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Primary students' expressed emotions towards mathematics education

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A body of research highlights factors relating to students' emotions—towards themselves, the social environment, learning, and the subject in itself—as being of pivotal importance for learning. This paper reports on a study interviewing students in grade two and five about their experiences with mathematics, specially focusing expressed emotions. Using a combination of deductive frameworks with an inductive search, nuances in students' expressed emotions appear, and tentative results indicate that issues of control is of great importance and that boredom conceals emotionally important complexities.

Introduction

Previous research has indicated that emotion is an intrinsic part of every learning situation, including mathematics learning (e.g., Hannula, 2006; Radford, 2018; Ryan & Deci, 2000; Schukajlow, Rakoczy, & Pekrun, 2017). Emotions "simultaneously emerge from, and shape experience" (Liljedahl, 2014, p.27), thus, playing a part in the individual's structuring of future action through the interrelationship between emotion, motive and action (Leont'ev, 2009).

It appears that student interest, motivation and engagement towards mathematics is inversely proportional to years of schooling (Blomqvist, Elamari & Sumpter, 2012; Hannula, 2006). However, available studies on affective factors like emotion primarily cover teenagers or adults (Dowker, Cheriton, Horton & Mark, 2019) and focusing mathematics anxiety in relation to solving tasks without explaining how these phenomena develop (Batchelor, Torbeyns & Verschaffel, 2019). Thus, there is reason to describe and analyse the nuances within emotions, as well as the supposed link and interplay between different affective factors, in order to better understand student actions and the basis for their stable emotion-based beliefs. Further, there is reason to believe that capturing the experiences of students representing the group between students with mathematics anxiety and the extremely high performing students would reveal previously hidden nuances. Therefore, the aim of this study is to further explore student emotions in relation to mathematics and in particular nuances in expressed emotions by addressing the following research questions:

(1) How do students' express emotion in relation to mathematics and what are the characteristics within these expressed emotions?

(2) How and by what mechanisms are student's emotions linked to expressed motives?

Background

Within the area of affective research resides a number of concepts, such as attitude, belief, motivation and emotion. One recent example is the 2019 special issue of *Educational Studies*

in Mathematics, focusing emotion, where Batchelor et al. points to an asymmetry in the researched student age groups as well as a need for a deepened knowledge around the potential interaction between affective and cognitive factors (Batchelor et al., 2019; Dowker et al., 2019). Here, due to space limitations, I will focus on emotion. Damasio (2004) differentiates between feeling and emotion. One way of describing emotion is to view it as bioregulatory reactions made of chemical and neural responses that the brain produces, and that this production is done automatically and in steps (Damasio, 2004). The initial initiation is followed by biochemical changes in body and brain and finally the emotion is made conscious, resulting in the emotion becoming a feeling and the person can "feel the emotion". This mechanism places emotion in the middle of the physiology–psychology divide as the mechanism that connects the two. Thus, approximating feelings to being conscious and emotion to being unconscious explains that the respondent expresses thoughts about feelings rather than emotions.

The division between emotion and feeling have been explored and discussed by other researchers (e.g., Sumpter, 2019). One conclusion being that emotions includes both bodily experiences and, sometimes but not always, a cognitive interpretation and/or expression of these experiences. Therefore, in this study emotion is defined as "conscious or unconscious mental states elicited by events that we appraise as relevant for our needs and that motivate behaviours to fulfill these needs" (Schirmer, 2015, p.26).

A body of research have been made in the field of psychology trying to establish whether the number of different emotional sensations are, from a practical standpoint, infinite or whether they are limited to a finite set of basic emotions (Shirmer, 2015). In a study from 2013 Löwheim advocates a finite set of emotions, namely eight, making the neurologically grounded argument that this figure represents the maximum amount of configurations one can derive from the three synaptic amino acids involved in the process of producing sensations in the brain. These eight emotions are: excitement, joy, surprise, distress, fear, shame, disgust and anger. Though the number is fixed, the individual experience of emotional sensations may be more varied, since sensations occur to various extent and can be more or less intense.

