Social media, school mathematics, and epistemology

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This article explores the impact of the Internet and social media on the ways young people interact with and approach school mathematics. Drawing on empirical research, the article highlights how the internet has transformed how students validate mathematical knowledge and seek out mathematical help and support from a range of sources, including online forums and educational websites. The article also explores how social media has provided a platform for students to express their emotions and perceptions about school mathematics in new and innovative ways. Through analysis of online activity, the article reveals that students use the internet to seek clarification on mathematical doubts and solve mathematical tasks. The findings challenge traditional notions of being a mathematics student and how mathematical knowledge is acquired and validated.

Keywords: Social media, epistemology, school mathematics, emotions, mathematical help-seeking.

Introduction

For some years, I have been researching how young people use the internet and social media in connection to school mathematics. This research has focused on using the internet as a source of mathematical help and a platform for sharing opinions and feelings about the subject.

This research suggests that the internet and social media have significantly impacted how students interact with and approach school mathematics. Through their online activity, students can now share their perceptions about the nature of school mathematics in new and innovative ways. They are also able to seek out mathematical help and support from a range of sources, including online forums and educational websites.

Indeed, the internet has transformed how students validate mathematical knowledge. Rather than relying solely on traditional sources of authority, such as textbooks or teachers, students increasingly turn to online communities to confirm and verify the accuracy of mathematical information (e.g., van de Sande, 2011). This trend is a significant development in mathematics education. It challenges traditional notions of being a mathematics student and how mathematical knowledge is acquired and validated.

In this article, I report on some of these findings, focusing on two issues:

- How people use a social network to express their emotions and perceptions about school mathematics.
- How students use the internet as a source of mathematical help to clarify their doubts and solve mathematical tasks.

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Using a social network to express emotions and perceptions about school mathematics

School mathematics is a subject that is commonly accompanied by an array of emotions, be they positive or negative, as observed by scholars such as Pepin and Roesken-Winter (2005). These emotions are of particular significance, as they form the cornerstone upon which individuals establish their relationship with and self-identify in school mathematics. Furthermore, attitudes and beliefs towards the subject play a pivotal role in shaping such emotions and are thus integral to understanding the complex nature of human interactions with school mathematics.

On the other hand, social media platforms allow individuals to share and express their emotions towards various aspects of their lives, such as work, personal relationships, food, exercise, pets, and school (Stieglitz & Dang-Xuan, 2013). Mathematics is not exempt from this phenomenon as a subject that often elicits strong emotions of love or hate. Twitter is one of those social media platforms where individuals express their emotions related to school mathematics. However, the potential role of this platform as a window into the emotions that people associate with this subject is not commonly recognized in the specialized literature.

Twitter has been proposed as a means to engage mathematics students in and out of the classroom (Soto & Hargis, 2017), and studies have shown that it positively impacts students' learning of mathematics (Vohra, 2016). Furthermore, Twitter has been used as an organizational tool to manage classroom issues, such as reminding students about assignments and upcoming tests (Danesi, 2016). Additionally, Twitter has been suggested as a space for exchanging ideas, dialogue, discussion, and interaction within the community of mathematics education research (Chernoff, 2014). Nevertheless, this article aims to support the assertion that Twitter can serve as a "mood indicator" in relation to school mathematics (Danesi, 2016). Specifically, Twitter can be employed to monitor and examine the moods and attitudes of individuals toward various subjects, including school mathematics. By scrutinizing tweets related to school mathematics, researchers can acquire valuable insights into the general public's perception of this subject.

In order to advance this argument, a brief analysis of how mathematics is represented in this social network is introduced; in particular, a categorization of users' tweets about school mathematics is presented. Such categorization provides insight into the emotions and perceptions that people associate with school mathematics nowadays.

Choosing and categorizing tweets

Twitter is awash with tweets relating to mathematics, such as popular articles, images, and videos about mathematical curiosities, announcements of conferences and academic events by organizations and their members, and publicity by scientific companies for new articles and journal issues. Simply searching for "mathematics" in Twitter's search engine confirms this. However, the following categorization focuses on tweets where authors express their positive or negative opinions or some form of sentiment towards mathematics or its related subjects. This categorization includes emotions such as sympathy, dislike, and confusion.

