3. How Spiderman Can Teach You Math: The Journey of Memes From Social Media to Mathematics Classrooms

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Abstract: Memes are humorous digital artifacts created by web users copying an image and overlaying a personal funny caption. They are virally shared in the web and represent an important part of the online discourse young learners are exposed to on a daily basis. The aim of this paper is to show how memes on mathematical subjects can inspire learning activities that harness the participatory and playful nature of these digital artifacts, connecting positive emotions, focal for learning achievement, to serious mathematical reasoning. The paper presents a collection of 3 examples taken from different learning scenarios: 1 from a spontaneous out-of-school learning environment and 2 from intentionally designed school experiences conducted with 6th- and 12th-grade students, all pivoting on the use of a popular meme based on a Spiderman cartoon. The analysis elicits the core properties of these experiences in order to show how they fit within the connected learning framework. I hope the outcome of this research can shed some light on how educators can leverage on students' popular culture embodied in memes to foster interest-powered learning outcomes in mathematics.

Introduction

Students' emotions and interest are acknowledged as key internal factors for learning achievement in the mathematics classroom. They can affect cognitive processing in several different ways, from the bias on attention and memory to the activation of reactive behaviors, such as that of math anxiety, that can hinder mathematical thinking (Hannula, 2015; McLeod, 1992; Schukajlow, Rakoczy, & Pekrun, 2017; Zan, Brown, Evans, & Hannula, 2006). For these reasons, fostering positive emotions in math class can be a winning practice that extends its effects well beyond the time span of the actual lecture. According to the connected learning framework (Ito et al., 2013, 2018), an effective way to associate positive feelings to learning experiences is building connections between academic goals and other areas of expertise and interest of the learners.

The aim of this paper is to show how memes on mathematical subjects can support building these connections, providing the basis for creative learning activities that harness the participatory and playful nature of these digital artifacts and bond positive emotions to serious mathematical reasoning. The paper presents a collection of three examples taken from different learning scenarios: one from a spontaneous out-of-school learning environment and two from intentionally designed school experiences, all pivoting on the use of a popular meme based on a Spiderman cartoon chosen for its relevance, which will be outlined in the next paragraph. The analysis elicits the core properties of these experiences in order to show how they fit within the connected learning framework. The paper concludes by discussing how educators can leverage on students' popular culture embodied in memes to foster interest-powered learning outcomes in mathematics.

Background: From Cartoons to Meme Icon

The image in Figure 1, known as *Spiderman pointing at Spiderman*, is a snapshot from a 1967 cartoon that in the last decade has been promoted to a new status. It became the template (i.e., base image) of an extremely popular meme, a humorous digital artifact created by web users overlaying an image with a personal funny caption, widely shared in networking websites such as Reddit or Instagram.

Figure 1. The Spiderman pointing at Spiderman template [Source: Reddit].

In the process of meme genesis, whose mechanisms lie far beyond the scope of this paper, the *Spiderman pointing at Spiderman* template acquired the metaphorical meaning of two similar things meeting (see KnowYourMeme, https://knowyourmeme.com/, the Internet meme database). In this sense it triggered a wide range of modifications and personalizations, all aimed at capturing the humorous side of the acknowledged metaphor, with the personalized caption either in a white strip above the image (see Figure 2, left) or superimposed on the two Spiderman figures (Figure 2, right).

Figure 2. Spiderman pointing at Spiderman meme examples [Source: Know Your Meme].

The popularity of this template is so widely recognized that the above-mentioned KnowYourMeme website recently (2019) listed it among "The Top 50 Memes of the Decade." Its fame propagates even outside memes' natural habitat (i.e., social media websites), inspiring a handful of re-creations, such as the real-life Halloween *Spiderman pointing at Spiderman* that kids posted on Reddit (see Figure 3, left) and the digital 3D Spidermen in the advertisement of a new superhero-inspired video game (Figure 3, right).

Figure 3. Spiderman pointing at Spiderman meme-inspired re-creations [Sources: Reddit and Twitter].

All these evidences attest how deeply this meme has been interiorized by web users, who easily recognize and decode it even when it is taken out of context. From the point of view of mathematical reasoning, the metaphorical meeting of two similar things described by this meme resonates with the idea of the commonality of meanings across different semiotic representations of mathematical objects, whose recognition and understanding are acknowledged as cornerstones of an effective mathematical activity aiming beyond the mere memorization of facts and procedures (Duval, 2006; Etkind, Kenett, & Shafrir, 2015). In fact, this template is widely exploited within online communities exchanging memes on mathematical subjects, where its *puzzle effect* (the template implies that the two things are connected, but it is up to the viewer to unravel why) challenges users, providing openings for spontaneous learning.

