Minding Emotions in Mathematics Education

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In mathematics education research, a focus on cognition in learning experiences often obscures emotion. Our ongoing research has underscored the importance of the emotional dimensions and social interactions that contribute to social solidarity. Through a sociology of emotions framing and event-oriented social inquiry, we identify salient characteristics in primary and preservice mathematics settings to show how social interactions can build social solidarity and help create an emotionally safe learning environment. We demonstrate that social solidarity includes three aspects: ritual objects; being-in/with others, and collective empathy.

Improving students' achievement in mathematics continues to be a pressing issue in Aotearoa New Zealand and internationally. A common policy lever for raising achievement is to focus on teachers' competencies for teaching mathematics. In a recent policy change, the Teaching Council of Aotearoa New Zealand (2024) now requires primary initial teacher education providers to assess the preparedness of graduates with mandated entry assessment of competence in mathematics. Year 5 students in Aotearoa New Zealand (see Caygill et al., 2024) also report that they are not confident about doing school mathematics. We take a position that attention to raising student achievement in mathematics includes building and transforming the emotional aspects of classroom learning environments.

Reframing negative narratives about emotions associated with mathematics is long overdue and approaches to responding to emotions are often counterproductive to learning. One strategy for promoting anxious learners' engagement in mathematics has been the adoption of games to cast mathematics as "fun" as part of an emotionally safe learning environment. However, efforts to "make maths fun" by simplifying the mathematics can mask and detract from students' opportunities to engage with challenging mathematical ideas (Bonne & Higgins, 2022). Mathematics anxiety has become an increasingly pervasive and unquestioned explanation for low mathematics achievement and poor relationships with the subject. The enduring and intergenerational entanglement between emotions and the teaching of mathematics (Foley et al., 2017) illuminates the challenge of transforming stubborn discourses, such as mathematics anxiety. The aim of this paper is to present insights from a body of research that focuses on how teachers and teacher educators can attend to students' emotions in mathematics classes to build emotionally safe learning environments. To do so, we unpack events that occurred in the context of students and their teachers playing whole-class mathematics games.

Considering Emotions in Mathematics Learning Environments

To date, cognition has been a primary focus in understanding education settings, however it is now important to bring emotions to the forefront to highlight the interdependent relationship between emotion and cognition, as explained in sociological theories of emotion (Collins, 2004; Turner, 2002). It is generally agreed that the place of emotions in education has been under-investigated. Zembylas (2005) suggested three reasons why this may be the case: first, that because emotions are fluid, they are therefore more difficult to describe than cognition; secondly, the dominance of cognitive psychology over education research endures; and thirdly, "there is the legacy of dualism, which has opposed reason to emotion, and accorded

(2025). In S. M. Patahuddin, L. Gaunt, D. Harris & K. Tripet (Eds.), *Unlocking minds in mathematics education. Proceedings of the 47th annual conference of the Mathematics Education Research Group of Australasia* (pp. 125–132). Canberra: MERGA.

reason the high status inscribed in Western thinking" (p. 123). Indeed, a seam of research continues to explore ways to measure emotions in mathematics contexts (e.g., Lin et al., 2020; Park & Flores, 2021), even though the fluidity of emotions proposed by Zembylas (2005) could make it problematic for researchers to treat emotions as an enduring trait, rather than a temporary state. However emotions are ever-present in mathematics learning environments, and we argue they need to be integrated with considerations of mathematics achievement. In both primary classrooms and teacher preparation settings, providing an emotionally safe learning environment and also competently teaching students needs to be a focus. In mathematics learning contexts, the challenge is for educators to attend to both hearts *and* minds, that is, emotions and cognition.