When discussing implications for teaching, it becomes important to discuss emotion from the aquisitionist versus the participationist paradigms (Liljedahl, 2014). The acquisitionist paradigm implicitly treats emotion as a psychological phenomenon that is a reaction to (interpretations of) an experience, held by the individual and regulating his future actions. In the participationist paradigm, the role of emotion is intertwined with the individual's actions through her motives, that in turn are created by her needs. Since motives, hence also needs, can be unknown to the individual, the emotions work as regulators of actions by feedbacking the fulfilment of the individual's needs. As a consequence of the causal chain: needs–motives–action the importance of motivation is significantly reduced in the participationist paradigm (e.g., Arievitch, 2017). The individual is understood not needing to have motivation (i.e., pleasure, salary or grades) in order to do something, instead she is considered having a need (personal, social or other), creating in her a motive for action (Leont'ev, 2009). Independent of paradigm there is still a need for expanding the multitude of affectively relevant dimensions even further. One attempt is made by Hannula (2006) where he combines eight dimensions, grouped together in three dimensions on the sides of a cube: Emotion, cognition and motivation

makes up the first side of the cube; psychological, physiological and social the second and the two temporal dimensions state and trait the third side.

Looking at empirical studies conducted within the Swedish context one indication, reported by Blomqvist et al. (2012), is that students' emotional disposition turns from positive to negative around the age of 9 years but, due to methodological constraints, the study neither discuss nuances within the group positive versus negative, nor potential causes for these emotions. Another indication is the connection between emotion and motivation (Gerholm, 2016; Nyman & Sumpter, 2019) and between emotion and achievement (Palmér & van Bommel, 2018). These studies, conducted within ages ranging from 6 to 18 years, indicates an interconnection between emotion and other affective and cognitive dimensions that is stable and established early. Karlsson (2019) discusses the issue of the anxiety towards mathematics expressed by poorly achieving students and points to a strong social link connected to negative emotions, but also that the emotional sensations can be either the cause or the effect of a situation. The examples from Swedish empirical research that depict emotion both as a concept interconnected with other psychological and physiological constructs and one that can have an inhibitory as well as a promotive function is well in line with international empirical research (e.g., Hannula, 2015; Radford, 2015).

Methods

Since the aim of this study involves capturing nuances in student expressions, semi-structured interviews were chosen as method for data collection. The semi-structured interview combines the freedom for the respondents to elaborate his or her line of thought with the structured format of a questionnaire. It allows the interviewer to pose both follow-up and clarifying questions but also for the respondent to ask clarifying questions to the interviewer. The interview guide was based on questionnaire instrument with seven items. This instrument was developed by Dahlgren Johansson & Sumpter (2010) and later used also in a study by Blomqvist et al. (2012). The questionnaire combined closed items using a four-step, picture based likert scale (in the shape of happy or sad faces), with free-text items and a drawing task at the end. In the present paper – focusing emotion, items nr 1, 2 and 5; "How do you like math?", "How do you feel before a math lesson?" and "How do you feel when you do math?", respectively, will be discussed. All 19 interviews were made by the author of this article and with the interviewees one by one, in a room near the classroom and during lesson time. Each interview was audio-recorded and lasted between 20 and 30 minutes.

Participants

Data was collected at schools in an urban region, picked out to represent both inner city and suburban socio-economic settings. Ages were chosen to be in grade two and grade five (ages 8 and 11 years respectively) to enable comparison with the previous studies (Dahlgren Johansson et al. (2010) and Blomqvist et al. (2012)). Due to the respondents relatively low age it was necessary to spend some time with each class prior to data collection, thus, for practical reasons the number of participating schools had to be limited to three. Ethics considerations stipulated by the Swedish Research Council through Codex (Vetenskapsrådet, 2017) was followed, therefore, every participant had written parental consent, and were informed that

participating was voluntarily and that they could stop the interview without having to give any explanations. At the day of the interviews the teachers were asked to pick out, among the volunteering pupils, individuals that they considered neither being extremely proficient nor having grave difficulties in mathematics. The teachers were also asked to consider whether pupils would react well in the interview situation and not feel stressed or uneasy. In total, 19 pupils were interviewed, 10 in grade two and 9 in grade five.

