



Theorising the place of emotion–cognition in research on mathematical identities: the case of early years mathematics

Laura Black¹ · Sophina Choudry¹ · Kelly Pickard-Smith¹ · Julian Williams¹

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Abstract

In this paper, we offer a theoretical account of the emotion–cognition dialectic (i.e. the unit of feeling and cognition in thought) in identity formation (or identification), focusing on early childhood and mathematics. We consider how contradictory (emotional-cognitive) experiences which arise in different forms of mathematical activity (a mathematical play activity versus formal classroom mathematics) produce and are produced by contradictory acts of mathematical identification. We illustrate this perspective using the case of Daniel (aged 6 years) who expressed the emotion of ‘astonishment’ at seeing himself on video engaged in a play activity. We highlight how this experience of emotion–cognition enables Daniel to articulate a juxtaposition between play that is ‘fun’ and his classroom mathematics that makes him ‘tired’, which we associate with contrasting mathematical identifications. This recognises that social/cultural symbolic forms of emotion–cognition and identification are present in dialogue with others/adults even at this young age. We therefore, call for a research agenda that explores how such identifications might become sedimented into mathematical identities as the child develops.

Keywords Emotion · Identity · Early childhood · Mathematics

1 Introduction

The concept of ‘identity’ has received increasing focus in mathematics education research in recent years (Darragh 2016) arguably, because of its value in explaining the alienation of many students from school mathematics (Williams 2016). As noted in the literature (Radovic et al. 2018; Darragh 2016), identity is frequently referred to in studies of access, participation and engagement with mathematics because it offers useful insights into both the learner’s affective relationship with the subject (Eccles 2009) and how this is mediated by structural categories (e.g. social class, gender, ethnicity) and their associated intersections (Solomon 2008; Nasir and Hand 2008; Mendick 2005).

However, much of this work has typically focused on students studying mathematics at secondary level (aged 11–16), and at post-compulsory level (Solomon 2008; Hernandez-Martinez et al., 2008) where identity is used to explain students’ decision-making regarding subject choice and/or

degree programme at university (Black et al., 2010). To date, there is very little research that has investigated younger children’s mathematical identifications (we explain the shift from identity to identification below) as they begin to encounter formal school mathematics (Radovic et al., 2018). This paper therefore, addresses a significant gap in the research by considering the emergence of students’ mathematical learner identifications in the early primary phase (aged 5 to 6 years). This is important given the hypothesis that early experiences of mathematics are crucial in shaping both affective and cognitive outcomes in later adolescence (Black et al., 2018).

Elsewhere in the field, some have sought to integrate concepts of mathematical identity with emotion (Heyd-Metzuyanim 2015; Hannula 2012) as a means to study students’ affective relationships with mathematics. Emotion and its associated concepts (e.g. motivation, attitudes, self-efficacy) have been a central concern in explaining patterns of engagement/disengagement (Hannula et al. 2016) and participation or persistence with studying mathematics beyond compulsory schooling (Pampaka et al. 2012). Yet there remains a need for further theorization since some affective concepts (e.g. ‘motivation’ which can be viewed as an individual’s internal conscious drive) conflict with conceptualisations

✉ Laura Black
Laura.Black@manchester.ac.uk

¹ Manchester Institute of Education, University of Manchester, Oxford Road, Manchester M13 9PL, UK

of ‘identity’—with the latter frequently referred to as socially and/or discursively constructed through activity (see Radovic et al., 2018 for more information). There is a need to better understand how aspects of emotion arise and are then experienced in mathematical activity and how this may mediate the kinds of identities/identifications which are produced therein.

In this paper, we investigate how young children’s mathematical identifications are producing and produced by emotion experienced in joint mathematical activity (what we will refer to as experience-in-action). To exemplify our argument, we present data from a video stimulated interview involving a 6 year old boy, Daniel, who viewed himself on video engaging in a mathematical play activity. Using Vygotskian and Neo-Vygotskian theory on emotions (Vygotsky, 1999; Roth, 2017), we consider how the relationship between Daniel and the researcher enacts an emotive experience which is given cultural form resulting in acts of identification. We then consider how emotion arises in this activity in order to consider its function in mediating Daniel’s agency and his relationship with the motive of the activity in question. Finally, we argue that experiences of emotion–cognition and their associated acts of identification can manifest contradictions which are made visible when young children transition from a non-schoolified activity, such as peer group play, to the formal teacher-led mathematics activity. This paper addresses the question: What role does emotion–cognition play in conceptualising mathematical identifications in the context of a joint ‘play based’ activity with young children (aged 5–6 years)?