Classroom studies in science education have investigated the complexities of how emotions feature in learning and teaching by using multiple framings and methods (e.g., Davis & Bellocchi, 2018; Tobin & Ritchie, 2012), yet in the field of mathematics education, few classroom studies to date have considered emotions from a sociological standpoint. Despite limited attention to emotions in mathematics education, as reported in the four-yearly *Research in Mathematics Education in Australasia* (Reid O'Connor et al., 2024), emerging research into emotions in mathematics learning includes work by Buckley and Sullivan (2023) in Australia. Notably this work investigates teacher pedagogical approaches that could help students manage anxiety and uncertainty associated with challenging mathematics tasks, with the potential to promote resilience and enjoyable learning of mathematics (Johnston-Wilder et al., 2021).

In Aotearoa New Zealand, recent mathematics education research has taken a focus on the broader construct of affect, described by Grootenboer and Marshman (2016) as including the personal constructs of beliefs, identities, attitudes, values, dispositions, and emotions. Marmur and Darragh (2024) have used the dual lenses of affect and identity to examine how significant memorable events in preservice primary teachers' mathematics learning shape their relationships with the subject. Ingram et al. (2018) suggested effective strategies for promoting pre-service teachers' productive relationships with mathematics included: explicitly attending to mathematical content knowledge; highlighting affective aspects of learning; and presenting practising teachers as positive role models.

A key reason why emotions are often overlooked in the learning experience is the prevalence of negative past experiences with mathematics among both primary students and pre-service teachers. To address such experiences and the emotions associated with them, we need to better understand the emotional dimensions of mathematics learning environments. Employing multiple framings and methods is critical to expanding the field of emotions and mathematics.

Theoretical Perspectives

Using a sociology of emotions framing (Collins, 2004; Turner, 2002) enables an examination of the emotional complexities associated with learning and teaching in mathematics classrooms. We draw on Turner's (2010) stratification of a large repertoire of emotions derived from four primary emotions (anger, sadness, fear, happiness), three of which are negative. Derived from the primary emotions, Turner argues that secondary emotions "are a way to reduce the power of the three negative primary emotions into emotions that can promote social and special control" (p.181). Collins' (2004) focus on interaction rituals is helpful for understanding social solidarity which, along with emotional energy and collective ritual objects, is one of the important outcomes of successful social interactions. We are interested in the dialectic relationship between collective | individual emotions and how these emerge and contribute to social solidarity.

Methodological Approach

Event-oriented social inquiry (Alexakos, 2015) in our program of research enables a nuanced reading of emotions in primary and preservice mathematics classrooms, illustrated in this paper by several events that we interpret as evidence of social solidarity of the groups involved. We used multiple methods, including classroom transcripts, cogenerative dialogues (cogen) (Roth & Tobin, 2002), an interactive response card system (clickers), one-to-one interviews, email conversations, and the research team's reflexive conversations. In considering how teachers and teacher educators attend to students' emotions in mathematics classes to build emotionally safe learning environments, we look back on two related empirical mathematics education studies to generate further insights about social solidarity. The first study is with a class of 34 students (10- to 13-years-old) and the two teachers who shared the class (Bonne & Higgins, 2022), and the second is with a class of 43 pre-service teachers who were taught by Joanna and Raewyn (Higgins, Bonne, & Eden, 2024). We use student pseudonyms throughout this paper.

In this paper, we trace three aspects of social solidarity that became evident when the students were participating in whole-class mathematics games. The first aspect of social solidarity is the presence of a ritual object. Collins (2004) described a ritual as "a mechanism of mutually focused emotion and attention producing a momentarily shared reality, which thereby generates solidarity and symbols of group membership" (p. 7). Following Collins' work, we see a ritual object being of an enduring nature and creating a common point of focus for interactions amongst the collective. The second of these aspects is 'being-in/with others' (Roth &Tobin, 2002) which is described as "being-in the world and being-with others" (p. 315). We have interpreted this to mean participants - regardless of their roles as teachers or students - being attuned to the same social context and physical space, providing a framing for learning and teaching. The third aspect of solidarity is collective empathy which is associated with shared emotional dimensions evident in classroom interaction rituals (Collins, 2004) and involves the collective's response to an individual's expressed emotion. The emergence of an emotionally caring safe learning environment can be seen as contingent on the generation of collective empathy.