Over the past years, I have collected a group of tweets by locating them in various ways (see Aguilar, 2021). These tweets were either in my timeline, retweeted by colleagues and friends, or found through monthly keyword searches using terms like "math," "mathematics," and "matemáticas." As a result,

I created a collection of 88 tweets, mainly in English but some in Spanish. Most of these tweets focus on school mathematics because the authors are likely to encounter mathematics in that setting. Additionally, many tweets are written in a humorous or satirical style. Notably, some of these tweets have received significant support, as evidenced by hundreds or thousands of "likes." This appraisal could indicate that many users identify with or appreciate the content of these tweets.

To categorize the 88 tweets, the technique of constant comparison, as described by Teppo (2015), was implemented. This process involved creating codes for each tweet, such as "tweets about struggling with mathematics" or "tweets regarding difficulties with mathematics homework." These codes were subsequently merged into five overarching categories. The resulting categories are as follows:

- Mathematics is difficult
- Mathematics is useless
- Mathematics tests
- I like mathematics
- Love and mathematics

In the next section, a brief description of each category is provided, along with an accompanying image corresponding to a tweet.

Emotions about mathematics

The tweets showcased in this section include the publication date, the username of the author, the number of likes and retweets they have received, and a link for accessing them. An English translation is provided if a tweet was originally posted in Spanish.

Mathematics is difficult

This category comprises tweets where users express the challenges of comprehending mathematics and the emotions, such as frustration, associated with such difficulties. Additionally, it includes tweets that depict mathematics as a complex and mentally demanding topic (Figure 1).

Publication date: July 10, 2016
Statistics: 11 retweets; 20 likes
Translation: When everyone understands the definition of continuity except you

Figure 1: Tweet by @Infinito307 retrieved from https://twitter.com/Infinito307/status/752341078523596804

Mathematics is useless

This category includes tweets claiming mathematics is useless in everyday life or work (Figure 2). For instance, some tweets devalue mathematical knowledge compared to skills such as writing a CV or understanding how to pay taxes. One example is a tweet that states, "Another damned day without using algebra."

Publication date: March 5, 2014
Statistics: 2,172 retweets; 1,540 likes

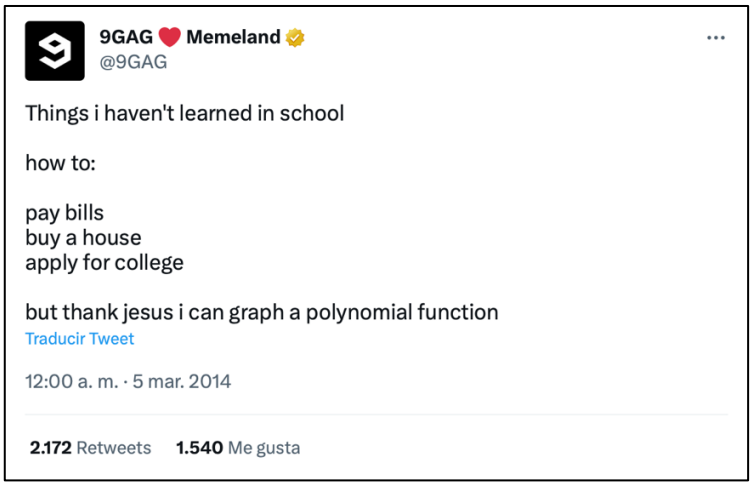

Figure 2: Tweet by @9GAG retrieved from https://twitter.com/9GAG/status/441090800676777984

Mathematics tests

Assessment is a critical element in the academic success of mathematics students. Numerous tweets express students' perceptions and experiences related to mathematics tests, such as difficulty level, unfair assessments, or unrealistic contexts in which problems are posed (Figure 3). For example, mathematical problems may refer to semi-reality, which some students find problematic (Skovsmose, 2001).

