enthusiasm is for student acceptance of stretching Objectification of exam questions	Students positioned as able and willing to engage Teacher positions self as knowledgeable other Intermediary/ mediator (Global) between students and assessment Instructor- exam preparation
S	*Sir...*		Ignored	

T	*But bear in mind that is the end of year 11.*	Confident Relaxed	Many earlier references to time as being important to this teacher. But also locating expectations of students (temporally). Contextualising	Students positioned as thinking ahead Positioning self as supporter on journey Positioning students as able to manage, anticipating success
Man y	[E.g.] *'we've got ages' 'that's ages away'*		'We' is either 'us' as students or 'us' as whole system including teacher	Students accepting proffered position
	...and do... have you been stretched today? [Hands wide in open gesture – almost like you already know this, or this is easy isn't it]	Confident	You (plural) and as You (singular)	Students positioned as collaborators Students positioned as willing Self-positioned as collaborator I am caring
Man y	*Yes*			Multiple acceptances
T	*Yes, definitely, just by doing the grade A stuff.*	Neutral		Collaborator, I agree You are able Positioned as team
	Right, can you...		SHIFT indicated by 'right' and change of verbal pace	Repositioning as teacher instructor
Sz	*Can we do that again?*			Extended acceptance of offered position
T	*... 'travullate' your learning objectives* [END]		[NOTE – 'traffic light' has become 'travullate', norm terminology for this class] There is also a unique hand gesture to support this request,	

			like asking them to write something down, but a wider across movement	

Table 4.3: Selected episode transcript and commentary for Adam, Lesson A1

Confident/assertive → neutral → confident → neutral → confident → neutral → confident → uneasy → confused → some certainty → interested →doubt/uncertainty → pensive → satisfied → pleased → humorous → confident→ neutral → confident → pleased, almost laughing → enthusiastic → confident → relaxed → confident → neutral

Figure 4.9: Adam's emotional pathway: Selected episode from Lesson A1

This complex pathway which continually returns to neutral shows a distinct pattern. This mirrors his teaching pattern. In the selected episode, this appears as a continual reforming and repetition of key points, an important dimension to his teaching

Presenting the selected episode from lesson A2: Constructing a stem and leaf diagram

The selected episode covers a sustained block of higher ESensor readings compared to the rest of the lesson (Fig. 4.5). The selected episode occurs early in the lesson, just after students have, as a lesson starter, revisited prior learning of median, mode and range. The selected episode begins as Adam displays an exam style question of mixed data, to one decimal point, with a question asking students to construct a stem and leaf diagram for this data. He asks a student to explain how to construct a diagram for this data. Adam clicks through a PowerPoint explanation as Amy explains the procedure. Later, after practicing drawing a stem and leaf diagram, the students will use their diagrams to find median, mode and range for the sorted data. They will then look at comparative stem and leaf diagrams.

There is limited variation in observed emotions (Fig. 4.11) in this selected episode, although there are changes in verbal and visual emphasis throughout. Adam nods and smiles approving as Amy explains. Once she ends the explanation, Adam reiterates the key points, supporting the explanation with gestures such as vertical chopping gesture for 'numbers-down-the-side' for stem and leaf division (Fig. 4.10).

Adam also uses pauses after using key terms to add emphasis. As for the previous selected episode, Adam demonstrates fluidity of teacher positions, such as shifts or repetition in different forms. These appear as reiteration of student explanation, expansion of explanation and emphasis of key points. One impression from this selected episode is aligning of mathematical explanation, both for the words used and repeated, but between student and Adam, an accepting of the proffered position on either side as promoting accord. The impact creates a positive climate, one conducive to positive relationships and learning. If we place this in conjunction with placing importance on the learning of mathematics, then we get a positive emotional outcome. I would like to introduce the idea of 'flip-flop'[5] in conjunction with this selected episode. By this I mean stepping in and out of mathematics, such as through pronoun use, e.g. you / it / you / it (Table 4.4), a pattern not appearing in the previous selected episode. This occurs on a local and global level, and seems to mimic Bronfenbrenner's concentric circles in action (Martin, Towers and Pirie, 2006), where classroom relationships are immediate and distal, as in emotional geographies (Hargreaves, 2001). If emotions, act as a mechanism for crossing boundaries, then this pattern might appear on a local as well as global level. In this case, we have stepping in and out of 'it' (usually 'the mathematics' as object) where the teacher acts as mediator in any such shifting or transition.

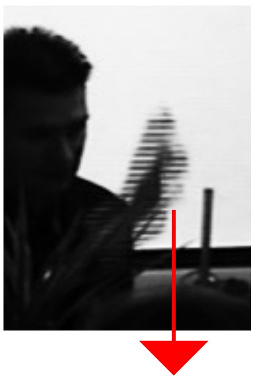
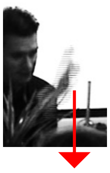


Figure 4.10: A repeated gesture used by Adam to indicate 'stem' for a stem and leaf diagram.

[5] A sudden or unexpected reversal, as of direction, a backward somersault. Also called flip-flop circuit in electronics, an electronic circuit having two stable conditions, each one corresponding to one of two alternative input signals or any of several similar devices having two alternative states, the change of state being caused by some input signal or by some change of input.

	Transcript	Assigned emotion	Interpretation (Observer notes)	Interpretation (Positioning)	Post-obs. teacher comment
T	*Amy, the expert is going to tell us about stem and leaf diagrams*	Interested Listening	Unusually for this teacher, he is seated. There is no negative to this comment Use of 'us' (plural, inclusive)	Student positioning positive, '*Amy, the expert*' I expect you to succeed Facilitator	*"I judged that she'd know a perfect how-to-do-it."*
Amy	*Well... You put... you look at the front, at the first numbers and you put them alongside, so you have 4... 5... yeah, like that. And then you put... you put the second numbers, and you put them in like in the right category, so 47 would go 4 and then you put the 7 on the other side, and then you find the 6 and you put 1 on the other side, and then it's a 5 then you put a 3...and then beside the four you put a 3, 6... 6... 8...*		Teacher follows Amy's step by step explanation using a public domain PP [Procedural explanation using 'you' global but also 'you' teacher] Nods at intervals, indicating approval	Teacher positioning as respectful of contribution I am aligning your answers with the 'expected' response (Assessment requirements) - mediation I am listening Amy positioned as instructor Amy accepts position of instructor (use of you) And collaborator in explanation e.g. 'yeah, like that'	*"Perfectly I think"* *"…who gave the perfect answer…?"*
	Until you… [Speaking more quietly] *I can't be bothered to...*		SHIFT student instigated (shown by slowing speech and pronoun shift you to I)	Student shift in position I do not want to instruct…	
T	[Interrupting] *well... have you done this before?*	Question-ing	[ESensor Peak] SHIFT teacher accepted.	Accepts shifted position	*"I was just thinking there, we'll probably just go to the marks."*

			You (global) restores relationship norm	Re-adopts instructor position Positions class as whole group	
All	*Yeah*		Confirmation that they might not need to do his planned lesson?	Accepting position	
T	*Yeah* [Several yeah responses]		Objectification of stem and leaf diagram as concept (they exist)	I am assessing your knowledge I am asking you to assess your own knowledge	*"I'm thinking of lots of things at once."* *"Where there's that potential change to a lesson, from what I'd planned to do."*
	So yeah, right, a quick recap on how they work.	Interested Neutral	[As he clears boards and takes a moment to stand still as pointing, is he reforming his plans?] This shift may account for the sensor peak as he is thinking on his feet as to what might happen next. This might be more stressful as he is being observed	I know, you know… but just in case. Mediator between you (plural and local) and them (mathematical object)	
	Um... you might have just a set of data like that. You may have something drawn for you already. The exam question might say draw a... ***un****ordered stem and leaf diagram and you have to do an* ***ordered*** *one.*		You could be local plural, singular or global (anyone doing the assessment exam) and may be inclusive of self? Shifting between local you and global as	Mediator (between exam and students – the exam is objectified?) Expert on exam requirements This mathematical language is important (verbal	*"…so for them to improve, it's often knowing exactly where they get the exam marks from."*

			locating students? Example of future predictive	emphasis shown in bold)	
	We'll come onto what that means.		SHIFT from 'you' as generic any other to 'we' (local, inclusive) Example of future predictive	I have planned ahead [He had not earlier and had to change the plan] I own this story Students positioned as passive audience	
	Um... you have to have a key.		'You' (Local and global, inclusive) Modelling reflection (um…)	Emphasis suggesting importance	
	Whereas Amy started off by saying 'you can have numbers down the side' [Vertical downwards chopping gesture – see image] *Those numbers down the side were representing tens weren't they?* [Rhetorical Q] *3 4 5 6 7 really represents 30, 40, 50, 60, 70.* [Stands up and points at board]		Distancing from task through assignment of expertise to Amy and physical repositioning away from board. He was using instructional 'you' now moves away from this. Objectifying 'those-numbers-down-the-side'	Tone suggests Amy did a good job Amy was right (accepting) What she said was important (Aligning) Repositioning Amy temporarily as expert By implication, positioning self temporarily as student	*Instructor*

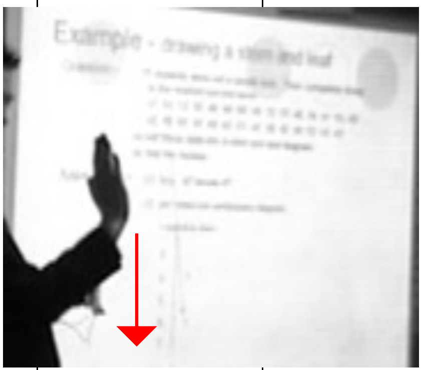
	So that's an important point to start. Those numbers there can be ***anything*** *so long as they are the* ***same*** *place value* [Repeats vertical downward gesture]. *So this could actually be 3 units, so we could do 3.1, 3.2, 3.3... Or 4.7 4.8.... Or they could represent hundreds. So this could represent 3 hundred and something, 4 hundred and something, 5 hundred and something... which is why you have to put down a* ***key*** [Circling where this point is written on the board].		back to student engagement flip/flop pattern 		*"I was just thinking… I've probably got to pick up the pace and go through this a lot quicker…probably adapt how I am going to teach this"*
	Exam tip, write this down [Uses scribbling gesture].			Instructor Exam referee-mediator	
	Writing down the key gives you a mark in the exam, ok [Pointing].			Narrator Exam referee-mediator	
	It is very important to write it down [Jabbing with pointed finger for emphasis].	Intense emphasis (tone of voice and gesture)		Position as instructor	

Table 4.4: Selected episode transcript and commentary for Adam. Lesson A2

Interested → Questioning (puzzled) → interested/ neutral → intense emphasis

Figure 4.11: Adam's emotional pathway: Selected episode in Lesson A2

Presenting the first selected episode in Lesson A3: Rules of nominating (A3/1)

There are two selected episodes (Table 4.5 and 4.6) from lesson A3, which was the last period of the school day. There was a lot of laughter from both teacher and students during these parts of the lesson as well as peaks (or noticeable troughs in A3/2) as indicated by the ESensor (Fig.4.5). The first episode (A3/1) is selected from the beginning of the lesson, just after starter, and shows how a new student is included in a questioning activity that elicits answers using a classroom norm. The emotional pathway (Fig. 4.12) shows resolution of doubt into positive expression.

	Transcript	Assigned emotion	Interpretation (Observer notes)	Interpretation (Positioning)
T	*Hands up if you want to revise division.* [Waits]	Relaxed neutral		I am responsive to your needs. Positioning students as able to choose
	Alright, we'll have to do that another... well we're going to revise some fractions next lesson and then maybe we could switch to some division another lesson.		Setting lesson in the wider curriculum context 'we' (local, inclusive, predictive)	We are working together We have choices
	Alright, so...[Pause] *Where are we up to?*	Slight confusion	Almost as if planning whilst speaking Question is rhetorical, but also inclusive, as opposed to 'where am I up to?' [Illustrative of ownership positioning]	We are working together I expect you to know what is happening Students positioned as willing participants Facilitator
S1	*We were nominating...*		At least one student does not see the question as rhetorical	Accepting position
S2	*Learning objectives...*		And another…	Also accepting position
Jack	*Jude*		Response to S1	
T	*Jude, nominate* [Looks at Jude]	Patient, but rapid	Example of norms, that Jude knows	Expectation of obeying rule

			what this request means	Organiser
Jude	*I don't know* [Pause all waiting for response 4 sec]		He doesn't! [We can only guess why not – it may be the first time this student has been asked to nominate? – He may be unwilling to follow rules? – He may not wish to be socially included? – He may not know the names of other students as he is new to the class?	1st rejection of position
Sx	*You've got to nominate*		Students respond before teacher With instruction on norms/rules of classroom	Accepting of position for norms
S4	*You have to nominate*			Accepting position
T	*Yeah, it's the rules of the classroom. You've got to pick on someone.* [Waits - giving the student time to shift position]	Relaxed	Deliberate slower and gentler response. Reiteration of student contributions. Rules objectified, they are not his rules Recognition of emerging issue?	Accepting position suggested by students (after all he has set them up to respond in this way) Collaborator
S4	*You can't be in here if you don't know to nominate.* [Now speaking to teacher and/or rest of class] [SHIFT] *He doesn't know our names and rules yet* [Supportive comment and tone]		Management by students. The teacher and students seek explanations [This appears in other episodes too], Really they can't choose whether to be in the class or not, but the	Reiteration of accepted position (now globally accepted)

			students talk as if they can choose. Nominate is objectified Rules owned by class not individuals	
T	*Oh, maybe, yeah*	Content		Accepting shifted position offered by S4 Agreement/aligning
Jack	*Just point at someone then*			Accepting new position
T	*Do you know anyone's name?*	Puzzled	[ESensor peak] Ensures Jude knows to take the offered escape route	Repositioning of student to offer new response
Sx	Do you know ours then?		'ours' group identity	Accepted by other students in the class
Jude				Tentative acceptance of proffered position
Amy	*He does know my name*		'he' as outsider, 'my' as insider	
Jude				2nd rejection of proffered position
T		Neutral		Tentative accepting of Jude's rejecting of position Aligning with Jude
Sx	*It's our rules!*		Although the teacher will let this non-compliance go, the class do not.	BUT Students enforce position and reject Jude's position
Jack	*Just point at someone then!*		Second suggested escape option from student	Positioning Jude as expected to comply in some way
Jude	*Why?*			3rd rejection of proffered position
T	*Because that's the rules of the classroom*	Relaxed	Repeat of earlier comments	Accepting that Jack's suggestion, that Jude should comply. Negotiating on student rejection of

				position of compliance
Amy	*It's our rules! You can't be in here Jude if you're not going to nominate* [Background frustration noises from students]		Teacher uses objectification of rules compared to student ownership 'ours'.	Social enforcement of class rules, quite insistent now.
T	*The whole class goes with it, right.*	Smiling	Resolution point Objectification of rules	Accepting position that students are requiring Jude to comply Positioning as teacher
	There's other things you need to know as well, like my favourite singer is Beyoncé	Laughing Playful	SHIFT in focus away from Jude in relation to the other students, back to himself. He uses another norm to make this shift positively Jude gets time to accept position as decided by whole class	Repositioning as non-teacher Look at me not Jude
Chorus	*Beyoncé, Beyoncé, Shakira, Shakira* [Chanted]		This is clearly a well-established norm for this class	Student body accepts position shift willingly
T	*Ok, so you need to know these things.* [Laughter]	Humorous Laughing	All class laughing	
	Jack, pick up....		In the end, Jude is not forced to comply as Jack is passed the baton. Perhaps next time Jude will comply?	Instructor
	…this is Jack... Jude... Jack... [More laughter]		Completion of humorous exchange by formal introduction of one student to another BUT tells Jude that he needs to know student names	Non-teacher Social organiser Jude positioned as it is fine not to know
Jack	*[Waving regally] Pleased to meet you...*			Modelling accepting of position

T	***Jack*** [Emphasis], *read the learning objectives please.*	Neutral	SHIFT to restoration Why emphasis? Drawing attention back to task? Focussing Jack's attention away from Jude? Ending banter? Making the point of compliance again to Jude? Ensuring attention of class moves away from Jude? All the above?	Back to teacher role as Instructor Manager
Jack	*Alright.* [Laughs]			Accepting position
Sx	[Aside] *Why would you not want to nominate?*		Pushing the point to Jude, supportive not critical tone, sounding a bit puzzled. Sx is still enforcing compliance on Jude even after the teacher has moved on.	Jude positioned as I expect you to comply
Jack	[Reading from the board] *To be able to find the next number in a sequence and describe the rule for a sequence.* [End]			

Table 4.5: Selected episode transcript and commentary for Adam. A3/1 from Lesson A3

Neutral → slightly confused → patient → relaxed → content → puzzled → neutral → relaxed → smiling/laughing → neutral

Figure 4.12: Adam's emotional pathway: Episode A3/1

Presenting selected episode A3/2: Shepherd counting n sheep

This selected episode (Table 4.6) follows immediately after it became apparent that the meaning of *n* in a sequence was not conceptually clear to all students. The teacher has just been asking about the meaning of *n* in *2n-4*, and asking questions about the history of numbers. On the board is APATGCLCVLSS, 4n-2, 1,2,3,4,5 and the naturals numbers (Fig. 4.13). In the selected episode, Adam designates one student to be a shepherd in ancient times and sets him to count his sheep, represented by the other (now bleating) students. The impression from the selected episode is willingness on the part of Adam to play and enjoy, yet used as a classroom tool, so there seems purpose in the playfulness.

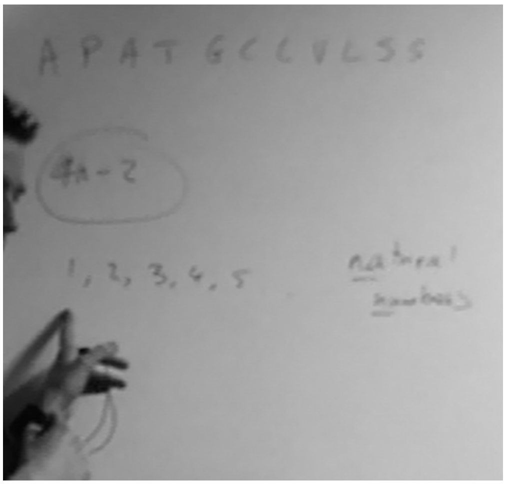


Figure 4.13: Board displaying sequences from Lesson A3

The selected episode illustrates the use of fun and entertaining stories and scenarios as aids to learning mathematics. This part of lesson is fast paced, with calling out from students that is not always audible or assignable to one student. In this selected episode, students are physically involved in role-play that repeats the main point. There are many and rapid changes or shifts for different purposes (Fig. 4.13), in comparison with other selected episodes from this teacher. The distribution for this episode is comparatively wider. This selected episode also differs from others, as the selected episode appears on the sensor as a noticeable dip rather than a peak (Fig. 4.5). The implication, as yet unsubstantiated, is that humour or laughter may act to counter stress for both teacher and students.

The whole lesson explored generating sequences from a rule, and introducing the creation of a rule for given sequences. I would suggest neither selected episode was planned, the first occurring because a new student was unfamiliar with the norms of the class, and the second as a spontaneous idea to reinforce a conceptual point, by using positive emotions, and initiated by the teacher. Adam seems to feel it is appropriate to spend time on reinforcing both norms and conceptual points judging by these two selected episodes.

	Transcript	**Assigned emotion**	**Interpretation (observer notes)**	**Interpretation (Positioning)**
T	*Right so…*		This is this teacher’s form of saying pay attention	I am about to instruct

	Mark, (yeah) pretend you are sitting in the corner of a field...	Anticipating	Delight in the unexpected (see deviation in discussion) This is setting up an extended deviation 'you' individual	Performance director Story creator
Jack	*Come on Mark...let's get you in the corner...*		Us/you	Complicit in positioning of Mark Aligning with teacher
T	*...being the shepherd, right. You can sit on the floor as well, yeah* [Some giggles]		[Student goes and stands in the corner of the classroom at the back]	manager
Sx	*Can I do something?*			Rejection of attempt to position by ignoring
T	*You've got to imagine Mark's got like a funny hat thing, and you're the sheep. Alright.*	Excited [Pleasure from playing]	THE STORY 'you' – local plural Mark is now positioned as shepherd not student, and class as sheep	Story creator Elicitor of visualisation Role play instructor
	(Baa) *Mark just... can you check all your sheep?* (Baa) *Can you do...?* [Pointing to each one gesture] *count the sheep. Alright.* [Writes counting numbers on the board, some laughter and inaudible banter at this point along lines of very difficult to do]		There is a high degree of risk involved in creating a spontaneous scenario like this. The students may go too far, it requires a positive relationship as can go sour, and a degree of confidence that students will not think it is silly or childish to become sheep in their mathematics class. He also has to carefully judge how far to go before returning to the task, so requires careful management too. Adam could have made himself shepherd, with a different relational impact	Students accept position as sheep by bleating Mark positioned as owner of class as sheep
	Did you, by any chance, Mark, do this? [Points		Developer of story 'You' - individual	Writing the play in action

	to numbers on board] [Another student shouts out no]			
Mark	*1 2 3 4 5...*			Accepting position
T	*Perfect, that's what a shepherd would have done* [Higher pitch of voice]. *Are they still here?*	Encouraging	[Sensor peak] The higher pitch is accompanied by wide hand gesture and leaning back Shifting Mark back from shepherd to student and back again	Collaborator with Mark
Jack	*Unless he was a Spanish shepherd?*		Attempt to deviate attention	Rejected contribution
Mark	*Yep*			Accepting collaboration position
Amy	*No, I left...*		Attempt to deviate attention	Accepting positioning from teacher but also attempt to shift attention as Jack, this is rejected by being ignored
T	*How do you know?*	Questioning Puzzled	Silly question! But Mark responds seriously	Seeker of evidence
Mark	*I just counted*			Accepting shepherd position
T	*Right, you counted them all again. Good job.*	Happy		Compliance rewarded
Jack	*How about Spanish?*		2^{nd} attempt	
T	[To Jack] *Sh Sh.* [Finger to mouth]	Slightly irritated		This too is rejected by being shushed Classroom manager
Mark	*...cos I could still hear Jack but...*		Also acknowledging Jack's contribution	
T	*Ok.*		The Ok closes the deviation. I would suggest the class would have no idea where this was going. They were	Scenario manager

	Are they still here?	Anticipating? Encouraging	interested and enjoying the scenario	
Mark	*Yep*			
T	[Pointing at Jack] *Easy!*		Blocking Jack's potential distraction by gesture and tone	Classroom manager
	Right. And that's what a shepherd would do all day long. Like... *'Time to count the sheep... Are they still here?* [Pointing one by one again] *Yeah. They're all still here. Good job'* [Speaking as if shepherd].	Happy Laughing Excited Pleased	He uses storytelling as a means of encouraging recall. Will they remember being sheep next time they look at sequences and start bleating along with 'n'? Another norm created?	Student positioning as shepherd removed Positioning self as shepherd instead (use of current tense)
	Thank-you. Mark, thank-you. That's fine, so... Mark started counting, 1, 2, 3, 4, 5... [A student continues as if fish song] Those are the ***natural counting numbers****, right?* [Writing this on the board] *Natural, natural, natural numbers...*	Calmer Serious	First SHIFT in pace to more serious purpose Returning and associating with the mathematics of the lesson Counting numbers exist as fact Repetition again	
Jack	*NCN sounds better*		Attempt to deviate ignored again	Rejected positioning attempt
T	*nuh... nuh... nuh... we use nuh, 'en' for number*	Playful	Playing with repetition 'we' – global, all mathematicians	Positioning students as if younger children? Intermediary between mathematics and students
Jack	*NCN*		2nd attempt. This boy does not give up!	Rejected positioning attempt

T	*So when we are dealing with sequences...*	Calm refocus	Second SHIFT next level of seriousness, back to task purpose fully 'we' ambiguous as global or local	I am the teacher This mathematics is important
Amy	*[Aside] He doesn't like NCN*		This is a sub-story between Amy and Jack, who from looking at all the videos are key movers in this class	Acknowledging Jack's attempt to position Also rejecting Aligning with teacher
T	*...4n-2. The **n** is just number. What are the numbers?*	Interested	Completion of story loop. This teacher often ends episodes with a generic open question, this one completes defining n	Instructor
Jack	[Sings] *1, 2,345….* [To tune of '12345, once I caught a fish alive']			3rd contribution from Jack, this time as direct response to teacher but also accepting position as young child
T	*...and so on.* [End]	Neutral	Comment ends the singing and retains management of group	Accepting Jack's contribution

Table 4.6: Selected episode transcript and Commentary for Adam. A3/2 from Lesson A3

Anticipating → excited/pleased → encouraging → questioning → happy → slightly irritated → encouraging → pleased/excited → serious → playful → calm →interested → neutral

Figure 4.14: Adam's emotional pathway: Episode A3/2 from Lesson A3

The pathway for this second episode has more interpreted expression of stronger emotion than earlier in the same lesson (Fig. 4.14). As well as using expressive vocal tone and emphasis to stress mathematical points, Adam's speaking pattern was different in this selected episode, compared to other parts of the lesson: the pace in these parts of the recording became slower and more repetitive. His voice had contrasting volume, and became louder for significant junctures in mathematical explanation. I would suggest that students, exposed to this pattern regularly, would soon ‘tune in’ to what Adam intended to highlight as important.

3 Adam: Positioning within the four selected episodes

Examining the selected episodes in detail using positioning, and considering what Adam is doing in each selected episode to position students, highlights how Adam uses emotions to engage with students, both consciously as engagement strategies, but also unconsciously. In all four lessons, I observed frequent laughter and banter. The selected episodes are illustrative of this appearance of positive emotions. Yet there are few specific emotive words used in the selected episodes, or in interview. Adam uses language, tone, emphasis and tempo to convey the positive. The tempo is important, when faster, it gives an impression of engagement and interest. He achieves an impression of strong emotional engagement with students by placing emphasis on key mathematical terms, and judging by my own experience of teaching this topic, artful and careful blocking of emergence of misconceptions. He positions through shifts, as in performing a play, where the lesson is composed of different acts, each with specific tempo and agenda. In these selected episodes, this pattern is for communicating the mathematics, but he also positions himself as interested in the students both as a group and as individuals. If performing a play, he would carry the audience, with emotional dips and peaks used to draw attention and to develop a mathematical storyline. He engages in ‘in-the-moment’ behaviour, acknowledging by eye contact, use of ‘we’, and facial expression some student contributions, thus maintaining his approachable style. He also breaks the storyline, not trivially but with substantial deviations, a characteristic with an affective impact discussed further in Chapter 5**.**

Adam is an experienced teacher, and his discourse draws heavily on changes in volume, emphasis, shifts in pace of speaking and using noises to such a degree that perhaps they have become norms for this class, and thus act to position the students. He uses mimicry and synchronisation, such as the repeated ‘uh’ noises in the middle of one selected. He uses repetition of terminology as a teaching strategy, yet this is also a mannerism. I would also suggest he teaches with his whole person, using gesture and body language in particular. As an observer, I was impressed by this synchronicity. He adopted a mediating role and articulated his internal thinking for the benefit of students, such as using rhetorical questions to model engaging in mathematics. I have interpreted Adam's articulation of internal thinking, especially the use of rhetorical questions, as placing himself into the role of student (an empathic manifestation) when solving a mathematical problem, but from a modelling position, along with pronoun use which is key in his positioning of students. The analysis reveals use of 'you' in conjunction with ownership of mathematics, which seems to act to position students between being experts and being doers of mathematics. Adam's language is action orientated, factual and concrete, even when he is not asking students to act. So not explore, imagine, feel terminology. His discourse has a strong future orientation as well as present i.e. *'you will…'*, language use which may have emotional implications. This future orientated teaching style is explored further in 5.2.

4 Adam: Analysis of interviews and the four selected episodes using ES

Ascending by degree of supportive evidence, the dominant ES for Adam are LMTY, supported by IRIT, CTO and LHSIA, with indications of GJD. In what follows I describe how the two stages of attributing dominance to these ES for Adam.

Adam: Building ES from Goldin et al.'s (2011) strands

The intermediate step between the data and ES are described by Goldin et al. (2011) as *strands* (Fig.3.3, p.90), which together form ES as described in 2.5.1 and 3.4.3. *Strands* are indicated in bold type in what follows. I draw from the data to illustrate how the strands direct the dominance of the ES. The process considers the data for each strand before drawing the characteristics together into ES.

In the videos Adam appeared able to focus single-mindedly on a task, a **behaviour** exhibiting a **desire** to experience flow, defined as complete absorption in what one does and tuning out of the rest of the world (Csikszentmihalyi, 1990). In Adam's examples, these are also expected **behaviours** for a mathematics teacher: an **affective pathway** to satisfy **need** by achievement of perceived obligations and through task completion regardless of whether, or what type of, learning is achieved.

One of the conventional 'expected' **behaviour** and social interaction rules for mathematical success is quickness (Black, Mendick and Solomon, 2009). This is illustrated by how Adam fulfils an identified **desire** for timely completion. The lesson observation data suggests he inhibits comments or questions from students in order to complete tasks quickly and promptly. From interview, we know Adam places emphasis on pace and recounts examples of competitiveness both in mathematics and in administration tasks. His losing some of his faith in mathematics, exactly when he was challenged at university and could not perform highly enough to meet the demands of this competitiveness, also reveals a perception of a **need** for affirmation that was unfulfilled, and subsequent seeking of a new, more satisfying **pathway**. He seems to feel the **need** for completion of activities, even if it means de-prioritising other aspects of learning, thus perhaps valuing utility. He also appears to find personal satisfaction in his own successes, both intrinsic and extrinsic. The satisfaction of mastery of teaching skills is perhaps illustrated through his use of idiosyncratic, observed yet subtle gesture and interjections, used to modify **behaviour**. His **external expressions of affect** include laughter and smiles, raised eyebrows used to encourage and question, and rapid and emphatic use of body movement. These gestures were quick and clearly **strategic** 'norms' for the group. For example, he used a rapid and directed 'Shh' for seeking the attention of the class, and he used the word 'travellate[6]', which had **meaning** for this class (they were expected to assess their learning) and students responded as expected. This well-established **belief** is evidenced when Adam talks about his own achievements. In particular, he frequently used a contented 'hmm' in interview when he was proud of a remembered experience.

Goldin et al. (2011) identifies for students 'Get the Job Done' through characteristics such as deference to establishment and following of rules. Although I have examples of engagement within the 'Get the Job Done' structure, within the data there is evidence that this is not entirely satisfying for Adam. A second ES I have evidence for is 'Look How Smart I Am'. A teacher adopting such a structure, as in the case of a student, would try to impress with ability or knowledge, both highly valued, and would give value to increased self-regard. They would respond to an

[6] Subsequently, this was identified as "*traffic light your objectives*"

admiring audience and may have a performance goal orientation that includes competitiveness. Yet Adam also exhibits elements of another ES, ‘Check This Out’, where value is given to utility yet also to mathematics solely as an enjoyable experience motivated by intrinsic or extrinsic reward, and includes both conscientiousness and consideration for what benefits there are in the activity. To a lesser degree there is some evidence of a further ES, ‘I’m Really Into This’ in Adam’s data. Goldin suggests that the underlying need within this ES is for understanding, a mastery and goal orientation. Adam finds satisfaction in the experience of teaching and in finding solutions to challenges within his role. Both are strongly associated with this ES. Yet the strongest match is with ‘Let Me Teach You’, with evidence within the data of a desire to help others understand and of adopting a position of nurturance. Adam shows satisfaction in fulfilling this desire, and that the belief that he will find gratification in a positive response or appreciation is well established.

As for Carol, examining these episodes as positioning informs and strengthens the allocation of dominant ES. In this case, the teacher positioning as collaborator in a common endeavour and as a modeller of engaging with the mathematics. There is a strong sense of empowering of students revealed by the positioning. The positioning fluidity and the variation of ES for Adam may be part of this empowering as is his acceptance of student contributions. However, the impact may be predominantly in the student responses. There seems to be more evidence of accepting of positions by the students in these episodes, and more attempts to negotiate. When rejection occurs, as in the case of Jude, it is of behaviours that are counter to the norms of the classroom. I suggest that, subject to future study, examining the ES of these students would reveal a dominance of student ES that are supportive of learning. The positioning is indicative of helping establish dominant ES, a point explored further in Chapter 5.

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Bertha (4.1B)

1 Bertha: Emotions and affect in interview and post observation discussion

I interviewed Bertha in November 2014. Bertha tells of loving school, of enjoying mathematics because she was confident and thought she was good at it, especially algebra. She *"hated"* high school, apart from mathematics and one mathematics teacher. She tells of not being a well-behaved student, *"I was a bit obnoxious".* Following school and work in care and in a factory, Bertha had children and was at home for 15 years. She then enrolled on an access course that enabled her to attend university where she studied a B.Ed. in mathematics (a joint teaching and subject degree, for ages 8 to 14 years). She tells of enjoying university, of mathematical confidence and of choosing teaching over social work or nursing for family reasons.

She may seek to be seen as a caring teacher, and admits *'I am very emotional'*, and one who *'wear*[s] *emotions very much on my sleeve,'* adding that she often cries when she hears distressing student stories. She is aware that her emotions are expressed by her face, but tells me, *'I can get cross without actually getting any emotion attached to it at all.'*

Bertha says she responds well to challenge, and to hard work. She mentions finding rudeness, especially if there is no perceivable underlying cause or justification, difficult to cope with. These statements are related as comparative to her last school, with the former being more challenging, yet with more acute social difficulties. She may want to be seen as relaxed and loving being a teacher, and having a good relationship with students and others. However, at the same time, she tells of problems with authority, referring to authority as *'they'* and that she is *'not allowed'* to teach A level. She does not see mathematics as central to the lives of students. She repeatedly says she gains reward from student understanding, and has a preference for working with lower ability students. She suggests she is comfortable in school, and has *'no ego to speak of'* (but this is contradicted later on when she talks about *'making a fuss'* and being *'loud'* in relation to her school role).

Bertha refers to her students as *'a bit of a 'naughty'* or *'bless him'* which made me feel uncomfortable. She says she listens to students, is relaxed when engaging in conversation, but I cannot support this assertion from the video data. It felt like she was distanced from the students. However, she tells me that she wants them to be friends with her and values when she thinks this happens, but at the same time refers to her students as *'little boys and girls'* and that *'they love to be talked to'.*

Bertha described the class as difficult, using language like *'needy'*, or *'skanky*[7]*'*. Her language assigns the class a uniform body, e.g. *'they're a very silly class'* as opposed to seeing them as individuals. She suggests that teachers should encourage students to speak in class, but in observation, this appeared only as response to teacher. She is open about frustration with students, including when discussing the observed lesson. The strongest frustration expressed in interview was associated with when she was unable to quickly solve a problem, or when she had run out of strategies to explain. She recognises that she is not good at managing noise levels, that noticing lack of planning and the associated unexpected makes her panic, even though she laughs it off as 'a disaster'. Her strongest emotions seem to be associated with this, that inadequate planning *'really bother*[s] *me'*, or makes [me] *'angry with myself'*.

During the post observation discussion, she talks about the role of a teacher as resolving muddle, and about practical responses to what she sees on the video. For example, that moving the reward chart located behind her desk would be positive. She allocates her own concerns to others, such as when she talks of another teacher having problems with the same class, she does this sotto voce[8], presented as depreciating and assigning guilt or shame through dropping to a whisper. Her perception of role is to control rather than manage students which implies she thinks teaching is about imparting knowledge. She implies in interview that student home life is primarily to blame for any lack in the classroom, that students are 'needy' as a result. Therefore, poor behaviour is not her fault. She believes that appearing

[7] *Skanky* is a slang term for being extremely unpleasant, especially because of being dirty, or of low quality or not stylish

[8] *Sotto voce* (literally *"under voice")* means intentionally lowering the volume of one's voice for emphasis. The speaker gives the impression of uttering involuntarily a truth which may surprise, shock, or offend.

confident is necessary, but at the same time suggests she is happy for students to see her errors, so long as they appear intentional.

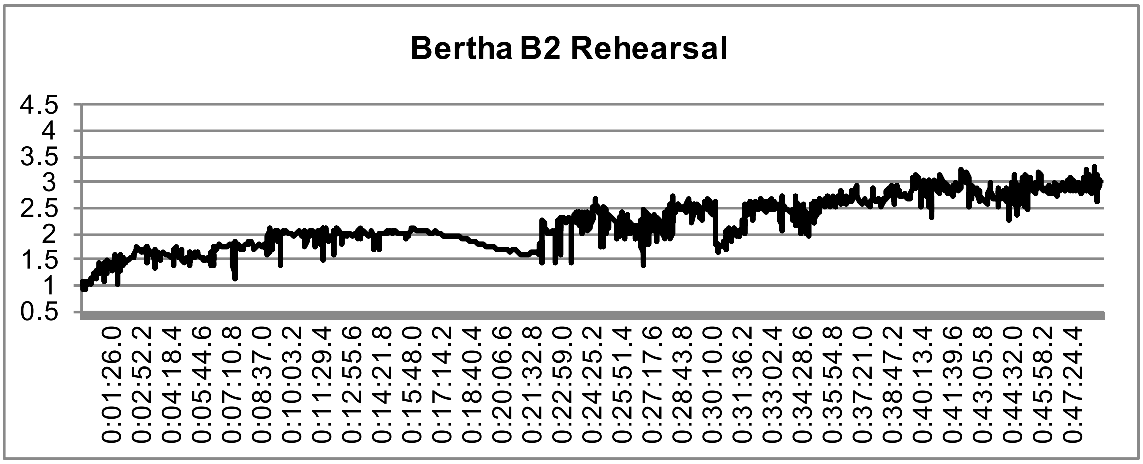
2 Bertha's lesson and the two selected episodes

I observed four classes in consecutive pairs, with a month between, early in January. All were audio recorded and two videoed. The lessons (B1 and B2) are both from the same year 8 class. There are two post-observational discussions.

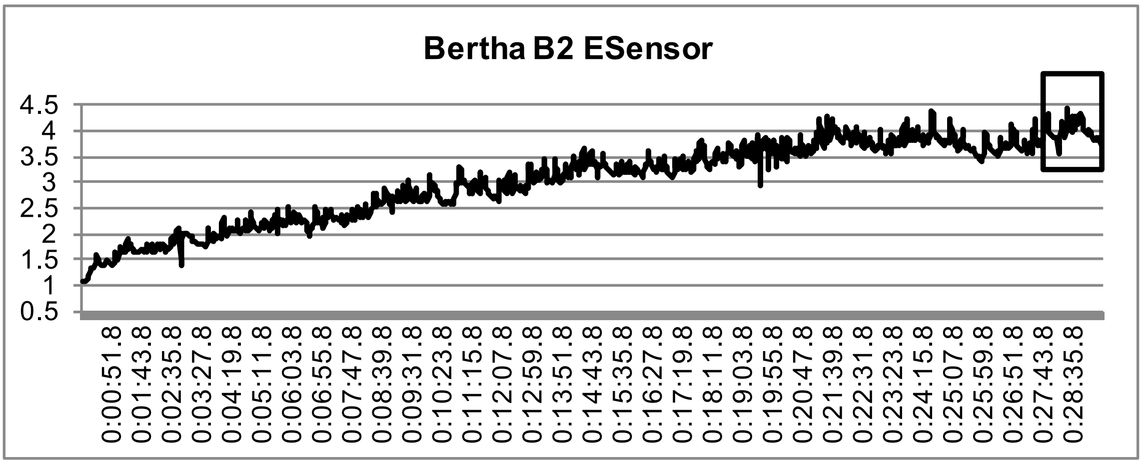
Bertha's room has a common layout of teacher desk at the front, to one side of an interactive board. The tables were in long rows across the room. There were 25 Year 8 (Aged 12-13) students and one teacher (Bertha). The observed lessons were with the same class in a double period interrupted by morning break. The first pair of lessons were questions on finding the area of a circle, the second pair on collecting and recording statistical data.

