Love is a mathematical journey: Memes as metaphors to unveil students' emotions and identity in the mathematics classroom

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In today's digital culture, memes play a significant role in communication, impacting collective identities and emotions. This study explores the educational value of mathematical memes and their effect on secondary students' identities, emotions, and engagement in mathematics. Using Lakoff's framework of metaphors, it examines how students participate in the creation of mathematical memes and the implications of the activity for emotional responses and identity formation. Data from a mathematical meme tournament show a connection between students' emotional responses and their mathematical interpretations. This suggests that mathematical memes can intercept the interplay between emotions and cultural frameworks to provide students with meaningful learning experiences.

Keywords: Emotion, Identity, Mathematical memes, Metaphors, Online learning

Introduction and rationale: Memes, emotions, and identity

In contemporary digital culture, memes have emerged as a ubiquitous form of communication, comprising images, videos, or text that convey humour or cultural commentary (Shifman, 2014). The social studies literature widely acknowledges memes' influence on the formation and expression of collective identities (Shifman, 2014), as well as their ability to evoke emotions (Jenkins et al., 2013). Indeed, memes are perceived as a shared language within online communities constituting the *memeshpere*, and their appeal is directly linked to their relatability in terms of shared emotions.

In mathematics education research, scholars agree on the role of emotions and identity to shape students' learning (Radford, 2015; Boaler, 2002; 2016). Specifically, Boaler (2002) emphasizes that knowledge is not static but rather co-constructed by learners, their interactions, and situational factors. In classrooms where students are passive recipients of knowledge, they ultimately became disaffected with mathematics due to pedagogical practices that did not align with their desires for expression and agency. Conversely, by inviting students to contribute their own thoughts and ideas to the mathematical discourse, educators empower learners to take ownership of their learning, countering disengagement observed in passive learning settings.

Focussing on the significance of memes for maths teaching, research in mathematics education agrees that memes offer opportunities to explore a unique crossing of mathematical concepts and digital culture (Abrams, 2021; Bini et al., 2022; Mutua & Mwangi, 2023). Mathematical memes use humour and visual imagery to convey mathematical ideas (Bini et al., 2023): they employ mathematical symbols or terminology in unexpected contexts, making complex mathematical concepts more accessible and engaging, and provide a bridge between students' spontaneous discourse and the language of mathematics, facilitating a deeper understanding of mathematical concepts. Moreover, the interactive nature of meme creation and sharing platforms fosters students' agency, collaboration, and participation, enhancing engagement in the mathematics classroom. Building on these premises, this study aims to investigate the educational benefits of mathematical memes and their impact on students' engagement in learning mathematics. Specifically, the study moves from the hypothesis that involving students in mathematical meme creation activities can uncover the emotions associated

with mathematics and provide educators with valuable insights into students' experiences, identity, and self-positioning with respect to mathematics.

Theoretical background: Memes as multimodal metaphors

Language metaphors, as described by Lakoff are “mappings across conceptual domains” (1993, p. 39), serving as cognitive tools that bridge abstract concepts with tangible experiences. These verbal tools provide individuals with a lens to perceive and comprehend the world (Lakoff, 1993; Lakoff & Johnson, 2008). By mapping abstract domains onto concrete experiences, metaphors offer frameworks for understanding complex phenomena, shedding light on how individuals navigate their lived experiences. Examining metaphors involves studying the linguistic choices that guides the recognition of cross-domain mappings as sets of “ontological correspondences between entities in a source domain and entities in a target domain” (Lakoff, 1993, p. 26). The epitomising example is the metaphor "love is a journey", from which the present study derives its title, revealing its intricate layers of meaning, portraying romantic relationships as dynamic adventures (Lakoff, 1993; Lakoff & Johnson, 2008). This metaphor captures the evolving nature of love, suggesting shared aspirations and destinations that couples navigate together, mirroring the complexities of real-life relationships. Besides Lakoff’s language metaphors, visual metaphors are also recognized as powerful cognitive tools. In mathematics education, visual metaphors are acknowledged as means to guide the reasoning process, helping students to move beyond sensory perceptions to logical generalizations, essential in mathematics. Presmeg, (1995) underlines the imaginative aspects of reason, including metaphor and mental imagery, considered crucial for meaning-making and reasoning, and Rolka (2005) highlights the potential of metaphorical mages to elicit students’ beliefs about mathematics.

Memes have been interpreted as *multimodal* metaphors: having both a verbal *and* a visual nature, they harness the cognitive strength of both linguistic and visual metaphorical mapping (Scott, 2021), Memes’ metaphorical meaning can be unpacked using a semiotic tool known as the Triple-S construct (Bini et al., 2023). According to this construct, the full meaning of a mathematical meme, which corresponds to a mathematical statement, is constructed by combining three layers of partial meanings: a social meaning carried by the image, following conventions established in the memesphere; a structural meaning carried by the compositional arrangement of the meme; and a specialised meaning carried by topic-specific information in the template or in user’s additions.