Publication date: February 13, 2014
Statistics: 502 retweets; 349 likes

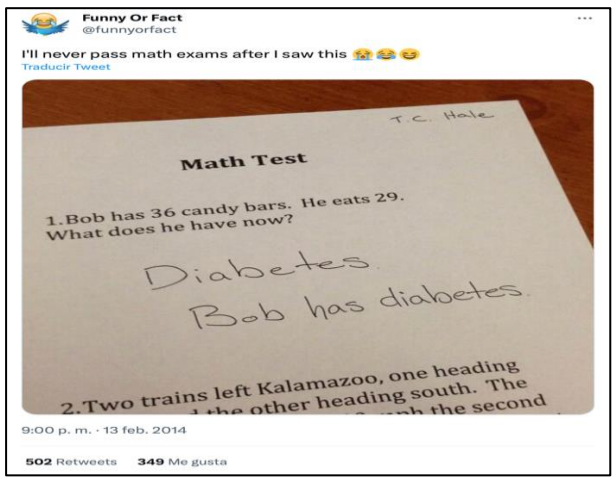

Figure 3: Tweet by @funnyorfact retrieved from https://twitter.com/funnyorfact/status/434160175592009729

I like mathematics

Although individuals share tweets expressing positive emotions towards mathematics, these tweets are not retweeted or favorited as frequently as those belonging to the abovementioned categories. While some people explicitly state the positive emotions that mathematics evokes in them, others express their affection for mathematics without providing any additional context (Figure 4). Some employ more imaginative means to convey their admiration for mathematics.

Publication date: October 10, 2018
Statistics: 1 retweet; 1 like

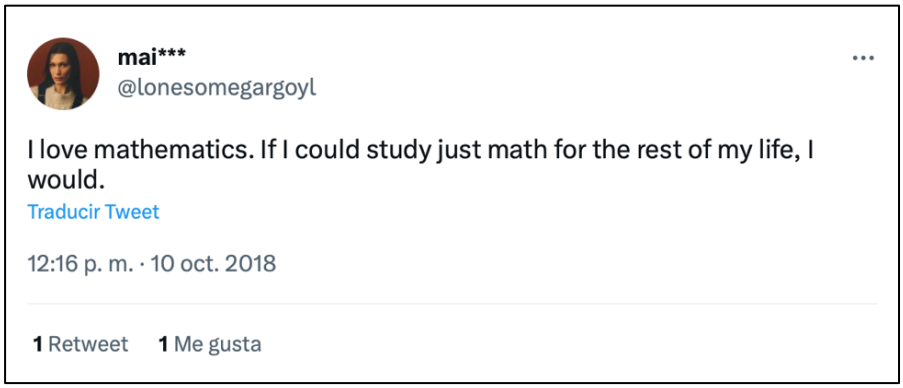

Figure 4: Tweet by @lonesomegargoyl retrieved from https://twitter.com/lonesomegargoyl/status/1050072549185466369

Love and mathematics

Indeed, some individuals tweet about both love and mathematics; however, their tweets do not pertain to a love for mathematics. Instead, these people tweet about romantic love, which may include sentiments of heartbreak, and attempt to draw connections to mathematics. An instance of such a tweet is: "I understand multivariable calculus, but I do not understand life without you" (Figure 5).

Publication date: December 24, 2014
Statistics: 8 retweets; 45 likes
Translation: I understand multivariable calculus, but I do not understand life without you

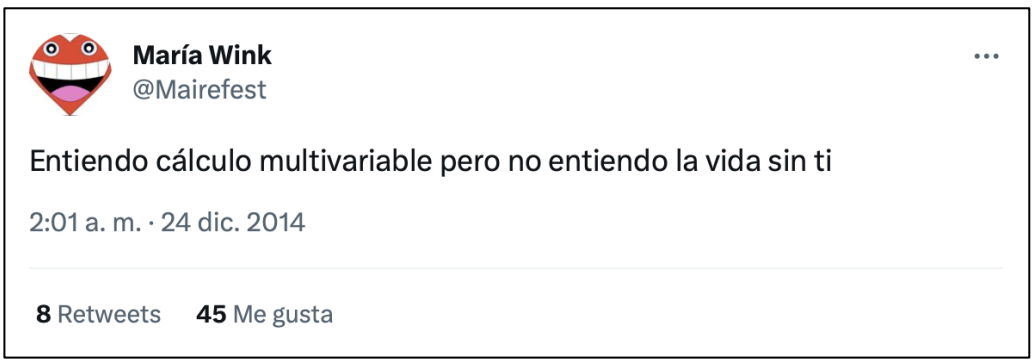

Figure 5: Tweet by @Mairefest retrieved from https://twitter.com/Mairefest/status/547663369923473408