Literature and Theoretical Framework

With 144 million occurrences of the hashtag #memes on Instagram in July 2020, memes are a viral phenomenon acknowledged as a significant part of the digital culture that shapes young people's media literacy (Danesi, 2019; Shifman, 2014; Wiggins & Bowers, 2015). Their relevance in the online discourse is so widely established that researchers at Carnegie Mellon University recently disclosed the results of research aimed at developing a new technology to make memes accessible for people with visual impairments (Gleason et al., 2019). Despite this massive diffusion and accredited potentialities, memes remain understudied in educational research (Knobel & Lankshear 2005, 2007, 2018; Romero & Bobkina, 2017) and even less in research focusing on mathematics education, where at the present, only a few exploratory studies have been conducted (Benoit, 2018; Bini & Robutti, 2019a; Bini & Robutti, 2019b). Since memes on mathematical topics dwell at the intersection of the spheres of learning involving personal interests, peer culture, and mathematical academic content, I believe that the connected learning framework (Ito et al., 2013, 2018) could be a suitable lens to observe the learning experiences involving these artifacts. According to the framework, spontaneous connected learning experiences share the core properties of being production-centered, organized around a common goal, and openly networked. These characteristics inform the design principles for the intentional creation of connected learning environments that pivot around participation, experiential learning, interest cultivation and challenge, and interconnection among learners and between learners and teachers. The common thread linking these experiences, whether spontaneous or intentional, is that they are emotionally satisfying, thus connecting the sought-after positive emotions to the learning process.

Zooming in from the learning setting to the artifacts, I will use the *triple-s construct* of the *partial meanings* of a meme (Bini & Robutti, 2019a) to guide the understanding of the memes and of teachers' and learners' interaction with them. According to this construct, the comprehension of the *full meaning* of a meme is achieved through the understanding and intersecting of three *partial meanings*:

- The *first partial meaning* is **structural**, and lies in having a consistent aesthetic: text font, color and position, and overall visual impact (see Figure 4, left, for the examples analyzed in this work);
- The *second partial meaning* is **social**, and it is conveyed by shared rules about the message carried by images and templates (see Figure 4, right, for the examples analyzed in this work and the KnowYourMeme website for other memes);
- The *third partial meaning* is **specialized** and is carried by elements referring to a specific topic, in our case mathematical (see Figures 5, 6, and 7 in the Data and Analysis section).

Figure 4. Structural meaning (left) and social meaning (right) of the Spiderman meme.

This study is therefore designed to address the following questions:

- How do mathematical memes provide opportunities for connected learning experiences?
- How can the connected learning framework and triple-s construct support educators in designing effective learning scenarios involving mathematical memes?

Method

This paper draws on my doctoral research on memes on mathematical subjects, developed throughout the last two years under the supervision of Ornella Robutti, exploring online communities and conducting school-based experiments with students creating and discussing memes. Data collected are memes and related comments for the online research, memes and questionnaires for the school-based research, complemented when possible with the videotaping of the creation processes and of the following discussion. This study presents three examples, chosen for their representative use of the *Spiderman pointing at Spiderman* template. The first is an example of spontaneous interest-driven learning, taken from r/mathmemes, the largest mathematical memes public community in the Reddit website, commonly acknowledged as the birthplace of memes (845,000 members in July 2020). The second example was collected during the discussion that followed a meme-creation experiment on complex numbers conducted with a class group of 29 12th-grade students (17 years old). The third example comes from a meme-creation experiment on exponents and powers conducted with two class groups of 19 6th-grade students (11 years old) each. In both school examples, the meme-creation activity was proposed after completing the indicated topic, with the didactical aim of fostering the reorganization of cornerstone ideas, possibly eliciting doubts and misconceptions.

Data and Analysis: From Meme Icon to Learning Object

Example 1: The Internet Spiderman

The meme in this example (see Figure 5, left) was uploaded to the popular r/mathmemes Reddit public community with the title "unit circle baby," and in the two following days it was commented upon by three different commenters (none of whom was the author of the meme). To protect the identity of commenters in the quoted excerpt, publishing dates are not shared and nicknames are replaced with the initials C1, C2, and C3; all comments are unredacted and originally in English.