2 Theorising emotion

Our interest in integrating emotion within a conceptualisation of identity builds on previous research in mathematics education, which has attempted to combine these concepts already. For instance, Heyd-Metzuyunim and Sfard (2012) present students’ communication of emotion as evidence of intensive identifying activity in the mathematics classroom. They suggest communication of emotion is therefore, useful for exploring identity struggles experienced by students. This work adopts a discursive account of emotion and identity, whereby emotion is limited to what can be discursively represented in ‘identifying expressions’—which they acknowledge includes the ‘emotional hue’ of semiotic gestures:

The emotional hue is what makes us interpret a person as communicating that she or he feels in a certain way. Such interpretations may be induced with verbal means, but more often than not they result from an intricate combination of words, tone of voice, gestures,

facial expressions, posture, glances and many other bodily actions. Just like color, which is a property of every material object, so is emotional tinting a necessary feature of every utterance, albeit in some cases, when it is unremarkable, the utterance may be deemed “emotionally neutral”. (p. 132)

Whilst we agree that emotion is ever present in all forms of action (discursive or otherwise), our account adopts a different stance located in Vygotsky’s (1999) work on emotion and particularly the dialectic unit of emotion–cognition. Firstly, this recognises the physiological underpinning of emotion (what Vygotsky refers to as ‘feeling’) which is bound up with cognition as a unit in ‘thought’. For instance, if one thinks of the term ‘mother’ this will generate specific meanings of the term (‘my mum’, I as ‘mum’ etc.) but this thought also produces physiological responses (warmth, stress, pleasure) which are part of the thought too. Secondly, feelings also have their own cognitive element which arises in the process of naming them (e.g. love, hate, astonishment). By holding on to the material basis of physiological feelings, we challenge a purely discursive account and instead explore how the physiological and cognitive expression of emotion acts as a unit of ‘thoughtful feeling’. All forms of joint activity involve ‘thoughtful feeling’ which mediate our subjective experience of it—hence we use the term emotion–cognition to refer to the joint, dialectical unit of emotion and cognition in thought and experience-in-action. What makes this ‘dialectic’ is that the feeling and the cognition are two moments that may be in contradiction, and that they therefore constitute a developmental dynamic. In our analysis below regarding Daniel, we will consider evidence of such contradictions at work in the emotion–cognition aspect of his experience-in-action as he views himself engaged in the play activity on video.

3 Theorising emotion–cognition with identity/identification

As noted above, we consider emotion–cognition as located in joint activity with others rather than residing inside the individual as an internal personality trait (Roth and Radford, 2011). This means recognising the child’s subjective emotional expression to be an inner reflection of the research activity in question. However, according to Vygotsky (1994), emotion–cognition does not solely reside in such joint activity, it also functions in the developing psyche of the child. Here we draw on the Vygotskian concept of ‘perezhivanie’ which has received much attention in early childhood research (Veresov and Flear, 2016). We translate this as an emotional experience which has developmental potential. A perezhivanie can be described as a relatively ‘dramatic’

emotional experience which requires some overcoming, hence development. Whilst this may refer to major ‘traumatic’ life events (e.g. starting school), Chen (2017) notes that even everyday experiences can produce dramatic collisions, e.g. the emotional task of sharing a toy with another child or going to bed. Such experiences require cognitive work, which if intellectually developed, may eventually turn inwards to co-ordinate inner mental actions (Holodyniski, 2013).

Elsewhere we have argued that ‘identities’ or ‘identifications’ can play an important role in ‘working through’ a *perezhivanie* and as such, they mediate emotion–cognition (Black et al. 2018). In these terms, identity is associated with but not reduced to a subjective sense of an activity. For example, identifying as a ‘maths person’ mediates the emotional experience of encountering and even overcoming what is sensed as ‘difficult maths’. Here the physiological feeling of discomfort/dissonance may contradict the intellectual/cognitive sense of ‘I can do this’ with the result being ‘overcoming challenge’ and a strengthening of ‘I like mathematics’ as an identification. Thus, identities, as cultural or symbolic representations derived from practice are tools, which can mediate the cognition–emotion dialectic at play in a given activity. Identity therefore, is not the same as ‘subject-in-activity’ but is rather a crystallised version derived from this, drawing on cultural tools (e.g. what it means to be a mathematics person), which offer the symbolic means to make sense of subjective experience (Holland et al. 1998). As noted above, emotion–cognition is located in the subjective experience of joint activity, and therefore it implicates the cognitive appraisal of a subjective experience crucial to the formation of an identity (‘that maths was fun for me’—‘I like maths’—‘I am a maths person’). An experience of emotion can become crystallised into a mathematical identity if one encounters re-iterations of that emotional experience, allowing time for the essential reflections on the experience that may be verbalized as “I am...” or some equivalent. However, at the same time, by engaging in joint activity, we also enact our identities and thus they are also implicated in the production of emotion–cognition in activity.

Finally, we also argue here that identity and therefore, emotion–cognition are likely to be experienced and produced differently at different developmental stages during the life course. Vygotsky (1994) noted this in the *Problem of the Environment* where he presents the scenario of three siblings of different ages experiencing the same ‘traumatic’ environment (living with an alcoholic mother) but refracted in three different ‘emotional experiences’. Vygotsky describes how each child’s experience of the situation depends on both their previous experience of engaging with emotions with others in joint activity and the degree to which such experiences have ‘turned inwards’ or have become the object of self regulation. Vygotsky uses this example to argue that emotional

experience (*perezhivanie*) is located in the relationship of the developing child to its environment—thus the child, the activity and the position of the child on the relevant developmental trajectory are an essential unit.