Findings

Social solidarity is an important aspect of emotionally safe learning environments or what Zembylas (2007) described as creating caring safe ecologies, in which the whole class is concerned about everybody's emotional wellbeing. Originally, we analysed interactions during games because we had evidence that students' emotions were amplified in this context (Higgins & Bonne, 2014; Bonne & Higgins, 2022; Higgins et al., 2024). More recently, we have re-examined our work across two classroom contexts and were struck by the emergence of social solidarity associated with playing mathematics games.

Context 1: A Primary Mathematics Classroom

During our work in a primary classroom, we employed clickers to build a picture of students' perceptions of the emotional climate over the course of mathematics lessons (see Bonne & Higgins, 2022). The peaks and valleys that we noticed in the data all occurred while the class played whole-class games, in contrast with the remainder of the time, during which there was much less fluctuation in emotional climate. The students were engaged in games that are common in classrooms in New Zealand to improve mathematical knowledge related to number facts and probability: "Round the World" and "Greedy Pig", respectively (for details of the games, see Bonne and Higgins, 2022). Primarily we aim to understand how games in a primary classroom can be a site for the generation of emotions that lead to social solidarity by

exploring elements such as ritual objects, being-in/with, and collective empathy. The evidence we present here is from three cogen sessions, involving six students and Joanna and Linda.

'The Talk' as a Ritual Object

In one cogen session, the primary students described one of their teachers using "the talk" to help manage the behaviour of students who were "out of line" (Higgins & Bonne, 2014, p. 58). What follows is an illustration of students' experiences of 'the talk'.

Illustration 1

"She'll just have the talk with you"

24	Quentin:	Yup like she's fun but like if you get out of line like she can give them a look sort of thing … she'll just have the talk with you you'll have 'the talk' [makes quotation signal with one hand, students laugh]
25	Kitty:	You always know when you're having the talk
26	Quentin:	Yeah because she's got this [taps on the table with one finger] and these stern features in her voice and stuff.

Mention of 'the talk' was met with a ripple of laughter across the group (Turn 24), indicating a collective awareness of the teacher's strategy for monitoring those students she deemed to be 'out of line'. Clearly, everyone in the class knew about 'the talk', which we consider to be a ritual object in this class. 'The talk' can also be seen as a cultural practice of this classroom, however, it is important to note that its meaning is emergent and contingent across and within participants (Alexakos, 2015).

Being-in/with Others

How the students see their teacher as aligning with them is an important aspect of "being-in/with". In an early paper (Higgins & Bonne, 2014), we observed how a teacher shifted her alignment with the students across different events in the classroom, illustrated next.

Illustration 2

"She's a big student"

15	Quentin:	You kinda need a teacher that you respect like as a person because otherwise you don't really listen to them [students all laugh] … like say [one of their teachers] she joins in with the class whenever they're playing games … and she makes jokes in class and she's a really funny teacher and stuff
16	Kitty:	She knows what kids really like
17	Scott:	She's like one of the students
18	Kitty:	Yeah she also knows how to like kinda help and work with the kids who are being naughty in class but she: and she does it in a way that's really good …
19	Quentin:	Yeah she's a big student
20	Scott:	And she knows like where the boundaries are set
21	Kitty:	Yeah so … she has boundaries but she also knows how to have a lot of fun

As the illustration shows, the students recognised the teacher's sense of fun and her understanding of what students like. We interpret the teacher's ability to have fun with her students, making jokes and generating laughter, as contributing to the teacher being-in/with the students and in solidarity with them.

Collective Empathy

Although empathy is often associated with a response to a negative emotion, the following illustration shows the students responding collectively to an individual student in the final stages of a game and then cheering as their classmate wins.