Given these premises, the study is guided by the following research question: How does the metaphorical interpretation of mathematical memes created by students shed light on their emotional responses and identity formation in the mathematics classroom?

Methodology and methods

Data for the study come from the 2021/22 edition of MathMemeThon, an annual online mathematical memes tournament designed by the author during the 2020 Covid-induced online learning period (Bini, 2022). In this competition, students team and compete creating memes on mathematical topics across successive rounds: an elimination match, a semifinal, and a final. The goal is to promote the re-elaboration and systematization of known mathematical topics, with each round focusing on different topics chosen by teachers. To institutionalise the activity and support formative assessment, teams present their memes and mathematical content to a jury, who scores the memes on mathematical and memetic quality and presentation accuracy. Each round includes an hour for meme

creation (offline) and time for online presentations. Memes are created using Imgflip (https://imgflip.com/memegenerator) and shared on Padlet boards allowing reactions (https://padlet.com/), and are subsequently published on Instagram @lifeonmath.

MathMemeThon 2022 took place from March to May, involving 8 class groups of 12th-grade students (about 120 students) and 4 teachers from a technical secondary school in Turin, Italy. Students were divided into teams of four, either self-formed or assigned by teachers. The jury included the teachers, the author, two mathematics master's students, and one PhD student. Online sessions were held on Webex, recorded, and transcribed. During the tournament, classes tackled calculus topics: functions, limits, and derivatives.

This study will focus on four girls from the same class group, who teamed up spontaneously and named themselves “the romantic ones”. Their work is noteworthy for two reasons: it has a deep and correct mathematical content, which allowed them to make it to the final, and it reveals a consistent emotional response to the different mathematical topics proposed by the teachers. Memes are analysed using the Triple-S construct; transcribed sessions are analysed using a qualitative methodology and interpretative approach as outlined by Cohen et al. (2007), focussed on eliciting the metaphorical implication of the girls’ productions in terms of emotions and identity formation.

Data and analysis

This paragraph presents the romantic girls’ team production and excerpts from their presentations. Figure 1 shows the memes created in the three tournament rounds: elimination match (left) on the topic of functions, semifinal (centre) on the topic of limits and final (right), on the topic of derivatives. To maintain the freshness of the memes, the original versions are presented here, added Italian text is translated in the 'Structural meaning' row of Table 1, which presents the partial and full meanings of the romantic girls’ memes according to the Triple-S construct (Bini et al., 2023).