In Black et al. (2018) we argue that the concept of ‘identity’ should also recognise the child’s position on a developmental trajectory and have made a conceptual shift from identity to ‘acts of identification’ to account for the development of children’s self-awareness. Since young children do not typically offer crystallised reflections of their emotionally laden subjective experience in research activities, we would not expect them to identify themselves as a ‘type of person’ (a sedimentation of social experience) in ways that we would easily recognise (Harter, 2012). Here, identification and identity are not separate concepts but rather are developmentally linked, so that developed cultural forms and their social relations underpin the process of development from the beginning (Vygotsky, 1997). Hence our definition of mathematical identification is viewed as any act or expression that is mathematical, which is seen or offered by others (e.g. us the researchers) as the ‘seeds’ of a recognisable mathematical identity we might observe in adolescence. Therefore, we argue for a relational definition of identification whereby the response by others (researcher, peer group, teachers, parents etc.) to an act/expression is crucial in differentiating between one’s subjective sense of an activity and an act of identification. In the latter, a recognisable objective form of identity is reflected back to the subject as a cultural form by others (e.g. ‘that’s really clever that is’) so that the act is subjectively experienced as an act of identification—it is this, which may later become an identity reflected on by the child/adolescent themselves. We relate such acts to emotion–cognition since in so far as they are subjectively experienced we can say that they have an emotional tone; the subject feels emotional in action, but also in experiencing the effect of that action, such as a reaction from others—hence a young child’s emotion–cognition in the moment is mediated by the cultural form provided by the adult/others and as such, is a necessary part of the act of identification.

4 The research

The episode we report on in this paper stems from a home-school mathematics project which involved 9 children in Year 1 (aged 5–6 years) across two schools. In line with the Funds of Knowledge perspective (Moll et al. 2009), we worked with children, families and schools located in disadvantaged communities in the UK in order to investigate how children’s perceptions of the mathematics embedded in their home/community activities related to formal school mathematics (in the UK, children begin the formal National

Curriculum at 5 years old). The project involved the following activities:

1. a photo elicitation activity where children were asked to take photographs of the mathematics they saw in their homes and communities. These photographs were then discussed in a photo elicitation dialogue with the researchers which focused on how the photographs represented mathematics;
2. a significant line activity, following Subero et al. (2017), where children were asked to arrange the above photographs (and their associated activities) on a line, which represented a continuum between what was most and least important to them.
3. A drawing activity where children were asked to draw themselves doing mathematics and the researcher asked them to explain what they had chosen to represent.
4. A videoed role-play activity (reported on in this paper), where children were encouraged to imagine themselves in the future as users of mathematics in the real world (as grown ups). This was followed by an interview where the children were shown video episodes of themselves 'at play' and were asked to discuss what they were doing and if/how mathematics was present. The purpose of this activity was to see if their subjective sense of the play activity could be made salient by the interview and thereby, solidify their mathematical identification. More detail on this is provided below.

We have chosen to focus on the play activity with Daniel to exemplify our theoretical perspective because the episodes we describe below stood out as displays of emotion–cognition, which contrasted with how he described his experience of classroom mathematics. To protect the anonymity of participants, all names are pseudonyms.

4.1 Daniel

Daniel lived and attended school in an inner urban area of high deprivation in the North of England. At the time of the research, 62% of students at the school were eligible for 'free school meals'. Initially, Daniel appeared to us to be quiet in class. He infrequently put his hand up to answer his teachers' (Miss Mitchell) questions during whole class discussions and was rarely selected to answer. At his table, Daniel typically worked through tasks on his own, rarely interacting with or being distracted by the other children. His teacher, Miss Mitchell described Daniel to us as 'quiet' but also 'different' - she said there is something 'not quite right' about his physical movement/gestures. We noted this too since he did not make eye contact with us (the researchers) often, and appeared nervous when talking to us at the beginning of the study. During the research project, Daniel expressed that he

experienced difficulty with learning school mathematics—he stated that it made him tired and he found it hard, especially writing sums. Such difficulties were also perceived by Miss Mitchell who reported to us (not in Daniel's presence) that he was working below the expected level for his age.

4.2 The play activity

The data extracts we discuss below stem from an interview between the first author (Laura) and Daniel whilst viewing a video of the play activity they had both been involved in. This play activity had also involved another researcher (Kelly) and three other 6 year old children: Nico, Bilal and Leila. It involved a time tunnel (a large, brightly coloured extended tunnel which children can crawl through), which the children were told to travel through into the future, where they could pretend to be grown-ups. At the end of the tunnel we had placed a collection of objects (which have mathematical associations) on the floor for them to play with. These were a calculator, a measuring tape, a cash register, three plastic pizzas that were portioned into different fractions (fractions were written on the back) and a microscope. Once the children had travelled through the time tunnel, they were told they could play with any of the objects for as long as they wished.