Selecting the episodes

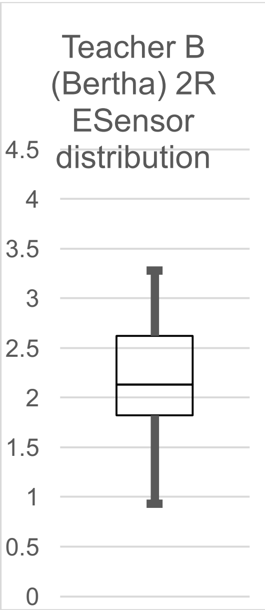
The ESensor failed to work for the first videoed observation, and recorded only the first part of the second visit. Therefore, the selected episodes from lesson B1 is observer based, seeking stronger expressions of positive emotion. The first selected episode shows Bertha expressing pleasure at successful resolution of a discrepancy. The selected episode from lesson B2 was the maximum ESensor value recorded in the first part of the lesson before Bertha disconnected the wire.



Rehearsal (R)



Figures 4.15R and 4.15: ESensor recordings as graphs for Bertha (B2 lessons only)



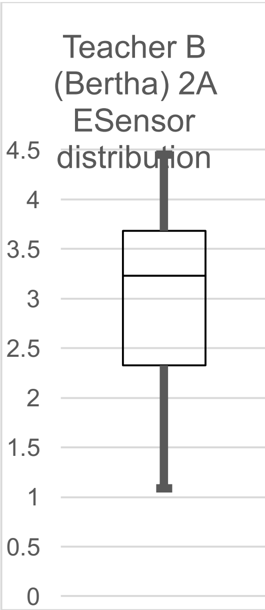


Figure 4.16R and 4.16: Distribution pattern for Bertha, Rehearsal (R) and B2

The rehearsal and videoed lesson graphs (Figs. 4.15R and 4.15) show a similar starting point, but the gradient is steeper in the second lesson. They were both in the morning, with a break between. The videoed lesson had more variation in the ESensor readings, and consistently higher values (Figs. 4.16R and 4.16)

Presenting the selected episode from Lesson B1: Calculating the area of a circle

The students were calculating the area of a circle, as a plenary activity ending the observed 60-minute lesson. They were using www.mymaths.co.uk. The image displayed (Fig. 4.17) is from this site. MyMaths is a widely used online mathematics site which presents screens of mathematics questions for use in schools and by students as homework or preparation for UK examinations. The teacher sat at her desk, guided the screen images and took answers from students. The selected episode started by showing the teacher entering a response suggested by students, one she has calculated herself, and finding that the input is incorrect.

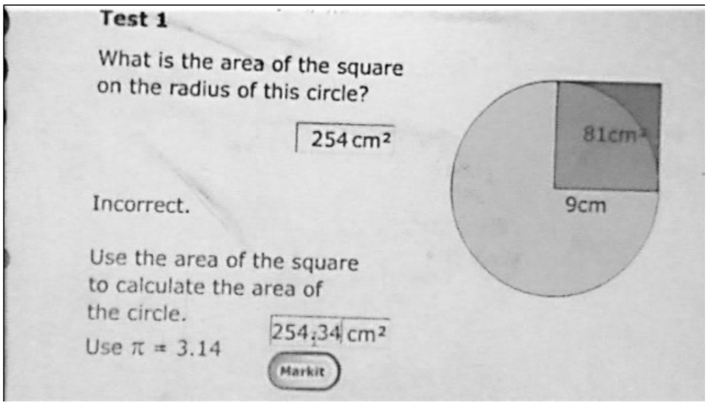


Figure 4.17: Screen-shot from lesson B1

The selected episode (Table 4.7) shows Bertha realising the need for decimal place accuracy. The observed expression of pleasure (See Fig. 4.18) that leads to satisfaction, comes from an opportunity to give praise, results from getting a correct answer from a student (Terry) who expresses uncertainty. The teacher encourages the student to speak in this episode.

	Transcript	**Assigned emotion**	**Interpretation (Observer notes)**	**Interpretation (Positioning)**
S1	*254.46* [Student is providing answer to question on the board]	Neutral	Teacher is entering the response onto the screen as shown in (Fig. 4.17). This is an incorrect response according to the screen	Receiver of information. Bridge between student and mathematics objectified as problem to be solved. Custodian
T	*.46*	Neutral	Verbal clarification of answer given by student	
S2	*I've got .34* [Different answer which legitimising other students who also have			

	different answer and they start calling out as well]		[Problem emerges] [Observer suggested peak as no sensor reading]]	
T	*Ok. Whoa, whoa, whoa, whoa, whoa.*	Confused Uneasy	Regaining voice as teacher. Possibly gaining time to think?	Controller/ Custodian
	Does anybody disagree with the 254 bit?	Neutral	Eliciting collaboration of difference	Arbiter between different answers
Many	*No, yes*, [Some hands up]			
T	*NO? Right*	Neutral	Confirming students only disagree about decimal places	Clarifier of problem
S3	*No*			
T	*Can anybody think of a reason...?*	Neutral	Whole class question	Questioner
	...oh I don't think if we can... yeah, we have.	Uncertain	Self-checking, although articulated [Asked about in debrief so explained post observation by teacher]	Externally apparent internal confusion
	Can anybody think of a reason why you might have different, very slightly different answers?	Confident	Fully formed question	Stronger questioner position
	[Terry among others raises his hand] *Terry...*	Responsive	Locating individual student who had his hand up	Controller
Terry	*Is it because like one of us...um...were like... we weren't... um.... I don't know if it's right or....*	Frowning in concentration as listening		The student positioning as uncertain (child) which elicits teacher as carer position (parent).
T	*Well just, Terry, just say it, have more confidence in yourself sweetheart...*	Sentimental Caring Encouraging Hopeful	I didn't like this, although I felt as observer that well intentioned. I am still not sure what made me uncomfortable. [Observed determined point of positive emotion expression]	Protector/ nurturer If a teacher takes this role then potential reward is appreciation.

Terry	*...some people pressed the... the pi button and some people didn't.*			Compliant response
T	*Absolutely brilliant, well done you.*	Presented to students as pleased, nurturing proud	Central selected positive emotion, an instance of praise for a student. What did this example of articulating a positive emotion do?	Teacher expresses pleasure at student compliance. The student gave the answer that the teacher wanted
	That's exactly right.	Satisfied	Reason for praise is associated with accuracy	Mathematics is getting the same answer as the teacher
	When you press the pi button on your calculator, it uses a really accurate version of Pi. If you just put in um... 3.14, [Writing something on wall behind teacher desk] *then that's not so accurate...*	Neutral	In teacher instructional mode. Factual information	Proclaimer An instructional 'you' position
	...and that's the only reason.	Satisfied	Certainty	Proclaimer
	But anyway, it's coming up and telling us we're wrong.	Dis-satisfied Confused Uneasy	Use of 'we' rather than 'I' contrasts with the rest of the selected episode	Incorrect position in relation to the 'expert' mathematics appears as a shift in language from 'you' to 'we'
	So it says use the area of the square, we've got the area of the square as 9x9, and then multiply it by 3.14... [Does this on a calculator]	Neutral	In teacher instructional mode. Imparting factual information. Think about what doing calculation herself means?	Continued as solving the problem is enacted. 'it' is mathematics objectified, 'we' as the others (them and us)
S2	*It's 254.34*			
S4	*Error*			
T	*... 3.14.... (Yeah) 254.34....*	Satisfied	My thought is that the students have just done this, but she still has to	This felt like rather than solving the

			do it for herself. It made me feel that she was not confident that the students would give her the right answer?	problem for students, she was doing it for herself as in the internal thinking verbalised earlier. A position as clarifier.
Many	*Yes!*			
S4	*Error*			
T	*...2...5...4....point... oh I see, point 3 4. Let's try it again [Enters answer which is shown on the projector]*	Confused to satisfied	As both students and teacher know the answer is right, why does this also need to be confirmed by the computer? It makes me think of procedures and tasks without reflection.	Clarifier Controller
	Yeah!	Pleased Satisfied	The interactive computer screen displays that the answer is correct. The teacher reacts and students follow shared reaction Resolution point	Confirmed in position
ALL	*Yeah!*			
T	*OK*	Satis-faction	Expression interpretation as completion, before moving to next task.	Controller

Table 4.7: Selected episode transcript and commentary for Bertha. Lesson B1

Neutral → confused → neutral → uncertain → confident → responsive → caring → pleased → satisfied → neutral → satisfied → uneasy → neutral → satisfied

Figure 4.18: Bertha's emotional pathway: Selected episode from Lesson B1

The expression of pleasure may come from student compliance, for guessing what she wanted, rather than because the student contributes. This interpretation corresponds with her post-observation discussion comments about this student, the lesson and characteristic emotional identity established through her professional story. If we look at transition of emotions as a temporal change, then there is evidence of satisfaction from resolving a problem, resolving confusion, from maintaining a position as defender of students from 'it', the mathematics. The teacher explains this part of the interaction, edited to focus on comments about Terry (I = Interviewer).

I *... So, um... can you tell me about, there was a lad that answered, and he was really hesitant, and you said be more confident about what you are saying...*

B *Well he is... he's a bit of a 'naughty'... Well he's not, he's a lovely, lovely lad, but he's […]*

I *Is he the one in the middle here? […]*

B *No, he's a little tiny thing actually. He sits just round here somewhere […] They are a really difficult class; they are the most difficult class I teach. Only because they're very needy, the boys especially are very needy, and some of the girls are very like...you know... they have got to that whole point of really... everybody's scanky and stuff.*

[External Interruption]

And a lot of them don't have a lot of confidence, but a lot of them are over confident, but some of the boys, the reason they muck around is cos they aren't confident, because they don't want to do it, because they might get it wrong and then they'll really feel more stupid because the girls will just tell them they are stupid type of thing. Which is why I made that comment, because he [Terry] *actually has an awful lot to give. But he... I don't know if he has been told he is rubbish all the time, but he behaves like he thinks he's rubbish a lot, so I think it is important myself just to let him know that, and then if he gives it a go, and then gets it wrong, then it doesn't matter, and he also needs to know that, cos if he'd of said, 'oh because...' I don't know, whatever reason, it wasn't right, I would of said 'ooh, that's a good idea' and moved on and he wouldn't... So that he knows that it's not bad.*

I *Yes, it's nice you can say well done for something...*

B *It is nice, yeah, yeah, yeah. It was just cos he... he said something under his breath I think, as well. And um... which was the right... which*

I thought was the right answer, which is why I really encouraged him to say it. Cos I think that I thought to myself, he does know what it is from something he said. Something else he said, but yeah […] and probably, if someone was in the classroom with me, they would say the same as I'd said to Terry, be more confident, and just go for it, and if they don't know then you can tell' em. That is Terry, yes... the boy with the hair.

Presenting the selected episode from lesson B2: Collecting statistical data from the class

This selected episode (Table 4.8) is from the second of two consecutive lessons. Students were working in groups, collecting statistical data on height, weight, foot length etc. The selected episode occurs when they are nearing completion of the task and reporting the data. The teacher acts as recorder for the data collected. The class is noisy and many students are not engaged in the task. The teacher seems unaware of this, although she looks up and frowns when a student shouts out on several occasions. There are several small groups of students waiting to give Bertha their results. The selected episode is disjointed and was not pleasant to observe. There are many voice talking simultaneously, making transcription challenging. Throughout this episode there are inaudible student comments, the bracketed exclamations only record those loud enough to be heard over the noise.

Speaker	Transcript	Assigned emotion	Interpretation (Observer notes)	Interpretation (Positioning)
Sam	*The gender is er… male...*			
T	*Yes, I know.* [Some nasty laughter from the other boys in the small group. This is not challenged by the teacher]	Impatient Sarcastic Irritated	This comment occurred with no eye contact or smile.	Instigator of derision Condoning of putting down of a student by other students
Sam	*... arm length...*			
T	*No.* ***Foot length*** [Shouted imperative with no verb] [Eye contact briefly made as shouting at student]	Impatient Hostile	Impression -You are not giving me the right information immediately	I am impatient with you
Sam	*Sorry, ah, 25...*		The teacher attitude made the student	Student positioned as

			humiliated enough to apologise just after being derided	inferior, and accepted it
T	*Hand span?* [Imperative with no verb]	Critical/ sceptical	Teacher briefly looks up	
Sam	*24, ah yeah.*			
T	*...rapid reaction?* [Imperative with no verb]	Critical/ sceptical	No eye contact	I am too busy to look at you.
Sam	*1.306*			
T	*1.306. You need one of those.* *Um. And Kevin, your information.* [Makes quick eye contact with Kevin]	Dismissive/ sceptical	Repeats student contribution. You are probably going to give me the wrong information Why does Bertha not say please? What does this tell us?	Instructor I do not have to be polite. I am not interested. You do not command my respect
Kevin	*for my height I've got 5ft 1*		Given in former UK units which are still common units of measurement	
T	*How much is that? How much is that in centimetres?*	Impatient		I expect correct information in the form I want it I need to be quick You are not meeting my expectations
Kevin	*I don't know...er...* [Teacher waits...]		This student is also derided.	
T	***Go away, find it out and come back again*** [Shouting] [Waves arm in dismissive manner, averts eyes and turns away directly].	Hostile / impatient	Excessive go away gesture, aligns with impatience, interpreted as 'get away from me'	Instructor I am the boss I do not wish to talk to you

T	[Turning to next group waiting to her left, begins recording their data] *(we wrote it down in our books)* *(So you are 155cm, Taylor...how much are you in centimetres?* ***(Hot dog)*** *How much are you in centimetres)* *(**leave him alone**)* *(Are you 155?)*	Neutral (Unsmiling expression)	[Sensor peak just after student shouts out 'Leave him alone'] Some quieter students are watching the teacher and raise their hands when they think she might look up – she doesn't.	Recorder of information [Not teacher]
T	*Yep, yep...* *(I **don't know**, what's 5? **A hundred and fifty**)* [Teacher briefly looks up at this point] *(ah you're catching up in height)*	Impatient/ irritated		You are not going fast enough
S3	*0.5*			
T	*You need to go and write your hypothesis* [Hands over sheet of paper] *(Can I go to the toilet please?)* *(You're horrible)* *(I've [?] my eyebrows)* *(We wrote it down in our books)*	Impatient	No eye contact	Instructor Recorder of information
T	*You need one of these to work out the hypothesis* [Hands sheet to student, looks at clock].	Neutral	No eye contact	Recorder
T	***It is quarter to twelve, everyone should have finished or should be finishing. You should either have one of***	Neutral/ frowning (concentration)	Importance of completing task/ time Use of 'should' in instruction, along	Instructor

	these sheets by now to write down your hypothesis, or some people are on the next stage, or you should be waiting to give me your data...		with 'some' people could be distancing from the successful ones?	
S4	*But miss...*			
T	***...One or the other.*** **[END]** [Goes back to recording data]	Neutral/ frowning	There are 3 choices!	Choose from my options Recorder of information

Table 4.8 Selected episode transcript and commentary for Bertha. Lesson B2

Impatient → sarcastic → hostile → sceptical → dismissive → impatient → irritated → neutral → neutral/ frowning

Figure 4.19: Bertha's emotional pathway: Selected episode from Lesson B2

Prior to this selected episode, the teacher can be seen exhibiting strong emotions interpreted as crossness, impatience or frustration, frowning implying disapproval or displeasure but which may be just concentration. There is no exhibiting of positive emotions in this selected episode as shown by the emotional pathway (see Fig. 4.19). In Table 4.8, shouting is shown in bold font.

3 Bertha: Positioning within the two selected episodes

The intensity of emotions revealed to students in the observed lessons is predominantly negative, appearing as frowns, sharpness and impatience usually associated with control. She used undirected general praise more than suggested by the selected episode, whilst directed and positive emotions occurred in conjunction with a student is obeying instructions, meeting expectations, or in conjunction with surprise at a student contribution. She is positioned as a receiver of information, arbiter or recorder. There is also a controlling element to her self-positioning. The students are positioned as expected to be compliant and quick to respond to requests.

4 Bertha: Analysis of interviews and the two selected episodes using ES

Five ES align for this teacher and are ranked. DDM has the strongest associated characteristics, and is hence most likely to be dominant, supported by SOOT and GJD, with some characteristics of LMTY and PE.

Bertha: Building ES from Goldin et al.'s (2011) strands

I start with **goals and motivating desires**. One short-term motivating desire and goal for this teacher is not to 'mess up'. She speaks of gaining pleasure from changing negative to positive experiences for students, and seeing student understanding. The resulting **behaviours** seen include what to me as observer feels false, such as a disingenuous over-concern with student well-being. There are also examples of spurious praise inappropriately allocated. For example, for spotting what she wants the answer to be. She sees students hitting each other with rulers on the video as funny, with no apparent embarrassment.

The perceived **need** is not to make mistakes, or to be found out by authority. There seems to be a **pathway** of self-depreciation within how she talks about relationships such as *'they are used to me making mistakes'*, that has become a **belief** within her perception of student relationships. Bertha has nearly 10 years of classroom experience, yet her behaviour management characteristics are commensurate with a novice teacher. She does not appear to be in control, or to want responsibility through control, which may mask a lack of confidence.

Her **external expressions of affect** are informative as to her **motivating desires**. She may expect positive recognition from extreme displays of emotions, such as sympathy for crying, from which behaviour she expects others to know how she is feeling and respond appropriately to her needs. She uses expressive words in conversation and in the classroom, her exclamations, and her facial expressions are dramatic, as are her hand and body movements. She suggests in interview that she self-regulates her emotions, by acting out strong emotions, a form of **meta-affect.**

Bertha’s **meanings** are located within her social/individual interface and are strategic such as being loud and ‘obnoxious’ covers much, as does self-depreciation. It changes the positions available to those with whom she interacts. She uses **self-talk and inner speech** to reinforce her need to be seen as a caring teacher, which may therefore also be a **value**. This is reinforced by her preference for low achieving students for whom (perhaps) she perceives less responsibility. In terms of **orientation** I would suggest avoidance rather than approach, and performance rather than mastery. Together these form a maladaptive **goal orientation**. Her **strategies** include self-depreciation, attributing difficulties to others where possible and becoming emotional if that does not work.

The implications are that the ES of ‘Don’t Disrespect Me’ (DDM) is dominant, as this shows the strongest associated characteristics. This ES is supported by SOOT and GJD, with some characteristics of LMTY and PE. Observing characteristics of ‘Pseudo-Engagement’ (PE), which includes avoidance behaviours was unexpected, as was ‘Stay Out Of Trouble’ (SOOT) which is associated with low self-efficacy. Similarly, LMTY was not so apparent in the data, and appeared in the form of attending to the needs of students, and that she is entitled to respect from them as for ‘Don’t Disrespect Me’ (DDM) rather than modelling engagement. ‘Get the Job Done’ (GJD) may be associated with exam orientated teachers. Although there is no intention to generalise or compare, it is worth noting that the summary of ES in Table 4.16 (p.231) shows an ES pattern that differs from the other participating teachers.

There is a degree of mismatch in this data, between Bertha’s practice, and her espoused view of her teaching of mathematics. This highlights a strength of the combination of the two lenses; that any such contradictory positions are revealed and can then be examined further. In this case, the controlling and power dimension of Bertha’s teaching is revealed by using PT, which aligns with the vulnerability expressed in the interviews which ES draws attention to. I would suggest tentatively, as the sample is small, that a teacher adopting this pattern of ES, alongside these positions (as illustrated by the episodes), would be less likely to play with students through positive emotion use, or to model enjoying mathematics. There is discontinuity in the story of the mathematics.

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Debbie (4.1D)

An exploratory paper on using ES with the data collected for Debbie appears in Lake (2014) and Lake, (2015a).

1 Debbie: Emotions and affect in interview and post observation discussion

I interviewed Debbie in January 2014, and later observed two consecutive lessons with year 8 and then year 7. The data from interview and post-observation discussion suggests Debbie engages with challenge and adds complexity. She talks of the importance of modelling of fun in engagement, and of how she enacts teaching as a performance. She told in interview about how her whole life is ‘being’ mathematics teacher, from work to socialising with other mathematics teachers with whom she lives. She feels she has always wanted to be a teacher, right from holding classes with her toys from an early age to enjoying her present role. Her drawing constructed within the preliminary interview (Fig. 4.20) has a certain simplicity in style, as has her phrasing as she brought her interview drawing into the discussion,

> *“I want to draw another picture.* [Draws] *I’m not very good at drawing”* [Laughs, doing more drawing].

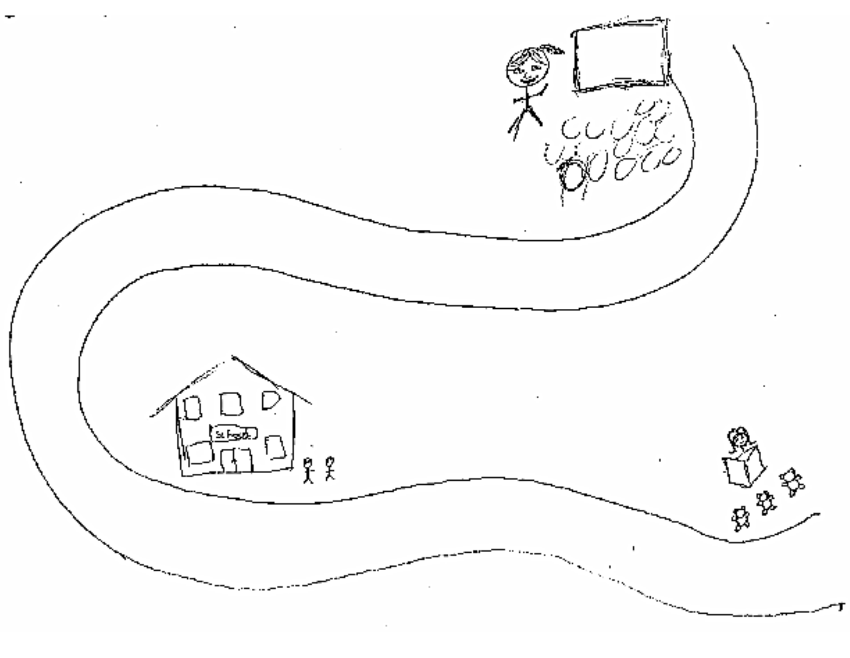


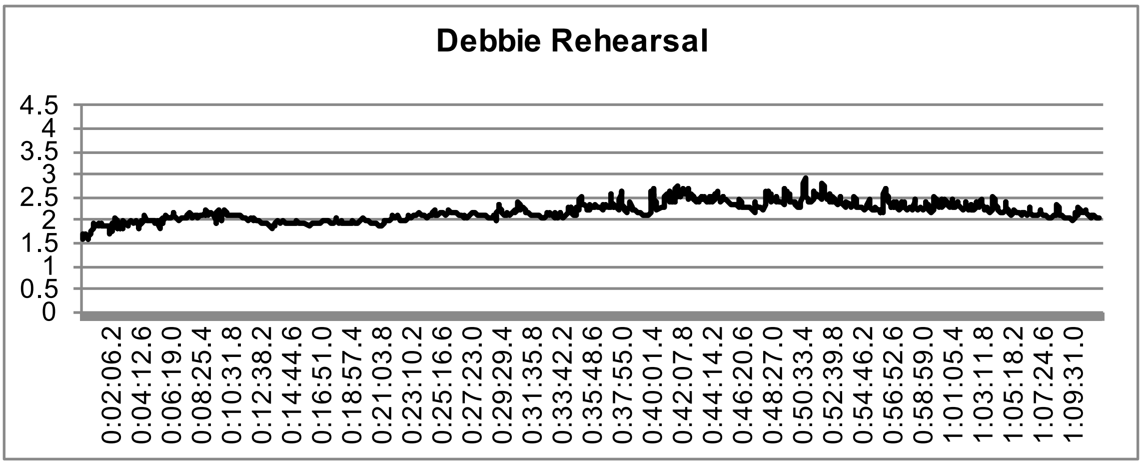
Figure 4.20: Drawing by Debbie in interview

2 Debbie’s lesson and the selected episode

The rehearsal lesson was a one-hour lesson with year 8 class, followed immediately by the videoed lesson with year 7. For this school, it is normal practice to seat students as boy/girl pairs, with quieter ones selected to pair for any unequal numbers. In this room, there were 3 columns of 4 pairs of tables, seating 24 students. I video recorded the class from the back to one side. This was a useful position as it was difficult at times to keep up with Debbie’s rapid movements around the class.

Selecting the episode

The selected episode for Debbie was selected as the highest sustained period, containing the second highest value during the lesson, as there were no clear peaks. The highest values occurred at the lesson end as students were leaving, so in this instance the second highest value was taken to form the video clip (Fig. 4.21).



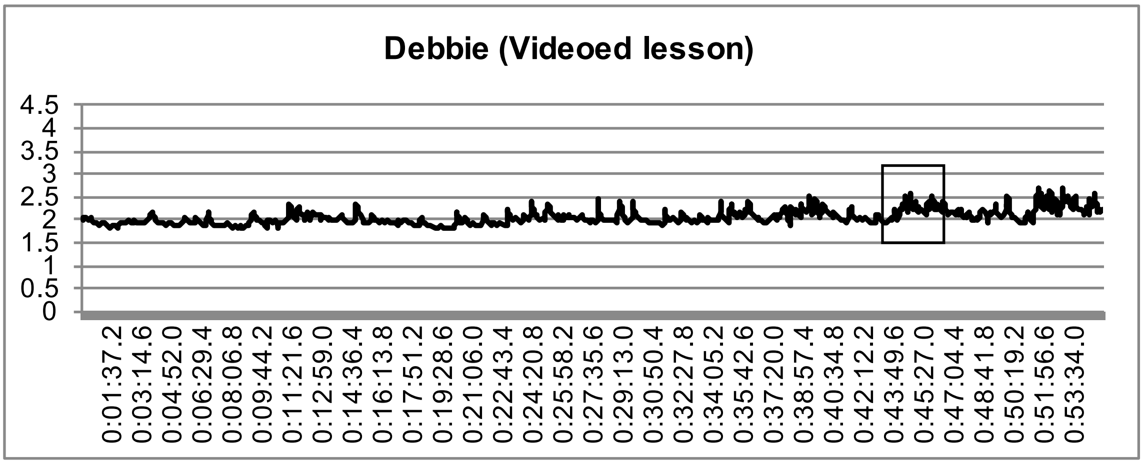


Figure 4.21: ESensor recordings as graphs for Debbie

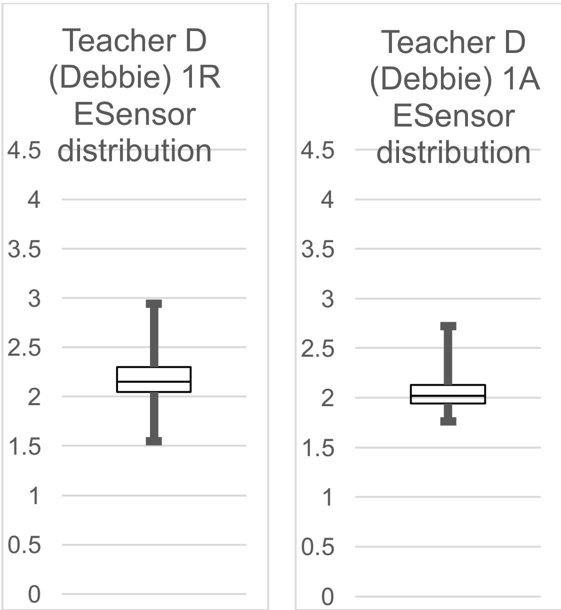


Figure 4.22 ESensor recordings as comparative box plots for Debbie (R and Lesson D1)

Given the active nature of Debbie whilst teaching, with rapid movements and many emotional expressions I would have predicted more variation in the graphs (Fig. 4.22), which are consistent. This perhaps draws attention to the internal and external nature of emotions. For example, a teacher who is overtly emotional whilst teaching may have reduced internal affect or vice versa.

Presenting the selected episode: The Tarsia puzzle

In the selected episode (Table 4.9) we see Debbie moving rapidly from one group of students to another, answering and asking questions, a repeated pattern within the observed lessons. My impression from this is that modelling enjoying doing mathematics is important to her, and in the selected episode she uses playful language and body movements. For example, waving her arms to show an aeroplane flight path to two students who were engaged in an extension task.

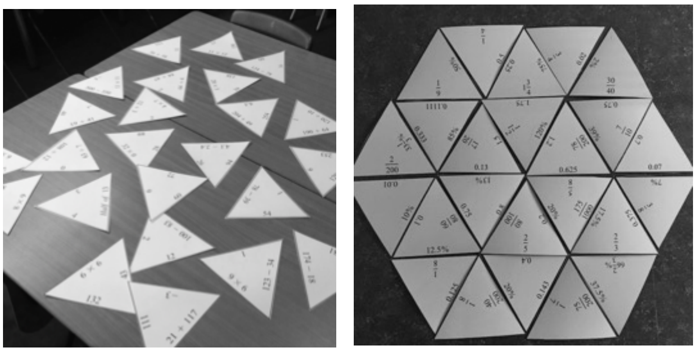


Figure 4.23: Illustrating a Tarsia from Debbie's lesson (not the exact version used)

Similarly, Debbie chose a Tarsia puzzle to engage students with operations on negative numbers, following a class discussion using number lines and mini whiteboards (Fig.4.23).

	Transcript	**Assigned emotion**	**Interpretation (Observer notes)**	**Interpretation (Positioning)**
T	*It's got to go down 180 degrees until it reaches zero and then it's got to go down another 45 metres.*	Interested	Using hands for emphasis It undefined but as a mathematical object	Instructor Knowledgeable about task Clarifier of task
	Yep. So 25 is correct.			Confirmer of mathematical correctness
S1	*Yep.*			Accepting
T	*Does that make sense? It's about looking at the context of the question and thinking 'oh if it's got to go down that far to the ground, then it's got to go down a further 45 metres'.* [Moves across class speaking as moving]		Uses transference from teacher to possible student position Physical modelling of plane positions	Mediator between mathematics and students Positioning as student as problem solver

	[To S3, louder] *Ok. Put it in a paperclip and go and get a merit.*		[S3 has completed Tarsia puzzle Fig.4.22] Responding as moving across classroom	Organiser of activity I reward quick work
	[Briefly checks pair at back next to window S4/S5] *Minus 13 add 24 did you get 14?* [Then moves to another pair S6/S7 next to window working on the Tarsia]	Quieter	'You'- local	Confirmer of task/problem Questioner/ mediator Observer of task
S6	*It's really confusing, that's got the answer there but it doesn't go with that one.*			Listener
T	[Takes her time engaged in the puzzle using and comparing with the answer sheet] *There are two 23's.* *It should be that 23.* *You need to move it.* *You need to move it so that all those sections have got to go there. See what I mean? So this bit, that's got to go to... this...* *So that bit goes...*	Thoughtful Confused Interested Engaged	'you'/ 'I'. both local and individual	Provider of solution Knowledgeable about task Instructor Explainer Problem solver
	[Moves to desk at the front, talking to two students S8/9] *Guys, sorry...*			Manager
S10	*Miss, we've done it!*			
T	*Wooo!* *Can you please put it in your um...Right, you are going to take that and you're going to do*	High excitement (verbal) Interested	Playful [ESensor peak value]	Excited as child about success

	that now...Put it in your paperclip and come and see me... so that's Kim and Lee, ok Lee. Right, take one of those, you are going to work on that between you...and stick it in...			Organiser of task Instructor
	Ooh...swearing? [Louder] *No!*	Irritated	Low level control	Behaviour manager
Dan	*Swearing? Did you swear?*			Aligning
T	*Dan get on with your work please*			Teacher role
T	*OK, Shhh....shshshshsh… Shhhhhhh... RIGHT... Shhhhh... Ok year eight. Um year eight, I think I have asked you to be quiet. Ok. We're going to stop there guys because we are running out of time and I've got a little thing to do with you at the end...*	Slight impatience [Mock cross]	Excessive shushing 'Year 8' - you as group Use of you, I as students and teacher separated We or you/I (local) used for management/ social compared to 'it' for mathematics?	I want your attention Whole class teacher in charge Organiser/ manager Giver of treats
	There we go, well done... [Running two conversations simultaneously, to class and two students]	pleased		Multi-tasker
	So...here's what I need you to do. Everybody that is still completing their Tarsia, well unfortunately, you are out of time. But well done you have worked really hard today. Can you swish it all up and put it in a paper clip please, then... if I gave you a nice worded questions worksheet... I need that to come back. And then I would like you to be packed away, everything except your mini whiteboards please.	Interested Mock sad Neutral	Distancing from failure to complete task [Implies good to complete] 'Swish it up' Accompanied by quick sweeping hand gesture	Organiser of tasks I reward completion I want your attention still Coordinator

	Lee and Meg? [Giving out stickers]			Responder Problem solver
Lee	[Inaudible Q]			
	[Students begin to pack away] *No, we are doing questions on a mini-whiteboard*			Instructor
	DAN! [Quietly] *You are being silly today.*			Manager of behaviour
	Have you missed it?	Interested		
	Well done Matt. *[END]*		[Giving out stickers]	Positioning as praise giver

Table 4.9: Selected episode transcript and commentary for Debbie. Lesson D1

Interested/Neutral → confused → Interested/ engaged → mock excited → interested → impatient → pleased → mock sad → interested /neutral

Figure 4.24: Debbie's emotional pathway

In the lesson, not only in this selected episode, I noted that Debbie was often speaking fast whilst moving, and frequently running several conversations at the same time, to the point of making things more complex than perhaps necessary. I would suggest she models enjoyment and playfulness in learning mathematics, shown by the emotional pathway in Fig.4.24. Playfulness is a theme explored further in 5.1.

3 Debbie: Positioning within the selected episode

The episode begins with Debbie as instructor, but she soon moved into a position as problem solver, aligning with the problem-solving activity that the students were engaged in (Tarsia). Her positioning was mainly as facilitator flipping with instructor in a rapidly changing pattern interpreted as high interest in the classroom activity.

4 Debbie: Analysis of interviews and the selected episode using ES

The dominant ES identified for Debbie are LMTY and IRIT as primary drivers supported by GJD and LHSIA.

Debbie: Building ES from Goldin et al.'s (2011) strands

This section relates the data to the *strands* (Goldin et al., 2011). Examples for Debbie from the first strand of **characteristic goal or motivating desire** include a desire to meet challenges, to solve practical problems and to be seen by others as creative. Underlying these desires is likely to be a **need** to choose options that give the highest reward, and to get satisfaction from meeting challenges.

As a result, Debbie's **behaviour** includes placing heavy emphasis on creating resources; this accent on creativeness was evident both in interview and in observation, suggesting Debbie invests a lot of emotion into creativity. She seeks and adds levels of complexity to all aspects of her teaching, seeking challenge in many forms. Identifying with creativity then may act to assign **meaning** for her. In the observed lesson, she was using Tarsia puzzles (Fig. 4.22), and she mentioned that these have proved successful and hence are associated with positive outcomes. Once the class was engaged in a variety of activities, most contact time was with students doing puzzles. The **meaning** construed from using puzzles probably then guides her practice, for example she likes younger students because they will engage in puzzles, supporting her self-perception of an engaging happy teacher, whilst to engage in puzzles fits well with part of her meta-level constructed mathematics teacher persona, that mathematics is a game.

This teacher is very **expressive**, both as an individual and in social interaction. The wealth of examples of this has significantly influenced my identification and interpretation of Debbie's motivating desires. Examining Debbie's **beliefs and values** can act to summarise her characteristics and **longer term orientations**. In terms of mathematics and education, she may feel that you get most reward from sharing and communicating mathematics with others. Within her role as a teacher, she values working hard, especially perseverance and focus, and that being different is strategically rewarding. I would suggest Debbie feels that children learn mathematics through their teacher modelling engagement, fun and activity and through the teacher enacting the satisfaction accruing to successfully meeting challenges.

In this section, I consider each ES for Debbie. There are necessarily elements from '*Get the Job Done'*, such as meeting the requirements of curriculum, and professional scheduling obligations for any teacher in the UK or elsewhere. For Debbie, this ES may include enlisting support of students in completing tasks, as she expresses satisfaction for compliance in her interview. However, her articulated philosophy of mathematics does not view mathematics as procedural and rule following, a belief strongly associated with this ES.

The ES '*Look How Smart I Am'* incorporates belief in innate ability and high self-efficacy. She is indeed confident in her own ability, and aware that successful teaching is effective in increasing her self-regard. Her adoption of the teacher-as-a-performer style may indicate that she derives satisfaction from achievement. However, an ES that appears to be more often applicable is *'Check This Out'*, as this ES is more communicative, an ES evolving and forming a belief in the inherent interest of mathematics, and I would suggest she often aligns, especially by modelling, with perceived reward coming from completion of a problem or conscientiousness. This 'payoff' also appears for her motivations within her career story. Yet there are two ES that seem to apply to Debbie, *'Let Me Teach You'*, which I expect to find as common to all my participants, but also *'I'm Really Into This'*. This ES is similar to *'Check This Out'*, but the reward is more intrinsic. She gets a 'buzz' from representing mathematics creatively to her students and from problem solving for its own sake. For Debbie, reward is enhanced when her students verbalise their engagement both with the effort she puts in for them and with the devised resource. The value given to problem solving and creativity is deep, to the degree that she seeks complexity and new levels of problems to solve. I suggest she is occasionally in flow whilst teaching. For example, she commented that she forgot that she was being observed. The bigger the challenge the more I feel she relishes it, but perhaps this applies more to being a mathematics teacher rather than for the subject challenges. IRIT is both indicative of, and forms a strong alignment of her different identities since in observation she frequently modelled IRIT to her students.

I expected to see the ES of '*Let Me Teach You'*, but not how well IRIT applies to Debbie. One latent purpose of establishing ES for teachers is to explore how ES enables or restricts ES for students. I would cautiously suggest that for Debbie, her dominating ES has potential to block more negative and egotistical ES for students.

In this case, the positioning analysis and ES for the data for Debbie are consistent. For example, the switching between facilitator and instructor as revealed by the PT analysis informs the dominance of IRIT combined with LMTY, and which is supported by the interview and post-observation discussion data.

Edward (4.1E)

1 Edward: Emotions and affect in interview and post observation discussion

In his story, Edward tells of his own learning of mathematics, of difficulties encountered in passing through university, as well as his travelling experiences prior to training as a teacher. He explains how he sees his relationship with teaching and students within his current role and his expectations for the future, including some uncertainties. Interview data for Edward is primarily description of his actions and reasons without overt emotional expression. His preferred emotional label was 'enjoy' and he also talked briefly about what he liked or wanted. Significant for Edward is an affective attachment to his interests outside of mathematics teaching, with indications of pleasure when these could be brought into the classroom, otherwise Edward's language and actions felt detached. He expressed awareness of conflicts between a need for novelty and task achievement and similarly between 'whims' and levelness. His thoughts on hard work were curious, where value appeared to be assigned only if the goal was perceived as achievable or aligned with a predictably successful outcome.

There is a degree of detachment, of not pertaining to self, when he talks about stronger emotions. For example, talking of the tears that can accompany the difficulties of the role are attached to his sister, who is also a teacher. I also think his pleasure from experiencing positive emotions arises from anticipation of the laughter of others rather from expressing himself. He describes his nature as *'level in what I do'*, but also recognises this as being problematic. He uses noticeably strong body movements, a physical orientation. When he does express humour, either with his students or during the interviews, this is quite idiosyncratic e.g. his 'if the student was a teacher joke' (E1/2) (which although expressed to the class was possibly directed at me, another teacher). It is reasonable to think of his lack of exhibited emotion as strong self-regulation – something that might be expected from an athlete, a role that I assume requires strong self-control.

2 Edward’s lesson and the selected episode

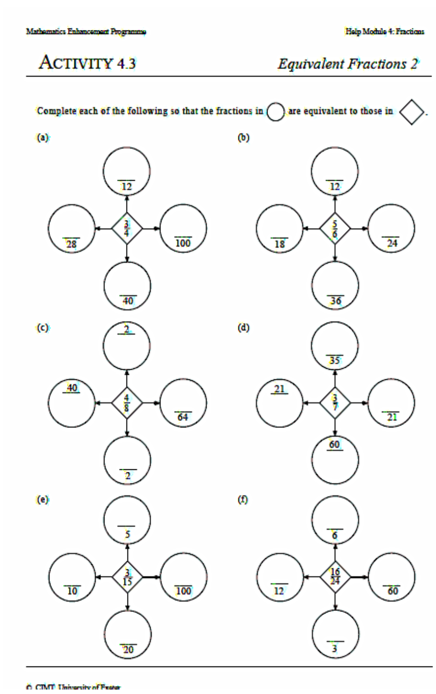


Figure 4.25 Lesson starter (Edward)

I observed Edward’s class a week after the initial interview, on a Monday morning in February, with both audio recording and videoing. The observed and videoed lesson was with a top set year 8, this followed immediately after a familiarisation rehearsal lesson with year 10, also a top set. The classroom was laid out in blocks allowing up to 6 students to sit at each table, there were 6 blocks of tables. There were 24 students present of mixed gender in the observed lesson. The students settled quickly and wrote their whole school learning outcomes for the lesson (WALT and WILF), in their exercise books copying from the board. They then did a starter equivalent fractions activity (Fig.4.25). The class had previously been working on division and the observed lesson was a review of methods of division in the context of changing fractions to decimals. During the hour lesson, the class reviewed ‘bus-stop’, the more traditional method for division used in the UK and ‘chunking’ methods of division, where division is broken into smaller steps. Later, after some practice using a worksheet on converting, Edward introduced a video clip, of a polar bear predicting the position of a seal before attempting to catch it.