Illustration 3

"A victorious cry"

During the final stages of a competitive mathematics game in which the last remaining student was left to challenge the teacher, Jack correctly answered a problem before the teacher, and realised he had won the game. At which point Jack raised his fist above his head and gave a victorious cry. The other students mirrored his emotion, by cheering, laughing, clapping, and surging forward towards the student and teacher, with several getting up on their knees. The teacher threw her head forward, feigning shame at losing the game.

The surge of emotional energy evident in this excerpt is what is described by Collins (2004) as the special kind of energy arising from participation in a ritual. This example demonstrates a dramatic emotional climate described variously as, for instance, collective effervescence (Collins, 2004) or high positive emotional exchanges (Davis & Bellocchi, 2018).

Context 2: A Preservice Mathematics Education Classroom

In the context of a mathematics education class with preservice teachers, we used event-oriented social inquiry (Alexakos, 2015) to analyse transcripts of classroom sessions included in an 8-week course that focussed on classroom pedagogy. We aim to understand how the interactions among students, and between students and teacher educators, highlighted the emotions involved in learning and teaching mathematics. Aligned with our work in a primary classroom context, here we specifically focus on how collective attention to emotions generated social solidarity. The evidence we present here is from transcripts of two consecutive sessions in the preservice teacher education mathematics education classroom.

A 'Gift' as a Ritual Object

In the pre-service classroom, a ritual object, a 'gift', emerged from an interaction sparked by a student's under-the-breath playful quip "so she thinks" that potentially challenged the authority of the teacher educator, by reminding the teacher educator that they cannot know everything that is going on in the class (see Higgins et al., 2024). The term 'gift' was coined by the teacher educator and subsequently adopted by the class as a humorous way to highlight the emotional aspects of interactions (Eden et al., in preparation). The following illustration, focussed on number patterns, shows the first occasion on which a student uses the term 'gift'.

Illustration 4

"I hear disagreement"

4	Charlie	But it's not...
5	Raewyn	I hear disagreement! Someone said it's not?
6	Rowan	Another gift! It's gonna go 1 2 2 cause it's still carrying on the 4 from the last time around, it's carrying on 12 12 instead....

In Turn 6, Rowan identifies "another gift", referring to the emerging disagreement about an aspect of a pattern identified in a choral counting activity (University of Washington, 2014). The 'gift' as a ritual object lifts the mood of the group to enable an emotionally safe environment for disagreement about which number comes next and reduces the focus on an individual. Later in the same session the teacher educator invited the students to think about the function of the 'gift'. The students' responses follow in Illustration 5.

Illustration 5

"These little in-class jokes"

8	Avery	It does something towards classroom culture, these little in-class jokes that only the class knows, it makes us feel together
9	Quinn	I was going to say the same thing

The student responses show an awareness of the contribution the 'gift' makes to the social solidarity of the class. The 'gift' had spontaneously emerged and, over time, retained collective acceptance. However, the 'gift's' enduring nature as a ritual object was contingent on at least one of the students recognising its function as an "in-class joke" (Turn 8).

Being-in/with others

The function of the 'gift' was re-examined by the class when it had to be explained to a student who had been absent at the time it had emerged as an in-class joke, illustrating the notion of 'being-in/with others' as an aspect of social solidarity. This plays out in the illustration below when Joanna realised that not everyone in the class was in on the joke, and this prompted a conversation about the importance of the teacher ensuring everyone is included.

Illustration 6

"t's been a gift gift but I don't know"

11	Billie	I have no idea what the joke is! I was doing all the maths, I missed it. So this whole lesson it's been gift gift gift but I don't know!
12	Raewyn:	So that punctuates the point a little bit I guess
13	Joanna:	We've just got another gift! It's the assumption everyone was in cause everyone was here, I made that assumption … so you're [referring to Billie] in on the gift now? [however, Billie has left the room, unnoticed by Joanna]
14	Avery	She left because she was getting frustrated. No, I'm joking! But you can see how in a class some students might stop listening
15	Joanna	Good point, ... I assumed all the people in the room were on board with the gift, it's like what building up the culture of a classroom is about.