Our purpose in conducting this activity was to explore whether the context of play might support the child's subjective sense of embedded mathematizing (Van Oers, 2010) mediated by the objects we had made available. The notion of 'the future' and acting at being 'a grown up' through play, aimed to provide a context which might provoke 'realistic' activities containing such embedded mathematics (e.g. working in a shop, or in a hospital). The two researchers (Laura and Kelly) were present throughout and on occasions intervened in the play activity in order to direct events towards scenarios where using mathematics might become more salient. This took place through questioning and posing problems connected to the role play (see below). In line with Van Oers (2010) we hypothesised that this activity might provide a space for the children to experience what Vygotsky terms 'everyday' concepts, through engaging with embedded mathematics.

We videoed the play activity throughout and then selected extracts to show the children in individual interviews, which took place a week later. Here the purpose was to provide a representation of the child's experience in the activity which could be reflected upon as an 'object' by the child and researcher through the interview dialogue. This draws on existing work on identity in early childhood which recognises the dynamic relationship between the child as subject (I) and the child as object (me) (Brooker and Woodhead, 2008). The video extracts were identified and selected by the research team based on whether we recognised evidence

of embedded mathematics being used by the children or prompted by the researcher.

During the interviews, the researcher (Laura) asked each child about what they were doing in the video episodes, whether they were doing any mathematics and how they felt about the activity (e.g. did you like or enjoy it?). The interviews lasted approximately 15 min and were audio recorded and then transcribed. As we attempted to transcribe the interview dialogue, it became apparent that verbal transcripts alone would not adequately record the emotional sense of each utterance, which was crucial to our theoretical position on the unity of emotion–cognition and its relation with identification. Therefore, we needed to pay close attention to the intonation, rhythm and other non-verbal sounds (such as laughter) in order to record the children’s (and researcher’s) expressed emotions and intended meanings. We constructed an initial transcription of the verbal dialogue, and then listened again to ensure emotional expressions were represented as accurately as possible. We later inserted descriptions of the video episodes into the transcript (see the table below) once we had identified parts of the transcripts of interest to the analysis—this allowed us to see which aspects of the video episode the dialogue related to in the interview.

Analysis of the interviews initially focused on identifying moments where the child—with-researcher recognised a use of mathematics in the video episode and/or where they appeared to express emotion or identifications explicitly in the dialogue. We then selected moments in the transcripts where emotion (and identification) appeared to be particularly salient to us (the research team), which were then analysed in more depth using the theoretical framework outlined above. We have chosen to focus on two specific ‘moments’ involving Daniel because they involve explicit expressions of emotion and identification (by both Daniel and the researcher) which contrasted with how he described his experience of classroom mathematics and how he was described by his teacher. We have attempted to strengthen the trustworthiness of our interpretation of this data (verbal and non verbal) by checking for consistency across the research team.

4.3 ‘Pizza shop’

During the play activity, after travelling through the time tunnel, all four children gravitated towards the cash register and the three pizzas laid out on the floor and began to role play a pizza shop scenario. Some children took on the role of shopkeeper and others as customers—they also rotated these roles. Both researchers (Laura and Kelly) made interventions at specific points. For example, Laura asked the children: ‘how much would you charge for one slice of pizza?’ and then helped the children to calculate

the cost of a whole pizza based on the total number of slices. However, during this play activity we (the researchers) found our efforts to intervene with such ‘mathematical problems’ were largely ignored by the children, who were rather more preoccupied in enacting their own version of the pizza shop scenario—using the objects we had provided.

During the subsequent video-stimulated interview with Daniel, we chose to show two video clips—one of ‘pizza shop’ and one where he is using a calculator and writing something on a piece of paper. We then asked him whether he had used any mathematics in these episodes in order to scaffold the idea that embedded mathematics might be apparent in play. We wanted to see if, through the dialogue, Daniel and the researcher could construct a relationship between Daniel’s ‘everyday’ or informal experience of play (captured in the video) and embedded mathematics. His response to viewing these videos was somewhat surprising to us (the researchers) given how Daniel appeared to be positioned by his teacher and his behaviour in class.

5 Astonishment at play

Our analysis of emotion–cognition in this data draws on and adapts Roth’s (2017) concept of ‘astonishment’, which he describes as the emotion–cognition of experiencing or encountering something new, alien or unanticipated. Astonishment is conceptualised by Roth (2017) as a process involving: (1) surprise—which is the initial awareness or grasp that something unexpected has occurred and (2) astonishment—the occurrence of affect in response to the ‘surprise’ (awareness that the unexpected has occurred). Our analysis below highlights Daniel’s and the researcher’s expressions of surprise and how this relates to astonishment (as a unit of emotion–cognition), before moving on to discuss its relationship with acts of mathematical identification.

This extract was recorded near the beginning of the interview and discusses the video episode of ‘pizza shop’. We present this extract in two columns in order to distinguish between what is occurring in the video and what is occurring in the interview dialogue between the researcher and Daniel. Gestures and non-verbal indicators of emotion (e.g. intonation, laughter etc.) are written in italics and words that were emphasised by the speaker are written in bold.