Sx *“it’s not as boring as the last one is it, sir?”*

T *“No, that was, really was boring. This is my favourite.”*

This did not run smoothly so the class did not discover whether the bear was successful. The reason for showing the video,

T *“There is no maths in it”*

was as suspense,

T "You'll see why I'm showing it in a minute"

After the clip, they had a task based on the hunting 'success' rates for various animals which can only be compared through converting between fractions decimals and percentages as a problem-solving task involving evaluation. The rest of the lesson was spent on this task with Edward moving round and helping individual students. The task is not summarised but this was verbally planned for the next lesson, as was revisiting the video that would not run properly.

Selecting the episode

The ESensor did not record correctly for rehearsal, and there is 30 minutes (Fig. 4.26) from the video recorded lesson. The post observation discussion used two short distinct episodes selected from the observation. The first selected episode surrounds the maximum recorded value (E1/1). I also chose to include a second episode (E1/2) as, when watching the video, I noticed the second selected episode was, in terms of mathematics and context, similar, despite a lower ESensor reading. Both episodes show Edward encouraging a student to come up to the board to demonstrate their example of division and both capture the teacher smiling at Joe and Sam respectively.

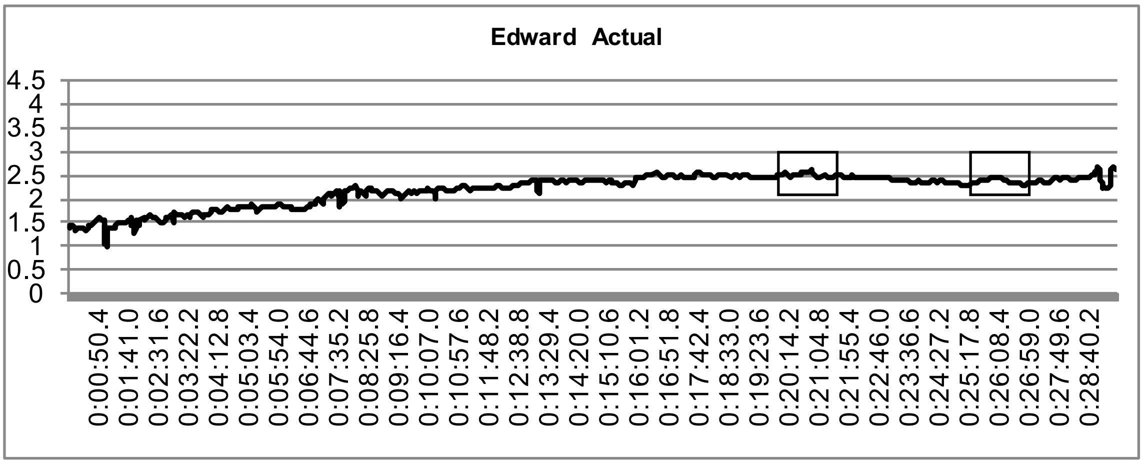


Figure 4.26: ESensor recording as graphs for Edward, showing the two selected episodes

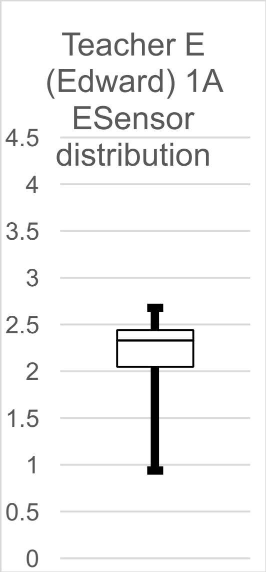


Figure 4.27 ESensor recording as a box plot for Edward

The graph (Fig. 4.27) for Edward shows some consistency in the readings. There is a gradual increase across the lesson that is common to all the teachers, but it is less marked for Edward.

Presenting the selected episode (E1/1): Joe demonstrating why 1/5=0.2 at the whiteboard using his own method

The students had just been asked to think about why 1/5 = 0.2. The first selected episode (Table 4.10) begins with Edward asking a student to show their method at the board to the whole class. Fig.4.29 shows Joe's working of 1 ÷ 5 with 0.5 2 0.2 written underneath to support his earlier verbal explanation just as the teacher is about to erase the working at the end of the selected episode.

	Transcript	**Assigned emotion**	**Interpretation (Observer notes)**	**Interpretation (Positioning)**
T	*So are you alright to say that?*	Considerate	Confirming the student intent	Respectful
Joe	*So basically....* [Student starts talking directly to the teacher at the back of the room]			
T	*No don't tell me, it's fine, I know Joe.* [Smiles at Joe] [Student goes up to the board, teacher stands at the back of the room]	Relaxed, good humoured	Overt purpose of dry humour to comfort the student? This comment shifts attention from teacher to class as audience for Joe. Standing at the back of	Supportive I am the expert I am confident

		Interested puzzled	the room physically distances the teacher from the student taking the instructional position The teacher puts his head on one side appearing to make sense of what is quite a confused and hesitant explanation	Distancing positioning I am interested I am listening
Joe	*So If you have um... 1... No that's not... (audible 'oh dear' from another student) You've got 1. You want 2... I put 1 over 0.5, and you get 2 out of it, so I put it to 0.2... No... that doesn't work*		[NOTE] [9] I felt this was a historically expected behaviour for this student, as not able.	
T	*Er.... Have you've convinced yourself that didn't work?*	Embarrassed	No praise given. Distancing. The teacher does not reiterate what the student said. Use of you and a question separates what the teacher sees as incorrect from the student	Positions student as incorrect, but task wrong not student.
Joe	*Yeah. That didn't work.* [Some whispers from other students. The teacher goes to the front of the room as Joe sits down. Fig. 4.29]		That didn't work compared to I got it wrong	Student accepts position allocated by the teacher as I am wrong
T	*Ok. What methods do we have for division? What do you have for division? Mark, what method do you have?*		ESENSOR PEAK Draws attention back to himself and the task Directs question shifts ownership we-you-Mark We as local – the people in the room or could be	Teacher as questioner Collaborator

[9] Possibly, what the student really said/meant was you get 2 lots of 0.5 out of 1, so if you want 5 out of 1 you put it [the 2] to 0.2. [It took me a while to figure out his logical thinking, replaying the clip repeatedly, that he was using 0.2x5=5x0.2=1. But of course this was too late, and the sniggering of other students in the class and the dismissal of the method by the teacher had already happened]

			'we' – all the people who do division Division presented as a problem to be solved	Manager Owner of solution?
Mark	*Er... you could do Bus stop*			
T	*So bus stop method.* *We've talked about the bus stop method, yes, over there, any others, Brad?*		We – whole class Students positioned as should know That mathematics has multiple methods	Teacher as Collaborator
Brad	*I was going to say the Bus stop method*			
T	*Bus stop too. Has anybody got a different one?*		That mathematics is open not closed. Shift- the solution becomes the object	Seeker of contributions
S1	*Chunking*		Other common method	
T	*Chunking?* *So what I want to know is can you use a method, because we know that this is right because it's a commonly used decimal.* *But one of the ones you have to do later is er...* *1 out of 21.* *So what I want to know is have you got a method for*	Questioning	He does not confirm by repeating as fact for both Mark and Brad's contributions, rather formed as a question Method more important than outcome, mathematics is applications 'Commonly used' – positions mathematics 'you have to' – positions students 'one of the ones' – task becomes object 1 ÷ 21 by bus-stop but why not use a calculator? Conflict as bus-stop is procedural whilst chunking needs conceptual and multi-step understanding?	Teacher as judging contribution Seeker of knowledge Positions students as knowledgeable of basics Teacher as task setter

	converting a fraction to a decimal? *We've got a method because we know it's division. But I would like you to do it. So could you please show me that 1 divided by 5 is equal to 0.2?* *Show me.* *So you need to write it down in your books so I can see it?*	Anticipating pleasure	Holding the process as object 'a method' –implies one like I have The use of method has shifted from method as one of many possibilities to specifically for division. Multiple layer for use of language, method is both method for division, within division as a method Shifts in person between I, you and we is interesting in terms of how it positions himself, students, mathematics, task and purpose	Assigns role of students to please teacher ('show me'), followers of instruction Controller but respectful. Task ownership is shifted to students
	So you have done it by bus stop method? Right. [END]	Pleased	[T Goes to mark individual student work] Repeat explanation of bus-stop.	I approve of this method

Table 4.10: Selected episode transcript and commentary for Edward. E1/1 from Lesson E1

Considerate → *Relaxed/Good humoured* → *Interested/ puzzled* → *Embarrassed* → *questioning* → *anticipating* → *pleased*

Figure 4.28: Edward's emotional pathway: Episode E1/1

Figure 4.29: Ending selected episode E1/1

Presenting the second selected episode: E1/2 Sam demonstrating why 1/5=0.2 at the board using chunking

The same process from selected episode E1/1 is then repeated with a different student, Sam (Table 4.11). Edward commented on both demonstrations positioned at the back of the room. Fig. 4.30 shows an example of bus stop from earlier in the lesson, whilst underneath is student working on chunking drawn from selected episodes E1/1 (Joe) and E1/2 (Sam).

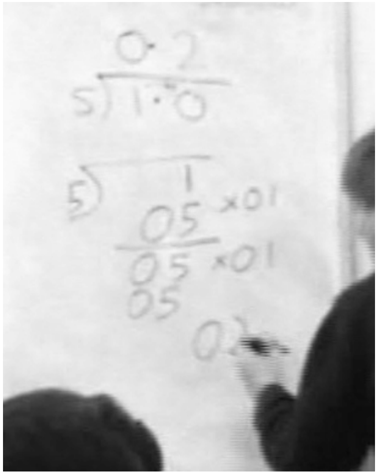


Figure 4.30: From Episode 2, Sam is demonstrating his chunking, on the board above is an earlier example of bus-stop method for division

On first impression, Edward exhibits little emotion and his tone and manner are very calm (Figs. 4.28 and 4.31). In the observed lesson, it was challenging to identify expressions of emotions although there are some examples of humour during the lesson, often delivered in a low tone and ironic in style. Yet I would suggest Edward's emotions, and how these are shared with students needs a deeper analysis. This view is supported by some fluctuations recorded by the ESensor (Fig. 4.26) and some dryly amusing moments, such as the interactions when introducing a video. The observational data provides evidence of his body language. For example, he used wide gestures whilst teaching, and his positioning at the back of the room whilst students 'took the floor' shows him putting his head to one side to show interest.

Speaker	Transcript	Assigned emotion	Interpretation (Observer notes)	Interpretation (Positioning)
T	*Has anybody done it a different way?*	neutral	Many methods possible 'It'- solved the problem	I value alternative methods

Sam	*Well I did chunking so...but I sort of started It with the 5 in the same way...*	uncertainty	Compare to teacher response to similar uncertainty for Joe	
T	*Do you want to come and show me what you do?* [Student comes to the board, teacher hands over pen and moves to the back as before, see fig. 4.29]	neutral	Student given teacher role	I am the one to be shown – proximinal positioning
Sam	*Well I started it with the 5 and the 1 as usual. And I... I knew that 0.5 is times 0.1, or 5. So I then... you take away 0.5, you are left with another 0.5, and then take away another 0.5.*		norm recognition drawing on prior knowledge shift from me doing to instructional mode – Accepts teacher role Procedural explanation	Student positioning himself as knowledgeable, then instructional Teacher positioning as classroom observer with Sam as teacher
S2 S3	*(I'm lost already)* *(I'm not)*		Audible asides. Discussion norm indications? Students aligning with yet not with Sam	
Sam	*It's equally 0.1.* [Aside comment as knew in front of board for some students] *for those who can't see I'll do this* [Some laughs as he moves away from board sideways and back again – I suspect he is copying what his teacher does]. *And 0.1 equals 0.2* [Stands back and smiles at other students. Teacher comes forward. Many students start talking about two methods shown to each other]	Funny Acting the clown?	Moving fully into teacher role Incorrect explanation as Joe earlier, but with clear board work (Fig. 4.30)	Positions self as confident Student Positioning more strongly as teacher

T	*Ok. So You need to remember...* [Takes back pen and pauses listening at front before quietening the class]	serious		Begins instructional position
T	*Shhhhhh.* *So if Sam was to become...* *…was a maths teacher he would show all this on the opposite side, so you can see what's happening,* *…and also make sure that his students are not talking straight after a little demonstration.*	Ironic humour with no change in tone	Draws attention from Sam Aligns Sam's adoption of teacher position. Talking as if teaching was a real future option Shifting Sam out and himself back into teacher role via humour and gentle criticism + little as demeaning? Is Sam a threat?	Shift to aligning position Accepting Sam positioning himself as current teacher
T	*You need to remember what chunking is. So chunking is often described as being repeated subtraction. And... starting with 1, we want to take away multiples of 5 until we get left with zero. So we can't start with 5 because 5 is bigger than 1, so the multiple of 5 we have to use is 0.5, which is 0.1 times by 5, point 5. Then we can take away, 1 take away 0.5, and get left with 0.5 again. So a subtraction here. And then we can take away another lot of 0.5 and then we get left with zero, which is what we want. So we've taken away 2 lots of 0.1 and so that adds up to that 0.2. Now we looked at both of these methods when we did division before. Ok. So you need to be able*	Neutral	Repeating Sam's explanation No allocation of who describes – distancing We as doers of mathematics We as the class You attached to 'be able' – does	Positioned again as teacher and as instructor

	to do that. You need to be able to divide in order to convert a fraction to a decimal. Ok. [END]		this reveal his view of mathematics learning?	

Table 4.11: Selected episode transcript and commentary for Edward. E1/2 Lesson E1

Neutral → serious → Ironic humour (no tone change)→ neutral

Figure 4.31: Edward's emotional pathway: selected episode E1/2

There is no maximum value sensor peak in this second selected episode.

3 Edward: Positioning within the two selected episodes

The examination of pronoun use is one way to use PT. Such use is revealing for these selected episodes. Edward's language is close (local) and then detached (global) at various points during both episodes. For example, he shifts from 'I' to 'we' [As teachers] and as 'his' [Student] method as opposed to 'our' method when talking of the *'bus-stop'* method [Either the class or possibly all mathematicians], which indicates an ownership of the second method. I would suggest this subtlety assigns a value to one method over the other and draws attention to a conflict in his teaching, between personal preference and accepting multiple methods. This positioning is explored further in 5.2.

4 Edward: Analysis of interviews and the selected episode using ES

Edward's dominant ES appear as GJD and CTO, supported by IRIT and LMTY. In what follows, I discuss the construction of these ES using the interviews and selected episode. I first identify the *strands* which determine the dominant and supportive ES for Edward. This is primarily through identification of the desire, need, evocation, behaviour and perceived reward as described by Goldin et al. (2011) and summarised in Chapter 4 (4.0, p.99-107). I then explain how the strands develop into and indicate the dominant and supportive ES for Edward.

Edward: Building ES from Goldin et al.'s (2011) strands

I would suggest this teacher **values** success from completion of **goals**, but primarily where **goals** are determined as easily achievable, and the **value** is given where success is attributable to hard work or a successful outcome from introducing novelty. He mentions his lack of responsibility and by implication is **motivated** by a wish to be free from responsibility. This position conflicts with the role of a teacher (and his perception of this role) and may be an underlying factor in his detached persona, shown by his lack of exhibited emotions whilst engaging with his class. He is probably aware of risks associated with this **motivation**, for example loss of confidence. He wishes to be seen as confident and associates this wish with a successful performance in the role of a teacher. This is not however adopting the role of performer (as for Adam). The subsequent **behaviour** includes a careful selection of challenges, both whilst teaching and in his career choices. Challenges are selected by how successful he predicts he will be and his narrative includes examples of walking away where it seems there is a perceived risk of not being successful at a given challenge. Important decisions are described as if happening by chance, by implication he is distancing himself from outcomes; he has not taken responsibility. This aligns with shifting from the first person in his speech and assigning lack of success to other people or institutions even when 'I made a mistake' is used in the narrative.

The **characteristic affective pathway** for this teacher is challenging, as he does not obviously exhibit emotions. From an affective view he does have a pattern of appraisal in comparison with others, especially in relation to his significant others. Socially he has important role models, significant others who play a path finding role, even if they are not present, and he talks of his mentors as such. He sees those important to him engaging in activities, sees the pleasure they get and appraises whether he should follow this pleasure as perceived. He seems to value hard work and effort, that performance and success are important but so is self-control. Edward's measures of success are in comparison to these values and novelty draws his attention, as does the taking of chance opportunities. The chance emphasis in his discourse suggests he does not need to be in control. In interview, he presents his choosing of a career pathway as chance or uncertainty, but possibly he is deciding emotionally, following his ‘gut feeling’, without really recognising it as such, or alternatively not speaking about his choices as emotionally orientated decisions.

There is evidence of **meta-affect** within the post-observation discussion, where his experiences are occasionally expressed by verbalising feelings. For example, he allocates seeing himself leaning on the board or wall as a need for reassurance due to a lack of confidence, and discusses this point in relation to his teacher training. The overall impression of detachment, of not showing emotions may act to cover perceived lack of confidence.

I would suggest that the strongest **expressions of emotions** are stimulated when his outside interests appear in his teaching. When there is an alignment or matching of his (often-conflicting) identities. His **self-talk** centres around confidence (and his perceived lack of it), responsibility and its avoidance. His body language and positioning during the selected episode is revealing. For Sam’s demonstration using Edward’s preferred method he remains standing to one side, yet he moves to the back for two alternative method demonstrations, possibly as a way of detaching himself. He may feel obliged to let students share ‘his’ board, which he later discusses in terms of ownership, because it is what we [Teachers] are supposed to do ‘these days’. This example provides evidence of distancing from perceived discordant current practices in mathematics teaching.

In relation to **goal orientation**, his view on mathematics as problem solving seems to be that it is appropriate to put in effort, but not if the **goal** is out of sight. This is in sharp contrast to my own perceptions of goal orientation as applicable to a marathon runner. However, he might have confidence, based on experience, of achieving a marathon goal. Overall, he could just be bored, working in a context that does not stimulate his emotional engagement, making him appear dull. Edward has challenged my assumption that to be an effective teacher requires observable emotional engagement. His language, calm manner and respect for students, with a focus on what is to be learned appear effective and there was observable engagement from students. He provides a good example to explore how aligning identities is important for emotional engagement in mathematics teaching.

Edward’s data shows evidence of a dominant ES of GJD and CTO, supported by IRIT and LMTY. This suggests he is likely to be procedural in his teaching, in order to complete his perceived role. He values task success, but also the logic of mathematics and the appeal of problem solving which aligns with CTO, as does the appeal of associated payoff from a job well done. CTO is likely to be dominant when he uses his own personal interest in the natural world.

When analysing Edward’s data, I initially thought the un-emotive language in interview and lesson left little to investigate in terms of emotions. The commonest emotive term used was enjoy. I was surprised therefore how, using ES and PT together, focussed on drawing emotions or affect from interviews and observation, has led to unexpected dominant ES. These align with a general impression of a thoughtful calm manner, where learning is interactive, collaborative and respect without judgement is important.

Freddie (4.1F)

1 Freddie: Emotions and affect in interview and post observation discussion

Freddie was observed once, using the three-stage model as detailed. I interviewed Freddie in November 2013 after school. The story of Freddie in interview focuses on relationships and Freddie talks about transition and change in his career development and during teaching. The theme of challenge occurs on several levels, as does a need for comfort. His main expressed pleasure within a mathematics classroom context is from helping. The story this teacher tells is of shifting from being a single-minded sport professional, through realising he was not good enough, disappointment, change, and finally almost drifting into teaching. Fig. 4.32 shows his view of self at the point of interview.

Figure 4.32: Freddie's interview drawing

Freddie's shorter term goals are student focussed, such as planning for positive experiences, or to witness student positivity during or after a 'good' lesson. He tells of pleasurable events that, judging from their smiles, were also pleasurable for his students. His emotions are tied to student achievements, both social and academic. He mentions negative emotions only in regard to personal disappointments or when students are not enjoying their mathematics. He recognises the work in changing student engagement, especially task shifts or multi-tasking, 'a long slog', but looks ahead to associated rewards. Importantly perhaps, he speaks of fun in association with learning rather than as a distraction or deviation.

He talks of the role of a mathematics teacher as a continual developing process (implying that classroom processes are important). For example, he is critical of an NQT who fails to progress. He places importance on being comfortable in an environment. When asked ‘what sort of mathematics teacher do you think you are?’ He replied that he likes talking too much and telling stories to the students because he wants to be seen as ‘a real person’. He uses self-depreciation as a teaching tool (such being measured against the mathematical perfection of footballer David Beckham’s face). He suggests it is important to enjoy, or at least be interested in new anything, and likes holistic projects that give a bigger picture. He values relationships, challenge, problem solving, helping and curiosity.

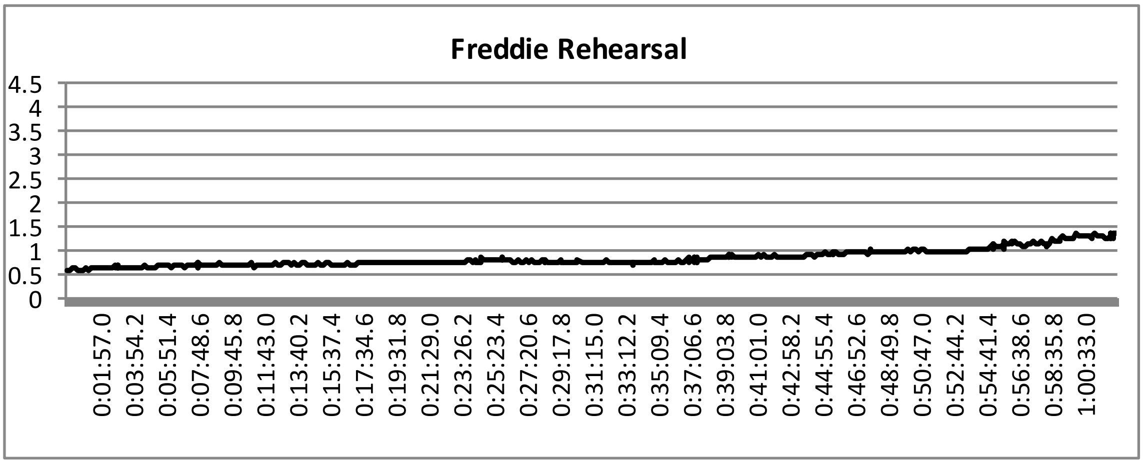
2 Freddie’s lesson and the selected episode

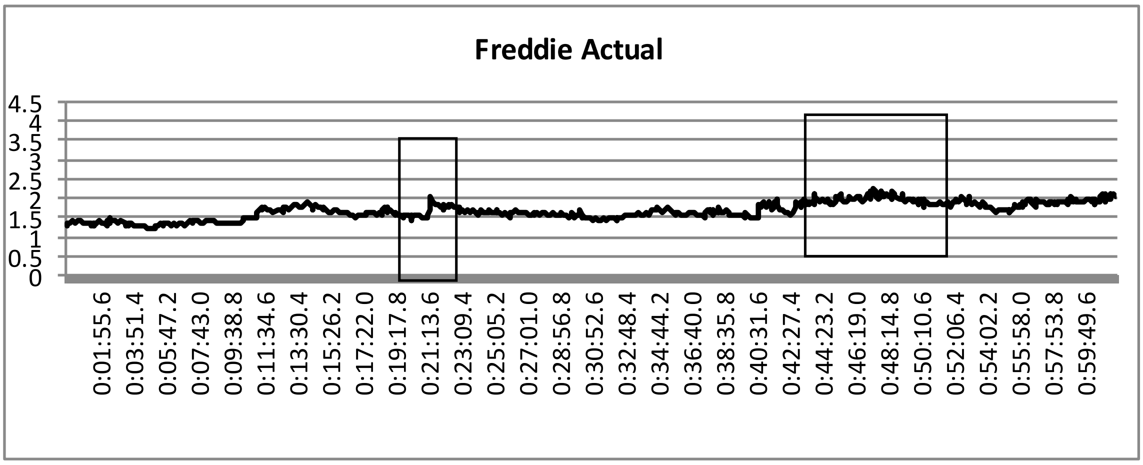
The classroom was arranged in blocks of tables, allowing up to 6 students to sit at each block, there were 6 blocks in a small room. In the videoed lesson there were 22 students of mixed gender. My position was at the back of the class, somewhat squashed behind a group of students. The lesson was on Fibonacci and the golden ratio. Students watched a video, collected some measurements and used these to compare to the golden ratio as an indication of pleasing proportions. This was presented to students as an active exploration. Students were seated as mixed gender groups chosen by the students. The room was bright and displayed student work in a colourful way. Freddie used an interactive whiteboard to show video and for recording measurements, although students had their own recording sheets. The teacher was predominately located at the front as movement between desks was limited.

Selecting the episode

I observed two of his classes, Year 8 and then Year 10 on a Thursday afternoon in January 2014 using audio recording and in addition, videoing the second lesson. The ESensor recorded data for both lessons. The lesson to be included was chosen by Freddie. There were two potentially useful selected episodes according to the

ESensor (Fig.4.33) to be used for post observation discussion with the teacher, which took place after school the following Monday. Discussion was based on one brief selected episode from the observation, labelled as selected episode F1/1: Rabbit babies, a noticeable peak identified for further discussion with Freddie and a longer selected episode; F1/2: Face measuring, which contained the highest values recorded. I was also guided by watching the video. Freddie exhibited characteristics of mild embarrassment in what was a predominantly positive and apparently comfortable lesson.





Figures 4.33R and 4.33: ESensor recordings as graphs for Freddie (Rehearsal) and Lesson F1. Two episodes (F1/1 and F1/2) are discussed for Freddie.

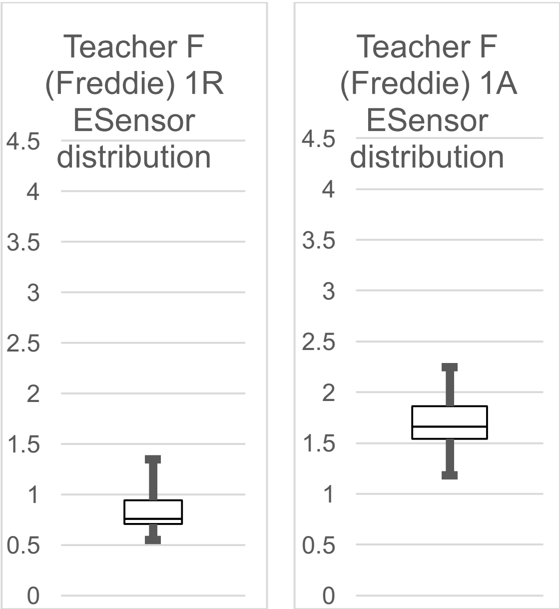


Figure 4.34: Distribution pattern for Freddie

The distribution within the lesson shown (Fig. 4.34) shows comparatively even values and consistency. From the perspective of observer, the lesson appeared calm and the teacher was mostly moving around groups of students, who were engaged in a practical class activity. The selected episode (F1/2) for Freddie was selected as a period of sustained higher comparative readings, rather than a peak as the distribution was otherwise consistent. The first selection (F1/1), was decided by a noticeable peak at 20 minutes into the lesson.

Presenting the first selected episode: F1/1 Rabbit babies

Fig. 4.33 shows a peak, which was used to direct discussion of the potential triggers in post-observation discussion.

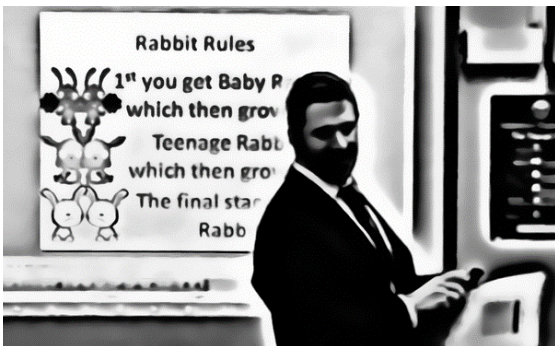


Figure 4.35: Extract from Episode F1/1

To place the peak in context, Freddie is repeating playing a PowerPoint presentation on the Fibonacci sequence, to check quiz answers, and showing how rabbits multiply according to the sequence. The image in Fig. 4.35 captures the moment when he realises that he can hear the voice recorder sound (so no longer recording) and looks directly at me as a result. The clip (Table 4.12) starts as Freddie is finishing handing out worksheets whilst giving answers to the PP and video quiz. Freddie then moves from the side to front of class where he re-runs the first bit of video for the last quiz answer. This is a transition point as he is finishing one part of the lesson before moving onto the worksheet activity. I asked him what he was feeling at that point of the lesson using the video as a prompt. He told me first that his wife was due to give birth shortly, but Freddie was already talking about babies earlier in the same lesson, with no noticeable peak from the ESensor. Yet he talked of thinking about the baby in this part of the lesson, that the word baby was a trigger for this reflection. Yet almost immediately after this point, the teacher found that the voice recorder in his pocket had started playing. Noticing this discrepancy may account for the peak.

	Transcript	**Assigned emotion**	**Interpretation (Observer notes)**	**Interpretation (Positioning)**
T	*You get babies which turn into teenagers which turn into adults.*	Neutral		'you' (global, but also personal)
Sx				
T	[Sotto voce to one student] *I want you to do this in your book.*			I/you (local)
	Ok. Ah right. And lastly, the last thing we have is the name of the video which.... [Music starts playing from introduction of the video]		[ESensor peak]	We (local/social)

Table 4.12: Selected episode transcript and commentary for Freddie. F1/1 from Lesson F1

Presenting the second selected episode: F1/2 Face measuring

The selected episode (Table 4.13) focusses on one group of two boys and two girls (S1-S4), who were invited to join Freddie at the front and to take his measurements as they had completed their own face measurement recording. We see Freddie standing still whilst two students measured his facial proportions and the other two students recorded the information on the board and completed proportional calculations (Fig.4.36).

Figure 4.36: Face measuring from episode F1/2 in Lesson F1

Selected episode F1/2 surrounds the maximum sensor value for the observed lesson. The graph also shows higher fluctuations for this selected episode. At the start of the selected episode he stands at the front with his arms behind his back in an apparently relaxed pose. He gestures four students to come forward, gathers rulers from the table behind him and waves them about before handing them to two of the students. They then proceed to measure him, two girls (S1/S2) measuring and two boys (S3/S4) writing results on the interactive board. He keeps an eye on the rest of the class whilst standing still to be measured. My notes include mentioning that this is a risky action as it potentially allows non-engagement for the rest as some measurements involve covering his eyes with a ruler. The selected episode ends as the last facial measurement is made and students return to return to their seats after completing calculations for the golden ratio.

	Transcript	**Assigned emotion**	**Interpretation (Observer notes)**	**Interpretation (Positioning)**
T	*Have you done? Good. Do you want to measure me?* [Holding out rulers*]* *Laura, are you done as well?*	Smiling, encou-raging	[Risk of this option?]	I am the organiser I am part of the class
	I'm feeling left out.	Mock Sad	Relationship building?	I am part of the class

				I am happy to work with you
S3	*Sir, we're done*			
T	*Right, you can be doing my calculations. Ok? So when the girls put the stuff on you're going to start doing the calculation.*	Neutral	Addressing a student on his right, not one brought to the front of class to measure	I am the organiser Instructional
T	*Ok, so if I give you... that* [Hands over board pen] *then you can start putting stuff on.*	Neutral/ interested	Handing over a board pen is a form of abdication of authoritative role? The student accepting the pen is accepting the given role	You are being assigned a role as recorder Instructional position
T	*Laura, what are you going to measure first?*	Neutral/ interested		I am the organiser I am the activity instigator
La-ura	*[Inaudible]...*			
T	*Ok.*	Neutral/ controlled	Teacher stands still and passive as two students measure his face and two more record his measurements on the interactive whiteboard	I am a willing participant
S1	*... to ... 19*			
T	*19*			Participant but also still instructor to recorder
S1	*Hair... I've got it the wrong way. 8*			
T	*8*			Checker of recording and measuring
S2	*4*			
S4	*4*			
T	*Thank you*			
Sx	*7.5*			
T	*It's only this... this from here to here.*			
Sx	*Thanks Sir.*			
T	*Surely it's only something like 3 centimetres or something?*			Shift back to not really abdicated instructor role
Sx	*I thought it was like round...*			

T	*No, no...*			
S	*Sorry*			
S	*No it's not...*			
T	*...it's actually the outside distance between my eyes...*	Neutral/ controlled	Uses hand gestures to illustrate	Instructor/ corrector
S5	[Another student] *Sir... which way is the length of the lips?*		The conversation preceding this question was from two boys in front and out of sight, but who could be heard discussing width and length for measurement purposes	
T	*Across*		Answering S5 whilst being measured	Responder/ holder of knowledge
S	*What is the hairline?*			
T	*12. Width of my head*	Neutral/ passive		
T	[To whole class] ***One more minute.***	Neutral/ passive		Time keeper/ supervisor Pace setter
T	*No, just straight across, just like in a photograph.*	Neutral/ passive		
S	*15*			
T	*Hairline?* [To S3] *You can start working out some.*	Neutral/ passive		Instructor Activity coordinator
S3	*Ok*			
S1	*about 7*			
T	*7*	Neutral/ passive		Collaborator
	Right I've got it about 1.6			
S2	*8*			
	What?			
	8 and then 1.26	Neutral/ passive		
	1.26			
T	*Just a second...*	Neutral/ passive		
S1	*4*			
S2	*4*			
S1	*7*			
S2	*5*			
T	*Ok brilliant.*	Satisfied	As activity is concluded. May include recognition of a task successfully completed	Recogniser of achievement

	[To whole class] *Right, everybody who's done, can they quickly do one of these calculations for me.* [END]	Neutral		Teacher/ instructor Pace setter

Table 4.13: Selected episode transcript and commentary for Freddie. F1/2 from Lesson F1

Smiling/encouraging → mock sad → neutral → neutral/interested → neutral/controlled → neutral/passive → satisfied → neutral

Figure 4.37: Freddie's emotional pathway: Selected episode F1/2

3 Freddie: Positioning within the selected episodes

This is an unusual example, explored further in Chapter 5. In the second selected episode, Freddie physically positions himself in a way that allows students close physical proximity within carefully defined task parameters. The selected episode raises questions about personal distance and control. It also presents a scenario where a teacher would not be able to express stronger emotions, even if desirable, as he has taken a position of participatory placidity (Fig. 4.37). If this was a different teacher, we might interpret this as a form of avoidance. However, in this case it is the opposite because of the physical proximity and inclusion in the activity. He responds to a perceived need for extension without disrupting the flow of the planned lesson, and it is perhaps a means of developing relationships within context. There is also the issue of how uncomfortable it made him feel. Externally he is showing no stronger emotions than interest, whilst later he talks calmly of the selected episode, whilst the ESensor sustained peak suggests otherwise.

4 Freddie: Analysis of interviews and the selected episode using ES

Freddie's dominant ES appear as LMTY, supported by CTO. In what follows, I discuss the construction of these ES using the interviews and selected episode and identify the *strands* which determine the dominant and supportive ES for Freddie. This is primarily through identification of the desire, need, evocation, behaviour and perceived reward as described by Goldin et al. (2011) and summarised in Chapter

4 (4.0, p.99-107). I then explain how the strands develop into and indicate the dominant and supportive ES for Freddie.

Freddie: Building ES from Goldin et al.'s (2011) strands

Freddie may be **motivated** by positive feelings from helping others or from being successful in a competitive form, as in being the best in a sport. He presents as ambitious, although he says he lacked this earlier in life. For this teacher, curiosity appears as a motivator, with anticipated reward from successful relationships. He finds being a mathematics teacher a fulfilling experience that fulfils a social need for interaction. He talks of puzzles and logic, and of training, even to the point of *'training students to enjoy maths'*. He sees that teaching should be a joint effort, *'not just being about me'*. That his role is to *'kind of juggle and manage'*. That decision making is a key skill, but motivation comes through challenge.

Subsequent actions include seeking out opportunities for collaboration with students or with peers. For example, he volunteered to be assistant head of house, an NQT mentor and runs a student puzzle club, although, in context, extra-curricular activity is expected of teachers at his career stage. His motivations manifest in classroom as discussion orientation and as practical interactive activities. He talks of decision making from a social orientation. The discussion is peppered with contingencies as well as an emphasis on social interactions such as using personal stories to teach, games or a **need** for fun when learning mathematics.

This teacher was less **expressive** in the observed lesson, almost distanced in this respect. Yet the selected episode may not be representative, as he says when being measured by students that he felt *'a bit like a plum'*. He presents as calm and confident which raises the question of how much having physical control internalises what, for others, might be externally noticeable affect. This might be a consequence of norms in some sports and training, as there was no doubt he was communicating effectively and body posture and gesture indicated that he was engaging positively. So in this case, **affective expressions** are perhaps less informative of **motivating desires**, although his **affective expression** shows interest and some enjoyment modelling, this is confirmed by his self-reporting of experiences of feeling good and especially of having fun interacting with students.

In terms of **meta-affect**, he may be pre-disposed towards positively interpreting his affect, with evidence in our conversations of self-monitoring which creates an impression of a degree if distancing from his own emotions. I would suggest he sees his frustrations as increasing interest, in that frustration becomes a challenge, a positive orientation that has become a **belief**. This matches evidence for **self-talk** or **inner speech** as some of what he relates is directed to himself in the form of thinking out loud, where comments, although appearing to be directed to me as interviewer, are neither intended for me nor directed at me. Usually, **self-talk** is considered in relation to children, with an assumption that it becomes more of an internal monologue (self and other in the same brain), as we get older (Vygotsky, 1978). If we consider the teacher as a storyteller, we have an adult form of identity forming **self-talk**. Adam (as discussed) talks his mathematical processes out loud using techniques such as rhetorical questions as a teaching technique. Yet, unlike Freddie, Adam's example is not quite self-talk as his commentary is intended to be heard by students.

Freddie's **interactions with linked systems of beliefs and values** can be divided into **beliefs** about mathematics education, self and social (Op't Eynde, De Corte and Verschaffel, 2002), beliefs which may impact on activation thresholds for ES. He talks about the nature of mathematics, himself as a mathematics teacher, the role of a mathematics teacher and how mathematics is taught and learned to varying degrees, yet he doesn't really talk about his mathematical **beliefs**, possibly as social interaction as helping others appears to be his primary **driver**. Freddie says he chose mathematics because he enjoyed it for himself. As he expressed in interview, he sees liking of a subject as essential for teaching, firstly through interest for self, followed by sharing of this interest.

In the longer term, Freddie's **intrinsic motivation** is to continue *'to be the best teacher I can be'*, by trying new things but there is also ambition. This ambition is not in the form of putting himself over the needs of others, since needs of others is core to his identities. My interpretation is that, for Freddie, relationships are important, but that you should also be able to enjoy helping others and be comfortable with self. Within **goal orientation**, my view is that approach is dominant, supported by some mastery and performance, but not avoidance.

The **strategies** that might be used in association with these beliefs, goals and motivations implies Freddie sees teaching as problem solving. Perhaps by addressing the problem of how one should engage effectively with mathematics in a teaching context, since his **motivating desire** must evoke supportive strategies. If Freddie prefers games, talk, interaction and stories when teaching, then his motivating desire is relationship building and his selected strategies prefer mathematical engagement as in interest. We would therefore expect to see use of strategies that preferentially promote interest or curiosity in others and for himself, as in CTO. In interview, he placed emphasis on reward, and the value of mathematics is from intrinsic pleasure, but with a practical value. He placed value on logic and problem solving, for example wishing to contextualise topics. A form of LMTY that identifies and supports student needs and applying effort accordingly.

