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Meanings in Mathematics: using Internet Memes and Augmented Reality to promote mathematical discourse

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Levering on the influence and use of social media in students' perception of learning mathematics, this project has a twofold purpose: the research aim is to contribute in breaking away from the idea that digital culture can be considered as opposed to school culture, investigating the epistemic and didactical affordances of mathematical Internet memes, combined with Augmented Reality technology. The coupled educational aim is to cultivate classroom discourse and maximize linguistic and cognitive meta-awareness in high school students. The project is a work in progress of which this paper presents the theoretical background used to frame the study, the results of a first exploratory teaching experiment - conducted with a group of 24 students attending the 12th grade of Liceo Scientifico in Milan - and the methodology and the next steps of the study.

Keywords: digital culture, meme, augmented reality, boundary object, discourse

INTRODUCTION

Internet memes have become a viral form of Web 2.0 communication, with an ever-increasing number of occurrences on social platforms as Instagram (from 37 million in March 2018 to 76 million in March 2019). Nevertheless, Knobel & Lankshear claim that “understanding successful online memes can contribute much to identifying the limitations of narrow conceptions of literacies and new technologies in classrooms” (2007, p.221) still remains almost unanswered. In fact, up to today, the possible didactic relevance of Internet memes is nearly unexplored by academic research and their meaning and use in mathematics education is an unmapped territory. Even if popular culture is playing an increasingly important role in the lives and learning opportunities of young people, Peter Applebaum’s regret that “little work, if any, has been done by math educators to probe the efficacy of mass culture criticism for education in math” (1995, p. 24) strikes for its up-to-dateness.

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FROM MEMES TO INTERNET MEMES

In 1976, well before the digital era, evolutionary biologist Richard Dawkins coined the term *meme* as “a unit of cultural transmission”, examples of which are “tunes, ideas, catch-phrases, clothes

fashions, ways of making pots or of building arches” that “propagate themselves in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation.” (Dawkins, 1976, p.249). Web culture (https://en.wikipedia.org/wiki/Internet_meme) gives credit to Mike Godwin for revamping the concept of memes in 1993, identifying Internet memes as a subset of memes and describing them as an activity, concept, or piece of media that spreads through social channels, evolving in the hands of the digital users and reaching a large audience.

Internet memes can be in the form of viral images, videos or files: in this work, we will focus on those made of “verbal and pictorial parts, which unfold their meaning through collective semiosis” (Osterroth, 2018, p.6); as they integrate different modes of communication, we think they can fall into the category of multimodal artefacts. They usually have a humorous or satirical intent and are widely shared by young people through social platforms (Facebook or Instagram), since they connect the participatory potential of the Internet with the quest for user-generated content that - through shares and likes - provides a form of social validation.

They are deeply rooted in visual media culture and catch users’ attention with their puzzling vibe that calls for the active contribution of the viewer to unlock the meaning and thus adds a gratifying flavour. Internet memes are created by users according to collectively established and shared rules that govern the so-called *memesphere*: these rules dictate the conventional meaning of the pictorial parts and the position, font, syntax and narrative structure of the text, they “cannot be enforced by a specific person, but the community sanctions wrong uses by downvoting, not liking or simply not spreading the misused meme” (Osterroth, 2018, p.7). These same rules shape meme generators websites as <https://imgflip.com/mememplates> or <https://makeameme.org/>: there are several accepted structures, two of the most common being those in Figure 1.



Figure 1: Two prototypical meme structures

Pictorial parts, usually identified with names, might have local or global recognisability: in Figure 2, a blank template of the *Success Kid* meme - globally used to boast of something good - is shown, followed by a general example of the meme propagation by imitation and an example of its psycho-pedagogical adaptation, to end with its mathematical variation.



Figure 2: Template and propagation of the *Success Kid* meme (source Google search, Sept 18)

The last example is representative of a rare situation in which mathematics *spontaneously* leaves the school context and is used to identify the belonging to a group and to set the author's position in the group. This kind of memes, in fact, are usually shared within specialized Internet groups, where products are scrutinized by skilled peers and acceptance grants the author the cited social validation.

MATHEMATICAL INTERNET MEMES AS KNOWLEDGE CARRIERS

To focus more on the concept of mathematical Internet memes and illustrate their epistemic potentiality, we shall analyse two examples of the *Drowning kid in the pool* meme (Figure 3), used to describe a situation where something is typically forgotten. On the left a correct version posted in May 2018 within a [Reddit thread](#), where was identified as “the quintessential math joke”, on the right its wrong variation, posted in another [Reddit thread](#) in June 2018.