Video play activity	Interview with researcher (Laura)	Video play activity	Interview with researcher (Laura)
	<p>Researcher: So what I've got is some videos...I've got some videos to show you. OK?</p> <p>Daniel: ok (<i>tentative</i>)</p> <p>Researcher: And we're playing (<i>emphasised</i>) with the pizza shop. Yeh?</p> <p>Daniel: yeh (<i>tentative</i>)</p> <p>Researcher: So we're gonna watch a little bit of video and then I'm gonna ask you some questions about it. Is that ok? (<i>rising intonation</i>)</p> <p>Daniel: Yeh (<i>emphatic</i>)</p> <p>Researcher: Alright then... so let's watch this one first. This is the pizza shop bit</p>		
<p>[Three children (including Daniel) are playing with the cash register and pizzas.]</p> <p>Leila: who wants some pizza?</p> <p>Daniel: 'I want to be the customer' 'I want to pay' [<i>shouts from what ensues, he means he wants to control the cash register</i>]</p> <p>Leila: I'll get the money out... I'll get the money [<i>takes pretend cash from the cash register</i>]</p> <p>Daniel: I want to pay [<i>points to the cash register</i>] I want to get some money out</p> <p>Leila: Ok [<i>relenting tone</i>] [<i>Leila swaps places and becomes the customer.</i>]</p> <p>Researcher pauses video</p>	<p>Daniel starts laughing ...</p>		
	<p>Researcher: Is it funny? Why's it funny? [<i>laughing with Daniel</i>]</p> <p>Daniel: [<i>still laughing</i>]...I used a funny voice</p> <p>Researcher: .. used a funny voice? Who's yours or mine?</p> <p>Daniel: mine [<i>emphatically</i>]</p> <p>Researcher: [<i>laughing</i>] oh right [<i>laughing</i>] it does sound funny when you're on film</p>		
<p>Researcher plays video [5 s]</p> <p>Leila: Please can I have cheese pizza? There's one over there [<i>picks up stray slice and puts it in the pizza pan</i>]</p> <p>Daniel: cheese pizza [<i>hands L one of the toy pizzas but then retracts it to arrange the slices better</i>] wait... wait, wait, wait</p> <p>Leila: Also I need money first [<i>takes some money from the cash register to pay</i>]</p>	<p>Daniel starts laughing again on hearing 'cheese pizza'</p> <p>Daniel Laughs louder</p>		
		<p>Researcher: Hold on a minute.. she might, she might ... does she want one slice, two slices? You should sell by the slice, you'll make more money</p> <p>Leila: I want all of them [<i>referring to slices</i>]</p> <p>Daniel: You want all of them?</p> <p>Leila: Yeh</p> <p>Daniel: You're gonna finish the lot...all of it</p> <p>Nico: you'll have to have one cos you've already had loads [<i>points finger at Leila</i>]</p> <p>Researcher: Or shall we charge her by the slice? And then she's gonna have to pay a lot of money. How much should we charge her per slice?</p> <p>Nico: Eight pounds</p> <p>Leila: Eight pounds</p> <p>Researcher: No let's charge her a pound a slice</p> <p>Leila: twenty pounds [<i>hands Nico money</i>]</p> <p>Daniel: Here's some money... your change [<i>gives Leila coins</i>]</p> <p>Leila: No...you need to give me them [<i>pointing to the notes</i>]</p> <p>Daniel: Here you go ...a pound [<i>hands Leila one coin</i>]</p> <p>Nico: I'll give you thirty pounds [<i>hands money back to Leila</i>]</p> <p>Leila: Thank you</p> <p>Researcher: She hasn't told us how many slices she's having?</p> <p>Leila: I want whole</p> <p>Researcher: How many slices do you want Leila?</p> <p>Leila: Erm whole</p> <p>Researcher: hold on we need to charge her by the slice. We're charging by the slice...so we need to charge each slice. One, two, three, four, five, six, seven....[<i>picking up each slice</i>]</p> <p>Nico: eight</p> <p>Researcher: so we need to charge her 8 pounds</p> <p>Daniel: pizza is ready [<i>hands pizza to Leila—she picks the pizza and moves it to her mouth as if to eat it, the slices fall to the floor whilst she makes a munching noise into her mouth</i>]</p> <p>Daniel: Oh my god. Oh my god. Who wants some pizza? Who wants some pizza?</p>	<p>Daniel laughs again</p> <p>Daniel laughs</p> <p>Both researcher and Daniel laugh</p> <p>Daniel laughsfalls off chair Researcher laughs: That's you</p>

Video play activity	Interview with researcher (Laura)
Video is paused	<p>Researcher: Did you enjoy playing that game?</p> <p>Daniel: yeh</p> <p>Researcher: Did you enjoy watching yourself playing that game?</p> <p>Daniel: [<i>interrupts</i>] Yeh ...I wanna play it again [<i>assertively</i>]</p> <p>Researcher: Do you? (<i>elongated</i>) Do you like it?</p> <p>Daniel: yeh [<i>emphatic</i>]</p> <p>Researcher: it was really good wasn't it? [...]</p> <p>Researcher: Have you ever played a game like that before?</p> <p>Daniel: No (<i>emphatically</i>). I wanna play again [<i>emphasis on again</i>]</p>