Analysis

Prior to analysis the interviews were transcribed by the author. The transcriptions were done verbatim, including non-verbal communication like exclamations and extended pauses. For readability the transcripts followed standard spelling conventions, for example, an utterance like *yu-no-wadda-meen* was transcribed as *if you know what I mean*. Questions number 1 ("How do you like math?"), 2 ("How do you feel before a math lesson?") and 5 ("How do you feel when you do math?") were the ones that explicitly framed emotions or feelings. Therefore, as a first analytical step, the transcripts were marked where the responses to the selected questions appeared. In addition, a second reading of the transcripts were made, looking for instances where respondents made additional references to emotions or feelings in the exchanges that were the result of following up other questions than the selected three. The first step in the subsequent analysis was then carried out and the instances were coded Positive or Negative with utterances like "I like math when …" and "It makes me stressed when …" respectively. An instance was coded Neutral when the respondent referred to factors that were emotionally neutral, such as hunger. The second step uses Löwheim's (2013) theory of basic emotions to divide the three initial categories in sub-categories. Finding these categories involved paying close attention to the words or expressions used by the respondents, for example "I feel relaxed" were coded under the subtheme Relief and "fun", "like", "happy" were coded under the subtheme Joy. This example also illustrates a decisive difference in emotional strength or intensity where "happy" is considered to be stronger than "like".

In order to expand the analysis beyond the descriptive, a framework for analysing by what types of motives or motivations the respondents framed their responses where adopted as a third step. This framework was described by Hannula (2012) and describes eight themes, four of which (cognitive, motivation, social and physiological) could be found in the data and one is the construct in focus in this article – emotion. Here the coding focused on the specific ways the respondents expressed their experiences. For example: "I'm challenged by it" connects to the theme motivation whereas "I don't want my friends to laugh" connects to the theme social. This example also highlights that each theme range over positive as well as negative emotions. The mapping of categories from step two over Hannula's framework resulted in a number of responses, for example, Contention, carried properties that were inconsistent with any of "Hannula's" themes. This called for a fourth and completing analytic step, following the approach of thematic analysis (Braun and Clarke, 2006) which is an inductive search for similarities. The remaining responses were then weighed against each other and the rest of the responses, aiming to define criteria for additional themes looking for criteria that captured the same level of motivating dimensions that the rest of the themes does. These criteria need to converge into intra-coherent but not overlapping themes that exhausts the data.

Results

As a summary of the results Table 1 shows the distribution of instances within each theme. The results are discussed focusing on qualitative differences between categories and themes even though number of instances is presented (in brackets) to offer an idea of relative frequencies between different themes.

	Cognitive	Motivational	Technical	Personal (relates to self)	Social
Positive (91)					
Joy (34)	Process (7) Position (8)	Challenge (19)			
Contention (15)			Situation (14)	Autonomy (1)	
Relief (20)			Control (20)		
Negative (64)					
Discontent (1)		Boredom (1)			
Stress (52)			Temporal ELC (7)	Personal ELC (45)	
Shame (11)				Personality (8)	Social (3)
Neutral (2)					
Physiological (2)					

Note. ELC = expressed lack of control.

Table 1. Students expressed motivations for emotions experienced in relation to mathematics education.

Among the Positive emotions, the first subtheme is Joy where Process and Position are closely related and both link to Cognitive dimensions but differ in relation to outcome, whereas Challenge link to Motivational dimensions. In all three categories respondents' express enjoyment or happiness originating in the cognitive development they feel in relation to mathematics. When an utterance contains expressions of development and cognitive expansion being enough in themselves it is coded Process, like David (Y2), saying that he "likes mathematics" because he "learns" and because "it's fun to work". When this shifts more towards the result of the work, like Louise's (Y2) response: "I like math, it's fun doing it, you get smarter and you get better" that shows a linkage to the person appreciating moving their position on a "mathematical ability-scale" and is coded Position.