The use of PT and ES for Freddie highlights the various forms that LMTY can take, in this case, centred on identifying need and helping through effort. The different forms of LMTY emerging for the teachers are discussed further in 5.4.3.

Gus (4.1G)

1 Gus: Emotions and affect in interview and post observation discussion

The first analysis stage highlights affect within the data associated with emerging themes or patterns. The discussion focus in interview centres on relationships in the teaching of mathematics, although the conversation ranged widely. This teacher has been teaching the longest of all the participants, and I was intrigued as to how his identities would align with his teaching role and with his view of mathematics, whilst acknowledging the unique nature of alignment of identities. The data for Gus emphasises the importance of talking mathematics.

2 Gus' lesson and the selected episode

I interviewed Gus in May 2014, and observed him with one Year 7 class which took place period 1, so there was no rehearsal. There were 21 students present, seated in short rows with a central corridor, Gus re-seated students to account for absences, so that no student sat alone. Gus' lesson was on 10^x and multiplying powers. By the end of the lesson the students had discussed x^0 as,

"zeroth law of indices"

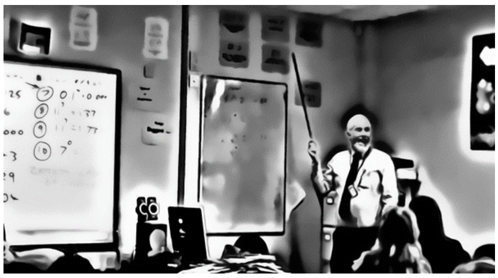
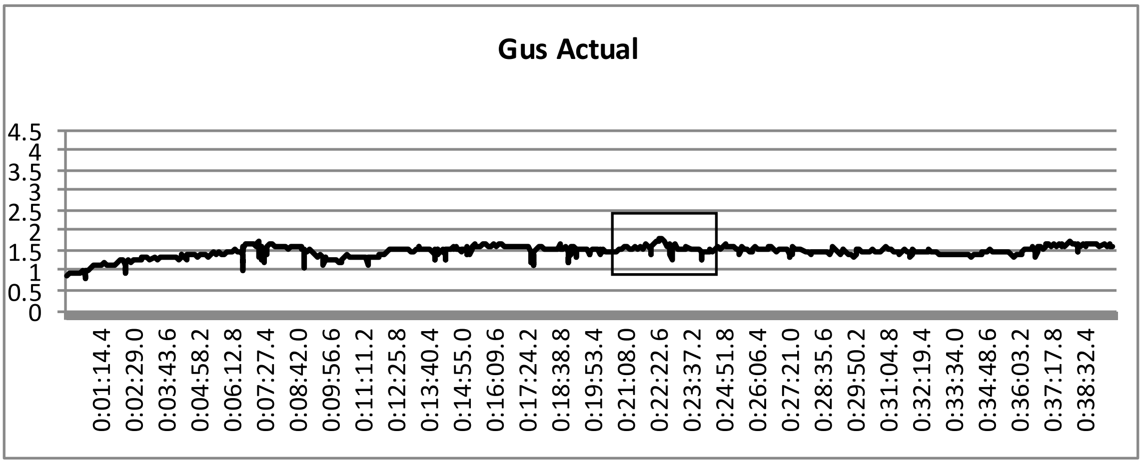


Figure 4.38: Pointing out the 'zeroth' law of indices

In Fig. 4.38, Gus points to this law displayed high up on the wall and enjoys that some students had not noticed this. Goffman (1997) suggests that there is less conflict where some expected roles have been abandoned. Gus in interview tells me that he has abandoned any behavioural rules within his classroom that in his view serve no purpose in learning. I would add that, given his extensive experience, his 'performance' is fine-tuned. Acting as relaxed in terms of behaviour, masks an intent by Gus to support learning.

Selecting the episode

The ESensor graphs and distributions are shown in Figs.4.39 and Fig. 4.40. I selected one selected episode for post-observational discussion based on the maximum value from the graph. The selected episode shows both teacher and students laughing loudly and represents the form of teaching used in the rest of the lesson.



Figures 4.39: ESensor recording as graph for Gus

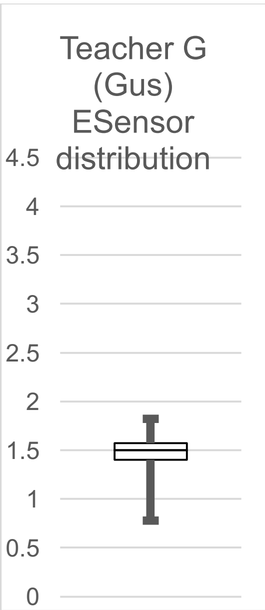


Figure 4.40: Distribution pattern for Gus

Presenting the selected episode: David Ginola and his hair

The selected episode (Table 4.14) shows Gus emphasising the correct use of mathematical language whilst waiting for students to complete a board task, before moving on to multiplying and dividing x^y. We see a small pronunciation error by one student, dissolve into a connective entertaining story about hair, football (David Ginola) and politics (David Cameron). However, as Gus returned to the mathematics, students were noticeably ready (as indicated by body language, face and attention), to fully engage in the task. The selected episode represents a pattern of on/off task throughout the observed lesson as well as common quips and banter used between students and Gus. The image shows Gus trying to control laughter whilst pointing at a student who had made an amusing quip (Fig. 4.41).

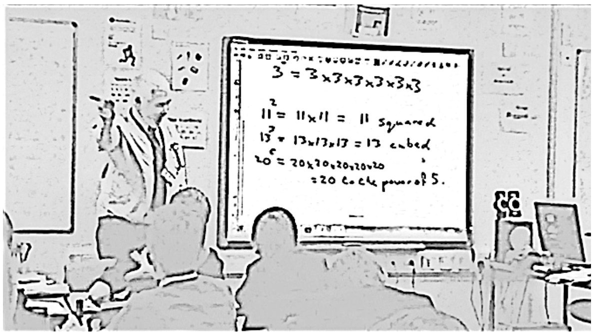


Figure 4.41 Gus attempting to suppress laughter

Speaker	Transcript	Assigned emotion	Interpretation (Observer notes)	Interpretation (Positioning)
T	[Completes oral words on board] *... and it's... it's making sure you use the vocabulary that maths teachers use. How do you become good at something? You use the right words. You use our language and we think you know what you are talking about. That's what you do in exams. If you go into a maths exam and use the right words, people assume you're brilliant. Ok? When you walk into your job interviews and you say... 'I can talk about your job in your language.' They'll think you can do it, whether or not you can. Right. Good Jem?* [Nods in confirmation]	Serious Happy and confident Cheeky grin	DEVIATION Beginning of story flows from task. Rhetorical question as thinking out loud Using hand gesture, me to you (mostly has hands to sides) The story moves to locating the point in a wider context, but is still about vocabulary use. Stories keep flow whilst allowing thinking time. Multi-levelled extrapolation, he is transposing himself to imagine being not just student, but student grown up, and student in a job interview context,	I am telling you a story I know how this works and am sharing this with you I am the expert, 'our language' aligning with mathematics I have wide knowledge, wider than mathematics I have more experience than you I am paying attention to your needs You can be anything you want to be

	So it just tells you um... just learn the vocabulary. You can walk in number 10 Downing Street and talk like a prime minister, and people think you can do the job... until you've been there for an hour.		still using the skill of vocabulary. The flight of fancy even transposes one of the class into being the prime minister!	
S1	*Is that how Dav... David* [Day-vid] *Cameron done it?*		Meant as cheeky comment but went a bit wrong in transmission, pronounced David more as French or Welsh	Accepting position
Jeff	*D**a**vid* [Dav-id] *Cameron?* [Laughter from students]		Quick picking up of nuance of speech, but not critical	Attempt at humour (1st QUIP) (mimicry of teacher?)
T	*Dav-id Cameron?*	Head on one side, smiling/ interested Playful	Returning attention to teacher, away from S1, but also takes the gentle ribbing one step further	Accepting attempt at humour Quips from students are Ok
S2	*It's not Dav-id, it's Day-vid*		Ignored comment	Rejected contribution
T	*Dav-id Cameron, who plays football like Dav-id Ginola? Yes.*	Still smiling	Stronger **shift** back to teacher from students. Thinking of David Cameron the UK PM seems to trigger thinking of David Ginola the footballer. The pronunciation is as the Welsh/ French (Dafyyd/ Da-veed) rather than English pronunciation (Day-vid). In this way he is repairing the student slip, and locating his own identity as Welsh. Gus also loves sport	Pay attention to me now. I can wrap this too into my current story

	[Looking at a 3rd different student to Gus' right] *You've heard of Da-vid Ginola?* [Louder laughter]		There is probably an underlying sub-story relating to this student and his knowledge of football, one that the whole class would know and respond to?	I know more than you I have more experience than you
T	*No?* [Laughter] *Sorry...* [Flat hand out to student]		[Sensor peak] Perhaps apologising for putting one student on the spot?	I am sorry, I do not expect you to know really
Jeff	*He said 'yes', so you'd think he knows what you are talking about* [More laughter, teacher as well]		QUIP (2nd)	You have assigned approval for quip, so I'm doing it again
T	*Nice one Jeff. No, seriously, did you know David Ginola used to played football for Arsenal,*	Laughs	Approval and then returning to story as unfinished at this point	Approval of quip
Sx	[Sings] *Arsenal are useless...* [Inaudible]...		Expected response, of no value to story at this point so ignored	Rejected attempt at deviation
T	*...and when he finished... when he finished his footballing career, he got a model... as a hair model... he used to advertise shampoo* [More laughter]	Happy and confident	This part is strange? Why would he continue the story? Is he still just entertaining? Perhaps it is because he has to be the one to finish the story so that he retains control?	I am the storyteller
S4	*Funny. You could do shampoo when you finish your teaching* [The students knew this teacher was retiring at the end of the school year] *You could do that.*		Student continuation of banter Is this what this class is learning? How to imagine and play?	Student is accepting story from teacher, realigning it with his own experience i.e. a distanced story is brought to the

			Also the student is attempting to position as if teacher	local context [Very skilful]
T	*Yeah, can you imagine this saying...? 'Grecian zero, for men who want to be grey'* [Laughter] [Gesture – strokes his head back as if still has lots of hair]	Happy and confident	He has grey stubble, so almost no hair. He is picking up the student contribution and taking it further	Accepting of contribution, including the local realignment. Positioned as man in a hair commercial Fantasising/ imagining is fine.
S5	*No* [More laughter]	Laughing voice	QUIP (3rd, but not the same student)	Accepting fantasy
T	[Dramatic pouncing steps towards S5 whilst laughing] *Was that you?*	Laughing Happy and confident	Playing physically as well as verbal Mock crossness ends the story He has to end the story, perhaps this is a control thing. Humour as control?	I appreciate your contribution
T	[Returns to board] *Ok. Right. So...* [Prepares board for writing] *Ok, So...* *[END]*	More serious	Once ended, the mathematics learning can continue and the task is promptly returned to	

Table 4.14 Selected episode transcript and commentary for Gus. G1/1 from Lesson G1

Serious → happy → cheeky grin → head on one side/smiling → laughing → happy/confident → serious

Figure 4.42: Gus' emotional pathway: Selected episode from Lesson G1

3 Gus: Positioning within the selected episode

As with Adam, the PT analysis highlights a strong future orientated positioning within the episode. In this case, there are several attempts by students to negotiate assigned positions, some of which are accepted by Gus and some rejected. This selected episode explores the place of humour, as deviation within mathematics teaching, as having both unexpected and entertainment value. For example, exploring whether use of humour is more associated with being off task ('not mathematics'), and if so, what role humour has when a teacher is constrained by time and curriculum. Suggestions include how humour can support classroom management and create a positive atmosphere for learning. Yet some teachers do not use humour in this way, yet still have supportive environments for learning.

4 Gus: Analysis of interviews and the selected episode using ES

I have identified LHSIA as a dominant ES for Gus, but he also draws from LMTY, supported by DDM, CTO and IRIT. I have positively characterised Gus as 'Let me entertain you whilst you learn', a serious frivolity position that distinguishes Gus' unique 'Let Me Teach You' (5.4.3).

Gus: Building ES from Goldin et al.'s (2011) strands

In terms of Gus' **characteristic goals and motivating desires**, this is not the only teacher to have relationships as a primary motivation. There is also evidence of a desire for social appreciation that appears to be deeply rooted. This appears as when talking of relationships with authority, the 'people' (kids) and other teachers as well as with mathematics as authority. Emotions are mentioned primarily in terms of relationships or when talking about his identities as a teacher. His **goals** are to communicate mathematics, to be relaxed but also to maintain control. The associated **patterns of behaviour** seem to produce an image of an engaged teacher who enjoys the role of sharing knowledge and who positions himself as a conduit between mathematics and students. The model he shares is one of patterns, associations, connections and he associates this with comfort in his working environment. His activity (as he describes it) outside the classroom supports this view, such as being involved in the Duke of Edinburgh (DoE) activity scheme. DoE, as for Scouts, is recognised as effective in developing relationships. Gus lives in the school catchment area and his own children attended the same school, so his local social relationships are wide. He taught many of the parents of his current students. Underlying this wider participation, he uses **strategies** to avoid personal boredom, but also which serve to relax students. His affective responses are used in the classroom through paying attention to presenting as continually having fun, in the true sense of serious frivolity (Claxton, 2003; Lake, 2017a). As an observer, this position presented as a performance, as on stage, but with constant interaction with his audience, such as a stand-up act. Audience participation was encouraged and recognised, as being supportive of relationship building but, as with any show, the lead comes from the stage. Therefore, the classroom power relationship remains firmly centred on Gus, and in some ways he teaches through a manipulative form of performance designed to engage the emotions of the audience.

A **characteristic pathway** appears to be centred on discrete selected episodes that are presented in the form of stories, often connective. The selected episode illustrates this pathway, as Gus takes the key learning point of the mathematics leading up to the selected episode and weights it with importance by the time dwelt on it. This choice emphasises to students that mathematical language and vocabulary is important, both to learn and to use. In the selected episode, Gus is socially linking and playing verbally with students. The lesson, as a whole, shows a **pattern** of intense mathematical concentration interspersed with banter and relaxation through story, anecdote and lots of laughter. I would suggest use of humour applied in this way plays a significant role in communicating mathematics. I observed a teacher who is visibly **expressive**, often smiling and laughing and using positive hand and body movements, which are stylised and exaggerated for various purposes e.g. a pouncing walk using to mock challenge a teasing remark from a student. The observable manner is supported by expressive use of language via storytelling.

There are many multi-layered **meanings** encoded in this teacher's performance. For example, he tries to develop imaginary scenarios both with and for his students. Much of his emotional expression seems to have a strategic purpose, although I am not sure he is aware of this dimension. I would suggest he **is** a mathematics teacher, not acting it (Goffman, 1997) and his identities are closely aligned to the role. His main means of communication is verbal. I would suggest his **internal representations** of mathematics are deeply embedded and strongly attached to emotions. This implies that he is not just feeling, but continually experiencing the **meaning** of his feelings in a **meta-affective** form. He seems to take potential negatives and even as speaking, shifts these to positives because his practice is so deeply embedded (and vice-versa) into his beliefs and values. The implication is that his **thresholds for motivating desires** in context are in a very different place, comfortably close to the surface. Yet at the same time he feels in control, that any challenges will be manageable. Goldin et al. (2011) suggests this means a lower threshold for ES activation that may also make positive emotions more likely. Gus' beliefs are attached to his 'in-the-moment', and his mathematical engagement is attached to the social. In terms of **goal orientation,** there is approach, mastery and performance, with performance dominant, this appears in a form characterised as 'Look how smart we are', reflecting his social orientation.

Gus is likely to draw from six ES, which shows a wide variety. DDM was evident, and in interview, he comments on having to be careful about dominating students. The other five ES; CTO, IRIT, LMTY and LHSIA are socially orientated which aligns for this teacher and all are likely to be positive, drawing attention in some manner, including from an audience. All ES that are associated with high self-efficacy. This also appears in his emotional pathway (Fig. 4.42). There may be significant fluidity in his shifting between ES, shown by examining the rapidly changing positioning in G1/1. This too is the case for the PT positions, which change fluidly and frequently within the episode. The new question for future research arising from Gus' analysis becomes whether it is not in fact the designation of ES that is significant, rather it is the fluidity and free movement between ES that is supportive of student engagement.

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Helen (4.1H)

1 Helen: Emotions and affect in interview and post observation discussion

I interviewed Helen in June 2014, and observed her the following week with Year 7 students, whilst the rehearsal was audio recorded for Year 10. The post observation discussion took place the next week. Helen presents as a cheerful and dedicated teacher. In interview, she tells of choosing mathematics because she enjoyed it at school. The discussion on both occasions was dominated by discussing individual students and the place of exams within mathematics teaching.

2 Helen's lesson and the selected episode

Helen has an unusually shaped classroom, in an L shape, which restricts how she might arrange desks in a small room. Her choice is to use rows, but some face inwards, rather than facing the board. The lesson was on preparing students for a forthcoming exam at the end of the academic year. In the first part, Helen did some questions for the whole class on the board. The selected episode is taken from the second part of the lesson after students are re-organised into groups. The task they are about to begin uses exam questions on slips of paper. Each group is given a slip, they work together to obtain an answer, and then check with Helen centrally. They are awarded points for correct answers and points are deducted for asking for help. The students seem familiar with this form of activity.

Selecting the episode

On this occasion, the ESensor did not record for either rehearsal or for the videoed lesson, so the choice of selected episode is based on repeated video re-watching. There were no clear indications of positive emotions to use, so the selection is based on noticing Helen expressing slight impatience.

Presenting the selected episode: Exam preparation activity

Figure 4.43: An image from the selected episode in Lesson H1

The clip (Table 4.15) begins just after students are finishing reorganising themselves into small groups, ready to do group questions as an activity. The groups are decided by the teacher. All are seated except one student (shown to the left in Fig.4.43) who takes a long time to move himself and his bags to his new group.

Speaker	Transcript	Assigned emotion	Interpretation (Observer notes)	Interpretation (Positioning)
T- to class	*Shhhhhh. Right listen carefully please, listen.*	Neutral	Looking round room. Louder for addressing whole class	I want your attention
T – to individual	*Sort yourself out quickly Joe please.* [He takes no notice and continues to move very slowly]	Slight impatience	Quieter speaking, hand flat out to right, but student is not facing her [See image]	Do as you are told I do not want to talk to you at this moment I want you to follow instructions
T- to class	*Sh, sh. Stop talking. Right, Ok.*	Neutral		I know where this activity fits in
T- to class	*We have done this before, but I'll just remind you of how it works. What's going to happen is that I am going to give each team a question. You will need to work on it in your groups. When you **think** you've got the correct answer, one of*	Neutral	Setting context of activity, in that it should be familiar. As Helen talks Joe is slowly carrying his bag from his original	I want your attention (Listen to instructions) Giver of instructions

	you needs to come up and check it with me. [Joe thumps his bag on table loudly] *If it's correct first time round you get 5 points. If it's not correct, you've got another two chances. Second time round you get three points...*		place in front middle to his allocated group. He then thumps his bag heavily on a table and slowly returns for a chair which he then scrapes across the floor to the new position	Organiser Rule setter (as in for board games) Instructor Confirmer of correctness
T – to individual	*Pick up the chair please, stop scraping it*	Slight impatience	[Joe is dragging his chair across the room, showing reluctance? She looks at him frowning]	(specific direct instruction) You will do as you are told by me
T- to class	*...and **third** time you just get one point if you get it right. If you don't get it right after three attempts you can move onto the next question, but obviously you don't score any points. Sh sh.* [Associated hand to mouth gesture] *If you want to ask for some help that's ok, you can have some help, but that will **count** as one of your **tries**. Ok. You **can** use a calculator, it's designed to help you with the calculator test, so it's those sorts of things, although actually it's probably a bit harder if anything...*	Neutral	Still looking to check following instruction Eye moving round as in checking **Nods as says these words, some hand gestures used for emphasis** Use of 'it' separates her from activity, not sure why when she created it [Ownership?]	Rule giver Help giver I too obey rules of learning (internal/external mediation) Mathematics is difficult?
T – to individual	*Please tuck that shirt in! If I have to ask you again it will be a detention.*	Cross (Mock)	[Now moving around the class handing slips to each group]	You will do as you are told or else... Role of teacher Rule enforcer
T – to Joe	*Excuse me, I need to be able to get through here*	Slight impatience		Expected of courtesy
S1	*we start now*			

T – to individual	*You can start as soon as you get your sheet* [END as one student brings up an answer]	Slight impatience/ neutral	Uses voice like 'you should have known that'	Instructor Invigilator

Table 4.15: Selected episode transcript and commentary for Helen. Lesson H1

Neutral →slight impatience → neutral → slight impatience → neutral → cross (mock) → slight impatience → slight impatience/ neutral

Figure 4.44: Helen's emotional pathway

In the observed lesson she smiled only once, and could not give a reason for this. The emotional pathway is indicative of the lesson (Fig. 4.44). There are no peaks indicated in the selected episode as the sensor failed to record.

3 Helen: Positioning within the selected episode

I would interpret Helen's positioning in this episode as that of a 'traditional' teacher, one who directs the class by instruction from the front rather than as a facilitator. Although the short episode is setting up an activity, and this means giving instructions, the interpretation agrees with her stance in the discussions, that mathematics is about passing examinations and the students need to be successful in these.

4 Helen: Analysis of interviews and the selected episode using ES

Helen's dominant ES are LMTY and GJD, supported by CTO, DDM, PE and SOOT, and as the case for another experienced teacher, Gus, she draws from a wide range of possible ES to activate within her teaching.

Helen: Building ES using Goldin et al.'s (2011) strands

In terms of **motivating desires and goals**, Helen talks of helping students formulaically and the observed classroom relationship was unequal between teacher and student and I felt like there was a formal distance between them, a distance that also appears for Freddie and Edward. Judging by her unemotional observed interaction and the way she talks of teaching, her goals dominate her desires. She talks of compartmentalising different roles in her life, which fits this interpretation. The need that requires fulfilling is for students to pass mathematics exams so her aim is towards this goal.

Her story and data from observation both show a **pattern of behaviour** that includes a strategic way of thinking. I do not have evidence of an emotional attachment to mathematics, other than she liked it for herself at school, and that she likes marking and algebra, both examples of where mathematics is formally structured. This implies that task completion appeals to Helen. The selected episode comes from a lesson formed as a series of directed task completions, the choice and format of activities is teacher led.

Helen's **pathways** are directed towards having a functional well behaved class, who are engaged in and successful in mathematics and she prefers top sets for this reason. Her **self-appraisal** is practical too. For example, when watching the video, she sees a need to talk slower or to tidy up the room. Judging by this example, there are two pathways running through the interaction that are distinct. These are between the social, where she is predominantly neutral in body and tone for whole class and interaction with individuals where the positional relationship is more of parent and child.

In terms of her **externally expressed expressions of affect**, there was no laughter in the lesson and she adopted a bland facial expression. I would suggest this is learnt behaviour. She tells of negative early career experiences that have encouraged her to suppress her emotions, to not show them in class, sufficiently so to have become an embedded trait. Although not emotionally expressive externally, Helen provides some clues from her body language and hand gestures and some negative interpreted facial expressions. She used voice, head, hand and body movements to indicate importance to students, such as an idiosyncratic nodding directly linked to key words or instructional actions. I would also suggest that this teacher has strong **self-regulation** that means her emotions are less observable as a means to provide evidence for her motivating desires.

Helen's **internal representation system** seems fixed and strategic, and although she imagines in the form of scenarios, this is strategic imagination. Her verbal communication is practical which aligns with a view that her role is primarily functional. She suggests in interview that she does not reflect deeply, living in the moment as a person. Her **self-talk** does shift her from interview into talking directly to a student, but unlike other teachers there is no evidence of placing herself into the position of students, in fact distancing is noticeable.

I would suggest the **beliefs and values** are evolved from experience rather than reflection, but then, as she says, she has no time to be reflective. I would suggest that restricting her role to functional instructing means feels that she has better control, although perhaps she does not in fact feel in control, despite appearing confident and being very knowledgeable about her subject. This indicates, unlike say Gus, a high threshold of activation of positive emotions, perhaps as expression is directly correlated in her belief systems as being out of control and therefore to be avoided. In terms of **goal orientations**, she exhibits traits of avoidance for the social dimension of teaching mathematics and mastery over performance.

The emerging **characteristic strategies** are that mathematics is strategically directed, a tool, that successfully negotiated will give a student, parent and herself (by implication) reward. Success in exams seems to be the primary driver, so students risking not being successful in exams is a vulnerability for this teacher. Associated with this, playing games and activities can only be allowed after exams (she says) because they are high risk in terms of paying attention to exam success – even perhaps to the point of time wasting. This may be a common position even when speaking to others of the rhetorically acceptable advancement of play within mathematics teaching, that what they say and do are not matching because the teacher does not truly believe it is of value.

Helen is likely to draw from LMTY and GJD, supported by CTO, DDM, PE and SOOT. Given that her observed lesson shared few characteristics with Gus, a further question is whether the order of dominance of ES is more important than the variety. LMTY and GJD are most likely to appear according to this data. Her interview was orientated to GJD with references to exams and rules as drivers. Her unique LMTY within her teaching was influenced by engaging in the other ES.

The GJD dominance seems to connect with the identified position in the selected episode, centred on exams and achievement as being central to learning mathematics. My experience suggests that, although this dominance is not so central in the other selected episodes for the other teachers, it may well be common among the population of mathematics teachers.

In 4.2, I draw together the ES for all the teachers, not to compare the teachers, but to consider any commonalities and differences and questions to explore that then guide the Chapter 5 discussion.

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4.2 Summaries of analyses; ES, PT and Pathways

4.2.1 Summarising ES for all teachers

	ADAM	BERTHA	CAROL	DEBBIE	EDWARD	FREDDIE	GUS	HELEN
INF It's not fair								
SOOT Stay out of trouble								
PE Pseudo-engagement								
DDM Don't disrespect me								
LHSIA Look how smart I am								
IRIT I'm really into this								
GJD Get the job done								
CTO Check this out								
LMTY Let me teach you								

Table 4.16: Summary of ES for all participant teachers

Key:

There are 3 shades which match the identification for each teacher earlier in the Chapter. The stronger the evidence within the data, the darker the shade. The categories are partial, supportive and dominant (dark grey). This does not mean that other ES are not drawn upon by teachers at various times during lessons.

Table 4.16 summarises the ES for each teacher. There is no intention to compare teachers as their teaching characteristics are unique. However, it is noticeable that the attributable ES are also unique, whilst examining the data in this way suggests some areas to explore further. For example, a preliminary conclusion, based only on this table, is that, as the participating teachers have more experience, the number of ES used increases, whilst the rate and fluidity between ES also increases (see Pathways, 4.1 A-H, 4.2.3). It may also be fruitful to explore the ordering of the patterns. The use of PT has proved useful in identifying the patterns for the participating teachers. The data presented in Table 4.16, and the analysis raises questions about which ES might prove to be more supportive of student engagement (5.4). Some may be less conducive to emotional expression or indeed learning, such as SOOT or PE, or to some degree, DDM, which seems to be a potentially authoritarian ES when considered for teachers. There are ES that may serve a variety of wider purposes for the participating teachers. For example, IRIT may support a teacher engaging in modelling of mathematics (See 5.2), or the frequently occurring CTO, may support modelling of a teacher enjoying engaging in mathematics for intrinsic pleasure (5.0). CTO might support telling mathematics as an engaging story (5.3) in a variety of ways. Some ES as appearing in this Chapter have a playful dimension (See 5.1), as well as a social orientation, whereas IRIT might be considered as self-experiencing of learning mathematics as enjoyable; a modelling of pleasure for self in doing mathematics.

The patterns and interconnectivity of ES, whilst allowing focus on one ES, seems useful. An advantage is the wide nature of ES, as it is a model that applies to more than mathematics. The way in which ES and PT connect and reveal patterns, for example through identifying possible pathways via discourse, suggests PT might give insight into mechanisms for ES. The interview summaries draw out any emotional attachment a teacher feels to the subject and how they view this attachment as impacting on their teaching, which then directs the likeliness and dominance of each ES.

4.2.2 Summarising PT for all teachers

The value of using PT in this study is on what it reveals that is more than one model alone. For example, Carol's aligning of espoused and enacted alignment is revealed by PT use. Similarly, the nuances between the two apparently similar episodes for Edward. The pronoun use as a pathway in itself was useful in this second example, and for comparing Edward's subtle positioning in regard to Sam and Joe. This subtlety in the way teachers are using positioning is intriguing. For example, there seems to be more acceptance or negotiation, compared to rejection, where there is fluidity between ES. The likely associations with experience, especially if combined with physical positioning as in the case of Freddie merit further investigation. These possibilities are explored further in Chapter 5.

4.2.3 Summarising Pathways for all teachers

The pathways are as follows. Most of the episodes are of a similar length, between 1 and 3 minutes, depending on the episode.

Carol (C1)

Neutral → slight impatience → puzzlement/confusion → doubt → interested → neutral → stronger interest → interested → neutral → interested → mild frustration →interested → neutral → satisfied

Adam (A1)

Confident/assertive → neutral → confident → neutral → confident → neutral → confident → uneasy → confused → some certainty → interested →doubt/uncertainty → pensive → satisfied → pleased → humorous → confident→ neutral → confident → pleased, almost laughing → enthusiastic → confident → relaxed → confident → neutral

Adam (A2)

Interested → Questioning (puzzled) → interested/ neutral → intense emphasis

Adam (A3/1)

Neutral → slightly confused → patient → relaxed → content → puzzled → neutral → relaxed → smiling/laughing → neutral

Adam (A3/2)

Anticipating → excited/pleased → encouraging → questioning → happy → slightly irritated → encouraging → pleased/excited → serious → playful → calm →interested → neutral

Bertha (B1)

Neutral → confused → neutral → uncertain → confident → responsive → caring → pleased → satisfied → neutral → satisfied → uneasy → neutral → satisfied

Bertha (B2)

Impatient → sarcastic → hostile → sceptical → dismissive → impatient → irritated → neutral → neutral/ frowning

Debbie (D1)

Interested/Neutral → confused → Interested/ engaged → mock excited → interested → impatient → pleased → mock sad →interested /neutral

Edward (E1/1)

Considerate → Relaxed/Good humoured → Interested/ puzzled → Embarrassed → questioning → anticipating → pleased

Edward (E1/2)

Neutral → serious → Ironic humour (no tone change)→ neutral

Freddie (F1)

Smiling/encouraging → mock sad → neutral → neutral/interested → neutral/controlled → neutral/passive → satisfied → neutral

Gus (G1)

Serious → happy → cheeky grin → head on one side/smiling → laughing → happy/confident → serious

Helen (H1)

Neutral →slight impatience → neutral → slight impatience → neutral → cross (mock) → slight impatience → slight impatience/ neutral

The episodes were, where possible, selected by emotional expression, so emotions are central except for the cases discussed earlier of Helen (4.1H) and Bertha (4.1B). The rapidity of changes in some episodes is noticeable, but are not consistent across individuals such as Adam (4.1A), for whom we have four episodes. Nevertheless, the pathways reinforce the potential significance of fluidity and complexity as indicative of ES and PT shifts and changes.

4.3 Concluding remarks

Carol, and to some extent Edward and Freddie, have challenged my formerly held view that, in to engage students in learning, there must be some notable teacher expression of positive emotions, that they have to be overtly expressed to be useful. Carol, although she uses positive facial expression, remains neutral most of the time, as does Helen. When Carol shows emotions, they are supportive, for example showing pensive, thoughtful or interested expressions that model being engaged. Although she rarely smiled during the observed lesson, Carol presents as interested and engaged in serious learning. The ‘serious-engaged’ may prove to be a strong affective position for any teacher, especially if students are unconsciously copying behaviours. I would suggest that Carol’s emotional states and affective traits are intended to, and have proved (for her) to promote social interaction and are supportive of learning. An exception might be impatience which appears in the interviews with Carol in association with guilt and boredom. Yet, since this teacher is very experienced, are her emotions then suppressed? Although we have no ESensor recording for Helen, the exhibiting of more emotion during discussion than in class may be indicative of suppression, as is (on average and comparatively higher) an internal GSR recording, as for Carol.

In this Chapter, I have considered the data in the light of Goldin et al.’s (2011) ES and examined selected episodes in detail using PT. Questions raised by this discussion include whether being more experienced increases the number of ES that are applicable or available to a teacher, or whether becoming more familiar with the roles and responsibilities lowers some activation thresholds or whether subsequent fluidity allows more dipping in and out of ES. Further, LMTY is not always a dominant ES and appears in a different form for each participating teacher. In 5.4.3, I explore LMTY further, to show how, although an ES might apply to all the participant teachers, there will be nuances and variations between individuals, suggesting subsets of ES.

I now know something about what gives the participating teachers pleasure in their professional lives, and can illustrate emotional use in action. Throughout this Chapter, I have been drawn to the various ways positive emotions are expressed as play or playfulness. This is particularly the case for Adam, Debbie and Gus, but appears in some form for most participants. Similarly, what the teacher is modelling when expressing positive emotions invites further investigation, and the storytelling seen in the teaching of both Adam and Gus seems to encapsulate how stories might have an important role within affective mathematics teaching. In relation to positive emotions, risks and benefits seem important. In Chapters 5 and 6 I further discuss some risks and benefits associated with these participant teachers. Finally, it is evident from the interviews that these experienced teachers articulate enjoyment of their teaching, so I have chosen to explore positive emotions for self as the fourth theme.

In Chapter 5, I consider these four social and individually located themes of self (5.0), play (5.1), modelling (5.2) and storytelling (5.3) that have emerged for me from this Chapter, initially by returning to these concepts in the literature and then discussing these themes in relation to the data. I return to ES and PT in section 5.4 to discuss some implications of use. This section includes an illustration of modifications that might be applicable to examining teacher ES in the future, based on the discussions presented here for the participating teachers, before drawing the discussions together in Chapter 6 in relation to the research questions. At no time am I seeking to draw some more widely applicable conclusions just from research involving 8 case studies.

Chapter 5: Discussion

In this Chapter, I explore how the participating teachers speak of and use positive emotions to establish a unique workable identity within a dynamic, temporally-changing relationship. I first exemplify teacher enjoyment within the teaching of mathematics, drawing mainly from interview and post-observation discussions, through which I explore positive emotions as espoused by the teachers as enjoying teaching; identifying the pleasure that such social activity gives to self (5.0). This provides a backdrop for exploring the three, connective classroom-located social themes identified in Chapter 4. The four themes, beginning with the individual teacher in 5.0, and the social themes (play, modelling and storytelling) in sections 5.1 to 5.3 of this Chapter are:

5.0 Teacher enjoyment within teaching mathematics

5.1 Activating positive emotions through play or playfulness in a mathematics classroom (such as a teacher being playful with students)

5.2 Modelling engaging in learning mathematics or of how ‘to be’ when learning mathematics

5.3 Storytelling as a means to communicate mathematics and to engage students emotionally

The discussion of positive emotions as espoused by the participant teachers and the three social themes provide structure for discussing the role that positive emotions take in the classrooms of these experienced teachers. The roles are illustrated using examples from the selected episode data. I conclude Chapter 5 with a review of the use of PT and ES in this study (5.4) and concluding remarks in 5.5.

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5.0 Teacher enjoyment amidst teaching mathematics[10]

Pleasure can be defined as a feeling of satisfaction and enjoyment, yet pleasure is also a subjective mental state experienced as enjoyable and hence worth seeking. It is a state that is satisfying more than just basic needs or biological drives. There is a psychological feedback mechanism that engenders a potentially addictive feeling of positive anticipation resulting from experiencing pleasure. Pleasure is used in this study in an aesthetic and ethical sense, unlike, say, the French term ‘jouissance’ that has stronger physical connotations. Litman (2005) suggests pleasure links mathematics with an appetite for food, where satiation or reward comes from positive feeding of social identity and community recognition. There is also a social reward, that for teachers is associated with recognition and service. Ethical hedonism is defined by Onfray (2007) as an introspective attitude to life based on taking pleasure yourself and pleasing others, without harming yourself or anyone else, which is ethical yet purposeful in context. When all three elements are addressed, the result is stronger and more memorable experiences of pleasure. Ethical hedonism can be thought of as joyful utilitarianism that additionally provides moral pleasure. This definition emphasises the social dimension of pleasure, whilst the positive emotional disposition or attitude of a mathematics teacher is derived from previously experienced pleasures (Di Martino, 2011). Yet, unlike happiness, which is more stable, there is a temporal element to pleasure. Whilst one can again experience pleasure on recall, a person cannot always be in this state. Yet this very temporality may effectively aid a desire for re-creation and compensate for any associated unpleasantness. Like Utilitarianism, the ‘greatest good’ of ethical hedonism engages a person cognitively and viscerally, whilst also aligning one’s own pleasure with that of others. This multi-levelled view accords to pleasure the dimensions of self, others and ethical. In this section, I explore whether there is

[10] This section also appears as, *‘Two things I like, maths and chocolate’: Exploring ethical hedonism in secondary mathematics teaching’* (Lake, 2015b).

evidence for ethical hedonism within the teacher narratives, whilst identifying what the teachers suggest gives them pleasure in their roles. To facilitate this, I next locate pleasures for teachers within research, and seek some structural themes to support the discussion of teacher pleasure.

5.0.1 Structuring pleasures for mathematics teachers: deviation, dependability and success

Research on the role of teachers, power relationships in classrooms (Walkerdine, 1988) and pleasures from deviation (defined as digression from a given plan or scheme) (Drodge & Reid, 2000), can all inform understanding of pleasure, as can Smith's (2010) examination of pleasure in the form of happiness in learning mathematics. She found that the stable trait of happiness for mathematics students, especially subject pleasure, came from the dependability of mathematics. Smith (2010) suggests that by using and reproducing a mathematical identity, people derive pleasure and hence happiness. Smith's research suggests that pleasure is often equated with success, and that work and happiness can coexist in contemporary society, where happiness is often presented as the sole purpose of life, and society promises to provide conditions for you to obtain this happiness. This balance of work and happiness can exist for teachers too, but with an additional complexity for the role of a mathematics teacher regarding vulnerability and risk.

Between freedom and compliance, within the autonomy of a mathematics classroom, lie experiences of deviations from 'norms' that can give pleasure. Vulnerability, in the context of teaching, derives from conflict of mastery and submission (Davies, 2006). In this model, risk or vulnerability may come from exposure to judgement, whilst pleasure derives from a sense of connectedness. The degree of emotion a teacher is comfortable showing may come from balancing these two limits. This perspective is important, as it may be that exercise of freedom, self-regulated within constraints, is what gives pleasure. Yet simultaneously, social recognition from being recognised as compliant in a system can give pleasure. If a teacher's own learning was empowering, and pleasure derives from successful teacher and student interactions, then revisiting an environment where success was experienced may trigger re-creation desires. If pleasure deriving from repeated experiences of success is significant, then teacher interviews would have frequent examples of classroom located positive educational experiences. Mathematicians also obtain a sense of pleasure from mathematical discovery that may also apply to a teaching context. Similarly, 'Ah-ha!' moments, such as when a method or solution becomes suddenly clear, and hence a success, are known to be pleasurable for learners and bring power along with the experience (Liljedahl, 2005). The same pleasure for teachers could be a revelation of a student misconception, or through being a witness to student pleasure from their 'Ah-ha!' moments. If pleasure is associated with deviations from the norm, either a discrepancy (Drodge & Reid, 2000) or an 'Ah-ha!' moment, then deviations can elicit emotional reactions and hence are likely to be recalled in interview, but may also elicit strong identifying statements that are directed at the deviator, often a student. Robert & Wilbanks (2012) suggest an enticement to engage in more similarly rewarding activities,

> *"We experience pleasure if the sudden resolution involves an unexpected connection. Making that connection has been likened to cognitive 'play' and to the feeling associated with solving a puzzle"* (p.1073).

Deviation may appear in many forms; difference from routine, deviation from 'normal' behaviour, as in the unexpected, or from the pleasure of making unexpected mathematical or social connections. A balance between affect and cognition is important for effective teaching. Frenzel (2014) says that,

> *"[T]eachers judgements of their capabilities to produce desired educational outcomes in their students, referred to as teaching efficacy in the literature […] can be a source of positive emotions for teachers."* (p.504).