In the above extract, there appears to be some sense of ‘surprise’ in Daniel’s response to viewing the video evident through his immediate laughter—which is triggered upon hearing his own voice on the video: ‘*I want to be the customer*’ and ‘*I want to pay*’. Roth (2017) defines ‘surprise’ as the sensing of a vague something which goes against expectations or alternatively, being affected by something unknown. In this example, we suggest that Daniel is affected by the unexpected—seeing himself speaking loudly on the video—which triggers a view of the ‘I’ as other—creating a subjective dis rupture (Holland et al. 1998) which is emotionally expressed (laughter). In the next moment, due to the researcher’s own sense of ‘surprise’ at Daniel’s laughter, she pauses the video and asks ‘*why is it funny?*’ At this point, the dialogue between Daniel and the researcher moves towards a cognitive appraisal of Daniel’s sense of surprise as he identifies what triggered his laughter: ‘*I used a funny voice*’. Next, as both continue to view the video, Daniel again starts laughing in response to his own voice: ‘cheese pizza’. This laughter then becomes increasingly physical (culminating in falling off his chair) as he observes himself shout ‘oh my god! Oh my god!’ in response to Leila’s gesture of throwing the pizza to the floor (thus transgressing the rules which typically govern school activities). Here, we argue that the previous cognitive reflection on Daniel’s initial laughter (*I used a funny voice*) engenders further feeling i.e. laughter. This is perhaps because his initial behaviour has been legitimised by the dialogue with the researcher: ‘*it does sound funny when you’re on film*’ but may also be a response to seeing further use of his ‘funny voice’ on video (i.e. the repeated use of ‘oh my god! Oh my god’). In any case, this repeated laughter indicates the reciprocal nature of the emotion–cognition unit of experience since the movement from affect to conscious awareness is not uni-directional; rather it contains both ‘feeling’ (laughter) and ‘cognition’ (it was ‘funny’) simultaneously. Subsequently, through dialogue

with the researcher, ‘enjoyment’ is identified in the play activity which then moves to Daniel’s assertion ‘I wanna play it again’ and ‘I wanna play again’. As such, we argue here that this emotional experience exceeds the moment of surprise (Roth 2017), initially brought about by an encounter with the newness of the researcher (teacher) showing Daniel expressions of his and other children’s agency in the video (e.g. throwing the pizzas on the floor). The momentary expression of laughter becomes part of a cognitivised sense of emotional experience (funny, enjoyment) as the feeling of laughter is cognitively worked on

6 Acts of identification ‘in play’

In the above extract, we can see how the emotion–cognition of surprise - astonishment is located in the joint activity of viewing the ‘play–pizza shop’ video between Daniel and the researcher. The dialogue which takes place appears to support a cognitive appraisal of the laughter Daniel displays at viewing himself on video. However, as noted earlier, such expressions of emotion–cognition also implicate acts of identification which are fundamental to the process by which emotional experience is worked through. In the extract below, which took place a little later in the interview, we highlight how acts of identification emerged through the dialogue between Daniel and the researcher and how these are mediated by an expression of emotion–cognition related to the ‘pizza shop’ episode above.

This extract takes place immediately after viewing a video clip where Daniel is seen using a calculator and writing something on a piece of paper. The researcher (Kelly) has queried how he might use a calculator for ‘work’ in the future.

Researcher: Right. what were you doing in that video?
[*questioning tone*]

Daniel: [*spoken quickly*] Err writing some numbers.
[..]

Researcher: So were you pretending to be in a **job** when you were doing that? [referring to the scene in the video where Daniel is writing ‘numbers’ using the calculator].

Daniel: yeh

Researcher: what job were you pretending to be? A grown up job?

Daniel: yeh.. It was counting the money. I was pretending I was counting the money.

Researcher: huh really? [*elongated - surprise*]

Daniel: yeh [*emphatic*]

Researcher: and you were using the calculator to do that? [*high pitch intonation—amazement*]

Daniel: yeh [*emphatic*]

Researcher: that's fantastic Daniel, that's really clever... [*intonation starts to lower in pitch*] and then you were writing it down as you were adding it up?

Daniel: yeh

Researcher: Do you think you might do that when you're a grown up?

Daniel: yeh [*less certain*]

Researcher: what kind of job do you think you might need to do that for?

Daniel: [*spoken quickly*] I would have to... I would have to give people some money for them to **pay**

Researcher: so what? If you were in a shop or something?

Daniel: if I was counting some money... I could tell them how many and then they could have it when they've paid and they could eat it all [*mimicks Leila's action of gobbling the pizza in the video seen previously*]

Researcher: Ah [*laughs*].

In the above extract, we see the researcher and Daniel constructing identifications across the dialogue: 'being clever' and imagining oneself 'counting money' as a 'user of mathematics'. Firstly, we ask Daniel 'what job he is pretending to be in' (re-iterating the question asked by the researcher (Kelly) in the video) and he responds with 'counting money'. The researcher's approval of his input ('counting money') is apparent in her positive affirmation 'that's fantastic Daniel, that's really clever'. Thus, the researcher's utterance here contains a reflection of Daniel's input as an expression of his subjectivity-in-dialogue which, in this instance, affords him an identification of 'clever'. Secondly, in the next part of the dialogue, the researcher questions which 'everyday' context or 'grown up' job Daniel might be in and suggests to him that this might be in a shop (in response to his use of the terms 'money' and 'pay'). Here Daniel and the researcher engage in another act of identification since, in response to the researcher's prompts, he imagines himself as a 'user of mathematics' or rather as a shopkeeper calculating the value of goods and the exchange of money (e.g. his use of 'if' and 'I could...' which denote this imagined self). This exemplifies a relational concept of identification since it emphasises the role of others in introducing existing cultural forms to the act. The researcher mediates the act of identification through her words and actions, as do 'others' who are not physically present (teacher/peer group/parents).