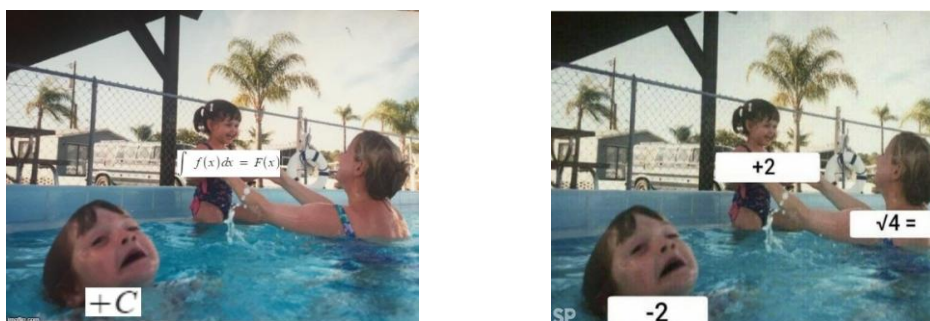


Figure 3: *Drowning kid in the pool* correct (left) and wrong (right) memes

Taking a look at the exchange triggered by the wrong one (some excerpts are listed below), we see how memes can act as knowledge carriers and starters of meaningful mathematical discussions:

- bike0121 This is not really correct. The function \sqrt{x} is always greater or equal to zero. The inverse of x^2 is indeed $\pm\sqrt{x}$, but $\sqrt{4}$ is always $+2$, not -2 .
- Dat_J3w Yea it's positive by convention; the square root of four is still plus/minus two
- functor7 Absolutely not. $\sqrt{4}$ is 100% only the value 2. The solutions to the equation $x^2=4$ are ± 2 . \sqrt{x} is a function, which means it only has one value. \sqrt{x} is a number, not a collection of numbers.

Dozens of Reddit and Facebook mathematically-themed groups (some with evocative names like “Complex Analysis Memes For Holomorphic Teens” and “The Name Of This Group Is Left As An Exercise For Its Members”) with thousands of users showing off their mathematical knowledge, discussing, posting and sharing mathematical Internet memes on a daily basis, suggest that the meaning of a meme can be looked for in a “sphere of practice (SP), [...] defined as the ‘community’ adhering to a common set of rules, within which mathematical meanings are constructed” and could be a suitable setting to address the issue of “communicating, transforming and negotiating the social meaning of school mathematics” (Kilpatrick et al., 2005, p.10).

PARTIAL AND FULL MEANINGS OF A MEME

As a first step of the study on mathematical memes, we tried to figure out how memes act as carriers of meanings and we identified a *triple-s construct* of the three partial meanings that contribute in building up the full meaning of a mathematical Internet meme.

- The first meaning of a meme lies in its being a meme, namely to have a specific and shared structure and graphics (font, colour and text position). It can be considered at a *structural* level (Figure 1).
- The second meaning of a meme is conveyed by the shared conventions connected to viral images, compositional setups and accepted syntaxes. It is at a *social* level (Figure 2, first image).
- The third meaning of a meme is borne by images, symbols or text referring to a specific topic (mathematical, but also political, physical or other). This is at a *specialised* level (Figure 2, last image, textual part).

The first two meanings ground in the popular culture rules that govern the *memesphere*, acting as Kilpatrick's sphere of practice, while the third calls some mathematical skills into action. The interplay of all three *partial meanings* unlocks what we call the *full meaning* of the meme, that triggers the surprise/membership effect. There are people who can only access the first meaning, merely recognising the artefact as a meme (and not a cartoon, for example). Others will stop at the second level, identifying the viral elements only. On the other hand, those who understand the specialized mathematical signs in the meme, but are not aware of the other meanings, will equally miss the full meaning. But those who succeed in appreciating all three meanings will crack the full meaning of the meme: they will laugh and feel part of a community. In fact, "meaning mobilizes feeling, and emotions only translate if we process images and captions in the same way" (Benoit, 2018, p.41).

To sum up, we think that it would be fruitful to investigate whether mathematical Internet memes can contribute to the construction of mathematical meanings and explore the possible epistemic affordances implied by their multiple referents (one of many being their visual component that can cater to different intelligences and learning styles). To pursue this research path we imagined that, having mathematics spontaneously already crossed the boundary between formal and informal learning, it could be worth exploring how to facilitate the crossing in the opposite direction and test mathematical Internet memes in a standard school context.