The collective had an opportunity to reexamine the role of the 'gift' in building social solidarity, prompted by the realisation that one of the students was unaware of its meaning. We note how as teachers we rely on the continuity of classroom culture for uninterrupted learning processes and ritual ways of being in a classroom. The emergence of a shared understanding at the same time presupposes that some individuals will not be-in/with the collective.

Collective empathy

The emergence of an emotionally safe learning environment can be seen as contingent on the generation of collective empathy. The illustration below shows a separate event in the same class in which empathy is evident in the group's suggestions about modifications to the game, "Buzz", in response to one student's emotional outburst.

Illustration 7

"It's the individual failure I hate"

4	Quinn	[taking turns] one, two, buzz, four, five, buzz, seven, eight, buzz, ten, eleven, buzz, thirteen, fourteen
5	Helen	Fifteen. [loudly and angrily] That's why I don't like this game. Because it's an individual thing, and I sucked at multiples, and I'd go out first, and everyone would make fun of me. It's the individual failure I hate. Because it makes you feel like crap
6	Joanna	Hmm. fair point
7	Chris	Maybe you could run the game and have someone sit it out if they didn't feel comfortable?
8	Joanna	Maybe. Let's ask the class
9	Sam	Set boundaries earlier. No hassling. Anyone who hassles can sit out
10	Nick	We could have a referee

The students' strategies for making the activity more inclusive (Turns 7, 9, and 10) helped to downplay the emphasis on individual performance and create a safe emotional climate. The co-construction of the environment "shapes how [students and teacher educators] are emotionally connected and engaged in learning together" (Zembylas, 2007, p. 357) and, we argue, demonstrates collective empathy.

Concluding Thoughts

The time for minding emotions in mathematics classrooms is long overdue. To help build achievement in mathematics it is important to consider how educators attend to the complexities of emotion in mathematics classrooms. Specifically, the evidence presented here shows that paying attention to individual and collective student emotion is essential to disrupting cycles of negative emotion associated with mathematics. Furthermore, the deliberate inclusion of everybody in the class was important for developing social solidarity.

We have shown that in both contexts, three aspects of social solidarity emerged: ritual objects; being-in/with others; and collective empathy. A close examination of events that all occurred during whole-class mathematics games, has illuminated a range of emotions associated with mathematics learning and teaching. This work contributes to reframing negative narratives about emotions associated with mathematics and offers new insights into building emotionally safe learning environments (Zembylas, 2007). We continue to raise questions about developing a broader explanation of how teachers and teacher educators might attend to the emotional dimensions of mathematics classrooms and foster social solidarity through ritual objects, 'being-in/with' others, and collective empathy.

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References

Alexakos, K. (2015). *Being a teacher | researcher*. Sense Publishers.

Bonne, L. & Higgins, J. (2022). Game playing and fluctuations in emotional climate. *Cultural Studies of Science Education, 17*, 1063-1079. https://doi.org/10.1007/s11422-022-10125-4

Buckley, S. & Sullivan, P. (2023). Reframing anxiety and uncertainty in the mathematics classroom. *Mathematics Education Research Journal, 35*(Suppl 1), 157–170. https://doi.org/10.1007/s13394-021-00393-8

Caygill, R., Borthwick, R. & Bennett, H. (2024). *TIMSS 2023: Mathematics Year 5*. https://www.educationcounts.govt.nz/publications/schooling/timss-2023-mathematics-year-5

Collins, R. (2004). *Interaction ritual chains*. Princeton University Press.

Davis, J. & Bellocchi, A. (2018). Objectivity, subjectivity, and emotion in school science inquiry. *Journal of Research in Science Teaching, 55*, 1419–1447. https://doi.org/10.1002/tea.21461

Eden, R., Higgins, J. & Bonne, L. (in preparation). *Promoting social solidarity in a pre-service mathematics education classroom: the "gift" as a ritual object*.

Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C. & Beilock, S. L. (2017). The Math Anxiety-Performance Link: A Global Phenomenon. *Current Directions in Psychological Science, 26*(1), 52-58. https://doi.org/10.1177/0963721416672463

Grootenboer, P. & Marshman, M. (2016). *Mathematics, affect and learning: Middle school students' beliefs and attitudes about mathematics education*. Springer. https://doi.org/10.1007/978-981-287-679-9_2

Higgins, J. & Bonne, L. (2014). Exploring classroom life through cogenerative dialogues. *Cultural Studies of Science Education*, 9, 53-61.

Higgins, J., Bonne, L. & Eden, R. (2024). Responding to negative emotion in a pre-service mathematics classroom. *Cultural Studies of Science Education*, 19, 633-646. https://doi.org/10.1007/s11422-024-10229-z

Ingram, N., Linsell, C. & Offen, B. (2018). Growing mathematics teachers: Pre-service primary teachers' relationships with mathematics. *Mathematics Teacher Education and Development 20*(3), 41-60.

Johnston-Wilder, S., Lee, C., & Mackrell, K. (2021). Addressing mathematics anxiety through developing resilience: Building on self-determination theory. *Creative Education, 12,* 2098-2115. https://doi.org/10.4236/ce.2021.129161

Lin, W., Yin, H., Han, J. & Han, J. (2020). Teacher-student interaction and Chinese students' mathematics learning outcomes: The mediation of mathematics achievement emotions. *International Journal of Environmental Research and Public Health*, *17*(13), 4742. https//doi.org/10.3390/ijerph17134742

Marmur, O. & Darragh, L. (2024). Emotional associations with mathematics: Using the lenses of affect and identity to understand preservice teacher stories. In T. Evans, O. Marmur, J. Hunter, G. Leach, & J. Jhagroo (Eds.), *Proceedings of the 47th Conference of the International Group for the Psychology of Mathematics Education (Vol. 3),* 185-192. PME.

Park, M. & Flores, R. (2021). Developing a questionnaire to measure preservice elementary teachers' emotions for teaching science and mathematics. *International Journal of Science Education, 43*(18), 2911-2935. https//doi.org/10.1080/09500693.2021.2001072

Reid O'Connor, B., Marshman, M., Ingram, N. & Grootenboer, P. J. (2024). Research in the affective domain in mathematics education. In C. Mesiti et al. (Eds.), *Research in Mathematics Education in Australasia 2020–2023*. https://doi.org/10.1007/978-981-97-1964-8_10

Roth, W-M. & Tobin, K. (2002). *At the elbow of another*. Peter Lang.

Teaching Council of Aotearoa New Zealand. (2024). https://teachingcouncil.nz/professional-practice/ite-providers/mathematics-requirement/

Tobin, K. & Ritchie, S. M. (2012). Multi-method, multi-theoretical, multi-level research in the learning sciences. *The Asia-Pacific Education Researcher, 21*, 117-129.

Turner, J. H. (2002). *Face to face: Toward a sociological theory of interpersonal behavior*. Stanford University Press.

Turner, J. H. (2010). The stratification of emotions: Some preliminary generalizations. *Sociological Inquiry, 80*(2),168 - 199, https://doi.org/10.1111/j.1475-682X.2010.00326.

University of Washington. (2014). *Choral counting.* Teacher Education by Design (TEDD). https://tedd.org/choral-counting/

Zembylas, M. (2005). Three perspectives on linking the cognitive and the emotional in science learning: Conceptual change, socio-constructivism and poststructuralism. *Studies in Science Education, 41*, 91–116.

Zembylas, M. (2007). Emotional ecology: The intersection of emotional knowledge and pedagogical content knowledge in teaching. *Teaching and Teacher Education, 23*, 355–367.