There are indications that pleasure appears both in discussions with the participant teachers and in the selected episodes. Identifying expressions of pleasure is both recognising appearances and interpreting the role that such appearances take.

5.0.2 Positive emotions as perceived by experienced teachers

"Two things I like, maths and chocolate" (Carol)

In 5.1 to 5.3, the role of positive emotions is discussed predominantly from a social perspective. Nevertheless, drawing from the literature and reflections from the participating teachers, it seems that the use of positive emotion has a beneficial role for individual teachers. The literature review and the analysis in Chapter 4 indicate that profounder pleasures experienced by mathematics teachers derive from a living of self, motivated by service to others (praxis). I frame the following discussion by identifying the three elements that give teachers the greatest pleasure in their teaching of mathematics, the constituents of ethical hedonism. Further, that to teach effectively, experienced teachers must continue to receive sufficient affective reward from engaging in teaching.

The first two constituents of ethical hedonism influence the analysis of interview data by suggesting a division into pleasure for self and pleasure for others. Pleasure for self can come from a teacher's relationship with mathematics and from self-identifying stories. Social pleasure for others derives from the role of a teacher as a professional, who acts by praxis and receives recognition from significant others, as well as from students. Thus table 5.1 presents a fuller structure for examining teacher pleasures.

Pleasure for self	Relationship with mathematics	Self-identifying stories
Pleasure for others (Social interaction)	Role of a teacher as professional (Praxis)	Significant others

Table 5.1: Analysis categories for examples of pleasure

I draw primarily on samples from the interviews to illustrate teacher pleasures. All the participant teachers talked about the four categories (Table 5.1) in some way and what follows both illustrates each category and develops into a wider discussion. The key terms used within the structured exploration of what gives pleasure to these school teachers, are *deviation*, *success* and *dependability,* the exploration of which is followed by a discussion of other more general examples from the data.

The teachers talked of their relationship with mathematics in all the interviews. They referred to it as a strength within their teaching, an integral LHSIA. For example,

> *"....my relationship with the subject, it's stronger than ever"* (Edward).

The relationship primarily exists as positive, with many comments relating to personal success in the subject,

> *"...just absolute joy. Nobody ever told me maths was hard...maths was just like breathing... I thought maths wasn't important because it was easy."* (Gus)

Or to the certainty and dependability that mathematics represents for them,

> *"I realised that I quite like maths, cos it's nice, you can have a... there's always a right answer, or most of the time...I really liked that..."* (Debbie)

Or

> *"…maths was something that was really important to me, and I enjoyed it"* (Freddie).

These intense and frequent illustrations suggest that, as well as the subject being central in terms of importance within the teacher's identity, teaching mathematics is dependable and safe for the participating teachers. Further that, as their identities were forming, these participants experienced personal success in mathematics. One of the rewards required to remain in the classroom may therefore prove to be from re-living such experiences. The role of a mathematics teacher enables a constant recall of positive experiences, something that can significantly counter some of the less positive emotional experiences encountered within the role. Further, the re-living through the teaching of a subject where teachers have experienced personal success, which effectively pleases the self**,** is located in an active social context, and is therefore perceived to benefit others, in a morally good way. Therefore, this re-living meets the three constituents of ethical hedonism.

All the participant teachers tell self-identifying stories of their self as student, such as,

> *"I have just always excelled at maths I could always do everything in maths lessons and I found other lessons quite hard."* (Adam)

Comments from each teacher show how deeply important and pleasurable mathematics was to them from the perspective of former student,

> *"Maths has always been my favourite subject when I was at school, and I enjoyed it, and was fairly good at it, and found it interesting and I kind of...I liked being able to solve problems and I don't know really, I enjoyed algebra." (Helen)*

However, the stories change as each teacher entered higher education, as they transitioned from school students to university level. All the participating teachers mentioned transition into university, especially the negatives, chiefly assigning the reason as the difficulty of mathematics.

> *"...by the end I kind of like lost the love a bit for maths..." (Adam)*
>
> *"I enjoy my maths but I didn't enjoy my degree" (Carol)*
>
> *"...started* [my degree] *and just, just hated it" [Laughs] (Edward)*

This critical transition point is well-known within Mathematics Education research, but what is significant is that although the participating teachers report having their pleasure in the dependability of mathematics shaken, they still chose to become mathematics teachers and therefore have a professionally successful outcome. The examples show teachers recalling halcyon school days, but also identify that the subsequent challenge that exists within points of change may prove to be essential for a longer term positive outcome. One might hypothesise that without this critical change point, the determination to persist and become a teacher may be abandoned.

The recollections are uniquely attached to subject. The participant teachers speak about their positive and successful school experiences in terms of mathematics, whether talking about themselves as individual students, or embedding subject comments into the social of school experience. Debbie however came to her dependability on mathematics by a slightly different route. Since she was ill during her school years, she was reliant on texts at home to learn, missing the social interaction of the classroom as she prepared for her examinations. She talks of mathematics, unlike other subjects, as reliably accessible during her illness. One might suggest that, as she phrases it, her *'horrid'* transition, occurred earlier than university.

Experiencing positive emotions through success in school mathematics seems to be a common experience for the participating teachers, something to then be relied on in their teaching. The conversations included fluid references to both past and present successes. For example, Carol often brought the past into her present role, using mixed tense comments in the interview. This suggests ongoing reflection, but also that her wider identity aligns with her current role. It is no accident that the quote about mathematics and chocolate derives from this teacher, occurring whilst she was commenting on a significant event in the development of her relationship with mathematics as a child,

> *"...at the end of primary school there was a competition...we [Dad and I] won a bar of chocolate [Laughs], …two things I like, maths and chocolate"* [Laughs] (Carol)

This is an event which provides an example of aligning intellectual and sensory pleasures. Social recognition as a source of pleasure is central within Carol's stories, suggesting that for her, as well as immediate reward, teaching offers a continuation of pleasure as socially recognised success. The social nature of teaching, combined with pleasure from having a professional role, is linked by some teachers to deviation. This may appear in many forms, such as deviation from normal classroom practices. In this case, it appears as an antidote to boredom, for both student and teacher, *"Maths can become incredibly boring... bore you to death by making you practice it forever, and that's not what I do. Cos maths has got to be exciting, it's got to have something in it other than sheer boredom."* (Gus)

Pleasure within the professional role can also appear as deviation from the normal teacher and student relationship. In Carol's case, she was positioned as a surprised receiver of praise for solving a challenging mathematics problem, one that had stumped students. Her usual role is to give praise, so this was potentially a welcome deviation. The strength of this event is clear, as Carol went pink on recall, long after the original event,

"...they couldn't do it... I sort of then showed them, and they clapped me...I didn't expect *it... it was just sort of 'Oh well done miss'..." (Carol)*

However, teaching as a whole, including the continual daily challenge, is perceived by some participant teachers as emotionally rewarding. In the film of the same name, Forrest Gump claims that *'Life was like a box of chocolates, you never know what you are going to get'*. Similarly, Debbie comments that,

"...teaching is different every day, it's a challenge, different challenges every single day...never dull, its lots of things but it is never boring..." (Debbie)

The teachers tell of pleasure from being creative, from surprises, or from making changes to routines, a motivator for several of the participant teachers. However, as Gus and Debbie both comment, without deviation through challenge, boredom emerges, and excitement is lost. A point significant for some of these experienced teachers,

"…I was saying on Friday to my husband that I didn't really feel excited about maths, we were talking about the emotion of it… and perhaps I'm not conveying it because a lot of it is the day to day of it, I've done it 20 times, 50 times, 100 times…" (Carol).

If deviation keeps the interest of the participating teachers in the classroom, it is also, particularly through pleasure from deviation via challenge or creativity, a lure or enticer into mathematics for students,

> *"... I go with the philosophy of fun. If I'm not having fun in the lesson, if I'm not enjoying myself, then the kids aren't either...there's no hook...so it's trying to make it fun, trying to let my personality come through a bit, have a bit of a laugh with them..."* (Debbie).

The participant teachers spoke of their deeper satisfactions from teaching, as well as specific, emotionally intense events, in stable-affective rather than dynamic-emotive terms, as contentment rather than happiness. They described their teaching through a multitude of terms; from interesting, pleasurable (including social pleasure), creative or transformative, through to labour, challenge, routine, or a part of life. The complexity of pleasure within a teaching context is illustrated by the descriptions, and moreover, that such pleasure is both individual and social. However, many of the comments merge intellectual and sensory pleasures. There seems to be a robust experiential dimension to what gives the participating teachers pleasure, one that emerges from aligning individual views on the purpose of being a mathematics teacher with a socially located identity. Yet even if an individual teacher does not show alignment of identities in this way, merely identifying with the mathematics teaching role can be a source of pleasure. Such as identifying with the location of the classroom,

> *"...other stuff that kind of takes you away from teaching...teaching's the fun bit..."* (Adam)

Or taking personal delight in exploring mathematics,

> *"...and I sort of enjoy that freedom to explore my subject... and take students along with that..."* (Edward)

Or by comparing with other pleasures of life,

> *"... I was playing teaching... I was teaching and it was more fun than playing rugby and therefore I didn't need the rugby anymore..."* (Gus).

A further similarity between the teachers is that they all mentioned one or more significant others, such as former teacher, or a friend or a family member, as a significant other within their mathematical experiences,

> *"My maths teacher for my GCSE, O level years was brilliant"* (Bertha)
>
> *"I got on very well with him [Her school mathematics teacher] ... someone I am still in contact with..."* (Carol)
>
> *"I just really clicked with him and that style suited me and could just practice, practice"* (Adam)
>
> *"...and I had this wonderful nun who was my mentor and tutor, and she was magic"* (Gus)
>
> *"...my dad...used maths a lot... I can remember him sitting down and helping me with maths...."* (Carol)

Noticeable in these illustrations is a sense of pleasure from engagement with others as well as self. All the participating teachers refer to former secondary level teachers as significant others, in addition to family members. The pleasure that the teachers gain from the successes of their students, a more indirect form of pleasure, but not necessarily less intense is also socially located. Pleasure in the success of students suggests that pleasing others is perhaps a stronger driver for the participating teachers, rather than being balanced by pleasure for self, as one might expect. This driver partially accounts for the prevalence of the ES CTO as well as LMTY, both of which require a social context.

Carol's 'maths and chocolate' quote provides one of the strongest examples of combining sensual and intellectual pleasure, I draw notice to this again as a socially located pleasure for Carol. Besides the analogy of eating chocolate as a sensual pleasure, the analogy draws attention to early social recognition as a reward for solving in mathematics, an intellectual pleasure, as well as success in relation to a significant other. Stories of this kind, particularly if repeated, support establishment of beliefs, such as that doing mathematics is pleasurable. Such an amalgamation possesses the ethical hedonism characteristics of harmless pleasure for self, others, as well as social recognition and acceptance. Carol is not unique in this respect, several of the teachers emphasise the social within pleasure, such as the pleasure of being able to help others,

> *"I remember somebody saying to me in the first lesson, where is the fraction key on the calculator. I think that was a bit of a 'oh, maybe I do know a bit more than you, I can help you. That's good.'"* (Helen).

And Carol states,

> [I was] "…*more comfortable talking to that group...cos they are weaker, so I feel I can help them more. They engage better".*

This is a position that is important to Bertha, who, by articulating as if she was a student, describes her rewarding experiences of student 'Ah-ha!' moments by proxy,

> *"...I teach quite a lot of lower sets and somebody in the class might say, 'oh right yeah, I get that now', and actually properly get it, and that will change... change their lives..."* (Bertha)

A common love of mathematics provides examples of social pleasure,

> *"...there's a little group and they're like, yeah, I really like maths* [Laughs]...*students I teach get that enthusiasm from me, and they like the subject... they like me as well"* (Adam)

As does social pleasure from classroom interaction,

> *"But actually, that's how I teach. Complete, complete enjoyment. And that class is an absolute joy to teach"* (Gus)

When pleasure is experienced by a teacher together with students, the stronger of the articulated pleasures appear. Fulfilling the role of a mathematics teacher is accompanied by satisfaction as there is an individual, social and moral dimension to pleasure from fulfilling the role. For example,

> *"...you can get the kind of challenge from that as well. I like the way that you can sort of relate it to real life. I like the fact that kids value it'* (Helen).

This common view of satisfaction partially accounts for the absence for participant teachers of the ES INF.

5.0.3 Revisiting success, dependability and deviation

Subject pleasure and happiness, as Smith (2010) found for mathematics students, comes from both successes in, and the dependability of mathematics. This data suggests the same for participating teachers, where mathematics is personally viewed as the ES IRIT, *'analogous to breathing'* (Gus), despite trust in the dependability of mathematics being shaken in transition through university. Pleasure in teaching through intellectual play (5.1), as suggested by Robert and Wilbanks (2012), may appear when a teacher chooses to deviate from classroom norms, to be creative in interaction and accept the associated risk. An approach that uses deviation as a teaching strategy might be designed to draw in and engage students, and hence provides reward to the teacher.

In these illustrations, it is possible to see how success, dependability and deviation provide continual pleasures for the participating teachers. This is something evident when they willingly talk about their professional lives, sharing their emotional relationship with mathematics, invariably in an open and jovial way. It is also possible to see that the most intense pleasures meet the criteria of ethical hedonism. Recalling and engaging in modelling joint completion of hard work or overcoming difficulties may conjoin success, deviation and dependability, providing a pleasurable and memorable experience for the teacher. The illustrations suggest that whether through proxy, recall or from social interaction in a purposeful context, the experience is often intensified by the presence of a significant other, described by the participating teachers as the 'brilliant' or 'magic' person. Zeldin & Pajares (2000) suggest that significant others are important in a professional career. The significant other provides an opportunity for mirroring or synchronisation of values, as well as reciprocity of pleasure in the subject. Carol, in her story of the pleasure of 'maths and chocolate', makes this reciprocity evident. Hobbs (2012) uses the term ‘meta-satisfaction’, by which is meant a deeply, pleasurably experienced resolution through ethical practice that occurs on the three constituents of ethical hedonism, on a personal, social and ethical level, that then shapes future action. The process develops the emotional orientation of a teacher. When repetition continues to give pleasure, this acts to strengthen emotional relationships to mathematics in a teaching context.

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5.1 Activating positive emotions as play or playfulness in the mathematics classroom[11]

In this section, I explore the role of play in learning mathematics. I began this study with a premise that teachers do not play with students in this context, as teaching mathematics in secondary school is not normally associated with play. Analysis of the episodes in Chapter 4 indicates otherwise, yet researchers such as Bibby (2011) claim that in the UK, there is a lack of effective use of play in secondary education, hence in this section I explore this apparent contradiction. I review what is meant by play in learning, how it can be identified, why play might support learning in secondary mathematics, such as through connections with positive emotions and exemplify different dimensions of play in context. I draw on the study data to illustrate play and discuss some important implications such as managing risk.

Research into positive emotions in the form of play is scarce within Mathematics Education, so I draw wider from the literature to locate and define play within learning. There is a parallel history for play between early learning in UK schools, such as play within Froebel's Kindergarten, and play as educational activity, which developed mainly from the early 21st century. Aldrich (2006, p.187), whilst discussing this evolution, defines play within education as active participation, with free choice and as essentially pleasurable, but simultaneously, as the opposite of work and learning and as having no purpose outside of itself. Aldrich reminds us that, among other social and cultural constructions of play, playtime is associated with and designated as an unserious part of the school day. Parallel to placing play within learning, play is expected to be active and physical, yet play is also a preparation through acting, imitating or practicing for perfection. Yet, somewhat contradictorily to un-seriousness, Aldrich talks of play as therapy (in a Freudian sense), which allows people to re-order people, events and circumstances into patterns, which is a core mathematical skill (Mulligan & Mitchelmore, 2009).

Play can be engaging in an activity for recreation or enjoyment, perhaps by participating in a sporting match or contest. Alternatively, one can, for example, play

[11] *This section has been adapted from Lake (2017a).*

a piece in a game with rules or one can amuse oneself by engaging in an imaginative pretence, as in performing a play. In a seminal text on play, 'Homo Ludens', [Man the player] Huizinga (1949) defines play; a general definition applicable to a secondary school mathematics context;

> *"…a free activity standing quite consciously outside 'ordinary' life as being 'not serious' but at the same time absorbing the player intensely and utterly. It is an activity connected with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner. It promotes the formation of social groupings that tend to surround themselves with secrecy and to stress the difference from the common world by disguise or other means"* (p.13).

Unsurprisingly, there is far more research about mathematical play in relation to young children rather than teenagers. Yet children (and adults) learn some of the limits of social interaction through play. Given the definitions, any age specific separation in regards to play is certainly historically, socially and culturally evolved and potentially artificial.

Play as a social endeavour balances emotions. For example, play can take a role in reduction of conflict, or in encouraging positive emotions in others. The dichotomy of play as both serious-purposeful yet also frivolous, correlates with the role of emotions as explored by Mandler (1989). He suggests some purposes of engaging emotions that I would suggest also apply to play. For example, Mandler suggests emotions activate other mental contents to deal with situations perceived as being a mismatch between what is intended and what occurs (unintended errors). It is reasonable to suggest that engaging in play, as for emotions, may help address mismatches and smooth adaptations to new situations. Further, it seems that humans not only prefer, but moreover have an emotional need to play. From a list of 24 psychological needs (Murray, 1938), play is located among affection needs. Play is defined, as distinct from the affection needs of affiliation, nurturance, rejection or succorance, as 'having fun with others', an idea developed further in relation to the ES of LMTY (5.4.3).

The preceding discussion explores defining play and the connection with emotions. Next I relate both to mathematics. In addition to play supporting the re-ordering of the world into patterns, Perry and Dockett (2007) suggest that in early childhood, many early mathematical understandings that create meaning are formed through play. They emphasise the role of play in creating situations supportive of innovation, risk taking and problem solving. Play is thus complementary to learning mathematics in an early learning context, as play has an integrative role within learning, such as through consolidation and making connections across experiences, or forming new representations. Engaging in play supports formation of rituals (e.g. rules of ball play) and establishment of norms (e.g. rules of the game) (Vygotsky, 1978).

Relocating activity in play rather than in 'real life' is useful when learning mathematics. The separation from reality that play allows creates a safe place for risk-taking, by supporting a reduction of potential shame or embarrassment, or a safe place for developing curiosity and for predictive exploration into uncertainties. Such a fictional mode of thinking, and significantly, keeping that mode distinct from the literal, is innate to the human mind (Abraham & Yves von Cramon, 2009). Similarly, Brown (2008) suggests prediction is advantageous for adaptability and that humans are designed to play. Predicting the future, as within imaginative play, is a skill that is essential for mathematical problem solving as it is supportive of creative thinking and innovation. There is a strong association between play and creativity in brain processes. We know play for young children supports brain development, making connections, brain crafting, firing up and generating passion and drive (Brown & Vaughan, 2009). What seems important is the activity inherent in play rather than passivity, as is the case for learning mathematics. Play in a form appealing to an adult, which we can define as playfulness that leads to pleasure, also leads to arousal or stimulus seeking and to avoiding boredom (Mandler, 1984). Holland (1998) suggest that 'serious play' causes new *figured worlds* to come about through the *''arts and rituals created on the margins in newly imagined communities''* (p. 272). Social play helps develop new ways of participating, implying that socially orientated ES would support play. However, as applies in mathematics, different dimensions of play, such as playing team games, are associated with winning (you should be good at what you do, ES of LHSIA) and playing fair (ethical game play, ES of INF) and especially following rules (Aldrich, 2006, ES of SOOT, GJD).

Once the connections between play, emotions and mathematics learning are established, the next requirement is for a means to identify whether episodes within mathematics teaching are indeed play. Reifel (1999) acknowledges that although all participants engage in play, there will be a lead person. In a classroom, this is the teacher because of inherent power relationships. Defining play, according to Reifel (ibid.), creates five essential characteristics for an episode to be designated as play. The first characteristic is that the lead person (the teacher) chooses to play and directs the play. Hence, the second characteristic is that structure and rules emanate from the teacher's mind. Thirdly, the means or activity should be more valued than outcome, so that it is play if process orientated. Fourthly, there needs to be a degree of imaginative remove from real or serious life, and finally, play needs an alert and active frame of mind (Reifel, ibid.) which might appear in context as playfulness. Distancing play from real life (Characteristic 4), although useful for mathematics, may be problematic in an educationally purposed context. Radford (1998) draws on a Vygotskian view that activity in play can be neither independent of context nor independent of motive. Radford suggests that motives underpin actions in play and that plots come from cultural reality, so any dialogue and actions displayed in play must be coherent with an individual's version of cultural reality. This coherence implies that activity that has a motive of mathematical learning is still play, as this is the teacher's contextual reality. The role of a teacher seems pivotal in making play connections (Perry and Dockett, 2007), and is also pivotal in secondary mathematics. If students are to enjoy and play whilst learning mathematics, then this requires a supportive environment, with space and time for the encouragement of play. I have identified how play, as one form of positive emotional expression, has recognised social, cognitive, creative and especially emotional benefits applicable to secondary mathematics classrooms. I now turn to how some of the participant teachers position themselves and their students to create a supportive environment.

5.1.1 Serious frivolity: Three exemplifications of play in secondary mathematics classrooms

Examples of play are frequent in just a few selected minutes of observation, whilst in interview, teachers indicated they are playful with their students for a variety of reasons. In the observation data, there are illustrations of imaginary play, including nursery behaviours, whilst play appears as storytelling, repartee, sharing of humour and teasing. Play emerges from the selected episodes as puzzle solving, as well as physical play in the form of modelling or discovery play. There are also examples of general playfulness in tone, voice and manner. In these exemplifications, I draw on such examples and consider some implications of play and playfulness, including any potential benefits for the learning of mathematics.

1 Adam: an example of mixing forms of play

Adam, in his lesson about the nth term for sequences (A3), entices his students into imaginary play. In the second selected episode (A3/2), students experience becoming a flock of sheep with a shepherd,

> *"You've got to imagine Mark's got like a funny hat thing, and you're the sheep"* [Pointing to class who delightedly begin bleating like sheep].

The mathematical purpose is to reinforce the concept within sequences of n as any natural number. The play in this case becomes a physical form, as the student positioned as 'shepherd' stands in a corner to count his 'sheep'. Similarly, within the same episode, Adam uses a neotenous[12] repetition of the phonic form of n, commonly used in early years reading, to further emphasise the concept,

> *"…nuh...nuh...nuh...we use nuh. En [n] for number."*

Later he connects with childhood by encouraging students to sing a nursery rhyme associated with the counting numbers,

[12] Neoteny - used here is acting, as would a child, yet in a positive manner applicable and appropriate to context.

“12345 once I caught a fish alive”.

This is teacher playfulness, used in a way that appears acceptable to these students. They are not primary aged children, yet they willingly engage in play, and as one tells Adam later, ‘I get algebra now’, which suggests this student has made new connections. Consequently, Adam says that he would employ counting sheep with other classes. This example illustrates a sense of playfulness that applies across all the observed lessons with Adam.

Also in Lesson A3, Adam plays a joke on his class, and the students seem uncertain as to whether he is serious. He tells his class that he will ask the exam board if the names they have selected for some common sequences can be added to the GCSE curriculum. There are multiple roles play takes within this example. For example, this is play with a mathematical purpose, such as the teacher wishing students to recall mathematical terminology. The use of positive playfulness empowers them with ownership to enable this,

> *“I thought... if they can actually kind of come up with the sequence themselves, rather than me telling them, ‘these are square numbers and these are triangle numbers,’ then they’ll get a bit more ownership of it and remember it more.”*

Yet in post-observation discussion, Adam is imagining future pleasure from extending the joke in forthcoming lessons,

> *“So I’ll tell them, I’ve got them tomorrow, I’ll tell them ‘I’ve been in touch with the exam board and they’ve said they’ll take that, your definition’”* [Laughs].

2 Gus: An example of Play as deviation

Gus, working with younger students (Year 7), repeatedly engaged his students in fast paced repartee, with a form that employs imaginary playing through seemingly unconnected flights of fancy. Imaginative play emerged from an important mathematical point about communicating the mathematical register, whilst also supporting students, by giving them time to finish a previous task. Playfulness emerged from an accidental slip of tongue, when a student mispronounces the name David, giving a Welsh or French pronunciation (Dav-id rather than Day-vid). Significantly, Gus allowed and shared his enjoyment of an extended deviation and creative storytelling which related his short grey hair and imminent retirement to David Ginola's famous flowing locks. The story drew on existing social knowledge about each other and reveals how positive emotions, in a social context, can connect parts of a lesson. As the deviation ended, the whole class spontaneously re-engaged in their task and appeared fully absorbed. This incident provides a lesson snapshot, where a pattern of periods of concentration interspersed with anecdotes, spirited banter and merriment occurred throughout. In post-observation discussion Gus tells of his belief that students who enjoy themselves through such patterning learn more, and it reduces anxiety about mathematics. The quote reveals his beliefs about positive emotional use in mathematics and teaching,

> *"…because maths can become incredibly boring, so all I do is I find ways of going 'not much to this, I can teach the content of this lesson in 30 seconds and then bore you to death by making you practice it forever', and that's not what I do. Cos maths has got to be exciting, it's got to have something in it other than sheer boredom".*

3 Edward, Debbie and Carol: Examples of Play as a teaching strategy

Edward's form of playing illustrates sharing of humour by being selected as amusing. Edward plays a video of a polar bear catching a seal. The video serves to introduce an activity on actual animal hunting data, which is employed to access the mathematics of ratio and proportion. As with Gus, Edward makes a choice to include an enjoyable dimension to the lesson. Afterwards he commented,

> *"It is one of my favourite clips, and I've played that... this is the second time that I've used it, without fail, every class has laughed at the bit where the polar bear pops up its head behind the seal."*

To illustrate how play might appear as physical, Debbie uses more traditional examples of play such as engaging in puzzles. This way of playing may originate in her own interests. For example, she tells of playfulness from a young age, *"I can remember when I was very small registering my teddy bears, having them all lined up and taking a register."*

In the observed lesson, Debbie used her entire body whilst teaching (D1), and successfully used neotenous mannerisms, sounds and movements that are usually associated with teaching younger children. At one point, her students join in singing the theme to Balamory, a nursery TV programme. Debbie used a jigsaw type of puzzle in the observed lesson (Tarsia), as a means of physically engaging her students in mathematics through problem solving. Further, Debbie comments on playing through gesture, such as how she models with her hands to support explaining a written problem,

"So I was trying to explain that when it [Aeroplane] hits the ground […] it's fallen from the sky, it's got to 180 metres when it has hit the ground, but it has gone down a further 45, how far has it gone down? […] So I was trying to do it with hands, so they sort of got the... that's the sky, that's the ground, it's fallen into the sea further, so... I think she did then go on to answer the question correctly, and she could explain to me why, which was good."

Carol's choice of an experiential learning lesson, where students used coins and dice to discover relative frequency, shows appreciation of the value of physical play for learning. Her classroom displayed colourful student work, a teacher form of visual play commonly associated with primary and not often noticeable in secondary mathematics classrooms. In interview, Carol talks of her own mathematical learning regarding mathematics and play. As a child, she engaged in a magic square competition. Her family encouraged such mathematical play, in the form of puzzle solving,

"He [Dad] recognised that I had an interest, and he sort of perhaps pushed that and promoted that a little bit."

In addition to play, there are other examples of physical play using body movement, such as when Freddie allows himself to be measured for perfection (F1/2) or when Adam's students become sheep (A3/2). The second example illustrates, as for Gus, how a teacher can instigate imaginative pretend play in a mathematics lesson. The choice of exploratory play within teaching shares pleasure in engaging in mathematics, as does a teacher sharing a comical video to bring a new topic to life for students. Neoteny, in a positive sense, should not be disregarded as a means to engage students, such as Adam saying 'nuh' as a playful emphasis on the importance of n when learning sequences, or when he used a nursery counting song. Debbie too employs neotenous strategies with effect.

In just a few short episodes, there are many examples illustrating an extensive range of play in some routine mathematics classrooms. In the next section, I consider how these episodes relate to the five characteristics of play as suggested by Reifel (1999), before discussing any possible emotional benefits and implications of using positive emotions in the form of play in secondary mathematics classrooms.

The five play characteristics previously introduced (Reifel, 1999) are: that there is a director; that the play is process rather than product orientated; that participants choose whether to engage in play; that some form of remove exists and that there is a positive frame of mind or disposition for playfulness. Within the sample of teachers, play exists on a continuum from pure play to none. Given power relationships in a classroom, it is unsurprising that the illustrations show the teacher choosing and directing the play. A defining distinction for play in this context is that the structure and rules of play emanate freely from the teacher's mind. Yet, in a social context, any emerging rules of play need to be negotiated, as seen in Episode A3/1, and may, subsequently, become classroom norms. In play organised by a teacher, students are not usually able to change rules, which is why Adam's proposed intervention with the exam board for sequence names is potentially powerful; in terms of the ownership of mathematics. Adam, in the 'sheep' story (A3/2), encourages socio-dramatic play. This complex form of play requires establishing of rules, and shared enactment of roles and imagined scenes. Vygotsky (1978) identifies a fundamental rule for this form of play; you must abide by shared understandings of the role that you are playing.

Observations of Gus or Adam show imaginative, perhaps frivolous, remove from real or serious life. Patterns of *'time in'* (period of fictional fabrication) and *'time out'* (return to reality, which can be temporary), appear in various forms of play, although these are more obvious for some forms, such as for Gus. *'Time out'* is engaging in mathematics, and has a clear demarcation in his teaching between *'time in'*, when he relates and engages in elaborate stories, and *'time out'*. It is no accident that Gus as director shifts seamlessly and at an engaging pace between *'time in'* and *'time out'*, and that at times, the distinction is blurred. It is apparent in the selected episodes that acknowledging 'I am just playing' would break the spell. The fifth play characteristic relates to willingness, that a teacher needs a propensity and a disposition for play. In these examples, when teachers appear to have an attentive and active frame of mind, enjoyment through play emerges. The teachers who engage in play have a range of ES, but the aligning ES for play seem to be LMTY, LHSIA, IRIT and to a lesser degree, CTO.

5.1.2 Risks, benefits and barriers for positive emotions as play in the context of a mathematics classroom

I have presented play as positive, yet for some observed teachers there was no evidence of engagement in identifiable forms of play. For example, in Lesson H1, Helen used a game to teach. This was not considered play by Helen or myself, partially as the primary purpose was product orientated; it was a game designed to support exam success. This raises questions as to what other barriers might prevent the use of play in a secondary mathematics classroom. Traditionally, teachers may see play only as games to be used at the end of term, or as a teaching tool to offer variety. Indeed, this view suggests a limitation formed by differences in teacher views of play. Helen, arguably a strategic, outcome orientated teacher, detaches learning and play. This, she claims, is due to the high risk of play when exam results are at stake, when playing becomes time wasting,

> *"…we are coming up towards a test … you kind of want to make every second really focussed and really count, and really relevant and really going to help them with that test rather than perhaps being a bit more exploratory and a bit more outside the curriculum, outside the box."*

In Helen's selected episode, students are being set an activity. The teacher gives instructions, positioned within the interactions as rule setter as for some board games, so in this respect this is play. The introduced activity is groups of students solving mathematics problems, rewarded by points, as part of the preparation for a forthcoming examination. This is play as a teaching tool activity, intended to alter pace, as opposed to deviating forms of play, as in other examples. Helen's selected position is as judge and adjudicator for the game, rather than as participant. One implication is to increase distance; however, the position enables her to monitor behaviour, which, judging from the interview data, is important to her. The adopted position, as judge and adjudicator, offers variety with little risk in terms of behaviour management. This view is supported by what she says in interview, about being able as a teacher to play with the curriculum,

> *"…but the way you deliver it […] you can vary that quite a lot."*

She goes on to add,

> *"...but you can also be much more imaginative when you want to, when you want to, when you've got time to."*

Play, as in the five play characteristics definition, especially being divorced from real life, suggest interpreting her comments as indicating that the value of mathematics in real life takes precedence over playing mathematically,

> *"I like the way that you can sort of relate it to real life. I like the fact that kids value it."*

So a utility view of mathematics, GJD in ES terms, one that seems likely to block play in the classroom. The utility view also has implications for student possible positions and longer term adoption of ES. Further, Helen's view of play is about games, such as,

> *"I like doing games. I am quite a fan of games. I do sort of an auction activity where kids bid for equipment and they have to do a task. I quite enjoy doing that..."*

Revealing of her view of play as activity, she suggests that,

> *"…some kids actually like just having questions to do, they actually just like having the structure they can get on with, rather than 'faffing about'[13] with scissors and glue sticks and playing games."*

A teacher not recognising value in play creates a discrepancy between actions in class, compared to rhetorically advancing play benefits. This may prove to be a common position. Engaging in play in a mathematics classroom can be chaotic (Perry & Dockett, 2007) and entails risk in terms of managing behaviour for learning. Play depends on what is important to a person, in addition to a willingness to potentially 'look silly', and exposes one's own values in relation to teaching of mathematics. There is a degree of vulnerability involved, as engaging in play involves revealing self. If a teacher 'pitches' it wrong, they risk damaging their relationship with students. It also takes self-control, intensity and effort to sustain playfulness, since it frequently requires rapid brain connections or activity. This implies that to engage fully in play, a teacher needs a perception of some reward for the endeavour, especially if engaging in social play in a work heavy context such as teaching.

European culture is one where childishness is often a criticism, so teachers also risk criticism of neoteny, in a negative sense. Yet Brown (2008) suggests that humans are adaptable in terms of problem solving just because they are among the most neotenous species on Earth. When an activity becomes habitual and therefore easy, it may lose its status as play, if engaging no longer requires conscious mental effort. A game requires an active, alert mind, one receptive to reflexive re-positioning, to do it well. An implication for an experienced teachers is that, like game players, they need to be willing to keep making the game different, such as through deviation, or to make the play harder, in order to raise the criteria for success.

However, since there are several examples of play within the selected episodes, the participating teachers must see benefits for themselves, their students and for engaging in mathematics. Gus suggests in interview that engaging in play might be calming,

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[13] Defined as spending time in ineffectual activity

> *"…there are bits which are stressful, but when the class and I are working together well, then it's great. We've got to do... all we do is just work together and it's relaxing."*

There may be a connection between reduction in stress and positive emotions, as a person at play is distanced to a certain degree from responding to external demands, or needs such as emotions experienced as stress or anxiety. Yet contradictorily, if play relaxes, managing play in a classroom requires teacher intensity and energy. During observed episodes where positive emotions are expressed, the pace is generally swifter, more dynamic, than in each lesson as a whole, which potentially adds to a need for intensity management. One risk is that whilst engaging in extended scenarios a teacher must manage behaviour carefully, especially as play may seem to students to be a relinquishment of expected routines. Whilst experiencing *'time in'*, students might easily lose sight of any mathematical purposes.

Teacher initiated play in a mathematics classroom may act to bring positive emotions to the fore. We know students talk of boredom (Jablonka, 2013), but teachers also experience boredom. The evidence suggests that rich forms of play can counter boredom. Further, play, as expressing positive emotions, can act to reduce emotional distances. The teacher, as an authority figure, and students form a power relationship within which distances are inevitable. Appropriate use of play, and positioning as playful, may break down such barriers and act to balance student and teacher relationships. Play may also act to facilitate the role of the teacher as a mediator between students and mathematics.

If engaging in play is perceived as effective, as for some participant teachers, the rewards are also perceived as meaningful. Play, through shared satisfaction and enjoyment, can balance and augment relationships. Adam or Gus' use of play, where play serves to keep student attention and structures the lesson, shows they have found an effective and unique teaching style. Prior experiences may have shown them that it is a successful stratagem and if they are willing to accept the associated risk, then they expect enjoyment. They appear to continually seek freshness, fluidly re-positioning to generate and support positive learning. These cases illustrate that when routine sets in, a self-aware and reflective teacher may seek different ways of playing to gratify and entertain both the students and themselves. Using play to model a connective learning of mathematics through playfulness and humour is likely to be self-perpetuating. The expression of positive emotions evoked by anticipation of enjoyment is likely to make the risk successful; students can see this modelling and expectation, and respond positively.

Although essentially discussing primary mathematical play, Perry and Dockett (2007), whilst reflecting on the ideal relationship between teacher and students for supporting play, suggest that an actively playful teacher guides students and deepens the sophistication of play. This guiding role requires a mathematics teacher to be disposed to act as provocateur, taking the role of one who challenges. For example, they might model playfulness in conjunction with engendering potentially controversial situations through use of questions, or through creating surprising connections or revelations. This may require abandoning some of the expected roles of a teacher, which is potentially risky. Yet one might easily suggest such teachers are likely to have more impact on student learning and engagement. Goffman (1997) suggests that when some expected roles have been abandoned, there may be less potential for conflict between teacher and students. A teacher can choose to be creative or to digress from expected role norms; to use deviative forms of play as a teaching strategy. In doing so, they need to accept any associated risk and vulnerability, and any associated emotions. The risks and benefits are summarised in 6.2.

Balancing play with managing classroom conduct is an art, but I would suggest from the evidence that teachers play more than might be expected. Yet, however good we know play might be for adolescents, mentally, physically and mathematically, a teacher needs to be willing to use their *'divinely superfluous neurons'* (Brown & Vaughan, 2009). Play requires energy, but also willingness, confidence, and self-discipline, as well as a disposition towards playfulness that is not necessarily developed through experience. What may prove important is that engaging in play implies activity that supports experiment and creativity and is process rather than outcome focussed, as for the effective teaching of mathematics. This is particularly pertinent to address topical issues such as how to develop problem solving skills.

Playfulness is a form of teaching that generates positive emotions, but also expressing positive emotions promotes playfulness, a self-perpetuating model.

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5.2 Modelling engaging in learning mathematics or of how ‘to be’ when learning mathematics

Modelling is defined here as socially located deliberate actions designed to change and shift others, since human beings mimic and synchronise with each other (Hatfield, Cacioppo and Rapson, 1994). This definition is adapted from Eggen & Kauchak (2013) who suggest modelling is,

> *“…changes in people that result from observing the actions of others” (p236)*

This position defines experiencing modelling as continual and shifting actions of reconstructing self in social contexts, guided by the influence of others. Teachers are engaged in deliberate re-modelling of one or more relationships with mathematics with the intended aim of changing students, either behaviours or through an expectation that students will model what their teacher does. Hence, although still a continuous two-way constructed relationship between students and teacher, it is not an equal one.

Furthermore, mathematics is a mix of forms; both an academic discipline (Schöenfeld, 1987), and an application in real life. Distinctly different again is school mathematics (Civil, 2002), often appearing with a primary agenda of passing assessments and existing in forms such as text, curriculum or as school expectations. On a local level, each teacher sees mathematics and their role uniquely (Ernest, 1989b). For example, teachers may see mathematics as experienced for its own sake, as problem solving, or as a means to access a higher level of learning, or as a combination of these. Such views are unique for each teacher since individual beliefs, values and experiences limit what can be and is modelled. The result is myriad forms of modelling. In the classroom, such modelling may designate what norms should apply in relation to engaging in mathematics, or foster socio-mathematical norms that communicate the meta-discursive rules of mathematical discourse (Heyd-Metzuyanim, 2013; Cobb, Yackel and Wood, 1992; Sfard 2007; Sfard & Prusak, 2005),

> *“For example, the teacher can, by condoning and modelling selected practices, through language and engaging in emotional interaction, act as gatekeeper to the community of practice of Mathematics”* (Lake & Nardi, 2014, p.50).

Cobb et al. (1989) explored how a primary teacher uses positive language to indicate how students should be feeling about their mathematics, how they communicate what are ‘appropriate’ emotional reactions, or show, through modelling norms, how language and emotions combine. Cobb et al.’s examples relate to the construction of norms, interpretation of situations and beliefs, (both beliefs about teacher roles and about doing mathematics) and as positive emotional acts that stem directly from mathematical activity. They conclude that modelling a norm that supports expecting challenge and excitement, achieved by exhibiting positive emotions and modelling excitement as a positive response, is supportive of relational learning.

The experiences and values that teachers bring to their teaching not only guide and limit available modelling positions, but also limit which ES are possible. For example, a teacher who believes mathematics in school is primarily problem solving may be disposed to teach experientially (Ernest, 1989a) or actively. This partially indicates the ES of ‘Check This Out’. Modelling is indicative of ES, but dominant ES also direct the possible modelling. Whatever the form, modelling has a primarily communicative role, where a teacher models ‘optimal social functioning’ (Nuttin, Lorion and Dumas, 1984) when engaging in mathematics, with an aim of inducing positive emotional responses, as well as an ethical dimension, that of helping others (See Ethical hedonism (5.0) and LMTY, 5.4.3).