THEORETICAL FRAMEWORK

It is beyond the scope of this study to evaluate why Internet memes in general, and mathematical Internet memes in particular, have this success in the social arena, although that "aha" moment we all experience when we finally grasp the joke resonates with what Mason (2014, p.1) describes as a "disturbance, experienced as surprise, as puzzlement or perplexity" that somehow "provoke[s] learners into taking initiative" and "call[s] upon learners to make use of their undoubted powers of making sense." Zooming in, we will focus our attention on the learning dynamics connected to the use of mathematical memes within the classroom: in this optics we will try to read our data through the lenses of the Boundary Objects framework as introduced by Star & Griesemer (1989) and

further developed by Akkerman & Bakker (2011) and of Anna Sfard's (2001, 2008) theory about discourse and communicational approach to cognition in a Vygotskian sociocultural perspective.

According to Star & Griesemer, (1989, p.393) "boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. [...] They have different meanings in different social worlds, but their structure is common enough to more than one world to make them recognizable, a means of translation." Our point is that mathematical Internet memes can be looked at as boundary objects between social media and mathematics, two separate worlds with separate rules and languages, whose "intersections of cultural practices open up third spaces that allow negotiation of meaning and hybridity—that is, the production of new cultural forms of dialogue" (Akkerman & Bakker, 2011, p.135), and therefore they can be fruitfully trialled in boundary-crossing activities. In a complementary way we argue that memes, together with the inner discourse brought into being to make sense of them and the collective discussion they trigger in the class group, are aligned with Sfard's statement that "the term discourse will be used to denote any specific instance of communicating, whether diachronic or synchronic, whether with others or with oneself, whether predominantly verbal or with the help of any other symbolic system [...] learning mathematics may now be defined as an initiation to mathematical discourse, that is, initiation to a special form of communication known as mathematical." (Sfard, 2001, p.28).

The research questions we are searching answers to are the ones below, they are big and complex ones and we are aware that this study just put a small dent into them, but we think they deserve to be stated because they outline the bigger picture we strongly believe is worth looking for:

RQ1: What are the epistemic affordances, if any, of mathematical Internet memes?

RQ2: Does creating and/or interacting with these memes implies/determines learning?

RQ3: Which characterizations identify a boundary object in this context? Which interactions among the communities of students, teachers and researchers are triggered by these boundary objects?

RQ4: Can memes, students' explanations vehiculated through the narrative virtual content and classroom discussion be identified as parts of a mathematical discourse?

METHODOLOGY: THE BUILDING OF THE TEACHING EXPERIMENT

The beginning of this project dates back to a few years ago when one high school student (of the first author) provokingly said that he had finally grasped a math concept only when coming across a mathematical Internet meme on the same subject in a social platform. Moving forward from this first naïve appearance of memes in the school environment and trying to figure out how to build a significant task to test our assumptions in an almost unexplored territory is, of course, a challenge that can be tackled only by small steps. We started observing students' reaction to mathematical Internet memes found in the web (examples in Figure 4) and used by the teacher to catch and hold attention, to stress specific aspects of already taught topics and to trigger classroom discussion.

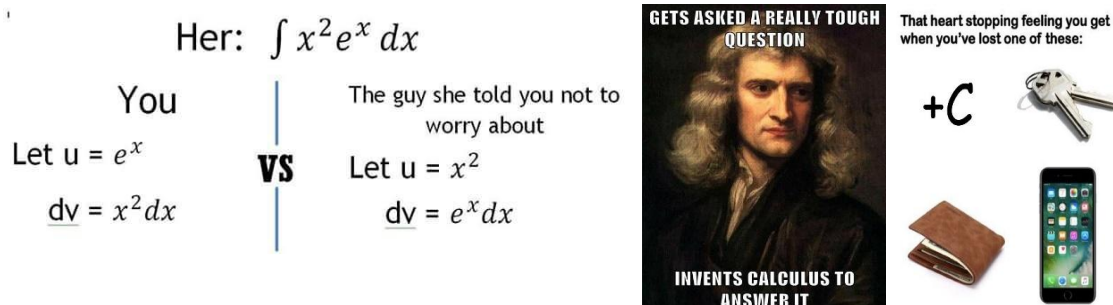


Figure 4: Examples of web-found mathematical Internet memes

The quality of the mathematical discourse enthused by these mathematical Internet memes convinced us that interacting with them calls mathematical competencies into play but, to dig deeper into the epistemic of memes, we realised that students had to create the memes themselves and shoot videos to keep track of the explanations of the mathematical meanings.

This is when Augmented Reality (AR) comes into action: vision-based AR technology refers to the triggering of a superimposed computer-generated layer (usually a video) when pointing a smartphone or other GPS-enabled device to a precise spot; it allows the connection of the meme to the corresponding explanatory video, that can be then viewed scanning the meme into the phone. Hopefully, the bonded couple meme+video will thus give origin to a multimodal and multimedia learning object, providing opportunities for the single student to maximize his linguistic and cognitive meta-awareness and systematize knowledge, for the class group to connect and revise knowledge and for the teacher to assess students' comprehension of previously studied concepts, to single out possible misunderstandings and misconceptions and give a formative assessment. Last but not least, it could cross the threshold of the school environment, be shared on the web and become part of the global network heritage as a viral meme.