The emotion-cognition expressed in this dialogue is significant in mediating the acts of identification we have delineated above. Firstly, the researcher's surprise at Daniel's input is expressed through the tone of her responses leading up to and including the utterance 'that's fantastic Daniel, that's really clever'. According to Roth (2017), this surprise is the initial grasp that something unexpected has

occurred which in this case relates to Daniel's explanation of himself as engaging in a mathematical act. This contradicts her expectations of Daniel, which may be triggered by (1) her knowledge that he is positioned by his teacher as underachieving with mathematics and/or (2) her prior experience of working with Daniel in other activities where he had given limited response in relation to questions about mathematics embedded in everyday contexts such as the home. Thus, the identification of acting in a clever way, which is afforded Daniel by the researcher, appears to be mediated by her sense of surprise at his input. The second act of identification highlighted above, where Daniel is constructed as a 'user of mathematics' (i.e. his imagined role as a shopkeeper), also draws on the emotion-cognition of 'funny' articulated in the previous extract. This is apparent in his expression 'they could eat it all' (referring to the pizza shop scenario) and accompanying gesture of gobbling the pizza, which repeats Leila's action in the first video. Thus, it appears that Daniel attempts to re-visit the emotion of 'funny' encountered in the first extract in the interview. For what reason? It may be to entertain the researcher who laughed with him previously or perhaps it is because he wants to experience again a sense of 'funny', which was pleasurable. In any case, we argue that this relational emotional experience, embedded in the activity of viewing the play videos, appears to facilitate a dialogue where both Daniel and the researcher can articulate how mathematics (counting) might be embedded in the role-play scenario of pizza shop—thus addressing the researcher's agenda.

7 Contradictions in emotion-cognition

Our account so far has highlighted the emotion-cognition at work in the extracts between Daniel and the researcher and how this is associated with particular 'acts of identification' when viewing the play videos. However, Holland et al. (1998) note that the multifaceted nature of identities raises the possibility of contradictions between them, which are significant since, in the right circumstances, they can bring about transformation of the subject (and object) (see Vianna and Stetsenko, 2011). Therefore, we now move on to consider whether Daniel's expressions of identification and their emotion-cognition imply contradiction or alignment. Here we remind the reader of how Daniel was positioned by his teacher (e.g. 'not achieving the expected level for his age') and how he enacted this position through his behaviour in the classroom as seemingly not actively participating. Furthermore, given Daniel's expression of 'funny' and 'laughter' plus his assertion 'I wanna play again', we might speculate the presence of some form of contradiction between his classroom experience and the experience of viewing himself at 'play'. In

the following extract we asked Daniel to compare these two activities directly by asking which he ‘liked’ better:

Researcher: you just said there is some maths in this...
 Daniel: because he (referring to friend Nico in the video) has to count the money for the pizza
 Researcher: oh yeh...*[delight]* you do... that’s great... and is that the same kind of maths as what we do with Miss Mitchell?
 Daniel: yeh
 Researcher: What do we do with Miss Mitchell?
 Daniel: we do adding and take away
 Researcher: so it’s similar to what you’re doing here then?
 Daniel: yeh
 Researcher: and which do you like better? Do you like adding and taking away here in the video? Or with Miss Mitchell in class?
 Daniel: err... there *[points to the video]*
 Researcher: there... why?
 Daniel: because I get so tired over there *[pointing to his classroom]*... this learning is fun because you get to drawadding and taking away. ...**Funny**. This one is **funny**.

What is interesting in this extract is that Daniel and the researcher are able to cognitively appraise the difference between the two activities of ‘play’ versus school mathematics in terms of their emotional content—the play activity (involving ‘adding and taking away’ in ‘pizza shop’) is again expressed by Daniel as being ‘funny’ whereas the ‘adding and taking away’ he does in the classroom with his teacher is experienced as making him ‘tired’. Thus, through the dialogue, Daniel juxtaposes the different emotional experiences that the two activities offer, which then mediates contrasting acts of mathematical identification. As noted above, the play activity affords Daniel an act of identification of ‘being clever’ and using mathematics in an everyday scenario (as a shopkeeper). By contrast, Daniel’s experience of feeling ‘tired’ when doing classroom mathematics expresses emotion–cognition which may be associated with the mathematical identification offered by Daniel’s teacher as someone who is underachieving or not performing as expected for his age. Note that we did not witness such an identification being offered by the teacher when Daniel was present. However, this labelling of his ‘ability’ is significant since it identifies how well the child fits the national benchmark for mathematical competence at this age and also what progress can be expected of the child as they move through school.