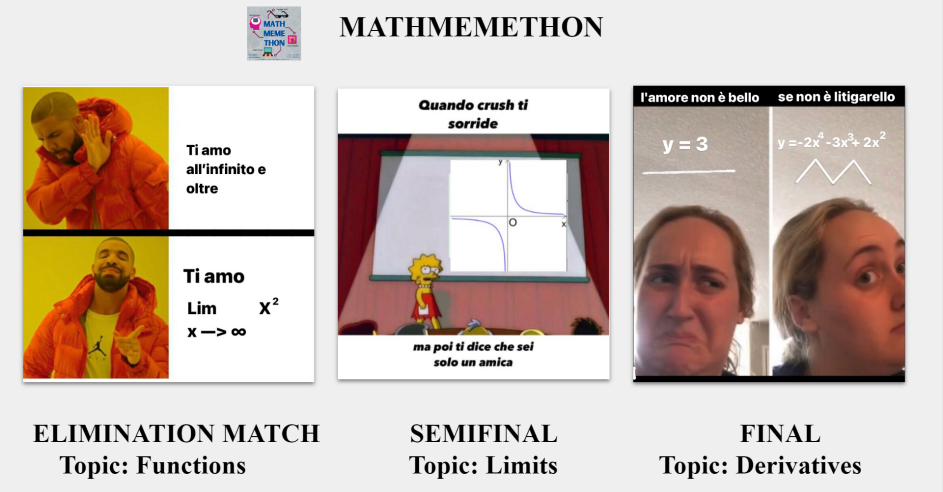

Figure 1: Romantic girls’ team mathematical memes

Table 1: Partial and full meanings of the romantic girls' memes

Partial and full meanings of the memes	Elimination match Template: *Drakeposting*[7]	Semifinal Template: *Lisa Simpson's Presentation*[8]	Final Template: *Kombucha Girl*[9]
Social meaning (from the online encyclopaedia KnowYourMeme)	Contrasting reactions implying a preference between two choices	Humorous or ironic depictions of factual evidence	Evolution from disgust to approval of something
Structural meaning	Two-pane (horizontal) texts are added in two lateral lines • Top line: I love you to infinity and beyond • Bottom line: I love you $\lim_{x\to\infty} x^2$	Exploitable: elements are added on the board and as top/bottom texts • On the board: $y = \frac{1}{x}$ graph • Top text: when crush smiles at you • Bottom text: but then tells you that you're just a friend	Two-pane (vertical) elements are added above and onto the images • Left text: love is not beautiful • Right text: if it's not quarrelsome • Left addition: $y = 3$ and sketch of the behaviour • Right addition: $y = -2x^4 - 3x^3 + 2x^2$ and sketch of the behaviour
Specialised meaning	Functions' limits	Functions' asymptotes	Functions' increasing, decreasing and stationary behaviour
Full meaning	$\lim_{x\to\infty} x^2 = \infty$	The function $y = \frac{1}{x}$ has a horizontal and a vertical asymptote	$y = 3$ is a flat function, while $y = -2x^4 - 3x^3 + 2x^2$ is a curved function with maxima and minima

The first thing to note is that meme creators do not have access to functional maths editors. On the one hand, this might contaminate the representation in the symbolic register; but on the other hand, it offers a rich potential for discussing on mediating the writing of mathematical content in an era dominated by images. Then, some cultural-situated comments are due to fully understand the final meme: the text "L'amore non è bello se non è litigarello" corresponds to an Italian proverb, translated in Table 1 as "Love is not beautiful if it is not quarrelsome", a popularised version of Shakespeare's "The course of true love never did run smooth" (A Midsummer Night's Dream). The graphical additions in the meme (horizontal and zig-zag lines) should not be read as the graph of the functions $y = 3$ and $y = -2x^4 - 3x^3 + 2x^2$. Instead, they sketch the behaviours of the functions as inferred

[7] https://knowyourmeme.com/memes/drakeposting
[8] https://knowyourmeme.com/memes/lisa-simpsons-presentation
[9] https://knowyourmeme.com/memes/kombucha-girl-trying-kombucha-for-the-first-time

from the sign of the derivative. In the experiment cultural context, slanted segments complement the derivative sign chart: upward segments for increasing intervals and downward for decreasing ones.

An initial examination of the memes created by the romantic girls reveals a recurring theme: they identify themselves as "the romantic ones" and consistently interpret their reality through this emotional perspective, even when tasked with mathematical assignments. Indeed, other mathematical memes created during the tournament also exhibit emotional elements, but these emotions stem directly from the students' experience of doing mathematics. The *Two Buttons* meme, created by another team in the elimination match (Figure 2), illustrates the authors' confusion when handling infinity and indeterminate forms (F.I. in the meme text, the representation of infinities addition is also a customary notation in the experiment cultural context).

Figure 2: *Two Buttons* mathematical meme

The difference is that the emotion in the meme in Figure 2 arises and concludes within the context of the authors' mathematical experience, whereas the emotions exhibited by the romantic girls' memes in Figure 1 originate from a different realm and are projected onto the girls' mathematical experience.

The interweaved mathematical and emotional contents of the romantic girls' memes are further developed in their presentations during the tournament rounds. In the following excerpts, *Student* indicates the romantic girls' team spokesperson.

Elimination match (Figure 1, left): Functions

Student — We are very romantic girls, and in addition to love, we are rational. Therefore, above, we have represented what a normal, unoriginal guy would say to us, and below, we have represented what a guy who would win our heart would say. It's very simple, very clear; a good mathematician knows that x^2 goes to plus infinity, so "ti amo" (I love you) goes to infinity and beyond.

Due to time constraints in the elimination match, teams had only a brief window to present their memes. Nonetheless, the romantic girls used this short timeframe to declare their identities, emphasizing that their romantic inclinations do not overshadow their rationality (*we are rational*). Coherently, they label as *unoriginal* the guy who simply says *I love you*, while connecting mathematical proficiency with the ideal suitor. They attribute an emotionally resonant (and mathematically correct) interpretation to $\lim_{x\to\infty} x^2 = \infty$, describing it as the mathematical

representation of the intensity of the lover's feelings. This can be interpreted as a metaphorical mapping of the intensity of the romantic feeling onto the functions' limits.