The second positive emotion, Contention, is an emotionally weaker concept compared to joy, still clearly positive but with less intense sensations. In this category we find two concepts, Situation and Autonomy, both framing the working situation but for different reasons:

Tania: Solving the maths-tasks, and talking to your friends, sometimes we're allowed to two by two and then we can talk a bit about maths and I think that's fun.

Matteus: That you can count in your own way, no one says like you have to write this or that.

The Situation-theme, illustrated by Tania, is linked to technical issues around the working situation like, where to sit, being allowed to listen to music, and similar expressions of mathematics being a safe and cosy activity. Autonomy is also linked to the working situation,

however, here the positive feelings are associated with the possibility of doing it "in your own way" as Matteus puts it.

The last on the positive also links to the working situation but the feeling is expressed as the relief of being able, and knowing how to get the work done, just as Matteus says:

> Matteus: I feel calm, can work at my own pace, not anybody else's pace. And it's not a contest. To be the first and such.

Comparing the positive subthemes with each other indicates two main sources for emotion; one related to inherent mathematical properties and another to factors outside the mathematical content. And even though the emotional subcategories can be placed along an intensity-continuum the different motive themes does not appear to form any similar simple patterns.

Turning to the negative emotions, the first one only has one instance, imposing caution in the conclusions: Chris (Y2) seem to have a hard time answering the question ("How do you feel before a maths-lesson?") because he needs an unusually long time to choose a face-card. Eventually he picks the happy face, however, with the following remark:

> Chris: Because it's a bit like I get tired from math but when I know there is going to come funny pages or something that perhaps is fun then it's number one.

Chris goes on explaining that he likes it "when it gets difficult also" because he feels that "it ain't fun when you have really easy stuff, like two plus two and stuff". After this the interviewer goes back and asks Chris' what it is that makes him tired:

> Chris: It's like when you must do super-many pages, you must do all the way to like page eighty and when you're on page sixtyfive or so, then I'm really tired in my arm.

Chris describes mathematics as being fun, however, necessary for this is experiencing some level of challenge by working with non-routine tasks. In the light of this, Chris' tiredness is interpreted as negative and categorised as Discontention. As Chris never explicitly says math is boring or uses explicitly negative words to describe his tiredness it is possible that this category is type of borderline-concept, indistinguishable from negative and positive valences.

Turning to the other negative subthemes, we see that Stress is the most commonly expressed emotion and that its motive is related to lack of control, divided between a Temporal and a Personal subcategory. Not having enough time to finishing tasks during an exam or keeping the pace of the class connects the emotion to temporal factors. The superficially similar category, Personal expressed lack of control (PELC), is probably a more disadvantageous emotion because it links to issues of self-efficacy, self-control and potentially also self-worth. Chris' introspection is a typical PELC-coded response:

> Chris: It's like, "Oh no, I don't know how to do it!" and I bet it'll take a long time to learn.

Though mentioned, time is subordinate, and based on where the emphasis is placed the analysis is that the salient issue is the fear of not knowing "how to do it". It is also worth noting that this group is not only the largest among the negative responses but the largest altogether.

Looking further, at Shame, one might argue that shame is always linked to social situations, meaning that you feel ashamed for something that you have done in relation to

others, however, sociality also represents being in or out of a group. This duality splits the category in two parts, where Vera's (Y5) response is an example of the group interpretation:

> Vera: It feels really difficult because my friend sitting next to me, she is rather fast and then I feel a bit stressed. That I'm rather far behind then.

Vera describes a shameful feeling, however, not connected to herself or her abilities, but her concern is that she will be left behind, literally be on her own. The analysis is therefore to code this type of instance as: Sociality. Now compare this to what Jane (Y5) is saying:

> Jane: Sometimes some say like this: "that one is really easy" – just blurts it out. And then I feel ashamed for asking. Because it feels like they might say that I'm bad at maths.

Jane's comment about what "they" possibly "might say" gives it its social dimension, but also indicates that this feeling originates in beliefs of self-worth. Therefore, this different type of shame-connected motive is coded: Personality. A proto-hierarchical structure seems to exist between the concepts: Personality, Sociality, PELC and TELC, in falling order of emotional strength and separated in levels of interaction.