8 Discussion

In this paper, we have extended our account of mathematical identifications in early childhood by examining acts of identification as expressions of the dialectic of emotion–cognition. In Black et al. (2018), we proposed a unit of analysis for conceptualising young children’s identifications with mathematics as the unit of ‘the child with others in the pursuit of joint activity’. Here, we highlight more visibly the child’s experience of emotion–cognition and its role in the production of acts of identification in joint activity. Using Roth’s (2017) concept of astonishment, we have demonstrated how Daniel senses surprise at seeing himself ‘at play’ on the video and this sense is both spontaneous ‘in the moment’ (evident in Daniel’s laughter at himself in the video/falling off his chair) and cognitively appraised as the subjectively sensed emotion ‘funny’ resulting in the expression of agency ‘I want to play again’. These experiences of emotion–cognition appear to result in acts of identification, which are offered by the researcher in the dialogue and are also expressed by Daniel as he articulates his sense of using a calculator for ‘counting money’ in the future.

Therefore, we propose a concept of identification for early childhood that accommodates the unity of emotion–cognition which attends not only to discursive representations of the self, but also ‘feelings’ in thought. In CHAT terms, the form that such emotion–cognition takes is a manifestation of the relation of the subject to the *object-motive* of an activity—its overall or collective purpose which may be objectively realised (e.g. recognised by others). As Roth (2017) notes, engagement in a given activity involves the subject positioning themselves in relation to its motive and we might argue therefore, that it is the nature of this positioning (e.g. alignment versus misalignment) that shapes how the motive is experienced emotionally (e.g. comfort/discomfort). We can argue, therefore, that the production of an identification may depend on how one experiences or is made conscious of the motive of that activity emotionally. In the above extracts, the joint activity of viewing the play video appears to contain two goals:

1. the researchers’ intention to help Daniel ‘see’ embedded mathematics in the play activity that is realised through both the researchers’ and Daniel’s actions (and those of the other children); and
2. Daniel’s goal of repeating this ‘funny’ experience by firstly, requesting the opportunity to play again (‘I wanna play again’) and secondly, by imitating the funny acts he has viewed on the video.

The unit of analysis we offer here suggests that all acts of identification (or identities) are mediated by ‘others’,

since they represent cultural forms, which according to Vygotsky, are appropriated by children through engagement in joint activity. Whilst the narrative identities we have highlighted in our interviews with adolescents (Black et al., 2010) may appear to express more agency, since they encompass ‘self reflection’ (or rather they ‘turn inward’ such cultural forms), these are nevertheless still the words of others. Therefore, we view the videoed play activity reported on here and the subsequent interview as pedagogic in part, since our analysis suggests the researcher introduces particular cultural forms (e.g. ‘everyday’ mathematics) which Daniel did not offer himself in the dialogue. We have identified these moments as acts of identification. The question then is how might Daniel begin to appropriate such cultural forms so that they become part of a developmental trajectory towards a more visible mathematical identity?

We argue here that emotional experience (perezhivanie) is central to addressing this question since what is sensed emotionally ‘in the moment’ may, in some circumstances, provoke reflection (by others initially) and may become the object of self-reflection later on. In viewing the video of the play activity with the researcher, both parties cognitively appraise two different and juxtaposing emotional experiences—one which is ‘funny’ associated with play and the other being the mathematics of the classroom which makes Daniel ‘tired’. These expressions of emotion–cognition may then support contradictory mathematical identifications, which in our data have been made salient through the researcher’s comparison of the two activities. These identifications are contradictory since they are in opposition to one another and thereby define each other’s existence (I enjoy ‘fun’ activities/my classroom mathematics makes me tired). Elsewhere we have argued that contradictions like this can provoke reflection (Black et al., 2018)—at some stage a crisis or conflict emerges which propels either an individual or group to act and thereby produce new forms of emotional experience and thus new forms of identification (Solomon et al. 2016). This is akin to the ‘working through’ of or overcoming an emotional event, which produces development (Veresov and Fleer 2016). Here, we speculate that acts of mathematical identification and their associated experiences of emotion–cognition may have developmental potential in that they provoke reflections which may become sedimented as a mathematical identity later, e.g. in adolescence. Of course our analysis here is speculative and we do not know the precise form such a developmental trajectory might take for Daniel. Nevertheless, existing literature on ‘perezhivanie’ highlights how such emotional ‘moments’ (e.g. being tired in the classroom) enact the ongoing development of the ‘self’ across the life course (Vygotsky, 1994).

We suggest this conceptual framework and analysis can help to explain how emotional experiences (often

expressed ‘post hoc’—after the event) mediate students’ mathematical identities (Pampaka et al., 2012). Brown et al. (2008) highlighted the powerful expressions of emotion narrated by adolescents in explaining their reasons for ‘dropping out’ of mathematics at post compulsory level. Furthermore, our own work has highlighted how adolescent’s engagement in different forms of mathematical activity mediate their motives for studying mathematics, with consequences for their developing identities (Black et al., 2010). We suggest here that identifying young children’s emotional experiences in the early primary phase (‘perezhivanie’) and their associated acts of identification, may make visible (and if needed, intervene) the origins of more crystallised, narrative identities in adolescence.

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