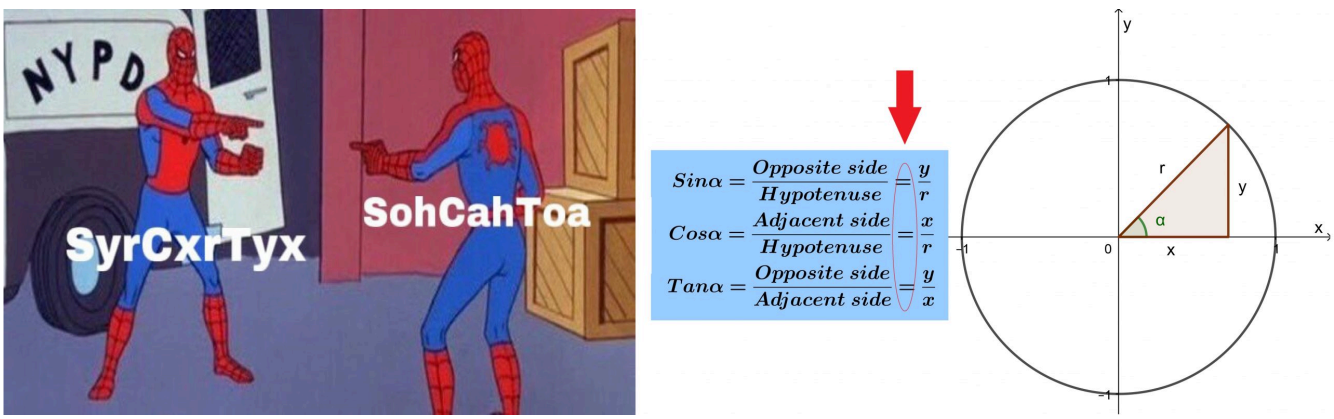

Figure 5. The Internet Spiderman meme (left) and my representation of the explanation (right).

> C1: [day 1, 9:40] Explain pls
> C2: [day 1, 13:44] SohCahToa is a mnemonic for trigonometry students to remember the right triangle definitions of the trig functions: soh is "sine is opposite over hypotenuse" coh is "cosine is adjacent over hypotenuse" and toa is "tangent is opposite over adjacent"
> SyrCxrTyx is using the circle definitions: sin is y/r, cos is x/r, tan is y/x
> C1: [day 1, 13:46] Oh thx didn't know that
> C3: [day 2, 00:29] It defeats the purpose of the mnemonic. If you can remember where the y,x and r are supposed to go you already know the formulas.
> C2: [day 2, 01:52] I absolutely agree. I was just explaining the joke to OP ["original poster" in Reddit jargon, i.e., C1]

This example shows how the sharing of a meme in an openly networked environment, where people communicate across national boundaries, provides a connected learning opportunity for commenter C1, who explicitly seeks help, going back to the website after a while to check for answers. Research in the Reddit website revealed that C1 is a nonnative English speaker, thus not acquainted with the SohCahToa mnemonic device for trigonometric functions, which is language sensitive and therefore diffused in English-speaking learning environments only. C2, a native English speaker, gives a thorough explanation of the SohCahToa acronym and its connection to SyrCxrTyx (as summarized in Figure 5, right, image elaborated by the author of the present study), confirming that mathematical meanings have to be framed within the "sphere of practice" where they are constructed (Kilpatrick, Hoyles, Skovsmose, & Valero, 2005, p. 10). C2 subsequently agrees with C3 in contesting the advantages of the second representation, whose clarification was nevertheless due in order to testify that he successfully cracked the meme. The challenge represented by the puzzle effect of the meme offered C2 an opening to show off his mathematical knowledge, attesting his position as a member of the community, and at the same time resulted in a connected learning opportunity for C1. As a final observation, we note how the *Spiderman pointing at Spiderman* popularity previously described led C2 to assume without hesitation that C1's explanation request was referring to the specialized partial meaning and not to the social one.

Example 2: The School Spiderman (Teacher Version)

This example focuses on a meme I created that was proposed in the class after the students' meme-creation activity, in a peer-based exchange of memetic productions between students and educators. Students received printed worksheets with the meme in Figure 6 (among others) and were asked to explain the specialized partial meanings; teacher and author were present. All students turned in correct answers for this meme, with the exception of one student who wrote, "I have no idea." This student, while filling in the handout, had asked me for support in decoding the meme, and some effort was needed to persuade him that he could simply leave it blank or write that he did not know the answer. He was convinced only after being reassured that he would eventually receive the requested explanation during the discussion. This behavior is diametrically opposite to what commonly happens in a math class, where students, unfortunately, rarely care for explanations of unsolved questions: I believe that this can be interpreted as evidence of the connected learning features of interest cultivation and challenge associated with the meme.