To illustrate these interrelations, Figure 1 shows the constructs on a two-dimensional surface. The *x*-axis indicates the different levels of social interaction found in Table 1. The Technical category on the "negative" side must not be seen as a negative interpretation of interaction, rather as highlighting this category to be qualitatively different, and parallel to interaction.

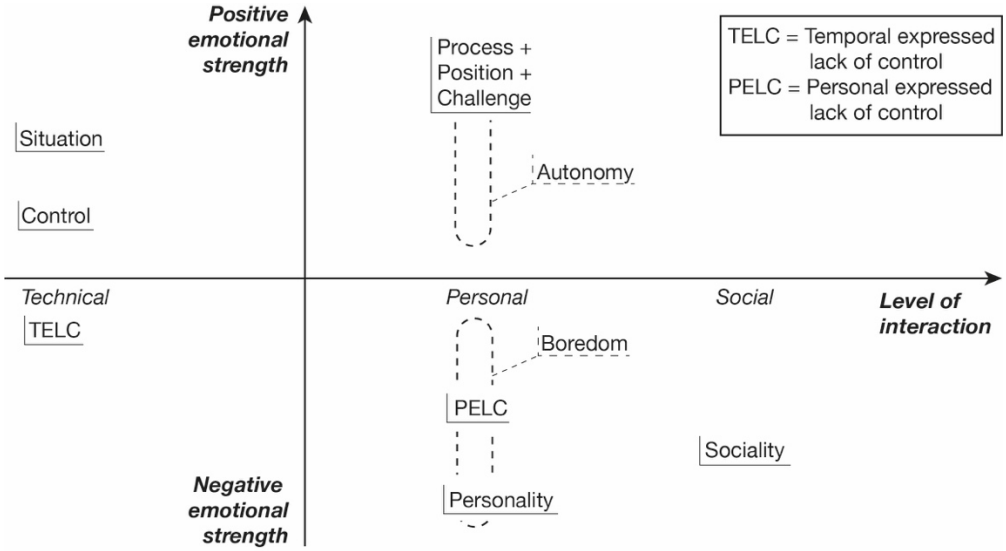

Figure 1: A theoretical model for the distribution of motives for emotions on a strength–interaction surface.

The *y*-axis (in Figure 1) shows the valence of emotion and illustrates the difference in strengths in emotional sensations that are only implicit in Table 1. Looking at Figure 1 we see that positive emotions are typically connected to technical and personal types of interaction, where the strongest emotions are personally connected. Autonomy is also believed to be a personally connected construct, however of lower strength. On the negative side of Figure 1, we find that Personality and Social are associated with high negative emotional strength, and contrary to Boredom that seem to manifest itself at different emotional strengths. Even though the data

supports the claims made in Figure 1, it must be noted that Figure 1 should be viewed only as a theoretical model since the study did not explicitly aim to capture emotional strength or levels of social interaction.

Discussion

Given the important part emotion plays in learning situations (e.g., Hannula, 2006; Radford, 2018) and that emotion reciprocally both shapes and is shaped by a persons' experience of education (Liljedahl, 2014), this paper contributes to describing and analysing these connections and to revealing some of the nuances within emotion and other affective constructs. This becomes relevant since emotion is a major ingredient in the individuals' motives for engaging in education, and therefore linked to achievement (Leont'ev, 2009; Schukajlow et al., 2017). The inherent property of "nuance" adding detail in both width and depth has a value in itself and this study reveals a small spectrum of emotional nuances within each of the two categories positive and negative reported by Blomqvist et al. (2012). But also, when respondents get the opportunity to expand on their experiences, a potential complexity in their emotional relation to mathematics can come to light. Here that has led to a smaller difference, relative to Blomqvist et al. (2012), between negative and positive when one respondent can give different responses that need to be assigned to negative and positive respectively. From a methodological perspective, eliciting responses using the faces from likert-scale items turned out to be more fruitful than anticipated when it prompted respondents to reflect on situations they associated with happy and sad faces respectively.