Semifinal (Figure 1, centre): Limits

Student	We are always the romantic ones. This time too, we decided to tackle the theme of love. However, this time, unfortunately, it's a bit negative. Our meme says, "when crush smiles at you but then tells you that you're just a friend." For those who don't know, "crush" is the infatuation, and precisely "just a friend" means entering the full friendzone. Entering the friendzone means being perceived as a friend when you want more. So, our meme is clear: we represented the function 1/x by solving it, finding its domain and limits. Now, as my colleague is writing, finding the domain, and calculating the limit at infinity and the limit at zero, in both cases, vertical and horizontal asymptotes are obtained. It means that we have asymptotes that will never touch the function; I don't know if I explained myself well.
Author	I'm missing the connection between the concept of friendzone and the asymptote: it's clear to me, but I would like you to explain it more explicitly.
Student	The concept is that the asymptote always gets close to the function, but it will never touch it.
Author	Which one is the crush? The function or the asymptote?
Student	The asymptote…

During the semifinal, teams had a longer timeframe to present their memes. The romantic girls explained their meme's mathematical meaning, drawing attention to the domain of the function $y = \frac{1}{x}$, its graph and asymptotical behaviour at infinity and around x=0. They discussed both the mathematical content and the language used, explaining terms such as *crush* (in English also in the original Italian text) and *friendzone* (also in English in the presentation), thus performing a metaphorical mapping between the challenge of pursuing unreciprocated love and the behaviour of a function approaching its asymptote without reaching it.

Final (Figure 1, right): Derivatives

Student	So, um, we are always the team of romantic girls. […] We wanted to represent love through derivatives. You can see that this girl on the left is not very convinced, in fact, the derivative is constant, and it says above that "love is not beautiful," and then it says "if it's not quarrelsome", and she's a bit more convinced because the relationship is a bit livelier, a bit more fun. In fact, in the derivatives, we find two maxima and one minimum, while the other one, which is a derivative of a constant, is flat, and so, love is monotonous.

In the final match the girls explained their meme connecting the behaviour of a function to the liveliness of love life (*we wanted to represent love through derivatives*). Thus, they choose a constant function ($y = 3$) to represent a flat and uneventful love life, and a polynomial function with extrema ($y = -2x^4 - 3x^3 + 2x^2$) to represent a livelier and captivating romance. In their presentation, they show to have a clear understanding of how derivatives can be used to determine a function's behaviour and extrema. Thus, the meme encapsulates the behaviour of functions across three distinct semiotic modalities: analytical (the functions themselves), graphical (the slanted segments sketch) and verbal (the metaphorical interpretation of the function increasing or decreasing trend).

Results and conclusion

A metaphorical mapping across conceptual domains can be now performed, based on the romantic girls' pictorial and lexical choices. We can ask: did these girls use mathematics to understand love or

vice versa? The girls' explanations clearly show that they mapped their own love experience into the mathematical realm: thus, for them, love is the source domain and mathematics is the target domain.

Table 2: Mathematics as Love metaphorical mapping

Meme	Source domain: Love	Target domain: Mathematics
Elimination match	Intensity of the romantic feeling	Functions' limits
Semifinal	Unreciprocated love	Asymptotical behaviour
Final	Love life	Increasing or decreasing behaviour of a function
Final	Good and bad love moments	Maxima and minima of a function

Metaphors bridge the gap between the known and the unknown, facilitating a deeper and more intuitive grasp of abstract ideas. They are cognitive tools that connect intangible concepts with tangible experiences, supporting meaning-making and reasoning (Presmeg, 1995). Lakoff (1993) explained how the linguistic metaphor of a physical journey provides verbal tools to describe the abstract feeling of love. Similarly, mathematical memes as multimodal metaphors provided the romantic girls with language and pictorial tools to bridge the abstract feeling of love to their perceptions of mathematical ideas. This process involved an ontological mapping from the source domain of love to the target domain of mathematics. In Lakoff's study, the cognitive process leveraged a metaphorical mapping from the concreteness of a physical journey to the abstractness of love. For the girls, both domains (love and mathematics) are abstract, but love is closer to their experiences, making it feel more concrete. The metaphorical power of these mappings offered frameworks for conceptualizing mathematical ideas like limits, asymptotes, or derivatives by linking them to vivid personal experiences, evoking emotions, stimulating imagination, and encouraging the exploration of mathematical concepts from different angles.

We cannot assume that memes support a deeper understanding of mathematics, but we can infer that they can promote creative thinking, enabling students to contribute to discussions, take ownership of their learning journeys, and actively engage with the discipline of mathematics (Boaler, 2002). Despite the study's inherent limitations, it is evident that this activity allowed students to project their emotions and identity onto a mathematical context, making the concepts as memorable as the emotions they represented. The class teacher corroborated this, noting increased engagement among students—a rare phenomenon in technical schools where mathematics is often perceived as disconnected from students' lives and devoid of personal relevance[10].

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[10] Did the romantic girls win the tournament? Spoiler: they did not, but you can see the winner on Instagram @lifeonmath

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