Figure 6. The teacher's Spiderman.

In the discussion that followed, the equivalence implied by the meme between the multiplication by i of a complex number and the rotation of the associated vector in the complex plane was further examined:

> Teacher: What does it mean?
> Students [in chorus]: that they are the same thing: on a graphic level multiplying by i is equivalent to a pi/2 rotation
> Teacher: Ok
> Author: And did you already know this or did you gather it from the meme?
> Students answer indistinctly; some voices can be heard saying "from the meme" […]
> Author: Who understood it thanks to the meme? [Five students raise their hands]
> Student [pointing to the meme and addressing his classmate] you rely on the meme … it means that they must be equal!

This excerpt shows another connected learning feature of memes, in this case how they succeed in linking peer culture and academic content. In fact, in this example and in other experiments involving this same meme, students' proficiency in recognizing the *Spiderman pointing at Spiderman* meme and identifying its social partial meaning, ascribable to the exposure to this type of artifact outlined in the background section, allowed mathematical specialized meanings to be easily carried. As a complement, the mentioned puzzle effect connected to the meme created a challenge that kept students hooked to the following review of the motivations supporting the equivalence, eventually leading to some shared learning.

Example 3: The School Spiderman (Student Version)

This last example incorporates two different memes, created by students in a meme-creation activity in which the mathematical topic and templates were assigned. Because of their younger age, and consequent lower exposure to social media, students were not all acquainted with the *Spiderman pointing at Spiderman* template and its partial meanings, which were illustrated by the teachers at the beginning of the activity using the triple-s construct. Students' creations were then shared and discussed in the class groups. The experience was followed after several months by a test and a feedback questionnaire.

In this activity the use of memes, instead of traditional exercises, positively challenged learners, allowing each student to participate and contribute according to his or her personal mathematical expertise. This constructive climate fostered metacognitive processes that enabled assessing the basic knowledge about powers (see Figure 7, left), and in some cases elicited misconception (see Figure 7, right).

Figure 7. The students' Spidermen.

The sharing and discussion of the memes orchestrated by the two teachers provided immediate feedback from peers in a nonjudgmental way and supported the learning process initiated by the memes. In the feedback questionnaire, 80% of the students declared themselves pleased with the experience "because we invented the jokes," and they described it as "a fast funny, different, easy way to learn math." After the summer break, the entry test administered to all parallel classes in the school showed that students exposed to the meme activity scored significantly better results in questions about exponents and powers than other students in the school. Surely this cannot be considered as the result of a proper quantitative study with control groups; nevertheless it argues in favor of the educational effectiveness of the engagement and motivation component given by the meme.

Results and Discussion

This work sampled the learning potential of a particular meme, but the overall investigation revealed that the affordances of the *Spiderman pointing at Spiderman* meme occur in many other templates: In fact, a moderator of one of the most popular mathematical memes groups in Facebook acknowledged in a public post in the group page that "without them [the mathematical memes] I wouldn't have discovered all the fun I want to learn and know!"

This is consistent with the idea that mathematical memes can provide opportunities for learning experiences characterized by the creative, participatory, challenging, and interconnected features that typify the connected learning model. I think that the common thread bringing together all examples is that they provide evidences of learning practices "linking deep 'vertical' expertise with horizontal expertise and connection to other cultural domains and practices" (Ito et al., 2013, p. 56). In this case the deep vertical expertise is the mathematical academic knowledge (the specialized meaning of the meme) and the broad horizontal one is learners' acquaintance with memes and popular culture (the structural and social meanings). Reversing the order of the factors, the connected learning framework can support educators in designing new learning experiences that incorporate mathematical memes. For instance, the interconnection feature, which was restricted to the class group in the reported examples, can be amplified by sharing students' memes at school level or ever further within online communities, and the challenge feature can be enhanced, allowing students to team and compete in a different way, not only encoding mathematical meanings into their memetic creations, but also decoding the mathematical meanings of memes created by classmates. In agreement with the connected learning stance, in these activities teachers should fall in the background, giving space to peer-based learning experiences in which students and students' creations are central. The triple-s construct can therefore be an effective tool for educators to survey and facilitate the process of didactic transposition (in the sense of Chevallard, 1988) that allows the transformation and adaptation of knowledge to the new means of communication.

I believe that the results of this work point to the potential of mathematical memes in associating positive feelings to learning experiences and in fostering interest-powered learning outcomes in mathematics, and show that the connected learning design principles together with the triple-s construct can support educators in creating activities that successfully link school culture and popular culture.