When looking at the data through the framework of basic emotions used (Löwheim, 2011; Schirmer, 2015) we see that some of them – both positive and negative – are represented: joy, excitement, shame and distress. And that factors of stress or shame, linked to personal or social dimensions are in line with what others have reported on, for example math anxiety (e.g., Karlsson, 2019) reflects both these qualities and manifests themselves both in test situations and during ordinary lessons. But we also see that there are instances implying connection to emotionally less intense concepts, pointing either to the need for expanding the number of emotional categories or that the respondents are not emotional in relation to mathematics. The latter explanation, however, is problematic since also the "weak" responses are clearly emotional in nature, like the feeling of relief that Matteus displays in the comment "I feel calm, can work at my own pace". Further, when mapping the concept of emotion against the other concepts in Hannula's model (2006), three things come to the fore: (1) emotion breaks up into several subconstructs, some of which are previously described basic emotions (Löwheim, 2011), (2) a large proportion of both positive and negative emotions fall beside the model's categories and connects to control, where having control creates a cosy feeling of joy, and not having control creates distress, and (3) cognitive as well as motivational dimensions appear within the emotions. This is parallel to the interplay between motivation and emotion reported by Nyman & Sumpter (2019). Hence, it seems that issues of motivation emerge when students are asked to describe emotion, and vice versa. These three points all calls for continuing research – preferably using a participatory methodology – with the aim of capturing some of the fleeting emotion-connected dimensions occurring momentarily during lessons.

Considering that Shirmer's (2015) definition of emotion rests on the concepts of appraisal and need, it implicitly connects emotion to motive (e.g., Leont'ev, 2009). Applying that to the results of the present study, while being careful not to make quantitative claims from this limited data, we note that the data contains no reference to the basic emotion surprise. Since surprise can be connected to a motive for understanding (the reason for one's surprise) it is potentially a starting point for further research.

A further result of this study is the distribution of the concept boredom. In relation to Hannula's framework (2006) boredom can generally be associated with motivation, pointing to a complex interplay between emotion and motivation (Nyman & Sumpter, 2019). Furthermore, student's expressions of boredom are potentially distributed over an emotional strength spectrum were the low-intensity end connects to motivation and the stronger expressions taps into issues of self-belief and self-worth. In connection to the onset of this study, the assumption of observing a declining engagement in mathematics starting as early as year 3, the emotional complexity in relation to boredom is perhaps more pivotal than previously acknowledged.

References

Arievitch, I. M. (2017). *Beyond the brain. An agentive activity perspective on mind, development and learning.* Rotterdam: Sense Publishers.

Batchelor, S., Torbeyns, J., & Verschaffel, L. (2019). Affect and mathematics in young children: An introduction. *Educational Studies in Mathematics, 100*(3), 201–209. https://doi.org/10.1007/s10649-018-9864-x

Blomqvist, A., Elamari, U., & Sumpter, L. (2012). Grade 2 and Grade 5 students' conceptions about mathematics and mathematics education. In G.H. Gunnarsdottir, F. Hreinsdottir, G. Palsdottir, M. Hannula, M. Hannula-Sormunen, E. Jablonka, U. Jankvist, A. Ryve, P. Valero & K. Wæge (Eds.), *Proceedings of NORMA 11: The sixth Nordic conference on mathematics education (pp. 187–196)*. Reykjavik

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), (pp. 77–101). doi: https://doi.org/10.1191/1478088706qp063oa

Dahlgren Johansson, A. & Sumpter, L. (2010). Children's conceptions about mathematics and mathematics education. In K. Kislenko (Ed.) *Current state of research on mathematical* beliefs XVI (pp. 77-88). Tallinn: OÜ Vali Press.