Allen and Carifio (2007) suggest an alternative lens for teacher modelling regarding emotions. Through examining student emotions during mathematical problem solving from an angle of mathematical sophistication, they suggest that differentiated emotions exist, and that sophisticated people not only experience more differentiated emotion but also manage their negative emotions better. Assuming an experienced teacher is sophisticated in relation to mathematics, then their modelling places more emphasis (as with Cobb et al.’s (1989) norms), on familiarity with what emotions may emerge. Allen and Carifio’s (2007) conclusion suggests there may be more sophisticated and frequent ES shifts for experienced teachers in action, as shown in Chapter 4.

Allen and Carifio (2007) conclude that avoiding cognitive dissonance and emotional conflict (which some teachers may do) disadvantages students in terms of recognising and controlling emotions. This conclusion implies that modelling appropriate emotional responses to mathematics is important. If emotions exist as a constructivist process of discrepancy, arousal or emotional construction and consciousness, then I would expect teacher modelling to appear at any point, such as within deliberately creating a discrepancy, modelling a response to an identified discrepancy, raising awareness by an emotional act or modelling curiosity as essential for deeper learning in mathematics. Modelling how to react to problems, mistakes and uncertainty using positive emotions in conjunction with problematic areas of learning mathematics seems crucial, as does modelling of reflection when engaging in mathematics. Modelling could occur, as Hobbs (2012) suggests, in the form of a teacher modelling enjoyment, primarily achieved by exhibiting positive emotions. Modelling attaching positive emotions makes something appear accessible and easy (Fredrickson, 2001). A skilful teacher might be expected to locate positive emotions for maximum impact.

Teachers model as an essential part of the role, and can be usefully considered as modelling of self (values), social (norms), mathematics or pedagogy. These overlapping divisions imply that teachers direct some modelling towards how to behave emotionally both in relation to social needs and as a socially located individual in a classroom, as well as modelling positively engaging in doing mathematics. In conjunction with positive emotions, modelling may engage students and reduce barriers to learning, such as by teacher modelling of thoughtful problem solving or of overt enjoyment in mathematical engagement.

Using the data from classroom teaching and teacher espoused views, I next present five paired illustrations of teacher episodes, each examining a different dimension of modelling of mathematics. The selection is informed by common issues within the teaching of mathematics. These include whether mathematics is taught procedurally or conceptually, the importance of procedural elements required for examinations and other assessment, or teaching through giving students practical experiences.

There are examples of overt and subtle modelling by a participant teacher of attentive, reflective listening to mathematical discourses, modelling of coping strategies in general and specifically for problem solving. Each paired illustration will be presented as a snapshot of the episodes, a brief description, relevant ES and positions, analysis and connection with positive emotions. The paired illustrations are:

1 Adam and Edward 'Stepping back': Modelling interest in mathematical explanation

2 Freddie and Bertha: Modelling and measurement

3 Adam and Bertha: Modelling dealing with mathematical error

4 Gus and Debbie: Modelling merging work and play: Neoteny and social teaching

5 Carol and Helen: Modelling mathematics as procedural or conceptual understanding

I conclude the paired illustrations with how modelling appears to act to increase or decrease emotional distances in a mathematics classroom and suggest that modelling is enacted by experienced teachers through impactful use of emotions.

5.2.1 Five paired illustrations of modelling in mathematics lessons

1 Adam and Edward: 'Stepping back': Modelling interest in mathematical explanation

> *"You may have to choose students to model or role-play alongside you"* (Linsin, 2012)

Adam and Edward both 'step back' to briefly hand over an instructional position to students, relinquishing the physical centre of attention. Adam's dominant ES are LMTY supported by LHSIA and IRIT, whilst Edward lies predominantly in GJD and CTO. These ES, in terms of modelling, imply that for Adam, his teaching can be generalised as modelling reflection and taking time to think, as well as apparent absorption in mathematical task in a 'flow' sense (IRIT). Adam uses out loud thinking, a modelling of thought processes and articulation of internal thinking processes (LMTY). In terms of modelling, Edward's teaching is characterised by carefully constructed questions and taking time to consider (characteristic of CTO), but is primarily outcome orientated as in GJD, modelling the practical application of mathematics. Both teachers commonly use facilitating positions whilst teaching.

To recap on the selected episodes from Chapter 4, Adam in Lesson A2 (Stem and Leaf), whilst seated at his computer early in the lesson, asks a student (Amy) to explain the process of constructing a 'stem and leaf' diagram (used for ordering unsorted data). Whilst Amy explains, Adam mirrors the explanation, using a PowerPoint displaying the data. His positioning enables modelling of interest in and listening to the mathematics for the class. The positioning shifts the engagement distance, (encouraging proximity between students and mathematics) by allowing students to direct discussion. The video shows his careful listening and approval of the explanation through his facial expression, body position, nodding in agreement and appreciative 'uh-hu' sounds, all without interrupting Amy. When he returns to position of teacher, Adam repeats Amy's explanation, shifting to an emphasis on exam mark allocation.

In Edward's lesson, as part of a lesson on converting fractions to decimals, two students, Joe and Sam, consecutively explain their method for division on the board. Edward stands at the back of the classroom. His body language shows attentive listening and he uses a neutrally positive tone of voice. In both cases, Edward uses guiding questioning but he reiterates only Sam's method. In the first case, Joe does not explain clearly, whereas Sam uses Edward's stated preferred division method.

These episodes show two dimensions of modelling; subtle modelling and a modelling of attention to what is deemed important within the mathematical topic. Adam accords value to being an expert through language, as when he labels Amy as 'the expert' who will tell 'us' (the audience of teacher (positioned as student) and the students) about stem and leaf diagrams (the mathematics). By not interrupting, his subtle message is 'we don't interrupt experts when they are talking about mathematics'. He also implies that the students can already process, positioning them as able for the future tasks, only now requiring a quick revision,

> *"Well... have you done this before? (Yeah) Yeah. Could you... roughly know how to use them? (Yeah) So yeah, right, a quick recap on how they work."*

This positioning works as a subtle message of trust and confidence in both Amy and the class. Adam is modelling paying attention to what is important within mathematics as he mediates between mathematics (as procedure for exam purpose) and students. He says,

> *"So for them to improve, it's often knowing exactly where they get the exam marks from."*

In the lesson, Adam models the process of engaging with the topic for maximum marks,

> *"So that's an important point to start. Those numbers there can be **anything** so long as they are the **same** place value [Repeats vertical downward gesture]. So this could actually be 3 units, so we could do 3.1, 3.2, 3.3... Or 4.7 4.8.... Or they could represent hundreds. So this could represent 3 hundred and something, 4 hundred and something, 5 hundred and something... which is why you have to put down a **key**" [Circling where the word key is written on the board] (Adam*) [Teacher emphasised words in bold].

Here Adam uses tonal emphasis to signal to students to pay attention to key words. Similarly, Adam's silence whilst Amy is explaining shifts attention away from him towards the whole class as audience. This shift is shown by his positional use of 'us' rather than 'me' labelling of the audience within modelling in this form, I would suggest such pronoun use is crucial for modelling interest for students. Both Edward and Adam give each student choice, modelling learning as interactive. However, a further example of crucial pronoun use as a shift occurs when Adam accepts Amy's eventual rejection of position of teacher as her confident explanation becomes repetitive number crunching. Amy's use of 'you' shifts from instructional (for the class),

"…you put a 3...and then beside the four you put a 3, 6... 6... 8... Until you, [Speaking quietly] *I can't be bothered to..."*

To 'you' as Adam. He quickly responds, almost interrupting, increasing the pace, and draws attention back by reforming 'you' to be directed at the class as audience,

"Well... have you done this before?" (Episode A2/1)

One of Edward's subtle underlying messages is that division should be done using 'bus-stop' (See 4.1E). He communicates this message by his language, such as when he repeats the second demonstration (the one using 'bus-stop' method). His interview comments also show his view,

"…the bus-stop, to me, seems to me the most efficient way of doing it. I think there is a certain elegance to it I suppose…"

Yet in his overt discourse, he states that students can use any preferred method for division. Edward also reiterates comments, showing approval for comments about bus stop, whereas for chunking he just moves on. He uses a positive stance and models careful consideration. In particular, Edward uses careful phrasing, such as,

"Do you want to come and show me what you do?"

Such pronoun emphasis in his phrasing implies both choice and positions the student as having ownership of mathematical skills, although in this sentence, positioning Edward as the one who needs to be shown (offering LMTY).

In this paired illustration, I have drawn attention to two teachers modelling enjoying reflective listening to students talking about mathematics, and how this modelling gives an impression of positive expectations. The teachers physically distance themselves from the mathematics by this action, but the effect is to draw the students closer to positive engagement in the mathematics. It also provides the teacher with an opportunity to extend and clarify. Taking the teacher role may also be an enjoyable student experience. This pleasure is most evident for Sam who deliberately and cheekily causes class laughter by gently mimicking the teacher's mannerisms whilst he is centre stage.

2 Freddie and Bertha: Modelling and measurement – Proximal and distal relationships with students; as-student and by abrogation

This illustrative example explores a different form of modelling within classroom interaction for Freddie and Bertha. Bertha's ES are SOOT and GJD. SOOT is a performance avoidance goal which may evoke emotions of apprehension, fear or relief, and where modelling may show avoidance of conflict. These ES imply a degree of distancing, and attention to curriculum as a task that needs only to be completed. Freddie teaches predominantly with a LMTY and CTO framing. In terms of modelling, Freddie's ES are more likely to support mathematical learning and closer engagement with students (4.1F).

In 'Face measuring', Freddie's students are measuring their physical dimensions. They are examining whether they are perfectly proportioned, using the Golden Ratio (See 4.1F). The episode starts with Freddie showing an encouraging smile, as he invites students to take his measurements. It concludes with Freddie expressing satisfaction. In the episode, four students move to centre front (the performance spot), and measuring the teacher proportions (Fig. 4.36). These students record Freddie's data on the board whilst other students sit at tables, collecting data on each other.

Bertha in the episode 'Collecting measurement data', records figures from a data collection measuring activity, taking a position of recorder. Beginning the previous lesson, the students, in small groups, take measurements such as height and arm length, and time their reactions to stimulus. In the episode, students come to Bertha's desk in their groups, surrounding the teacher. She writes down their measurements on a summary sheet and issues a new task sheet as each group completes. Some students are still measuring around the room, whilst others have an extension task sheet. This is not a positive emotion example, the teacher exhibits impatience and from my value position, is discourteous to students.

Although the episodes are based on the same learning objectives (Former NC4-6 objective; Collect and organise small sets of data), the conducting of measuring differs in terms of engagement with students and mathematics. The episodes differ regarding the future use of the measuring, and especially in terms of modelling engaging in a measuring activity. This difference is especially evident as Freddie's group is positioned at the front, recording publically on the whiteboard. Freddie is modelling processes of measurement for the class, modelling that learning mathematics is about activity and group work, that it has a social orientation, which aligns with his ES as described. Freddie is active whilst students measure his proportions and overtly models what students should be doing. He discusses accuracy with the small group, continually adapting and correcting their actions. He models physical proximity, and models engaging in mathematics by being 'as a student' in this task. Even though, as he says, he felt *'a little bit like a plum.'*[14] By relating measuring to the golden ratio, he connects different syllabus elements (in this case measurement and ratio) and gives the activity a deeper mathematical purpose.

By allowing himself to be measured, Freddie is modelling being a participant in the activity, reducing the distance between teacher and students. This participation implies that relationships are important for this teacher, which aligns with LMTY, an ES where social interaction is valued. For example, this lesson explored Fibonacci, a potentially engaging topic in the mathematics curriculum, one that involves patterning and sequences. A school mathematics teacher can use the topic to make strong links between mathematics and its purpose in the real world, modelling a view that mathematics is everywhere, from music to fruit, and that exploring such connections is engaging. Although an acceptable deviation within the UK school curriculum, in terms of assessment preparation, the topic rarely occurs in exams in a Fibonacci form, although linked to both sequences and ratio. The consequence is that, unlike Freddie, other teachers may opt to omit the topic. Freddie is modelling the practicality of mathematics and justifies this choice in subsequent discussion,

> *"I kind of wanted to use myself as an example, [...] if I have my measurements on the board then it's like I'm part of them. So I can discuss with them rather than just...I think it just brings us more onto sort of an equal playing field, so we can sort of discuss it. Like 'I've got*

[14] A bit silly to be positioned as an object

my results, you've got your results, how did you do?' 'Oh, my ears are a bit off proportion' or something like that."

There is potential risk in including himself within the student activity and allowing the measuring, as his data will be public. Allowing physical proximity contradicts his generally cool calm demeanour; where overall there appears a degree of distancing in terms of visible emotions. He adds,

"…and I was kind of like posing but trying to stay still to be measured, and trying to keep track of the time."

Yet students mimic his calm, controlled and confident manner and the class feels purposeful.

Bertha's lesson (B2) was also collecting data, with an identical National Curriculum reference. Bertha controls the data recording at this point of the lesson, so ownership of the mathematics is with the teacher. She is (unlike Freddie who also engages with students outside of the small group), abrogating the role of teacher whilst recording. The choice of activity models that precision and recording of data are important,

"You see I was thinking should I... all the time I was thinking should just I let them write their own data, no, no, no, they will just write it all wrong. They'll just put it all in the wrong order."

Choosing to model being data transcriber has implications if students are unsettled or unengaged in an activity. Bertha, in post observation discussion chose to discuss some disengaged students,

"Cos they sit down and they're like 'we're finished' and all that sort of stuff and no they haven't. [Laughs] *You can probably see the expression on my face"* [Video shows her negative expression].

In this paired example, I discuss two teachers and their students collecting measurement data. Freddie models engagement in the activity, where students control the process of measurement and recording, whilst Bertha models acting as scribe where the teacher controls the product. Comparatively, there are implications in terms of future student engagement in mathematics. Freddie achieves emotional empathy by modelling participating in the activity; his whole body is engaged. I would suggest this engagement assigns value to the activity for students, whilst his affective expression models interest in the activity, and some enjoyment. In interview, he confirms this view by reporting experiences of feeling good when having fun in interactions with students. The reported fun is associated with learning rather than as distraction or deviation as the case in paired example 4.

Interpreting the physical distancing role that positive emotions take in these episodes, Freddie gets close to students, breaching the invisible physical distancing between students and teachers, but which, in terms of modelling, is perhaps effective. Bertha on the other hand is almost detached, taking a role which is not mediation, and without any visible expression of positive emotions. The result perhaps moves students away from engaging in mathematics.

3 Adam and Bertha: Modelling dealing with mathematical error[15]

In this pairing, both teachers uniquely and successfully address a numerical error. In both episodes the teacher expresses emotions, yet they differ in their emotional pathway from recognising discrepancy to resolution, illustrating disparate ways of modelling. The dominant ES for Adam is LMTY (supported by IRIT and LHSIA). Bertha's dominant structure is DDM (supported by SOOT and GJD). Within an ES of LMTY, an error is more likely to be merely a distraction, similarly for IRIT and LHSIA. In comparison, engaging in SOOT aligns with seeing errors as problems to avoid, or as an impediment to GJD, a product orientated ES.

In 'Upper and lower bounds' from Lesson A1, Adam writes 2 for the difference between 4.5 and 3.5 when demonstrating upper and lower bounds for 5 – 4. As he reads the four possible answers aloud, '2,0,2,1', he slows, quietens his voice and movements, pausing with pen poised, whilst his head moves from side to side scanning. He then steps back and just looks for several seconds, appearing absorbed. Once he has identified the error, he utters the sound 'uhh', interpreted as

[15] This section also appears as Lake, (2017b)

‘never mind’. Adam then engages in a repeated exchange of noises with one student, corrects the mistake, rewards a student who is quick to align, and continues in the same faster pace as at the start of the episode, quickly moving on from the error.

Bertha, in ‘Calculating the area of a circle’ from Lesson B1, uses a well-known mathematics website to produce questions on the area of a circle. Following the students finding the area for a given radius, Bertha enters a volunteered answer, but the website rejects this answer. As Bertha has already calculated the answer herself, agreeing with the student, the website rejection brings an unforeseen problem that Bertha addresses in the episode. The discrepancy is between using π or 3.14, so it relates to the degree of accuracy required.

Bertha tells in post observation discussion of a formal observation that went wrong because the questions on the website changed. A repeat experience, when again being observed, albeit for research purposes, is likely to re-evoke emotions associated with insecurity, and a need to check solutions with a form of authority, in this case the website answer. This modelling of a need for accuracy, for rechecking, reinforces a product orientated ‘feel’ for episode B1, where correctness takes precedence, even if taking time from learning.

In both cases, there is modelling of internal thought processes. In Bertha’s case public thinking out-loud for self,

> *“[*Muttering quietly] *…2…5…4…point…oh. I see, point 34. Let’s try it again.”*

Possibly this indicates Bertha seeking mathematical correctness, aligning with SOOT and GJD ES. This corresponds with what she says in interview,

> *“I don't see myself as a mathematician. I see myself as someone who is good at maths and you can teach me anything in maths and eventually get it, which does again sounds obnoxious but that's...you know... it might take me a lot longer with some of the things.”*

Seeking confirmation of correctness perhaps indicates a belief that ‘real’ mathematicians do not make errors. This example shows an intention to model what she thinks a teacher should be doing, indicating a disparity between real and aim. Hobbs (2012) suggests that, if repeated, the wider implication is that if a teacher is not confident or feels unprepared, then students will not experience modelling of what it looks like to enjoy the subject or modelling of personal engagement.

In contrast, Adam models shifting ownership of the error by repositioning from ‘we’ to ‘I’, modelling that gives an impression that it is ok to make mistakes. He positively manages the error, moving sequentially from a point of uncertainty into exhibiting positive emotions using humour via exchanging noises and giving praise, which acts to restore lesson balance. His modelling of how to deal with error includes distraction of attention and shifting attention via assigning a social reward for correction of error. In the episode, the error becomes an object unassigned, before it is quickly shifted into a positive outcome. As observer, it felt as if he was pinning the error somewhere distant from self. However, he included students in his happiness at resolving the error, and hence was rewarded. Either interpretation is a modelling that downplays error. As he says afterwards,

> *“Oh, yeah, did I put a mistake on the board to start off with? (Yeah) Yeah...I’m not fussed with that. It happens quite a lot. I always say to the students... I’ll make mistakes, and they’ll make mistakes...and there it goes...”*

The different responses of the teachers, both successfully resolved in that student reward is given as restorative praise, have different longer term impressions. Adam says, ‘gold star’ for a student and quickly moves on, whilst Bertha draws attention to the correct answer, and to rewarding the student. The impact on students of repeated modelling of ‘not my error, let’s move on’ (process interruption only) compared to ‘we must get this right’ (product orientation) may be significant. Shifting attention acts to distance the teacher from the ownership of error, modelling addressing error as positive. This distancing compares to a negative impact that models dealing with errors as an annoying problem, one owned by both teacher and students. There is inevitably a degree of uncertainty in relation to error management. These examples represent extremes of a management continuum from valuing error as a learning experience (modelling an expectation of error into learning), to a belief that errors are obstacles to avoid. The risk to teacher and student relationships may therefore lie in not using positive emotions to manage error.

4 Debbie and Gus: Modelling merging work and play, neoteny and social teaching

> *"We have a bit of a giggle and we get on with it and we get the work done which is always good."* (Debbie)

Earlier I discussed positive emotions in the form of play (5.1). Here I draw attention to the role of playfulness as a disposition. I present illustrations from the teaching of Gus and Debbie whom, judging by interview and observation data, thoroughly and overtly enjoy their role as teachers. I will explore what such overt pleasure in teaching models to mathematics students. Debbie is a teacher who combines work and play in a neotenous form (See also 4.1D, 5.1) whilst Gus models mathematics and social pleasure as inseparable. I suggest that the illustrations show modelling engagement in mathematics as an exciting challenge, a model that is likely to be supportive of learning.

The identified ES for Debbie are CTO supported by LMTY and IRIT. In terms of modelling, this ES combination would predict modelling of helping students, but also modelling engaging fully in the mathematics. Whilst Gus has LMTY, and a socially orientated form of LHSIA. From these ES, I would expect to see modelling as performance of an interactive, communicative style of learning mathematics. Both teachers have a problem-solving form of LMTY (See 5.3).

In the episode (Tarsia puzzles), Debbie moves rapidly around the room, engaging briefly with pairs of students. Some students are engaged in completing a jigsaw type 'Tarsia', some answering questions on angles of depression. Debbie laughs a lot and uses childish mannerisms including sounds, mock surprise or gestures as she darts about the room.

In the illustration from Gus' teaching (David Ginola and his hair), there is a humorous exchange between the teacher and year 7 students, one that connects two parts of the lesson whilst slower writing students catch up copying from the board. The laughter emerges from a point the teacher makes about using the right mathematical language that develops, via a mispronunciation and a football anecdote, into an imaginative and incongruous picture of a grey and short-haired teacher modelling hair shampoo.

Gus models intensity and concentration on mathematics, interspersed with entertaining rest breaks or deviations. These breaks serve several purposes, such as modelling connectivity and enjoyment of social interaction. This modelling is of a verbal exchanging, discussion-based form of teaching. For example, at the start of the lesson, Gus moves students so that no-one is required to sit alone. There is a multileveled social dimension to this teacher's interaction with students. His constructed model combines work and pleasure and, importantly for emotional engagement, his confidence in enjoying mathematics was obvious, modelling a pleasure in mathematical interaction, as well as care for others. In the lesson, I observed a high degree of contributions expected and provided by students. The episode shows the transition between a 'starter' task and new learning. Gus uses banter and stories which may appear random, but act to 'break up' the lesson in terms of pace. Within this structure, care was taken to allow for slower students to keep up, whilst engaging and maintaining the attention of students. He actively sought slipping from mathematics into diversions, suggesting he finds this personally stimulating. It may be that, for this teacher, being central to activity is essential for this style of modelling.

Debbie feels that children learn mathematics through their teacher modelling fun and activity and through the teacher enacting satisfaction accruing to successfully meeting of challenges. She models to students that 'I'm Really Into This' (IRIT), throughout the observed session. Debbie engages with challenge and adds complexity, modelling fun in engagement, and enacting teaching as a playful performance. Debbie spoke rapidly whilst moving, and engaged in several conversations at the same time. It was almost as if she was creating new levels of challenge within the existing one, and encouraging her students to do the same. For example,

> *"When they do Tarsia puzzles I try to make it [...] a bit more complex by putting the same answer in, but I only do it with one answer, just because they've done so many of them before".*

The valuing of complexity seemed to be just for the fun and novelty of it, such as creating mathematics murder mysteries. Although she used the term stressful, my feeling is that she liked,

> *"…juggling around six different things".*

Or finding a new way to manage tiredness,

> *"When I have had a long day, I will sit on my wheelie chair and wheel myself around the room,"*

So even tiredness is, for her, a problem to solve creatively; to turn into fun. Her performance was interactive, she rarely stood at the front of the class for long, and I had trouble tracking her rapid circling of the class with the camera. The video shows her style as dramatic, highly active and full of gesture. For example, her directions to students are physical e.g. *'swish it all up'* for collect your papers together, accompanied by a wide sweeping gesture. Perhaps overly so, as she acknowledged when asked about these gestures, '*I was just being silly.*' She used many overt noises such as *'Wooo!'* and *'Oooh...swearing? No!'* which shows a strong appreciation of absurdity. She made use of comic pauses and punch lines and attached emotive language to objects e.g. *'nice worksheet'.* The impression given was that she really enjoyed the session, and hopefully students felt the same. This impression was supported by much laughter in interview, but also in the classroom. An applicable ES modelled by Debbie is 'Check This Out' (CTO). This ES is communicative, an ES evolving and forming a belief in the inherent interest of mathematics, and I would suggest that she aligns, especially by modelling, with perceived reward coming from completion of a problem or conscientiousness. This 'payoff' also appears for her motivations within her career story.

Gus and Debbie both exhibit playful characteristics in their teaching, whilst they both talk in interview of deriving enjoyment from their teaching. However, the dominant

ES reveal differences in their styles. CTO for Debbie aligns with combining mathematical work and play, and LMTY in conjunction with LHSIA aligns with a centre stage playfulness that combines mathematics and the social for Gus. I noted differing patterns in their classroom interactions for both teachers, such as differences in cadence, rhythm and pace, and how these then model engaging in mathematics.

5 Carol and Helen: Positive emotions when modelling learning mathematics as procedural or conceptual

Carol's ES are LMTY and IRIT, which suggests that her lessons would include a placing of emphasis on social learning and the encouragement of deeper engagement such as through using extending questions and through modelling discussion, as well as absorption. This occurred from the first interview, where she took time to check what it was that I, as interviewer, was looking for. Modelling of a positive response to frustration is likely for this ES combination, and that mathematics is intriguing. Helen's predominant ES is also LMTY, but in a form that combines with and appears in conjunction with GJD. In terms of modelling, a ES of GJD predicts time efficient strategies, procedural teaching and a negative response to frustration. There may be systematic following of instructions, and an emphasis on fulfilling obligations.

In the relative frequency episode for Carol, she is interacting with a group of three students who are throwing a dice and constructing a graph of the data. The lesson is experiential, and the students design their own graphs to represent their data. Carol watches the students, asks questions and then shows the group how frequency graphs are constructed using a textbook. The episode shows Carol modelling checking first; a careful assessment of the situation before acting. She ascertains the student view and their point of understanding in relation to the task before intervening and helping. She models patience and thoughtfulness when doing mathematics. The episode is a textbook model of what a 'good' teacher does. Her positioning aligns to students and then to mathematics in three distinct communicative pedagogical phases. Firstly, she models listening as she encourages explanation from the students with her head on one side, with expectant body posture and an interested face. The second phase is checking of what students have done by asking questions, and waiting for their responses. Finally, she intervenes and models by sharing a book example. Her three phases in the episode show her standing listening (Fig. 4.3a), seated for asking questions, as she says, ‘at their level’ (Fig. 4.3b), and then aligning physically with mathematics as authoritative textbook (Fig. 4.3c).

Whilst modelling a process for learning mathematics, Carol models that it is important to take care when doing mathematics. The PT analysis draws attention to Carol’s subtle shifts in pronoun use, shifts indicative of positioning students and self within a discussion. Based on this, I suggest that she is modelling process over product in learning mathematics, and that mathematics is social problem solving.

Helen, in the selected episode, is preparing year 7 students for a forthcoming examination. The episode shows the transition into an activity in the second part of the lesson. The students are reorganised into small groups by number, and each group is given a slip containing an exam type question. When they have an answer, they bring it to the teacher for checking, with points awarded on a descending scale from right first time through to needing help.

Helen models rule and instruction following in the episode, and that mathematics is serious. Although the episode provides an example of encouraging discussion about questions (not problems as for Carol, since Helen’s students are revising for an imminent exam), this is not through modelling of discussion. The impression was that group activity was chosen to change the lesson pace, perhaps as part of what teachers are expected to do. In the episode, Helen expresses mild impatience. Her attention is drawn to a student who is deliberately (and in my view provokingly) slow in moving to his activity group when the rest of the class is ready to start. Helen directs impatience as a direct instruction, in the form ‘do not’, at the action of thumping his bag on the table and scrapping a chair across the floor. Her impatience appears to be because the student is not responding quickly and appropriately to instruction. The impatience continues, moved onto speaking sharply to other students about general school rules. When asked about the incident afterwards, in interview, Helen attributes the first boy’s action, *“Oh for goodness sake, you are not thinking are you!”*

She also suggests that her planned lesson was not working smoothly as she had not allowed sufficient time for movement, that she was ‘stressed’ about time management, adding that she felt pressured as it was the last lesson before an end of year test. Her other comments suggest that assessment is important to her view of teaching purpose, whilst being exploratory and outside the curriculum is a treat,

“I am looking forward to [Activities]...that’s quite acceptable at this time of year, it’s fine.”

Play (5.1) for Helen is seen as a luxury, only allowable at the end of term, modelling that play is not of real value. For example, in the lesson Helen avoids the social dynamic, taking a detached role as does Bertha (5.2, Example 2) and perceiving risk in students not being successful. Helen positions herself as arbiter in the activity, the primary source of help, as opposed to the students helping each other,

“If you want to ask for some help that’s ok, you can have some help, but that will count as one of your tries.”

In terms of modelling of process or product, Helen values product over process for learning mathematics. She models that the purpose of doing and learning mathematics is to pass exams. Helen’s interview includes references to being judged on outcome, and that her primary responsibility is for students to do well in tests. The episode shows Helen placing emphasis on the rules of the activity and on how to achieve points, rather than on the discussion dimension; modelling that it is important to follow rules. The following of rules is not limited to mathematics. When giving instructions, her deviation also relates to rules, such as,

“Please tuck that shirt in. If I have to ask you again it will be a detention.”

It is not what she says, more how and when, the deviations appear as a random intense interruption to a set of teaching instructions. In interview, Helen talked positively about the product-orientated dimensions of mathematics. For example, that she liked mathematics because of the practical applications that value strategic problem solving and for the kudos of the status as well as the utility value. Helen appreciated the reliable and relatively fixed nature of syllabus content and structure, yet recognised there is space for variations by a teacher within the structure, and hence unsurprisingly, she expressed concern about the imminent shift in UK assessment towards problem solving.

My impression as observer was, despite no overt examples of humour in either example, of a positive atmosphere in both classes. For example, in the selected episodes, Helen and Carol communicated intensely with students, and in interview both teachers indicated a secure knowledge of student capacity. The students in both classes appeared engaged and attentive, yet without significant evidence of modelling of the pleasure of doing mathematics to students.

In the following extended extract from Carol after the lesson, Carol describes the session, revealing how she sees the modelling of the process of learning, usefully describing the effect of the lesson on the next session for these students,

> *"... I was a bit surprised that they hadn't managed to get more out of what they were doing […] whether they didn't understand or whether they weren't gelling as a group properly […] because I knew they should be able to do it, but they weren't giving me anything back […] that's probably why I sat down, because they weren't really engaging with me. And so, rather than standing there, I'm the teacher telling them what to do, I was trying to get down on their level and having more of a conversation […] That's me trying to get stuff from them rather than... tell them (yes) because I'm quite often too quick to sort of go ahead and tell them stuff […] I'll get excited about it, I'll keep talking, so when I am doing that, it's me... don't stop […] because I hadn't given them a relative frequency graph, I wanted them to just come up with it (yes) but they got themselves in such a muddle with it and were trying to graph […] But they weren't getting the cumulative aspect of it […] Which is why I was trying to do it practically, because it is summat* [Something] *they always seem to forget […] I'd come away from that lesson thinking, ah, that flopped a bit, and that hasn't really worked the way I was intending it to, they haven't got as far as I*

wanted, they haven't put as much on paper, (Yeah) which is always the danger with group work isn't it. That they haven't achieved, I've got nothing to show for this hour, (Yeah) but once we have had today's lesson and they are actually drawing out the graphs, they're understanding... 'Oh, that one's a relative frequency, right so I'll plot it like this' (Ok) because they've tried it themselves, so they understand... what the numbers meant. And the questions I had today were much better, much more advanced than what I was expecting. (Ok) Which is weird isn't it. I didn't feel that I was getting much from them."

The extract shows Carol's deep emotional engagement with her students, relevant because her emotions in the observed lessons are not extreme. I would classify these emotions as 'gently positive'; modelling learning of mathematics as pensiveness, thoughtfulness and interest which indicates that learning mathematics is a serious business, but not unemotional. It also shows the importance of communication for her, and what gives her pleasure in her teaching.

In this last example I have considered the modelling of importance within the learning of mathematics, contrasting teachers who are process and product orientated. Yet both teachers talk of insecurities and mismatches associated with being positioned as a 'good' teacher, based on their beliefs about what this constitutes. For example, how much control is required or what emotions can be revealed to students.

5.2.2 Synthesis of these five examples in terms of ES and PT and some implications of expressing positive emotions in the form of modelling

The episodes show teachers attempting to model ideal ES patterns for learning, which, in PT terms, students may then mimic, synchronise with or reject, hence choices in modelling may prove to enable (or hinder) student shifts in ES. To illustrate this potential for influencing student ES, the example of Adam (1, 3), who has a dominant ES of LMTY supported by LHSIA and IRIT, is useful. Positioning

Amy as an expert (1) encourages her to adopt a position of LMTY, which is partially accepted, and of which he models approval. The supportive ES of LHSIA appears in his subtle modelling of the importance of being an expert in relation to mathematics, an importance he encourages students to accept. IRIT appears in his absorption in board work during the 'upper and lower bound' episode (3). Here he models being a problem solver, a position that aligns with all three ES. This position is illustrated by Adam's use of summative rhetorical questions, which also serve to refocus student attention, such as,

> *"What happened there?* [Pause] *I minimised the difference."* (A1)

In terms of student ES, his modelling of problem solving by verbalising his thinking processes and rhetorical questions, would, combined as they are with expression of positive emotions, lead students towards ES that are positive for learning. When a teacher wishes students to pay attention specifically to the mathematics, it takes effort to place emphasis. Mason (1989) calls this 'the shifts conjecture'. By this, he means that shifting attention is a useful trick to address simultaneously *"cognitive uncertainty, affective disharmony...."* when the whole is potentially overwhelming (p.247, p.252).

The participant teachers use a range of complex and fluid forms of modelling that illustrate expert emotionally orientated pedagogy in action. The paired examples illustrate how a teacher might model in forms that contribute to the emotional climate. The first two examples (1,2) show how positioning within modelling can evoke positive emotions; Adam and Edward through physical position, Freddie through being 'as student'. Bertha's abrogation, where there are also negative emotions, shows how important teacher modelling is for known issues in learning mathematics, in this case coping with error (3). I have also considered modelling as emotional display, using two teachers who show pleasure in their engagement with mathematics teaching (4). Ziv (2010) asks, specifically for humour, whether a teacher can go too far. I suggest that, provided a teacher is comfortable, and functions within individually set limits, there seem to be advantages to modelling enjoyment of learning mathematics as both neoteny and a social pleasure. Example 5 considers how control and expectations of teacher behaviours may act to limit positive emotional display, as for Helen and Carol. However, modelling does not appear in isolation to other ways or means of expressing positive emotions; it is part of the story of teacher interaction. In the next section, I take a closer look at storytelling as a further form of expression of positive emotions.

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5.3 Storytelling as a means to communicate mathematics and to engage students emotionally

> *"Story is everywhere in human lives and cultures and it features strongly in the processes of teaching and learning. Story can be called narrative, case study, critical incident, life history, anecdote, scenario, illustration or example, creative writing, storytelling; it is a unit of communication…"* (Moon, 2010, preface).

The third teacher positive emotion form of expression emerging from Chapter 4 is storytelling. Storytelling aligns to classroom mathematics since stories act to connect, orientate, support understanding, give students a sense of anticipation and provide a temporal connection with other learning. Whilst learning mathematics involves being receptive to new stories. Stories also act to align emotions of teller and listener. Hence, an important place for storytelling is during daily interaction in a mathematics classroom. This section establishes what is meant by storytelling within mathematics teaching and suggests a model (based on Fineman, 2000) that structures storytelling, in order to examine participant teacher emotion use in this form.

There is no doubt that everyone enjoys listening to or telling a good story; it is part of human nature. There is a long oral tradition for communal learning through storytelling (Connolly, 1990) as people think and understand the world in terms of stories. In modern times, storytelling is often associated with young children, implying that there is no place for storytelling in a secondary mathematics classroom. Yet storytelling, as for play (5.1), appears in many forms that are valuable for learning. Stories appear as simply telling a story to another person (such as in interviews), telling to self, telling of an object (e.g. telling of mathematics or of one's relationship with mathematics), or they appear in classrooms as a teacher storytelling to students about mathematics. Students also create stories to share in class. Schiro (2004) suggests that situating problems in lengthier stories means students will be more likely to dream about, discuss, imagine, share ideas about, and re-play in their minds story events, such as what will happen next, and how mathematical problems emerging from within the story might be addressed. All these are part of teaching and learning and, similarly to ES, can act to enable or constrain other stories,

> *"…the scripts students can write and act out in the classroom are greatly affected by the Mathematics story facilitated by the teacher"* (Gadanidis & Hoogland, 2003, p.489).

Mathematics classroom examples of storytelling exist as a unique narrative form with characteristics distinguishable from other forms of communication. Stories have a recognisable structure, with beginning, middle and end, forming a narrative unit or episode. Gadanidis & Hoogland (2003) place mathematical engagement within the context of mathematics as a story in itself. They also consider what types of student and teacher roles make for a good mathematical story (See also Zazkis & Liljedahl, 2009; Balakrishnan, 2008). Although primary based, they suggest a 'good' story is about presenting mathematics to allow emotional engagement as experienced by an audience, that the skill of keeping the attention of an audience is achieved through managing audience emotions. Whilst Fineman (2000) suggests that it is through 'good' stories that feelings can be seen, felt and articulated and communities confirmed. Gadanidis & Hoogland (2003) suggest a story, appropriately for mathematics, embodies complexity and is multi-modal which,

> *"…refers to story's ability to hold the complexity of experience in a single work [Lesson] and to present sensory, emotional, and conceptual information simultaneously, through image and metaphor."* (p489).

Other benefits follow from placing emphasis on attention and engagement, such as through characteristic cadence in story form, rhythm, pace and emphasis. Dewey (1934) remarked,

> *"[t]he live creature demands order in his living but he also demands novelty. Confusion is displeasing but so is ennui[16]" (p171).*

[16] Ennui - a feeling of listlessness and dissatisfaction arising from a lack of occupation or excitement. As in "he succumbed to ennui and despair." Synonyms include boredom, lethargy, restlessness, dissatisfaction, melancholy or depression.

Rhythm, for Dewey, is found in the tension between order and novelty as summing up and carrying forward relationships. Rhythm, he said, is not expressed in the 'tick-tock' theory of movement from order to novelty and back again, but is experienced in an energetic driving forward of the tick-tock cycle. Therefore, one way that demand for novelty and energy, and subsequent student engagement can be met is through the pace, cadence and variations integral to and accessible through storytelling. Gadanidis and Hoogland (2003) suggest that mathematics stories may be experienced in schools as 'flat-lined' (p.489) without peaks and troughs essential for an engaging story, and therefore is not a 'good' story to live through, either for teller or listener.

There is a distinction between planning to use stories, and spontaneous use or appearance within usual mathematics lessons. Zazkis & Liljedahl (2009) suggest categories for assigning a purpose for a story, such as providing a framing for exploring storytelling or as accompanying or intertwining mathematics. Stories can introduce mathematics by concept, activity or as question posing or be used to clarify mathematical points. They can also form jokes or appear within relationships as teacher self-depreciation. Moreover, a story, as for emotions, might be used to give or take control, to facilitate lessons, or flow over time.

The emotional hue that a teacher imbues within a story may achieve the persuasive role of storytelling. Heyd-Metzuyanim and Sfard (2012) define emotional hue as,

> *"…what makes us interpret a person as communicating that he or she feels in a certain way." (*p.132)

Positive emotions as used by teachers serve to restore pleasure in the learning process (Gadanidis & Hoogland, 2003). Moreover, teachers act to mediate between curriculum and students to restore aesthetic pleasure and make learning of mathematics meaningful, for the teacher as well as students. Positive emotions thus appear as empathy within stories, where empathy is a mechanism for revealing feelings. Storytelling as evoking empathy is described by Fineman (2000) as an art form, sharing four basic boundary features. These are that norms are established within a story. Secondly, dynamic tensions appear, (which in our context may appear as deviation or the unexpected. Thirdly, a story should include capacity for growth or movement, (as Dewey, 1934). Finally, a 'good' story contains future possibility. Combining these basic emotionally orientated features defines whether there is a story within the discourse, unlike say a scenario. These four features: boundaries, dynamic tension, growth and future possibility, provide a definition for selecting from episodes of teaching as illustrating storytelling.

The literature suggests that storytelling is rare in mathematics lessons, is 'flat-lined'; the essential cadence of story is missing. Whilst Zazkis & Liljedahl (2009) suggest,

> *"We might occasionally tell a 'mathematical' story in the course of teaching children, but it is only an incidental accessorizing of the 'real work', which is often perceived as practicing the mathematical algorithms themselves."* (p.2)

Drawing from Chapter 4, I would argue the opposite, that these participant teachers see the 'real work' as the dynamic communication of mathematical stories, and that these are embedded norms for their practice, not just prepared as part of lesson planning. Next, I use the interview and observation data to assess whether this view can be substantiated. I explore in this section how the participant teachers talk about and use storytelling when interacting with students.