References

Benoit, G. (2018). *Mathematics in popular culture: An analysis of mathematical Internet memes* (Doctoral dissertation). Teachers College, Columbia University, New York, NY.

Bini, G., & Robutti, O. (2019a). Meanings in mathematics: Using Internet memes and augmented reality to promote mathematical discourse. In U. T. Jankvist et al. (Eds.), *Proceedings of the 11th Congress of the European Society for Research in Mathematics Education*. Utrecht, The Netherlands: Freudenthal Group & Freudenthal Institute, Utrecht University and ERME.

Bini, G., & Robutti, O. (2019b). Thinking inside the post: Investigating the didactic use of mathematical Internet memes. In A. Shvarts (Ed.), *Proceedings of the PME and Yandex Russian Conference: Technology and Psychology for Mathematics Education* (pp. 106–113). Moscow, Russia: HSE.

Chevallard, Y. (1988, August). *On didactic transposition theory: Some introductory notes*. Paper presented at the International Symposium on Research and Development in Mathematics, Bratislava, Czechoslavakia.

Danesi, M. (2019). *Memes and the future of pop culture*. Leiden, The Netherlands: Brill.

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics*, *61*, 103–131.

Etkind, M., Kenett, R. S., & Shafrir, U. (2015). Learning in the digital age with meaning equivalence reusable learning objects (MERLO). In R. Railean, G. Walker, A. Elçi, & L. Jackson (Eds.), *Handbook of research on applied learning theory and design in modern education* (Vol. 1; pp. 310–333). Hershey, PA: IGI Global.

Gleason, C., Pavel, A., Liu, X., Carrington, P., Chilton, L. B., & Bigham, J. P. (2019). Making memes accessible. In ASSETS '19: *The 21st International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 367–376). ACM. https://doi.org/10.1145/3308561.3353792

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). Switzerland: Springer International.

Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., … Watkins, S. C. (2013). *Connected learning: An agenda for research and design*. Irvine, CA: Digital Media and Learning Research Hub. Retrieved from https://dmlhub.net/publications/connected-learning-agenda-for-research-and-design/

Ito, M., Martin, C., Cody Pfister, R., Rafalow, M. H., Salen K., & Wortman, A. (2018). *Affinity online: How connection and shared Interest fuel learning.* New York: NYU Press.

Kilpatrick, J., Hoyles, C., & Skovsmose, O., & Valero, P. (2005). Meanings of 'meaning of mathematics.' In J. Kilpatrick, C. Hoyles, O. Skovsmose, & P. Valero (Eds.), *Meaning in mathematics education* (pp. 9–16). New York, NY: Springer.

Knobel, M., & Lankshear, C. (2005, November). Memes and affinities: Cultural replication and literacy education. Paper presented at the National Reading Conference, Miami, FL.

Knobel, M., & Lankshear, C. (2007). Online memes, affinities, and cultural production. In M. Knobel & C. Lankshear (Eds.), *A new literacies sampler* (pp. 199–228). New York, NY: Peter Lang.

Knobel, M., & Lankshear, C. (2018). *Memes online, afinidades e produção cultural (2007–2018)* [Online memes, affinities and cultural production (2007–2018)]. https://doi.org/10.13140/rg.2.2.34717.77280

Know Your Meme. (2019, December 17). *The top 50 memes of the decade*. Retrieved from https://knowyourmeme.com/editorials/meme-review/the-top-50-memes-of-the-decade-40-31

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics, teaching and learning* (pp. 575–596). Reston, VA: National Council of Teachers of Mathematics.

Romero, E., & Bobkina J. (2017). Teaching visual literacy through memes in the language classroom. In K. Donaghy & D. Xerri (Eds.), *The image in English language teaching* (pp. 59–69). Floriana, Malta: ELT Council.

Schukajlow, S., Rakoczy, K., & Pekrun, R. (2017). Emotions and motivation in mathematics education: Theoretical considerations and empirical contributions. *ZDM: Mathematics Education*, 49, 307–322.

Shifman, L. (2014). *Memes in digital culture*. Cambridge, MA: The MIT Press.

Wiggins, B. E., & Bowers, G. B. (2015). Memes as genre: A structurational analysis of the memescape. *New Media & Society*, 17(11), 1886–1906.

Zan, R., Brown, L., Evans, J., & Hannula, M. (2006). Affect in mathematics education: An introduction. *Educational Studies in Mathematics*, 63(2), 113-121.