Having students create memes and videos themselves matches different goals: it allows taking advantage of the aforesaid participatory thrust of the digital world, it leverages on the notion of identity as “a perfect candidate for the role of “the missing link” in the researchers’ story of the complex dialectic between learning and its sociocultural context” (Sfard and Prusak, 2005, p.1-43) and finally it will hopefully facilitate the emergence of the students’ linguistic and cognitive meta-awareness, which are the declared educational aims. This last expectation grounds in the concepts of “active response” and “meaningfulness” advocated by Burbules in his description of the virtual, that “should not be understood as a simulated reality exposed to us, which we passively observe, but a context where our own active response and involvement are part of what gives the experience its veracity and meaningfulness” (2006, p.38).

A FIRST TEACHING EXPERIMENT

At the end of May 2018, a first exploratory teaching experiment was conducted with a group of 12th-grade students, aiming at testing the potential educational effectiveness of memes. The assigned task, to be done individually at home, was to create a meme on one of the year's math course topics (optionally using one of the said meme generator websites) and shoot a video with the smartphone explaining the mathematical concept recalled by the meme. Students then were asked to bond meme and video through [HP reveal](#) (a free augmented reality web app) and post the meme in

the collective space, using the free web app [Padlet](#), set up for the occasion to mimic the social media environment, allowing the sought-after tribal reward reactions.

Connecting students' memes to our *triple-s* analysis, we can see that all productions comply with the structural meaning and that they all call for the viewer's engagement mobilizing an emotional reaction due to a misalignment between different parts of text or between text and image. Looking at the social meaning, that seems the element that crosses the boundary "maintaining the common identity" (Star & Griesemer, 1989, p.393), we have identified three main categories (examples in Figure 5).

Finally, examining the memes' specialized meaning, further clarified in the coupled videos, we completed the possible analysis in Table 1 (videos – in Italian - can be seen downloading the HP Reveal app to a smartphone, following *lfeonmath* and then scanning the images in Figure 5 – due to monitor light reflections, it works better with printed images).



Figure 5: Example 1 (left), Example 2 (centre), Example 3 (right)

CATEGORIES	SOCIAL LEVEL	SPECIALIZED LEVEL
Figure 5 Example 1	meme caption starting with a "when you/they" statement	mathematical terms in the meme caption.
Figure 5 Example 2	meme describing the effect of an action or operation	image connected to the mathematical action, mathematical symbols used to label elements in the image
Figure 5 Example 3	meme creating a pun based on a bivalency of meanings	meme caption with terms that have a mathematical and a common use meaning

Table 1: Analysis of the produced memes and videos

Considering these data, a first observation is that technology seems to intervene with different roles: it acts both as an instrument for students to create the learning objects and as an environment with rules that informs designers and users. From the educational point of view, their creations seem to confirm that students knowingly selected a topic in which they felt comfortable (cognitive meta-awareness) and made an effort to explain it clearly using appropriate lexis (linguistic awareness). Looking this preliminary analysis through the lenses of our framework theories, we ventured that the boundary object could be looked for in the social level that "maintain[s] a common identity across sites" (Star & Griesemer, cited), while the couple meme+video appears effective in triggering a special form of mathematical communication in which meta-cognition and language

accuracy play a relevant role. This is, of course, a first rough attempt that has to be refined, breaking it down and trying to identify the steps of the boundary crossing (identification, coordination, reflection and transformation) and the commognitive constructs (word use, visual mediators, narratives, and routines), once the observation of the cognitive processes will be implemented.

NEXT MOVES

Although the results of this first exploratory teaching experiment seem encouraging, there are still many shadows hanging over this project, one among others being its replicability. In order to dispel at least this first doubt, in the upcoming months, we are planning to set up a focus group observing 2/3 students, coming from a different school environment, during the process of creating memes and videos on a fixed topic. In the light of the data collected, we will hopefully structure a larger study in a class group, giving space also to class discussions, teacher's feedbacks and possible students' revisions of the products, together with the assessment of the learning after a few months.

As we recalled in the opening paragraph, this work is still in progress, with no assessed conclusions and many unanswered questions, but we strongly believe it is worth to keep venturing in this almost unmapped territory because this is something more than a traditional technological learning experience, as memes produced by students can leave the school environment and spread virally in the web. It is a unique situation in which the virtual world comes into contact with the school world, expectantly enabling us to learn something new about the impact of the digital revolution and new communication technologies on epistemological pathways and learning practices.

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