5.3.1 Positive emotions as storytelling: Illustrations from mathematics classrooms

The focus here is not stories that participant teachers tell about themselves in interview, nor stories designed within lesson planning to support learning, such as Hobbs & Davis (2013) or Zazkis & Liljedahl (2009) examine for narrative as a pedagogical practice. Rather, I present selected stories observed as part of daily interaction between experienced teachers and their students. I suggest that storytelling in this form is common, emotionally located, yet highly dependent on teacher willingness, imaginative ability and positive relations with students. I also suggest that classrooms norms are important within effective storytelling.

The four examples of story discussed all include laughter, identified as strong positive emotional expression in the classroom and appearing in interview. In these examples, teacher use of story appears to support conceptual understanding (Sleep, 2012) or allows students to imagine power in relation to syllabus (Adam), connects different parts of mathematics together (Freddie) and spontaneously emerges from mathematics communication as part of patterns of discourse (Gus). Three examples are unplanned by the teacher or expected by students. They emerge through a willingness from both teacher and students to engage in discussion.

1: Freddie in interview – Deliberate connective stories

Freddie enjoys connective storytelling in his role as a mathematics teacher, if specific emphasis in interview is an indication,

> *"And... my job, I was... I was a lifeguard and sort of water sport specialist and I spent all day, sort of 30-degree heat, teaching canoeing and kayaking and sailing and swimming and windsurfing... and... sort of, there were kids around all day um... and in the evening we would tell them ghost stories and things and looking back now I think that was amazing…"*

He adds how he sees storytelling as a means of making his relationship with students 'real', such as by making himself the foolish one, using both the imaginary and his life stories to achieve this,

> *"I think I talk too much, which I don't know if this has come across over the microphone, um... but I like to tell a lot of stories, in... when I am teaching. Um... I try... I have a story for pretty much every lesson that I teach. Um...Which... my personal opinion is that the kids... like, because a lot of the stories involve me in some way, so I give across quite a lot of myself to the kids, and I think they genuinely like that because I think that they see me as quite a real person, because I give a lot... a lot of myself off to them and they know that um... I relate very well... or I try and relate myself as well to them as I can, so I try and...and so quite a few of my stories put myself at like a disadvantage in some way, so they never... I like to think they never feel like an idiot*

> *or whatever because I've made... I've put myself down first, so it doesn't matter if they mess up because I have already said something where they can, so I'd like to think where... like a typical lesson I might have some kind of engaging starter I might kind of um... tell a story and um... introduce the topic, we kind of practice it a little bit, and then try and apply it in some sort of game…"*

When Freddie talked about his drawing (Fig. 4.32), produced in interview he adds,

> *"Yeh, I've got my table in groups. Um... this is me sort of dressed up in my sports gear ready to sort of go and play some sport. Um... yeah, cos this is kind of my lesson really, I sort of er... tell a nice story, relaxes everyone, and sort of introduces a topic, then they kind of work together and help each other, interact and talk about the maths…"*

This example is of a teacher talking of storytelling as a teaching strategy, with deliberate purpose of developing social relationships, and addressing potential negative emotions of great importance to teenagers, such as not looking foolish, we also see this use of positioning as one who does not mind appearing foolish enacted in his lesson (5.2 Example 2). This position suggests he sees stories as reducing boundaries and that dynamic tension forms part of his lesson design as well as being open to opportunities to use stories whilst interacting. His storytelling as described emphasises the application value of mathematics, and is used as a relaxer for potentially anxious students, and as a lead into activities. Freddie's dominant ES are CTO and LMTY, as discussed later (5.4), both conducive to storytelling.

2: Adam and the sheep – Using a story to support conceptual understanding

This and subsequent episodes are drawn from classroom episodes that already appear in conjunction with play (5.1) or modelling (5.2). Adam and 'the sheep' (A3/2) appears in a setting where norms are strong (A3/1). He sets the boundary expectations of 'not student' (fantasy role) behaviour clearly, *"Right so… Mark, (Yeah) pretend you are sitting in the corner of a field... being the shepherd, right. You can sit on the floor as well, yeah [Some giggles]. You've got to imagine Mark's got like a funny hat thing, and you're the sheep. Alright."*

Adam's teaching includes deviations, where entertainment is expected as a norm for this teacher and students. In this illustration, the students do not know where this story will go, which addresses a need for a story to have dynamic tension. Nevertheless, they trust that it will entertain (shown by student willingness to engage in the new story, in effect accepting the position offered by the teacher), one student asks, *"Can I do something?"* and others happily bleat from their positioning as fantasy sheep. This story emerges from the mathematics, and is not prepared in advance. Adam cannot predict exactly where the story will go, or how these teenage students will respond. There is dynamic tension for Adam too in this episode. However, as he is an experienced teacher, he has established expectations, and has the skills to manage students who might attempt diverting from the story for other purposes (See Jack's attempt at a subplot in transcript). As discussed for play (5.1), he is the initiator of the story, a story intended to move students forward in their mathematical understanding. Adam's language has a strong future orientation often using the future predictive in the form of you will… or,

"We'll come onto what that means" (A2),

A form appropriate to keeping suspense (Fineman, 2000) and meeting a requirement for a story to include growth or movement and to contain future possibility.

In terms of the aural traditions of storytelling, this episode includes shifts, pauses, pace, emphasis and changes in tone of voice, characteristics that you would expect from a story read aloud. Much more is conveyed in this way than transcript can show. My identification of the episode as a story is dependent on these emotion-inducing aural dips and peaks that act to break a mathematical storyline by deviation. The affective impact is evidenced by laughter and evident pleasure for both teacher and students. In my notes for this episode, I comment that if he were performing a play, he would be carrying the audience in this way, with emotional dips and peaks used to draw attention, and to develop a desired storyline. Yet teaching is not a stage performance with a passive audience, here the students are integral actors in the fantasy construction.

There are some essential requirements of a teacher to make storytelling possible and effective, such as verb use. The use of PT draws attention to this. Adam's speech in this and other observed lessons is predominantly action orientated, both current and future, even when he is asking students to listen and not actively participate. There is also a factual concrete element to his mathematical discourse, not language of explore, imagine or feel reserved for storytelling, a certainty in language that acts as a foil to any flights of fantasy. I have used this episode as the teacher discusses it afterwards, and the ESensor indicated a sustained period of intensity, yet there were similar episodes in the observed sessions, although none perhaps so dramatic. As for Adam's other established norms, I expect that all he will need to do in future is to say 'sheep' and students will recall, by association, the significance of n. In terms of emotions, the impression as observer is a willingness on the part of the teacher to play and enjoy this, but as a classroom tool. There is a mathematical purpose. Adam's dominant ES is LMTY supported by LHSIA and IRIT, a combination that may support storytelling.

3: David Ginola, Gus and his hair – Temporal, future and connective storytelling

This example is a story without mathematics, although the story emerges spontaneously from mathematical discourse. The episode breaks into story as an interlude or deviation from the mathematical task, a choice that has multiple implications. From interview, we know that it is important to Gus to tell a continuous story, so that students do not lose interest. Gus achieves continuity by shifting in and out of mathematics, at a fast pace, a form of managed deviation. The storytelling seems to act as a verbal filler, intended to keep the flow as the teacher takes multiple positions in rapid succession, a pattern that PT analysis captures.

In the selected episode, Gus waits for some students to catch up with taking notes. The story, a predominantly anecdotal one, acts to engage student attention, keeps focus and pace, and reduces the chance of student time wasting. The example is of a recurring pattern of on and off task in the lesson where Gus models adaptive reasoning and connectivity, and smoothing shifts and transition between tasks through storytelling. The episode illustrates this teacher's future orientation, a characteristic of good storytelling (Fineman, 2000), through association with possible future activity as mathematicians. The growth and future possibility as presented to students is apparent in this episode. For example, the implication is that students have a bright future ('*They'll think you can...*'), that success is expected, but in a positive form bounded by relevance and applicability to 12 year olds, through associating with their knowledge and experiences of football, politics and TV. This interpretation is one dimension of a complex story, as he presents mathematics from a wider context and purpose, using vocabulary as a tool.

A further characteristic of a good story is dynamic tension. As observer, I felt as absorbed in the lesson as students evidently were. There was delight for me as observer in knowing that no-one, possibly including Gus, could be sure where Gus would go next. Hence the students were hanging on Gus' every word, anticipating enjoying the interaction, whether mathematics or banter, the distinction being blurred. The consequence was a productive disposition, evidenced by their willing engagement in the mathematics in this lesson.

The use of PT reveals in detail how Gus manages the storyline, highlighting the temporality of the discourse and how accepting or negotiating appears as the norm in the classroom discourse. In the management of the storyline, Gus skilfully rejects competing storylines to keep the story flowing to desired conclusion. To illustrate this flow, we can look at how he shifts a potential criticism of one student's pronunciation into a football story.

S2 *It's not Dav-id, it's Day-vid*

T *Dav-id Cameron, who plays football like Dav-id Ginola? Yes.*

This episode highlights the ownership of the story. It appears, through accepting and building on the comments of students, that the storyline is shared between teacher and students, but closer inspection shows that the relationship is one where the teacher is in charge. The story continues until control is clear; the teacher decides the story end.

The episode illustrates connectivity, as it shows the key mathematics learning point leading into the episode, and how the teacher weights mathematics language and vocabulary with importance by the time dwelt on it. Looking at the whole lesson, there is a pattern of intense mathematical concentration interspersed with banter and relaxation through story, anecdote and laughter. This teacher told me in interview that he has abandoned behavioural rules that for him serve no purpose in learning. Gus' dominant ES is LHSIA, supported by LMTY. This combination may be ideal for effective expression of positive emotions in the form of storytelling.

4: Adam and the exam board – Serial storytelling

Amid the data, some episodes stand out in terms of the intensity of the positive emotions expressed and the potential for impact on student learning, this is one such episode. I appreciated the student enjoyment, alongside the teacher's skill and artistry in conducting the lesson, and on another level, awareness of some subtle messages underlying the interaction. The 'exam board' story is a serial story, begun spontaneously in the first lesson observed, and continued the following week by the teacher, and then, as the teacher reports, extended to other cohorts. As Adam convinces the students that they have the power to change the curriculum, that their suggestions for names for sequences (square numbers, triangle numbers) have been agreed by the exam board, he uses a strong degree of persuasion (positive emotion as effort). It is uncertain how much students believe the story, but the potential effect is student imagining of a more powerful position that has implications for learning the relevant terminology, even if some students are unbelieving. The story boundary lies within the classroom context and the future expected activities of students, thus aligning to their future needs. The story, as for a soap opera, includes the 'cliff hanger' of what the exam board will say, with instalments of reporting to students on intermediary discussions. Post observation, the teacher laughed as he recalled the episode.

5.3.2 The diversity and complexity of storytelling in action

The four examples provide a range of what stories might appear and the varied purposes. I would suggest that there are ES more supportive of storytelling such as LHSIA, CTO, IRIT or LMTY. Comparing these ES to those dominating the teachers used as examples, for Gus and Adam, both dominant and supporting ES come from this group. Not only is there laughter and evident pleasure in the exchanges, but they emerge spontaneously. In terms of encouraging enjoyment in mathematics lessons, the spontaneous, which is likely to involve shared communication, may have more impact. Fineman's (2000) characteristics of a good story are norm establishment, dynamic tensions, growth or movement and future possibility. These act in conjunction with norms and using positive emotions whilst teaching mathematics. Judging by student response, storytelling in the forms described is part of normal classroom practice for the participating teachers, within the boundaries of their classes.

Schiro (2004) writes of storytelling for mathematics in primary schools, suggesting that the experienced story is temporarily real as for play (5.1). This temporary reality applies on an individual level, but in relation to emotions in the learning of mathematics, on a social level as well. Stories can position both storyteller and listeners as being part of a local community, in a story that tells of sameness and difference. In the classroom, the teacher provides students with stories about mathematics in hourly chunks, but also over the years, that act to model imaginative futures. Through stories, Adam, Freddie and Gus model what students can expect as both proximal and distal. For example, by locating a topic in the wider syllabus, or suggesting where a topic leads or extending beyond the classroom boundaries into what it would be like to be a mathematician or a mathematics teacher.

These examples show story might support conceptual understanding, allowing students to imagine power, story connects mathematics together and is part of patterns of discourse. Stories emerge through a willingness from both teacher and students to engage in discussion. The use of positive emotions on the part of a teacher becomes possible through storytelling. Fredrickson (2001) suggests that positive affect facilitates approach behaviour and persistence, and I would add that positive emotions evoked by storytelling are supportive of such behaviours. Gus' example in particular illustrates this theory in action, evidenced by the willingness of his students to engage in both banter and mathematics. These examples suggest that expressing emotions as storytelling engages students and provides, in Dewey terms, the cadence and impulse of rhythm that drives learning.

For any storyteller, appropriate 'pitching' of the story for an audience, in this case teenagers, requires skill. For example, managing smooth integration of stories into the scenes and acts of a lesson, altering pace and emphasis and shifting attention through stories. Storytelling in supportive conditions, including a receptive audience and a skilled narrator, can be a source of pleasure, a powerful form of emotional mediation between students and mathematics if used to communicate mathematics as one part of a multiplicity of roles for a teacher. This implies a teacher needs to be willing to regularly use connective imagination and a predictive mind to make mathematics come alive in this form. This study considers experienced teachers, and hence raises new questions for future research, such as when during professional development does storytelling becomes part of daily practice? Should trainee secondary mathematics teachers be encouraged to incorporate stories into their lessons?

This concludes the discussion of the four selected forms of positive emotional expression, self (5.0), play (5.1), modelling (5.2) and storytelling (5.3). In this Chapter, I have explored what it means for the participating teachers to enjoy mathematics teaching. It is evident that the participating teachers derive a great deal of pleasure for themselves from their teaching and it seems that some teachers position themselves, and have dominant ES, that maximise deriving pleasure for self in the classroom. 5.1 to 5.3 emphasise the social role of emotions in teaching and learning mathematics. They show both the interconnectedness and the range of expression within a few episodes, and that emotions play a vital role in all three forms. In the next section, 5.4, I evaluate the role that ES and PT have played in this drawing out of interpretations.

5.4 Evaluating Engagement Structures for mathematics teachers in conjunction with Positioning Theory

> *"A new construct requires addressing several criteria: its need and the purposes it serves; its fit with other proven constructs; its theoretical utility in characterizing or explaining phenomena under discussion; the potential for its empirical validation or confirmation; its empirical utility, e.g., in suggesting new questions for study; and importantly, its potential practical value—here, as a tool to improve mathematics teaching."* (Goldin et al., 2011, p.548)

In 5.4.1, I evaluate the use of ES and tentatively review which ES or patterns of ES seem appropriate for engaging students when emotions also appear in class. I also examine whether using ES as a lens supports the examination of the role of teacher emotions in a mathematics classroom. In 5.4.2 I suggest that for examining emotions in context, PT supports examination of the fine detail of interaction, whilst complementing ES, and provides important clues indicative of ES formation. I conclude that, based on this study, new ES have not emerged from the analysis, although further modifications may be needed, as a mathematics teacher's professional role acts as a barrier to adopting all the ES that are available to students. To illustrate modification, in 5.4.3, I look in detail at how one ES, LMTY, alters for the participant teachers. Here, I explore the subtle divisions in how the ES of LMTY may work for teachers. This choice of exemplar is guided by the fact that LMTY, originally developed as an ES for students, is the only ES that appears in the analysis for all the participant teachers, but somewhat unexpectedly appearing with varying degrees of centrality and dominance.

5.4.1 Evaluation of ES. Do they work for teachers?

In Chapter 2, I introduced Goldin et al.'s (2011) ES for the analysis of emotions in the classroom. In Chapter 3, I explored how this introduction might be achieved in the context of my teacher orientated research. In Chapter 4, I assigned ES for each teacher, drawing on these within the earlier Chapter 5 discussions. One original reason for choosing ES was the universal nature, as Goldin et al. (2011) states, *"We see them as universally or near- universally present in individuals."* (p.554). On this basis, the model seemed to be applicable for studying the affect of teachers, particularly as the context, a mathematics classroom, remains constant. A second justification for selecting ES, for why this model seems appropriate for purpose, was because I saw value in this model for developing practice. Therefore, part of the process is to evaluate not only whether ES are portable to teachers, but whether there is usefulness in applying the model to teachers. Overall, the ES as used in Chapter 4 seem to provide a useful lens for the bigger picture of how a teacher interacts emotionally with students, one that can indeed identify dominant structures, structures constructed from interview and observation, suggesting portability. For this study (as discussed in 5.0 to 5.3), the use has revealed new dimensions of emotion use in a mathematics classroom, providing unique insight into classroom practices. Yet given that portability based on this sample of data remains feasible, there are some limitations and a need for some variations. In this research, I cross an interpretive boundary between students and teachers. I also assumed from the start, in order to maintain consistency within the model, that unless the analysis showed otherwise, the original ES are directly transferrable. Based on this data, the analysis has not showed otherwise, despite some nuanced differences as illustrated for LMTY (5.4.3).

One risk is that although designed with affect in mind, the model, if not used carefully, may lose the emotional dimension. This risk emerged early when applying the model to sample data. The result was selecting episodes based on emotional expression, using the ESensor data where possible, prior to using ES as the lens, which kept sight of the positive emotional focus of the research. Similarly, the labelling of transcripts with affective pathways kept the emotional dimension to the fore. ES in conjunction with teacher reflection on episodes where emotions are expressed provides a model for analysis of teaching that is particularly useful for affect in classrooms where stable positions and fluid positioning can be analysed together.

Which are the 'best' ES for teachers?

Pedagogical approaches that contribute to student disinterest are well known (e.g. Boaler, 1997, Nardi and Steward, 2003); it seems reasonable to suggest that ES influence engagement similarly. Goldin et al. (2011) asserts that no ES are bad in themselves. I would add that patterns of ES, and the degree of dominance may prove to be significant in supporting engagement or otherwise. Table 4.16 (p.231) shows no significant patterns across the sample of teachers, suggesting that ES act in combinations, which are determined by context.

In terms of play, modelling and storytelling, the ES combinations are mainly LMTY, with IRIT or CTO. This is based on the summary ES of participant teachers, those judged in the observed mathematics lessons to be using emotions in these forms within their teaching. IRIT and CTO, which are potentially commensurate with using emotions, may require effort on the part of teachers, more so perhaps than the other ES, whereas branching into other ES makes the role manageable, such as GJD. Countering this interpretation is Gus (whose combination is diverse, with dominant ES of LHSIA and LMTY, supported by CTO, IRIT and DDM), who views the use of emotions as reducing stress for himself and his students.

What may be helpful for future exploration of ES is examining the mechanism of how teacher positioning acts to position students into useful ES, within the context of fluidity and change in a mathematics classroom. There are preliminary indications that engaging lessons show more shifts and variations in the emotions shown to students, so there may also be value in exploring patterns of ES throughout a whole lesson. It might be that the rapidity of shifts and the associated fluidity and flexibility in ES only applies when positive emotions are used, and is therefore indicative of engaging teaching, rather than indicative of the dominant ES in themselves.

The next section focuses on LMTY as the common ES across all participants. Using LMTY, I exemplify the importance of patterning between the ES, drawing attention to how LMTY varies in combination with other ES, as LMTY is, as one would expect, particularly relevant to teachers. Yet as with any individuals, the way in which it appears within lessons, specifically how it relates to emotions, varies.

The use of PT evolved later in the research, addressing a perceived gap between the fluidity and transitory nature of emotions. It was introduced to provide balance and detail, and because, in early analysis, ES seeming to be drawing more evidence from the interview data (traits) than from the selected episodes from classroom interaction (states) that are central to my research questions.

5.4.2 Combining Engagement Structures and Positioning Theory

Accepting that discourse determines positions, which then, through experience, become firmed into dominant ES, provides two levels of lens for identifying teacher and student positions as they appear in the classroom. Goldin et al. (2011) address this temporality for individuals in terms of affective pathways, as used in this study, which they suggest become fixed into beliefs over time and repetition. Developed specifically to structure individual students engaged in problem solving, the pathway model invites an examination of emotions within discourse in the classroom. In this study, the attention is firmly on the teacher, so the analysis tells of the individual teacher's affective pathway. Yet when affective pathways are considered alongside the socially constructed PT analysis for each episode as in Chapter, the influence and response of the students begins to appear, showing potential for future research. This can be seen in the case of Bertha, where there is a degree of mismatch between Bertha's practice, and her espoused view of the teaching of mathematics. This highlights a strength of the combination of the two lenses; that any such contradictory positions are revealed for further examination. A second example of the increased power of combining the lenses emerged when analysing Edward's data. I initially thought the un-emotive language in interview and lesson left little to investigate in terms of emotions. Using ES and PT together, focussed on drawing affect from interviews and observation, led to unexpected dominant ES.

Further, if emotions play an activating role, then a mechanism is implied. For example, positive emotion use acts to support accepting or positively negotiating a position as offered by another. Accepting, rejecting and negotiation of positions as in PT that then form ES, brings the fluidity of PT to the fore and provides a feasible social mechanism by which individual affective pathways are directed and ES are constructed. The use of PT has proved useful in identifying this pattern. The evidence in this study suggests that use of positive emotions encourages the receiver to accept proffered positions rather than to reject. The analysis model of PT draws attention to this facet of emotions. Yet, perhaps contradictorily, in conjunction with power, the use of positive emotions may also act to encourage increased student negotiation of positions. The students feel sufficiently empowered to contribute their own positions, even if subsequently rejected. For example, student S1 attempts to negotiate in Lesson C1, similarly S2 in Lesson A1, Jack in Lesson A3/2 and another student in lesson G1, illustrating how such negotiating might occur. These attempts are rejected in positioning terms by the teacher, but that students even attempt to negotiate seems to be associated with the flexibility of teacher ES. A student feeling able to negotiate positively as well as accepting, may be less likely to experience negative emotions if their contribution is rejected or ignored. We can see this across the episodes discussed earlier in this Chapter, where positive emotions occur in complex forms. When considering modelling (5.2) and storytelling (5.3) it is PT that comes to the fore, whereas ES provides a framing structure to support and confirm the detail, showing how the social and individual align in-the-moment. This is particularly illustrated in the episodes from Adam, Edward and Gus, where overall, although the student ES are not identified in this study, students are more verbal and contributed more to whole class discussion, both in the episodes presented, and across the observed lessons. The importance of student contributions is well documented, yet implies that some patterns of teacher ES may be more supportive of negotiation. In Chapter 4, although all but INF of student ES also appear for participant teachers, some appear in conjunction with arguably less positive teaching (Table 4.16, p.231).

5.4.3 The centrality of 'Let Me Teach You' (LMTY)[17]

Within the ES, LMTY might be expected to be applicable to all teachers. I assume this as it is hard to imagine any teacher not adopting LMTY at some point whilst engaged in teaching. Teachers expect to, and are obliged to engage in LMTY as part of a teaching role, in comparison to LMTY for students, for whom this ES may be less often dominant. In this section, I explore how the characteristics and ES that are dominant in conjunction with LMTY change the nature of LMTY. Based on the data, LMTY is not a dominant ES for some participant teachers, so I look at the various ways LMTY appears in the data. Yet given this focus, the frequency or variations of LMTY remain potentially fruitful areas for further exploration. I start with clarifying student LMTY as appearing in the work of Goldin et al. (2011), attending to the transferability of LMTY to teachers. This is followed by a discussion of affection needs from Murray (1938), providing distinctions that may account for LMTY differences, as this source provides a basis for some alternative structures for LMTY. I illustrate these alternatives in relation to the participant teachers. The discussion concludes with considering some implications of the alternatives as likely to be conducive to, or oppositional to, student engagement.

Goldin and student LMTY

Goldin et al. (2011) present ES as meta-level structures, more complex than experienced emotions. Each ES has a different dynamic, although all have affective, cognitive and behavioural elements. For example, Goldin compares 'Let Me Teach You' (LMTY) to 'Look How Smart I Am' (LHSIA). In action, both ES would evoke different responses, although both have a mathematically communicative element. Changes in body stance indicate ES, such as establishing LMTY through leaning forward; as approach behaviour. According to PT, the interlocutors could accept, decline (reject) or negotiate the proffered expected response, altering their own positions as a result. For LMTY this might mean accepting a passive position as an

[17] A version of this section appears as Lake (2016).

ignorant recipient, declining the proffered teaching or responding by attempting a repositioning of self or other in a different way. Examining such interaction, including non-verbal communications, reveals participants motivating desires, whilst knowing some underlying motivations or beliefs through interview can predict how a person might behave or respond, hence determining which ES might be activated. The LMTY proposed by Goldin specifically for students whilst learning mathematics is summarised in Table 5.2.

Let Me Teach You	**Desire**	To help another understand or solve the problem.	Math has understandable internal logic, and the person has high self-efficacy **beliefs**. Understanding and helping others are both valued. Murray described a need as a *"potentiality or readiness to respond in a certain way under certain given circumstances"* (1938).
	Need	The **need** Murray identifies as nurturance includes: "to gratify the **needs** of a mentally confused person" (p. 184).	
	Evoked by	Evoked where a person who has insight or knowledge to share notices someone who does not understand.	
	Behaviour	**Behaviour** includes trying to help by explain or demonstrate	
	Emotional satisfaction	**Satisfaction** derived from the other person learning and/or appreciating the help.	

Table 5.2 Summary of LMTY (Based on Goldin et al., 2011)

A student attempting to assist a peer is not necessarily equitable to a teacher trying to help by explaining or demonstrating, although the desires, needs, evocation and satisfaction seem equally applicable. Goldin draws on the example of a student setting out 'to get the job done' (GJD), to just follow teacher instructions, but then the student might realise they understand better than their peers, so they move to LMTY. This new ES might prove a stronger motivator for the student than GJD. Yet the adopted ES might be declined by the peer response, they may not value his mathematical knowledge. The result might a further move into a performance ES such as LHSIA as the governing ES, in order to impress. This example is for a student, but if considered in relation to a teacher, then GJD might appear as achieving the lesson objectives, and a teacher is more likely to adopt LMTY because of their mathematical expert role and because their role is to notice where help is needed. Although there are some differences, and I consider some finer distinctions within the ES of LMTY, I did not find any need to alter, specifically for teachers, the structure of the ES classification.

The evocative social situation of awareness that another person does not understand lies at the core of teaching, especially when the teacher role is to offer adult guidance. Yet the underlying human gratification from appreciation for resolving confusion, or for providing a successful explanation is universal. Enacting LMTY is intricately bound to the identities of a mathematics teacher, as the one who helps, which has implications if students decline the LMTY as presented, or try to renegotiate. Declining in this context has serious emotional implications. Hagenauer & Volet (2014a) suggest,

> *"empathic emotions are more likely to occur if someone feels responsible for others, just as teachers frequently do, at least to some extent, for their students"* (p.255).

However, teachers have social responsibility, whilst simultaneously having responsibility for the success of their students. The implications are intensified if a teacher holds strong beliefs that value helping others, or if the teacher's self-efficacy is not robust. Declining of the LMTY ES by students threatens a teacher's self-efficacy and similarly, declining the teachers' explanations of mathematics impacts on the dominance and form of LMTY.

Adapting LMTY for teachers

Goldin draws on affection needs, originating from Murray (1938). Returning to this source assists in discriminating between different forms of LMTY. Alongside a nurturant attitude, as used in the LMTY previously described,

> *"To nourish, aid or protect a helpless O [Other]. To express sympathy. To 'mother' a child."*

Murray adds four more affection needs,

> *"…to do with affection between people; seeking it, exchanging it, giving it, or withholding it".*

The original four definitions are as follows,

> *"Affiliation (Affiliative attitude). To form friendships and associations. To greet, join, and live with others. To co-operate and converse sociably with others. To love. To join groups. Rejection (Rejective attitude). To snub, ignore or exclude an O* [other]*. To remain aloof and indifferent. To be discriminating. Succorance (Succorant attitude). To seek aid, protection or sympathy. To cry for help. To plead for mercy. To adhere to an affectionate, nurturant parent. To be dependent. To these may be added with some hesitation: Play (Playful attitude). To relax, amuse oneself, seek diversion and entertainment. To 'have fun,' to play games. To laugh, joke and be merry. To avoid serious tension."* (p.83)

These apply to an individual in varying degrees, but some are more important to an individual, and guide their LMTY in action.

Next I draw from the analysis of three participants, Gus, Bertha and Carol to illustrate the five needs underpinning LMTY. The aim is to understand the model in context, further exploring whether LMTY as an ES is transferrable or translates between students and teachers. In the form applicable to students, LMTY misses some of the complexity inherent in the role of teachers. There may be ES patterns indicative of traits and characteristics that are conducive to encouraging positive engagement and supportive of student learning.

LMTY as a combination of affiliation and play (Gus)

LMTY is not the primary ES for Gus, the most experienced participant. LMTY is likely to be activated along with LHSIA, modelling engaging successfully in mathematics (5.2). The selected episode from G1 describes how a mathematical point about the importance of correct mathematical language evolves into fast-paced banter. His emphasis is on the importance of talking mathematics and a desire for social appreciation appears to be deeply rooted. In interview, he talks of emotions from a social perspective. Additionally, from observation, within his teaching there is a strong element of self-enjoyment through performance, yet he actively sought student contributions (5.1, 5.2, 5.3). He was visibly emotionally expressive through smiling and body language and the students responded positively. My interpretation is that Gus structures LMTY as ‘Let me entertain you and you will learn as well’. The distinguisher is the level of communication, as equals rather than say, as in Transactional Analysis, a parent to child model (Berne, 1964). This form of LMTY positions students as able. Gus tells of enjoyment as increasing learning directly, providing an example of where affiliative affection needs dominate, because of his overt social and enjoyment focus,

> *“You set things up and then they happen whether or not you are in the room. So you can sit there and relax, and tell jokes and what I do is set up situations where they can enjoy and relax, and not necessarily really learn from me but learn from themselves and process.”*

Later he adds, mirroring the affection need of play,

> *“Because if the stress levels get high for the class, then reptilian brain kicks in and you cannot learn.”*

LMTY as a combination of succorance, nurturance and rejection (Bertha)

A further example of potential adjustments to LMTY for teachers is the case of Bertha. Her LMTY is less dominant than DDM, GJD and SOOT which seem to be more individually orientated. Hardy (2000) offers a further position applicable to Bertha, ‘I expect you to have difficulties’, which pathologises the student via positioning. Hardy was discussing power relationships in the classroom and provides two techniques of enacting power for this position, normalising and surveillance, where the discourse determines what is ‘normal’ and what the ‘rules’ are. If we consider Murray’s affection need of succorance, the term summarises a need to seek aid, protection or sympathy, to cry for help, plead for mercy, and to be dependent on others for solutions to problems. When talking about her problems with class behaviour, Bertha allocated her own concerns to others. She talked of another teacher having problems with the same class, but did this sotto voce, presenting as depreciating and assigning guilt or shame through dropping to a whisper. In interview, Bertha said, *"I am very emotional, that's something that probably you should need to know before you do it... very, very emotional. I wear my emotions very much on my sleeve and there has been more than one time when I've cried in the classroom because kids says things that affect me very much and I'll take a child outside and they'll start telling me their life story and I'm in floods of tears and they're going are you all right miss and things like..."*

Murray assigns a nurturant attitude as,

"To nourish, aid or protect a helpless O [Other]. To express sympathy. To 'mother' a child."

Bertha refers in interview to her students as 'a bit of a naughty' or 'bless him' a parent to child form of discourse, also used in the classroom,

"Well just, Terry, just say it, have more confidence in yourself sweetheart..." (Episode B1/1).

She values when students appear to value her, but at the same time refers to her students as *'little boys and girls'* and that *'they love to be talked to'.* She says in interview that she listens to students, and is relaxed when engaging in conversation. The same applies to mathematics learning, a deficit model of the value of mathematics that Hardy (2000) assigns as 'I expect you to have difficulties',

"They may not see it because they can't do it, so they don't know any different, but to be able to walk down to the train station and read the timetable instead of somebody saying oh... you know...what time does the next train go and you go 'oh I don't want to get the train' and so you don't go out that day because you can't cope with the train timetable." (Bertha)

There is a discrepancy between this espoused nurturance and LMTY as rejective, as appearing in Bertha's classroom. The intensity of emotions as revealed to the students in the observed lesson is predominantly negative, such as frowns, sharpness and impatience. Episode B2/1 illustrates this negativity.

LMTY as nurturance and affiliation (Carol)

Nurturance within LMTY can appear as positive; Carol provides such a nurturance example. Carol talks of a strong desire to help others understand and solve problems in interview, so the beliefs associated with LMTY in student form, peer to peer, align well. She talks directly to students of resolving confusion,

> *"So although I wanted you to find some of the patterns yourself, I don't want you to be completely confused."*

This is seeing need, including that mathematics has an understandable internal logic, and meeting need. Carol places a strong emphasis on explaining and demonstrating. Her primary reward is, I think, recognition or appreciation of help, or that students learn. When asked about a particular student, she responds from a nurturance and affiliative teaching position,

> *"Andrea, Yeah. She feels she's quite weak in the group. She needs a lot of reassurance, but she's actually better than she thinks. Very thorough with what she does. She'll often ask questions, often write things down fully. I think I've got quite a good rapport with her."*

Yet here too is an anomaly. Carol does not show positive emotions overtly in the class, yet she speaks of a strong emotional attachment to students in her interviews, and in addition to teaching mathematics, she has a pastoral role. In Murray (1938) terms, this might indicate her positioning as a teacher as more discriminating, indicative of a need to remain aloof and not become emotionally attached. This draws attention to emotional regulation (3.1). Emotional regulation may act to restrict the forms of ES accessible to teachers. For example, Zembylas (2005) summarises a view that teachers may hold, that,

> *"…negative emotion was an individual problem and that should be taken care [of] during one's own private space"* (p.943).

Zembylas suggests this view perpetrates a myth within teaching, that avoiding appearing unprofessional is more important than whether expressing the emotion is helpful or constructive. If true, this would act to limit the evidence for ES for each teacher, and partially explain why some teachers were more forthcoming in interview compared to in lessons (e.g. Carol, Freddie or Edward). The accessibility of emotional expression is important within a teacher and student relationship. For example, hurt is easier to express than anger for a teacher. Logically, the same may apply to positive emotional expression.

Carol's LMTY appears in conjunction with IRIT and CTO, both likely to be positive and potentially engaging ES. If we consider Murray's affection needs for Carol, then her pastoral role aligns with nurturance. The data for Carol also indicates affiliation. This social emphasis becomes clearer as she says,

> *"...my view of myself is quite difficult, I think I am a teacher first, then a maths teacher and I don't know that everyone would say that, I think a lot of people I meet in maths specifically really love the subject, (ok) …are really keen to impart that information."*

The social dimension is also evident in her teaching discourse (4.1C). Later, in interview, she adds,

> *"I'll get excited about it [mathematics], I'll keep talking, so when I am doing that, it's me... don't stop... stop myself."*

Implications of LMTY patterning

Here I have reconsidered LMTY, an ES applicable and in my view transferable as a structure to all teachers, but to varying degrees and centred on differing underlying affective needs of nurturant, affiliative, rejective, succorant and playful attitudes. I have presented LMTY as an ES for students, and suggested how the ES might differ in order to address complexity of the role of a teacher. I have suggested differing patterns related to the dominance of LMTY, how it appears for teachers in relation to other ES that are likely to be evoked in action and supported the discussion with data from three participant teachers.

There are indications that LMTY does indeed have variations for the participating teachers. The example of Carol supports nurturance as a positive form, but there may be better forms to support engagement, such as Gus for example, as affiliative and playful. For Carol, an affiliative attitude appears in conjunction with nurturance, both indicative of a more socially orientated need. Therefore, an important characteristic may be a social orientation to LMTY, in order to support engagement. Especially as affiliative is not characteristic of LMTY for Bertha. I would suggest that such a model is worth exploring further, when seeking patterns to explore in more depth, particularly for use with mathematics teaching. I would want to further explore positive emotions in conjunction with PT within episodes from the lessons of teachers who meet their needs for affiliative and playful attitudes whilst teaching mathematics, such as Gus.

5.5 Concluding remarks

In this section, I draw some key points from sections 5.0 to 5.4. Accessing the functions of positive emotions through the categories of play, modelling and storytelling, via the lenses of ES and PT, provides a basis and structure for future exploration of how positive emotion use can act to support teaching. The participant teachers take pleasure in their classroom teaching, in having strong relationships and in being effective when communicating the mathematics that students need to be successful (5.0). In this endeavour, emotions play a subtle yet central part within their normal classroom practice. The use of the ESensor to hone in on emotions in-the-moment, despite the unreliability and difficulties of use in the field, has strengthened this aspect of the study. Since play and playfulness (5.1) are evidently a source of pleasure for the participating teachers, and (judging by the observable responses) students, I conclude that there is a place for play as serious frivolity in the secondary mathematics classroom, but that behaving in this way involves risk. The use of modelling as a teaching tool is part of common knowledge, whilst this study makes clearer how emotions may play a role within this essential dimension of teaching. In 5.2 I suggested a provisional structuring for making modelling most effective, since one of the roles of a mathematics teacher is to model what is important within a mathematical discourse. This aim may be achieved by a teacher paying attention to the mathematics, or through emphasis and tone of voice. Further, although planned storytelling is known as a teaching technique, there seems to be a place for spontaneous use of stories and for communicating using the essential components of storytelling (5.3).

Further research might explore how much lesson time is spent in each dominant ES, especially as it may be the flexibility to shift between ES that has the capability to increase engagement. In 5.4, I suggested that some combinations of ES are more conducive to maintaining an environment supportive of teaching and learning mathematics. The data suggest these potentially supportive combinations include LMTY as a dominant ES in conjunction with CTO, IRIT or LHSIA, but that GJD may be part of the mix. This confirms that ES are not by nature positive or negative, rather that it is the combination that may prove to be significant. Patterns of combining and fluidity, as for these participant teachers, may prove to be characteristic of experienced teachers.

A longer-term aim for ES use is to explore the potential for mapping between teacher ES and those of students. If we have commonality in the model, then this connection becomes possible. Based on the data, I have not, as yet, found commonality discrepancies that would prevent later exploration of this longer-term aim. Similarly, teacher awareness of their dominant ES, and how ES act to support engagement may prove valuable. PT use reveals a possible, socially-located mechanism of repeated experiences that guide the dominance of ES within classroom interactions. ES and PT seem to work in tandem; as PT offers a lens through which to consider the fluid, constantly evolving ES of the teachers.

In my research questions, revisited in Chapter 6, I asked whether mathematics teachers use positive emotions in their teaching. For the participating teachers, positive emotion use is common, varied in purpose and is habitually embedded within their activity, often perhaps, unconsciously. This embedded use is particularly apparent in how emotions appear within play (5.1), modelling (5.2) and storytelling (5.3). These discussions incorporate some of the social benefits of positive emotion use, such as in establishing a common language and a supportive climate, as well as benefits for individual teachers through reward. I next elaborate on each of these as, in Chapter 6, I return attention to the mathematical benefits.

Exploring teacher enjoyment within teaching mathematics shows some benefits for individual teachers (5.0). Frenzel (2014), whilst addressing emotions as prior experiences, outlines some implications of repeated positive experiences for quality of teaching, a view supported by my data,

> *"in the classroom context […] teachers with predominantly positive emotional experiences may be able to effectively utilize a broad range of teaching strategies, these teachers are possibly more creative in class, more open to "riskier" (e.g. less traditional) teaching strategies, and better able to flexibly deal with unexpected obstacles that crop up during class- and as a result, provide better cognitive and motivational*

> *stimulation while teaching. In addition, they may also be more successful in building trustful relationships with their students."* (p.509)

Further, the reciprocal effect of humour, to give pleasure to others by making them smile or laugh is rewarding, making a person feel liked. The data includes evidence of such reward through student feedback to the teacher. For example, we have the story of mathematics and chocolate, and also for Carol, an unexpected reward from spontaneous applause for solving a problem (5.0). This need for reward is unsurprising, as teachers spend most of their time with students in a classroom environment and need a form of valued gratification to remain as teachers. The wider rewards from teaching others are well documented. For example, Sutton and Wheatley (2003) strongly associate teacher satisfaction and pleasure with student progress. In addition to a teacher reward from engaging with students (as for the ES of CTO and LMTY), the attention drawing properties of positive emotions suggest that teachers with a disposition to playfulness, who wish to stretch and challenge personal limits or to experiment, may subsequently become more aware *'in-the-moment'* and come to fluidly use a range of positions and ES. The known benefits of positive emotion use from a social and individual perspective, confirmed by the data, imply that such use is helpful, but not yet whether essential. It remains uncertain whether overt teacher expression of positive emotions is essential to engage students in learning (See 6.1).