Damasio, A. (2004). Emotions and Feelings. In A. Manstead, N. Frijda, & A. Fischer (Eds.), *Feelings and Emotions: The Amsterdam Symposium (Studies in Emotion and Social Interaction*, pp. 49–57). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511806582.004

Dowker, A., Cheriton, O., Horton, R., & Mark, W. (2019). Relationships between attitudes and performance in young children's mathematics. *Educational Studies in Mathematics, 100*(3), 211–230. https://doi.org/10.1007/s10649-019-9880-5

Gerholm, V. (2016). *Matematiskt begåvade ungdomars motivation och erfarenheter av utvecklande verksamheter* [Mathematically talented teenagers' motivation and experience of developmental activities] (Licentiate thesis). Stockholm: Stockholms Universitet

Hannula, M. S. (2012). Exploring new dimensions of mathematics-related affect: Embodied and social theories. *Research in Mathematics Education, 14*(2), 137–161. doi: https://doi-org.ezp.sub.su.se/10.1080/14794802.2012.694281

Hannula, M. S. (2006). Motivation in mathematics: Goals reflected in emotions. *Educational Studies in Mathematics 63*, 165–178. doi: 10.1007/s10649-005-9019-8

Hannula, M. S. (2015). Emotions in problem solving. In S. J. Cho (Ed.). *Selected regular lectures from the 12th international congress on mathematical education,* (pp. 269–288). doi: 10.1007/978-3-319-17187-6_16

Karlsson, I. (2019). *Elever i matematiksvårigheter: Lärare och elever om låga prestationer i matematik* (Doctoral disertation). Lund: Institutionen för utbildningsvetenskap, Lunds universitet.

Leont'ev, A. N. (2009). *Activity and Consciousness.* CC-SA: Marxist Internet archive.

Liljedahl, P. (2014). Emotion as an orienting experience. In L. Sumpter (Ed.), *Proceedings of MAVI-20 Conference.* (pp. 21–32). Falun: Högskolan Dalarna.

Löwheim, H. (2011). A new three-dimensional model for emotions and monoamine neurotransmitters. *Medical Hypotheses 78*, (pp. 341–348). doi:10.1016/j.mehy.2011.11.016

Nyman, M. & Sumpter, L. (2019). The issue of 'proudliness': Primary students' motivation towards mathematics. LUMAT, (2). https://doi.org/10.31129/LUMAT.7.2.331.

Palmér, H. & van Bommel, J. (2018). Young students' feelings towards problem-solving tasks: wht does "success" imply?. In B. Rott, G. Törner, J. Peters-Desdemir, A. Möller, Safrudiannur, (Eds.). *Views and beliefs in mathematics education. The role of beliefs in the classroom,* (pp. 69–78). doi: https://doi.org/10.1007/978-3-030-01273-1

Radford, L. (2018). Teaching and learning (algebra or something else): Working together to make sense of similarities and differences between theories (and understanding oneself). Paper Presented at the AERA Symposium Dealing with Diverse Discourses (3D): Can We Build on Each Other's Research Contributions?, New York.

Radford, L. (2015) Of love, frustration and mathematics: A cultural-historical approach to emotions in mathematics teaching and learning. In B. Pepin, B. Roesken-Winter (eds.), *From beliefs todynamic affect systems in mathematics education*, (pp. 25–49). doi: 10.1007/978-3-319-06808-4_2

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology, 25*, (pp. 54–67). doi: 10.1006/ceps.1999.1020

Schirmer, A. (2015). What is an emotion? Modern thoughts and concepts. *Emotion.* (pp. 42–70). Thousand Oaks: Sage Publications. doi: http://dx.doi.org/10.4135/9781483378619.n4

Schukajlow, S., Rakoczy, K., & Pekrun, R. (2017). Emotions and motivation in mathematics education: Theoretical considerations and empirical contributions. Germany: Springer Science + Business Media.

Sumpter, L. (2019). Preschool educator' emotional directions towards mathematics. International Journal of Science and Mathematics Education, 1. https://doi.org/10.1007/s10763-019-10015-2

Sumpter, L. (2013). Themes and interplay of beliefs in mathematical reasoning. *International Journal of Science and Mathematics Education, 11*(5), 1115–1135. doi: 10.1007/s10763-012-9392-6

Vetenskapsrådet. (2017). *God forskningssed* [Good research practice]. Vetenskapsrådets rapportserie 1:2001.