However, the use of positive emotions can, as for humour, create a common language, enabling the communication of subject by reducing social distance (5.1, 5.2). For example, uniquely contextual humour that reflects common experiences can give pleasure to a group. The teaching of Adam and Gus is peppered with insider references, such as when we see Adam introducing a new student to the 'importance' of the singers Shakira and Beyoncé (4.1A, Episode 3). The use of positive emotions becomes an even more powerful tool for a teacher where fear or tension exist for mathematics students, since emotion is defined as affect that is sufficiently powerful, has sufficient intensity, to redirect attention (Ziv, 2010), in ES terms, to redirect student affective pathways. The episode from 4.1A illustrates redirection in action.

A supportive classroom climate for the learning of mathematics includes group cohesion, reduction of conflict or tension, and enabling of classroom management. The role of positive emotions as supportive of group cohesion seems particularly important within positioning, as the resulting climate potentially increases acceptance or positive re-negotiation rather than rejection, that rejection of teacher instigated positions becomes less likely, and further, students are likely to position themselves favourably (5.2, Example 1). In the episodes (4.1), the group identity indicated by local 'we' is common in classes that include positive emotion use as norms. Used in this way, positive emotions become an intrinsic tactic within the communication of the classroom, promoting student learning whilst providing pleasure to the teacher. Similarly, a teacher may shift pace to increase student effort, or to reduce stress through diverting into storytelling, as does Gus (5.3). What the positive examples have in common is care for the emotional needs of students and, somewhat contradictorily to a model of emotions being effective through intensity (see earlier discussions of IRIT and CTO), with a minimal degree of perceivable effort, even when the ESensor records intensity. Adam in 'rules of nominating' (4.1A, Lesson A3) is an enlightening episode that details how a new student is brought into alignment within a group with pre-existing positive relationships. Significantly, alignment is achieved by the students as well as the teacher. Adam uses distracting humour, based on existing classroom norms, to draw attention away from Jude, deflecting interest elsewhere through generating laughter that restores the lesson. The effect ensures Jude knows what is expected (4.1A (Lesson A3), 5.3). If indicative of lessons as usual, this playful approach seems effective at reducing and bridging distances between students and teacher. The product being a positive environment conducive for learning mathematics.

There are no 'recipes' for positive emotion use, but there are emerging patterns of ES to explore further (4.2.1), such as provisional LMTY distinctions (5.4.3) and some emerging characteristics such as the role of ES in restoring balance. Adam, who has ES identified as positively orientated, potentially 'loses face' by making an error on the board, but this is averted by rapid norm banter and a change of pace (4.1, Lesson A1). When Adam asks questions without noticing the answers are written on the board, he uses self-deprecation which generates shared laughter. Without positive emotions, both examples were potential threats to Adam's authority. Such threats indicate risk, and reasons why teachers might not use positive emotions in their teaching. Risk is discussed further in Chapter 6 in conjunction with the discussion of the research questions.

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Chapter 6: A F.R.E.S.H. story

6.0 Teachers' use of positive emotions in the mathematics classroom: A study overview

I began this study by establishing in Chapter 1 that much affective research is student centred, and from a desire to contribute to debates that counter common, often negative, public perceptions of mathematics. I also aimed to investigate what teachers might do that has potential to increase student engagement in mathematics. For example, I aimed to investigate what helps increase time on task, or supports recall. Early in the investigation of affect, I realised that little is known about the use, or the degree of intensity of emotional expression, or even whether positive emotions are used at all by individual teachers. Similarly, there are few research tools specifically designed for simultaneously researching affect and engagement. These two realisations significantly shaped the development of this study. Based on the analysed accounts of teacher use of positive emotions, that focussed and directed positive emotion use by teachers has potential to counter known problems within Mathematics Education such as T.I.R.E.D (Nardi and Steward, 2003). I deliberately chose to focus on experienced teachers in the classroom. This choice was to facilitate exploring positive emotion use in an everyday context, and as a means of later informing professional development, since entering teaching is intensely and emotionally challenging. Additionally, research on transition into teaching is comparatively common, whilst centring on experience prepares the way for future research on emotions in the classroom.

In Chapter 2, I summarised an exploration of the literature that informs the agenda. I explored widely, drawing from mathematics education and other disciplines since affect, and especially emotions in a classroom context, are under-researched. I identified four key research questions and two analysis models which seemed fit for purpose. In Chapter 3, I designed a data collection and analysis method, before analysing the data from the teachers in Chapter 4, using ES and PT as complementary lenses. This analysis stage resulted in the identification of four themes of self (5.0), play (5.1), modelling (5.2) and storytelling (5.3), which then formed the discussion within Chapter 5.

In this final Chapter, I review the research questions, beginning with RQ1 and RQ2, and in the light of the analysis in Chapter 4 and 5, draw together from earlier discussions some of the potential risks and benefits from using positive emotions in mathematics teaching (6.1). In Section 6.2, I address RQ3, suggesting some implications and naming some areas for future research, including some limitations to the study, and assessment of the contribution. I continue discussing the contribution in 6.3 whilst reflecting on the selected research tools and discussing RQ4. I conclude the study in 6.4 by taking a ‘fresh’ look that summarises the potential of a teacher using of positive emotions in a mathematics classroom.

RQ1 Do teachers use positive emotions in their mathematics teaching? If so, how? Are positive emotions used to support the teaching of mathematics, to communicate mathematically? If so, how? RQ2 What are the risks and benefits within how participating teachers make use of positive emotions? RQ3 What implications emerge from how participating experienced teachers use positive emotions whilst teaching? RQ4 Does combining Engagement Structures (ES) with Positioning Theory (PT) support examination of emotions in the dynamic context of the mathematics classroom? If so, how?

6.1 Summary of findings related to the research questions (RQ1 and RQ2)

6.1.1 Do teachers use positive emotions in their mathematics teaching? If so, how? Are positive emotions used to support the teaching of mathematics, to communicate mathematically? If so, how? (RQ1)

My original proposal asked whether emotions even appear in mathematics classrooms. This was based on the premise that student 'T.I.R.E.D.-ness' (Nardi and Steward, 2003) was partially because they did not, thus suggesting one reason why students do not always engage in learning mathematics. The data undermine this premise as, for these experienced participant teachers, emotions do appear. Further, the example pairs in 5.2 illustrate a wide range of uses and purposes. Emotions appear within modelling as interest in mathematical explanation, engaging in measurement, dealing with mathematical error, neoteny in teaching and modelling mathematics as procedural or conceptual understanding. I also found that the dominant ES of CTO and IRIT seem important within modelling for the participating teachers, alongside LMTY.

The evidence for these participant teachers suggests an affirmative answer: they do use positive emotions, but with provisos. Some teachers play, model and tell stories, using elements of positive emotions continuously and interactively, in forms that engender laughter and which seem supportive of mathematical learning. However, there is a spectrum, from overt laughter within lessons through to lessons with fewer identifiable positive emotions. Some teachers appeared more emotional in interview than in the observation (Bertha, Carol, Freddie), raising an additional question as to where positive emotions need to appear within teaching. Through examining the data with an ES lens, since this lens incorporates both beliefs and actions, the evidence suggests, somewhat contradictorily, that although use might not be visible in lessons, it may be sufficient that positive emotional expression appears in expressed beliefs, as for Helen or Carol. For example, the analysis of a lesson from

Helen shows that she rarely smiled. Tracing her emotional pathway (4.1H, 4.2.3), I interpreted her observed emotions in the selected episode as mainly neutral with slight impatience. Overall, neither Helen or Carol overtly displayed positive emotions. Yet neither class could have been seemingly responsive and engaged without extensive preparatory work to create the observed positive climate. Bertha's class (4.1B) represents one end of a continuum, and exemplifies how students can experience a mathematics lesson without observable positive emotions on the part of the teacher. Examination of Bertha's ES confirms that the dominant ES of SOOT and DDM may not be conducive to good teaching, similarly for PE, which was rarely dominant for any of the teachers. It is possible that appearances of positive emotions are not centred on the teaching of mathematics, that their use is primarily social, or appear in conjunction with an individual teacher's relationship with mathematics, or as a combination of these.

However, the selected episodes discussed in Chapter 4 and 5 show interrelated mathematical learning purposes. Purposes including emotions intended to restore balance (A3), or to correct unwanted behaviour (such as ignoring distractions in order to keep the mathematical focus (D1, and E1/2)). Emotions are used by participant teachers within modelling (5.2), as part of acceptance of error (A1 and E1), as control or to indicate listening such as nodding and smiling (A2 and Helen), or for student empowerment and support (A2, B1 and E1/2), for redirecting/shifting attention (A3) or within deviation (A3/2 and G1).

Positive emotions appeared in the data as breaks and rest points (see Gus, Adam, Freddie, and Debbie (singing Balamory)), which were not necessarily attached to the mathematics being studied in the class, but which played an important role in the composite story of the lesson (5.3). For example, Gus continues a valid point about communicating mathematically into a ridiculous story about Grecian 2000 hair dye, but we also see that he is ensuring that slower students have completed the required note taking. In this case, considering possible PT positionings within the episode was useful for drawing out why this apparent deviation seemed effective in terms of student responses. My favourite purposeful diversion, in the form of storytelling (5.3), is when Adam convinces the students that they have the power to change the curriculum, that their chosen names for sequences (square numbers, triangle numbers) will be used by everyone taking the national exam as he has spoken to the exam board. They are likely to remember the associated terminology, and the potentially empowering (even amid the observed surprised but uncertain disbelief) positioning that suggests that they could, as students, change the establishment in some small way. Adam revisited this story over several lessons, suggesting that continuity in the use of positive emotions is worth further investigation. I am convinced that for most of the participating teachers, expression of positive emotions is intended to support mathematics, and in surprisingly complex ways. I review next the complexity within the 'how' they are used, structuring the discussion through considering risks and benefits.

6.1.2 What are the risks and benefits within how participating teachers make use of positive emotions? (RQ2)

The picture painted so far is that, based on this data, using positive emotions in a secondary mathematics classroom is positive and beneficial. Yet any teacher should be careful how positive emotions are used for several reasons, as there are perceived threats and risks involved (as discussed in 4.1 for Freddie, Edward and Helen, 5.2, Example 3, Example 5 and 5.3 Example 2). In this section, I review some issues arising from the data and analysis in terms of what is required of the teacher when giving a role to positive emotions in terms of risk. I summarise within this study how those participant teachers that use positive emotions allay such risks, or at least manage them. This summary highlights some reasons why not all the participant teachers used positive emotions in their teaching of mathematics. In the next section, I discuss playing safe versus risk, before I refer particularly to Helen (who uses a risk averse style in the observed lesson) and to Gus (who after more than 30 years, has perhaps comparatively less perceived risk). I then summarise the role of emotions within the discussions of risk.

*R*isk Managing

> *"I have never refused the bitter-sweet drink of philosophical criticism, but have taken it with caution, a little at a time. All too little, my opponents will say; almost too much my feeling tells me. All too easily does self- criticism poison one's naiveté, that priceless possession, or rather gift, which no creative man can be without."* (Jung, cited by Murray, 1938)[18]

Classroom management includes assessing the balance between losing control and safety in the familiar. Adages such as 'don't smile before Christmas' and judging how much risk is appropriate are challenging for teachers. Teachers are open to student, parent and institutional judgements, and playfulness includes potential criticism of neoteny, in a negative sense. Other judgments include assessing the likelihood of rejection by students for whom perhaps playfulness is either not the norm, or who only see such behaviours as an opportunity to push limits. Teachers function within systems of rules for behaviours, and may perceive taking risk averse choices as reducing risk of criticism. For example, a mathematics teacher role description would not include telling stories, whilst to deviate with a possibly negative outcome for student learning is unacceptable. The duty within the role is to meet curriculum requirements, usually in the form of examination success. Within these constraints are individual dispositions, whilst within what is already often an effortful role, using positive emotion requires intensity and hence effort. The use of the ESensor in this study provided an approximate means to access points in a lesson that are intense. Further, it takes energy to put oneself 'out there', to attempt humour which will not necessarily be accepted, so there is vulnerability too, as experiencing the rejection of attempts is painful to an individual. In a mathematics classroom, the existing norms may not be conducive to the use of positive emotions. If used unsuccessfully, teachers may not repeat and may withdraw further attempts, as it seems to be perfectly possible to teach mathematics without any emotional

[18] Although referring to philosophical criticism, not mathematics teachers, this quote seems pertinent. Jung was a collaborator of Murray, from whose work I have drawn, as does Goldin for ES, which makes the remark somewhat appropriate within the story of this study.

displays, either positive or negative. Similarly, teachers are continually assessed, so the connection between joyfulness and teaching (such as Debbie's or Adam's neoteny (5.1)) and the essential creativity to engage in the action of play might disappear through too much criticism, either from self or from outside judgements.

I know from interview that Helen had poor behavioural management experiences in her former schools, and it is reasonable to assume such experiences would increase her awareness that showing emotions in class has associated risk, thus perhaps forming a block to risk taking in the classroom, and hence to expressing positive emotions, *"We learn by experience whether or not it* [humour] *is a tactic we can use effectively"* (Ziv, 2010, p.12). My interpretation is that security is important to Helen who communicates this importance to students in the observed lesson. In the lesson, she followed common procedures associated with the role of a teacher, and was not overtly playful. There is security for teachers from teaching mathematics in a textbook form, as any balance is not then risked by experiment. The balance in Helen's case lies between assessment requirements (upon which the students and hence the teacher are judged 'good' or not) and individual needs (in terms of understanding school mathematics only as required for assessment).

In contrast, Gus is established in his career, so risk, as discussed for Helen, has perhaps become unimportant. Yet under his good-humoured persona, as he approaches retirement, his risk is imminent change, to being outside the classroom, as I would suggest his person and role are not just aligned, they are the same. In a paper about university teacher's emotions, Postareff and Lindblom-Ylänne (2011) found that the more teachers identified themselves as teachers, the more positive emotions they reported, in particular joy and enthusiasm towards teaching,

> *"…that their identity as a teacher did not differ from their identity as a human being, and that they behaved the same way as a teacher as outside their work."* (p804)

In interview, Gus talks of not needing rugby anymore because he has teaching (5.0). He appears to have reconciled his actual and ideal identities, evidenced by apparent authenticity. He expertly manages what, to other teachers might be risks, by going with the flow and sharing ownership. But this is under the proviso that it is his room, so the risk is located within secure management limits, an ES of DDM. He deals with uncertainty through continual reconstruction (Zembylas, 2005), entailing rapid shifts, adaptation and subversiveness through deviation from teacher role norms and expectations, as well as resistance to context specific ‘emotional rules’, a characteristic that Adam and Debbie share.

However, emotions can potentially be used to manage risk. I discuss this here for vulnerability, fantasy and reducing conflict. Emotions can manage risk in the form of vulnerability as ‘a state subject to emotions’ (Kelchtermans, 2005). Emotions can address perceived threats and effect resistance or subversion if required. This emotional response may be more apparent when constant reconstruction is, in Zembylas (2005) terms, more contingent and fragile. Indeed, seeking risk is itself a motivator, associated with the ES of LHSIA (Look How Smart I am). This ES seems to dominate for Gus, Adam and Debbie (Table 4.16, p.231) who appear to favour risk as a strategy in class. Bullough (2005) when discussing management of the risk for the vulnerabilities of a teaching role, suggests,

> *“Some teachers seek to make themselves invulnerable, immune to the possibility of failing, whilst others seem to enjoy risking self”* (p23).

And Kelchtermans (2005) adds that because vulnerability enables a pedagogical relationship, then it enables joy too and should be embraced, not contained.

A further role of positive emotions in regards to risk has emerged from the criteria for play (5.1) and for storytelling (5.3). The five classifications for storytelling of deliberate connective stories (using a story to support conceptual understanding; temporal, future and connective storytelling and serial storytelling) show the importance of a fantasy dimension for using positive emotions when teaching mathematics, especially that positioning as removed from real life reduces risk for both teacher and potential anxiety for students. Used well, positive emotions by remove, not just humour as discussed by Ziv (2010), do not endanger a teacher’s authoritative position,

> *“Part of the pleasure that is created by every humorous message stems from the awareness that “this is not for real.” This awareness*

> *offers a respectable way out of expressions or actions that threaten the group. If these were taken seriously, punishment or rejection would follow, but when exactly the same message is conveyed humorously, it is more easily withdrawn. It is enough to say, "But I didn't mean it seriously," and the threat is removed."* (p.13).

Further, Morreall (1983) suggests laughter is indicative of security for group members, that conflict is unlikely. In my context, the implication is that teachers who use positive emotions can safely engage in teaching and learning without threat to self-esteem or status in that place and time, and indeed this suggests positive emotion use is an effective means of social management applicable to a mathematics classroom. Yet each teacher needs to assess how much risk to incorporate for themselves, and to come to find the pleasures, playfulness, stories and modelling of enjoyment of mathematics at a unique and appropriate point in their teaching career.

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6.2 Implications for mathematics teaching and teacher development (RQ3)

Although outside the remit of this study, this study has strengthened my belief that teacher ES play a significant role in forming and guiding the ES adopted by students. Within this model, PT shows how this forming and guiding might work in action. Goldin et al. (2011) have already partly set this question, for their own work, asking,

> *"What teacher interventions affect development and activation of particular Engagement Structures in mathematical contexts, and how?"* (p.558)

Although there are no 'bad' ES, as they serve different roles, some ES seem to be more conducive to teaching and learning. A future role of PT in this respect is to examine how teachers encourage ES that may prove to be positive in terms of learning.

6.2.1 What implications emerge from how participating teachers use positive emotions? (RQ3)

Expertise permeates the data. I witnessed episodes where, with less skilful handling, there were opportunities for belittling other students (Adam's rules of nominating, Bertha where the teacher encouraged belittling), or where a teacher risks losing student trust because they made a mathematical error or missed something (Upper and Lower bounds, Terminology, Answer discrepancy). I have evidence of the skilful use of positive emotions to value and enable extended student contributions (Stem and leaf, Joe and Sam demonstrating, face measuring). There is also evidence of emotions being used expertly to manage activity transitions, which some participant teachers identified as potential stressful parts to a lesson (Helen). Some teachers used positive emotions to maintain class norms (Shakira in rules of nominating (Adam)), or for attending to the importance of careful listening (Gus).

There are examples of participant teachers taking delight in the ridiculous and absurd, or of gently mocking. But, drawing from the interview data, underlying these examples are both positive intentions and the enforcing of compliance with social and cultural expectations. This emerging evidence of a wider behaviour management role of positive emotions includes the power to change behaviour. There are examples from this study where, without positive emotions, even outright rebellion becomes possible (Bertha's class or boy in Helen's class). Similarly, based particularly on the data from Adam and Gus, the use of positive emotions over time seems to develop a culture of anticipation of a positive experience, which gives the capacity for spontaneous use of positive emotions in addition to any planned use. If there are implications for other classrooms, and if recognising generalisation is important as Williams (2000) suggests, then this characteristic seems likely to transfer to other contexts. It also seems that for some participant teachers, the role of positive emotions within shifts, especially rapid shifts, may promote and increase engagement through pace and unexpectedness combined.

As a former mathematics teacher in secondary school, and now engaged in training teachers, this research is aimed towards a wide audience and is inspired by my need for a contribution of value to teachers. My work contributes to discussions of best pedagogical practice and supports teachers who wish to develop affective aware teaching. The study tries to give a 'voice' to the emotions of teachers whilst teaching mathematics. I would hope that the reflective practice of the participant teachers has been developed by being able to watch themselves teaching and through discussion about how they use emotions in their teaching, and that drawing attention to their emotions whilst teaching has been beneficial.

6.2.2 Limitations

This study is an initial investigation, with datasets from eight school teachers. As such, one limitation is that some avenues suggested by these preliminary analyses and discussion remain unexplored. These avenues include the wider context, as classroom practices do not occur in isolation, and other, as yet unexplored, factors influence dominant ES, such as school cultures, power perceptions, agency and resistance. This study uses the original nine ES as identified by Goldin et al. (2011).

These are not intended to be fixed, and whilst this study has not found need to create new ES, other researchers are exploring these possibilities. For example, Sanchez Leal et al. (2013b) suggest that there are 14 engagement structures that range from complete immersion to active avoidance of any type of mathematical task engagement. There is also some bias, as a position of adopting risk averse choices in teaching and hence reducing unpredictability (Sutton and Wheatley, 2003), as discussed for Helen and Gus, is likely to be common. I suspect I did not see this view of mathematics teaching more often in the study as such teachers would be unlikely to risk being 'discovered' (in what might be perceived as a form of duplicity) through observation, and hence are less likely to engage in emotion research. This is purely supposition perhaps, but likely, and a further limitation of my study.

6.2.3 Future research

These are diverse, from suggestions for professional teacher development, for exploring similarities and differences in patterns of ES and finding out more about how ES are constructed in a mathematics classroom, through to using the tools developed to explore play, modelling and storytelling in more depth.

The discussions in Chapter 5 indicate potential in exploring patterns, since, as well as differences existing between individual teachers, local patterns emerged within modelling (5.2). I would like to explore whether, for both teachers and students, raising awareness of ES changes dominance patterns. Further, I would use PT with new data, taking examples from teachers who draw fluidly from multiple ES, to explore whether student negotiation or acceptance differs in these cases. There is also a hidden Chapter, mediation, a theme from the data which never made it to the final 'cut', but which I am developing further (Lake, 2017c), and that is how positive emotions act as a mechanism when a teacher is mediating between students and mathematics in its various forms.

The focus on experienced teachers to identify benefits for all teachers seems particularly valuable, whilst the emerging model of ES with PT provides a basis for further research. I have some pairs of participants from the same schools, and there are similarities that implies a cultural similarity in terms of ES to investigate further.

The appearance of play (5.1), and the criteria by which play is judged as applicable to secondary classrooms has potential. I would like to further explore the implications of spontaneous play within mathematics teaching. It would be valuable to know whether effective use of playing by teachers in secondary mathematics can be learnt or whether it is a disposition, since play seems to offer a powerful tool to add to a teacher's repertoire. The proposed model for determining whether an episode in a classroom is play could be explored further. Using the appearance of emotions with intensity to select episodes potentially masks the prevalence of play, so a deeper investigation is called for. Similarly, the five ways by which engaging in mathematics is modelled has potential as a further research focus. In 5.2, I suggested a provisional structuring for making modelling most effective since one of the roles of a mathematics teacher is to model what is important within mathematical discourse. Modelling combined with emotions forms a new future research question about not just whether, but where exactly in lessons, positive emotions can be used to best effect. Similarly, the capacity of spontaneous storytelling in mathematics could be explored further.

This study is part of a bigger research movement which takes what we know about positive affect for individuals and applies it into the social context of the mathematics classroom. Although the learning and teaching of mathematics is unique in some ways, and there is no intention to generalise to all teachers, some of the discussion may prove transferrable to other situations where learning is intended. The design is interdisciplinary, using and sharing skills and knowledge from a range of disciplines to achieve the aims of the research. I plan in the future to disseminate to a wider audience and to contribute to ongoing discussions aimed at shifting negative social and cultural views of school mathematics. To support this aim, my final contribution in 6.4, after reflecting on RQ4 in 6.3, presents a structure, drawn out from this study, for discussing teacher positive emotion use.

I have merged two research analysis methods, ES and PT (5.4, 6.3), which may be of interest to the research community. But I see them also as being of relevance to mathematics teachers themselves and to teacher educators. My view is that these two approaches are compatible and act to bridge the temporal divide between stable affect and fluid emotions and reveal how these operate as mechanism and effect. I would suggest PT as useful tool for examining what exactly the teacher is doing in the classroom, in terms of positive emotions, and hence the ES of students when learning mathematics. In terms of future research, an intervention that encourages teachers to develop practice through recognising their dominant ES, and to examine the implications for the mathematical engagement of their students seems feasible. For example, examining where IRIT or CTO has most impact on learning. There is also potential for teachers to self-assess student responses to each ES. The capacity from a teacher being aware of their own ES and that of their students makes this a powerful tool for exploring and developing classroom practice. This preliminary study indicates that there is value in using this tool for such a purpose. I have already begun collaborative work that compares the ES of an expert (Adam) and a novice teacher (Khahil, Lake & Johnson, in press). I reflect on further possible research directions specifically for the ES/PT tool in 6.3, as I address RQ4.

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6.3 Methodological Implications (Collecting Affect Data: Measuring intensity via an ESensor; Analytical Framework: The potency of using ES and PT, RQ4)

6.3.1 Reflecting on the use of the GSR ESensor

One element of this study that has drawn attention, both from school teachers and during early discussions within the mathematics community, has been the use of the GSR ESensor. The use in this study, although problematic in execution, has a number of important features. Firstly, the use and sharing of each resultant graph, by acting as a focus for discussion, has facilitated discussion between myself and the participant teacher. The post observation discussions enabled each teacher to explore their emotions during the selected episode and to articulate these through the medium of the ESensor. Secondly, the study is encouraging of the potential for GSR use in future research, both to validate the use of a sensor as having value within affect research and as a means to address the concern of affect researchers around the unavailability of emotions and hence one known limitation in any study of emotions. Thirdly, the use seems to combine well with this research design, providing an additional means to capture (as best possible) the fluidity of emotions as experienced by the participating teachers. There are however limitations to the use of any such devices. For example, the GSR ESensor as a tool for the selection of episodes was supported by repeated watching of the video. The unreliability of use in a dynamic active context is a further limitation, as it occasionally disconnected mid-lesson. Additionally, there could be many reasons both for the patterns as shown in Chapter 4, and the varied interpretations offered by the participant teachers, such as random external thoughts, such as Freddie's rabbit babies. However, given these advantages, I will be seeking ways to explore the use of GSR in the classroom along with other means of measuring fluid emotions in mathematics classrooms.

6.3.2 Does combining Engagement Structures (ES) with Positioning Theory (PT) support examination of emotions in the dynamic context of the mathematics classroom? If so, how? (RQ4)

A review of the research method as enacted appears in Chapter 3 and elsewhere (Lake, 2015c). Here I summarise how the two models of analysis contribute and combine to reveal teacher positive emotion use within the dynamic context of the classroom (a fuller review appears in 5.4). One model originates from researching students, and the second from another discipline, although already known and used in Mathematics Education. Combining these models in this study is experimental. For example, assessing whether a model for students can be applied to teachers, which then makes a new framing for study of the classroom possible.

I now see affect for teachers on three conjoined perspectives because of combining ES and PT with the same data. Firstly, within ES, the combining of strands which encompass stable traits and emotional states provides a bigger picture of how a teacher might engage with students, whilst the ES patterns of dominance informs this picture. Such patterning, as in Table 4.16 (p.231) seems a useful element for further research. Secondly, combining ES with PT improves the bigger picture by placing a stronger emphasis on the fluid and temporal emotional characteristics of classroom interaction. Thirdly, PT offers a means of examining what might prove to be the mechanism of ES; that over time, repeated positioning forms stability regarding which ES are likely to dominate in a repeating context such as a mathematics classroom. This mechanism is something unexplored as yet, although Goldin et al. (2011) considers affective pathways, one of the strands informing ES, for this role. There are significant differences between PT and affective pathways as PT highlights the interaction between teacher and students, attending to the discourse, whilst affective pathways map the observable emotions of an individual in their mathematical engagement, without attending to the social dimension. Given the significance of social interaction for learning, using PT to investigate mechanisms as social forming of ES may be worth future exploration. The lenses are complementary, in that ES provides a beneficial structure and overview as to which ES are typical for each teacher, whilst PT offers a means to examine how ES functions in conjunction with emotions. In this study, the conjunction reveals the roles of positive emotion use, but the potential is wider.

A further agenda in terms of ES and PT in this study is whether the model would prove to have sufficient commonality for future research that compares the ES of students and teachers. For example, whether teacher ES limit or encourage student ES patterns, patterns that subsequently hinder or support engagement and hence learning, or whether student ES direct teacher ES in a responsive patterning. Within this agenda, the identification of how professional constraints affect teacher ES is important and remains an area for further exploration. In this study, I have shown how this constraint might occur with the analysis of LMTY (5.4.3). Yet there are ES which a teacher is less likely to have as dominant, such as INF. Unlike LMTY, which is integral to a professional teaching role, there are likely to be constraints around professionalism for other ES. However, in terms of drawing wider conclusions for the role of emotions within the other ES, including INF, in the sense suggested by Williams (2000), there is insufficient data within this study to robustly argue a general case. This is a scale induced limitation of the study.

The combination of ES and PT forces a deeper level of analysis and an alternative reconstruction of the data that yields more than the sum of the data parts. As discussed earlier (p.90), this is partially achieved by a degree of overlap, and by using the social and individual lenses. Hence, there is potential in exploring this combination further, such as establishing likely ES for a teacher and a sample of students, and investigating how the identified teacher ES and student ES work together using the PT criteria of acceptance, negotiation and rejection. PT connects closely with the emotional pathways described in 4.2.3, the complexity of which is a further area to develop, as preliminary indications suggest both more complex pathways and more fluidity between ES for teachers who use more positive emotions. The indications imply that teachers are repositioning more frequently, which is associated with being responsive to students, but which is potentially more effortful. With further research, it may prove that the order of ES dominance is indicative of the form of teacher and student interaction.

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6.4 A F.R.E.S.H. model for teachers' use of positive emotions in mathematics

Following from the summary of positive emotion use as **Risk managing** (See 6.1.2, p.330), this final summation is structured by firstly considering **Focus** on what is important in mathematics followed by the role of positive emotions within **Experimentation and modelling** (which includes the roles of emotions within novelty and deviation), **Shift as transition** (positive emotions and change) and **High intensity**. For example, I summarise how expert teachers engage students positively in mathematics through modelling how emotions can be used to reduce mathematical anxiety or counter unexpected negatives as they appear. This may be by shifting attention, which we know requires emotional intensity, or by restoring balance, which also acts to reduce anxiety. I consider how positive emotional use acts to redirect attention within mathematics, such as drawing attention to key vocabulary or to important points by adding emphasis or telling a story. Positive emotion use may act to engage students generally, but also specifically at points of transition, or through offering novelty and deviation. A point which suggests a future research direction.

Focus on what is important in mathematics

Here I attend to the teacher role of addressing importance within mathematical information, adaptability, risk and error, including how attending to importance might be achieved. Research (e.g. Mason, 1998; Boaler, 2016; Johnston-Wilder, 2010) suggests important skills required for engagement in learning of mathematics include independence, resilience and adaptability. Additionally, observable positive emotional expressions, such as Helen or Adam nodding for emphasis (4.1) can be a means of identifying what is important within given mathematical information. Positive emotions draw student attention, especially when presented in the forms of play (5.1), modelling (5.2) and stories (5.3). The role of positive emotions within pushing boundaries as part of experiment acts to cushion and even functions (as suggested by Ziv (2010) for humour) to stretch the important skill of adaptability within a mathematics classroom, stretching the boundaries of what is possible before *"irreversible sanctions kick in"* (p.13). A teacher can model pushing boundaries as supportive of learning mathematics, or model risk taking on the part of students. Students can imitate teacher actions, such as their use of positive emotions and mimic behaviours seen as successful on the part of the teacher, ideally as 'thoughtful imitation' (Sfard, 2007, p.610). Adam, who appears careless of error making, shifts the error seen in Lesson A1 into an apparently meaningless exchange of noises with one student. Yet even mimicking of exclamations models an important point of how to behave in the case of a revealed error: to laugh. This example contrasts with the modelling of error from Bertha, where 'saving face' is a primary driver over positive relationships with students (5.2, Example 3). Further implications of teacher error are discussed elsewhere, using the data from this study (Lake, 2017b). Ziv (2010) suggests that humour both emphasises and blurs the hierarchy of the social structure. This generally recognised benefit is important in learning mathematics, where attending to softening and reducing impact of criticism, such as for error, is key. We can see softening in action in 5.2 (Example 1) as Edward responds to the contributions of students.

Consciousness of emotions, or even awareness of the activity of teaching is an issue especially pertinent to studying experienced teachers. New teachers are cognitively conscious, although not so effective at noticing wider than singular activity, such as when working one-to-one (Mason, 2002). Whilst experienced teachers often find it hard to articulate what happens when teaching, as only discrepancies are memorable. Unconsciousness applies to physical movements as well as engaging automatically in the actions of teaching. Adam used repeated specific hand gestures, often in relation to size, but also associated with norm activities (e.g. A1, 5.2). Similarly, Debbie used expansive gestures to accompany instructions, and Helen used a repeated nod to emphasise importance, either verbs of instruction or mathematical vocabulary. Physical movement, as for emotions, indicates importance for students, who quickly recognise how mathematical importance is identified by each teacher.

An experienced skilled teacher refocuses on what is deemed important through continually modifications. The story within an engaging play or book has sections, episodes, acts etc., variations and structures of which are used to engage the audience or reader. The same applies in a mathematics classroom as a teacher engages in their role of structuring information. Teachers decompose a lesson into bite-sized pieces, the size of which depends on variables that are continually being appraised. Continual shifting in active interaction continually changes the dominant ES, and potentially the ES of students, and as emotions are involved, is arguably effortful. Decomposition has emotional implications as it is often challenging to meet curriculum needs, be flexible and to continually adapt without running out of time. Teachers are often preoccupied with clock watching for this reason, something that Adam, Helen, Edward and Freddie mentioned often in interview. Focussing the attention of students on what is important is part of the role of the teacher. I am suggesting that not only are focus, modelling and risk important, but that experimentation is also required.

Risk managing

This important element affecting the use of positive emotions in mathematics classrooms is discussed in 6.2, (p.330).

Experimentation and modelling

There are five forms of modelling emerging from the data. Firstly, using positive emotions as modelling the enjoyment of experimenting in mathematics (5.2), which is characteristic of the ES IRIT or CTO. Hobbs (2012) suggests that an individual such as a teacher, acts as agent between an object, such as mathematics and feelings about the object. Portraying mathematics by modelling it as an experience of enjoyment can support engagement, such as Freddie and the Fibonacci video (4.1F, 5.2). This position resonates with Dewey's (1933) view on the experience of enjoyment of beauty; all that is required for a positive experience is for the person experiencing the enjoyment to recognise it as such. This requirement applies to mathematics; that mathematics is only beautiful if you think and feel that it is. Secondly, there is a reciprocal effect within modelling, not only is giving pleasure to others by making them smile or laugh rewarding, the effect is reiterated and exaggerated by social communication mechanisms of mimicry and synchronisation

(Hatfield, 1994). Thirdly, modelling how to engage with mathematics as a learner is central, as seen for Adam (A2, 5.2, Example 1), who attends to how to emotionally manage error and criticism in mathematics. Fourthly, modelling experimentation in mathematics requires emotions as teachers are pushing various limits to assess student responses, and reciprocally we see students putting out suggestions which are, in positioning terms, accepted, rejected or negotiated (e.g. 4.1, E1, 5.1).

This experimental dimension relating to the use of positive emotions in a mathematics classroom is particularly pertinent, as it combines with a teacher modelling experimenting when doing mathematics (5.2). The teacher is in a unique position to instigate experiment, and it can become a tool for learning. Finally, Sutton and Wheatley (2003) suggest that engaging in more positive emotions may generate more teaching ideas and strategies as well as broad minded coping skills (Also Fredrickson, 2001). The episode from Debbie illustrate this penchant through the pleasure she gets from resource creation, a form of experiment. Ziv (2010) suggests that positive emotions expressed as humour can 'test the waters', to judge and gauge the beliefs, views and positions of other members of a group.

Shifts and transition

The idea of shift, which I define as the action of applying effort to effect change, extends positive emotion use into a new role. Emotions are integral to processes of change (2.1, 2.3), but there is evidence in the episodes, which is particularly revealed by examining positioning, that a primary function of positive emotion use is centred around points of shift. Shift may come in many forms such as shifting a teacher to a new ES, shifting pace, or shifting student activity. Gus's pattern of 'time in, time out' indicates a continual shifting pattern in dominance, mainly between LHSIA and LMTY (4.1G, 5.4.3). Shift, as a continual modification of teaching and learning in response to needs is one dimension of effective teaching. Episode A2/1 provides an example, Adam makes a judgement to intervene and shift forward Amy's explanation (5.2 Example 1). As discussed earlier (5.2 Example 4), transition points, where the teacher needs to change pace or task, require more intense emotions on the part of the teacher. A further role for positive emotions is when students are experiencing physical transition. Adam's management of Jude, who has just moved into the teaching group, illustrates this (A3/1). Ziv (2010) reinforces a function of positive emotions in the form of humour being to redirect,

> *"Laughter directed at someone who behaves contrary to existing norms is experienced as a kind of punishment, and the offender will take care to mend his ways and avoid further transgressions."* (p.15)

This particularly comes to the fore when the new student resists the norms established by Adam and his class.

High Intensity and points of impact

Becker, Keller, Goetz, Frenzel and Taxer (2015) suggest that intensity comes from attributing more value. Not only is teaching effortful, the mechanism of using positive emotions exacerbates effort. Ideally, teachers direct their communicative effort and intensity towards points of most impact on learning, meaning to change the pace of interaction, such as to quicken, to interrupt as in performance or to restore emotional balance (See episodes for Adam, Debbie, Edward, and Gus). Yet teachers cannot continually sustain high intensity, so there is much to be learnt about deliberate and instinctive placing of intensity, such as when positive emotions appear in conjunction with play. Gus' graph has noticeable dips, implying intensity dips, which encourage further investigation of this dimension (4.1G). In terms of positive emotions expressed as humour, Ziv (2010) suggests that intensity plays a part both in the lessening of fear, and associated tension; that using positive emotions intensely at the right point can be effective in shifting attention from the negative. The idea of managing emotions of others through meta-awareness of intensity is not new. Mason (1989) talks of meta-awareness in terms of 'Knowing-to', which is,

> *"…the kind of knowledge which enables people to act freshly and creatively"* (p245).

However, looking for points of high intensity and maximum impact implies planning. Amongst the participants, I observed what seemed to be unconscious and almost instinctively managed tailoring of intensity. Both covert and overt emotional intensity is attached to being a teacher of mathematics. I have seen extremes in this respect, from free expression of intense negative emotions (Bertha) through to almost riotous joviality (Gus). The use of the ESensor was aimed at partially addressing this methodological challenge, as assessing the degree of emotional regulation is important to interpreting emotions of classroom teachers. My research suggests that regulation may inadvertently hide a teacher's love of mathematics, evident in the teacher stories (5.3).

F.R.E.S.H.

> *"Overall, teacher emotions seem to be inextricably linked to classroom processes, including both student and teacher behaviours. However, conspicuously little is known about how to support teachers in maintaining a positive emotional attitude towards their classes and teaching or how to break vicious circles in case negative emotions predominate the classroom atmosphere."* (Frenzel, 2014, p.513)

The study of experienced teachers is valuable in a research area such as affect. One common issue for teachers is classroom management and behaviour for learning. In terms of evaluating the models, there may be value in discussing teacher's emotions through ES and PT in relation to this issue, and I propose a structure to begin such a discussion. A discussion leading to the development of strategies for teachers that encourage emotive practices that are supportive of learning, and which inform behaviour for learning. In this sense, I am speculatively generalising with future research in mind, since this is an explorative study.

With the deepest respect to the creators of the acronym T.I.R.E.D, (Nardi and Steward, 2003), I would ask those interested in this research whether a F.R.E.S.H model for teaching mathematics, one which places the use of positive emotions by teachers as central, is appropriate to counter T.I.R.E.D students, that a step towards addressing this issue is discussing teachers who use their emotions in a F.R.E.S.H manner. One that is,

F ocused (on what is important in mathematics)

R isk managing

E xperimental and modelling

S hifting of learning

H igh intensity (directed to the point of most impact)

To conclude, I give the last word to my 'F.R.E.S.H.-est' participant Gus, since it is the teacher beliefs about and enactment of positive emotions in the classroom that truly matter, *"That's me, the more you laugh the more you learn."*

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