This article section aimed to illustrate how social networks can serve as a medium to gain insight into students' emotional experiences while studying mathematics in school. This kind of data source can enhance our comprehension of how students perceive and engage with mathematics in an educational setting.

Using the internet as a source of mathematical help

School mathematics is an educational experience where students commonly encounter doubts. It is also common for students to seek sources of help to clarify these doubts. The sources of mathematical help that students resort to can be varied: their classmates, the mathematics teacher, a family member, or a book, among others. Thus, help-seeking is an intrinsic part of studying and learning school mathematics. The help-seeking behaviors that enable students to clarify their doubts independently can be interpreted as manifestations of self-regulated learning.

Along with Danelly Susana Esparza Puga from the Universidad Autónoma de Ciudad Juárez in Mexico, we have studied how digital resources such as the internet, mobile devices, and social networks shape the help-seeking behaviors of mathematics students. Our initial explorations focused on internet-based mathematical help-seeking practices among Mexican engineering students (Aguilar & Esparza Puga, 2015; Esparza Puga & Aguilar, 2015). Specifically, we sought to answer the following questions:

- What websites do students consult when they need help in mathematics?
- What do students use those websites for?
- Why do students trust the mathematical information provided by such websites?

The research method to address these questions primarily focused on self-reports from participating students provided through focus groups and individual interviews. The findings showed that the most frequently used sites for mathematical help-seeking were the Google search engine, Facebook, and YouTube. The latter was identified as the most popular source of help among the participating students. Regarding the uses that students give to these sites, the following were identified:

- Finding different ways to solve a mathematical problem
- Clarifying doubts and reinforce knowledge
- Getting ready-made results or mathematical problems solved
- Comparing their results or answers to problems with other answers to similar problems found on the internet
- Catching up with a class they skipped

Regarding the issue of trust in mathematical information provided by these websites, we began to notice that students do not seem to pay attention to the intrinsic mathematical properties (Lithner, 2003) of the obtained information but rather base their assessment on features not related to mathematics, such as the academic prestige of the person or institution that publishes information. These two student statements illustrate this situation:

> Student: YouTube seems reliable to me because university teachers upload the videos.
> Student: SlideShare...I think is more reliable because there the doctors [PhDs] send [slides presentations].

Delving into the use of YouTube as a source of mathematical help

The outcomes of initial exploratory studies prompted us to delve deeper into the type of mathematical assistance students search for on sites like YouTube and the reliability criteria they use to validate the mathematical information they discover there. We pursued this research by making methodological improvements to complement the self-reports and interviews used in the exploratory studies. In particular, we employed surveillance software to record students' activity when seeking mathematical help online (see methodological details in Aguilar & Esparza Puga, 2020). Direct observation of students' online activity when attempting to solve a mathematical problem allowed us to identify two types of help-seeking behaviors among students.

The first type is *executive help-seeking*, which refers to situations where students aim to find something or someone to assist them in solving a problem or achieving a goal on their behalf. For example, when students turned to community-driven question-and-answer websites like "Yahoo! Answers," where they could effortlessly obtain answers to specific mathematical tasks. This type of behavior, in which students seek mathematical help in community forums—some of them without getting too involved in the construction of the answer or solution—has been previously reported by van de Sande (2011).

The second type of help-seeking behavior identified was *instrumental help-seeking*, where students' searches are more focused on promoting a self-understanding of an idea or a problem-solving process. For example, we found evidence of a student who identified a YouTube video through a Google search based on keywords such as "definite integral exercises solved," "calculate area under a curve," and "area under the quadratic equation curve." The student could extrapolate the integration technique they learned by repeatedly watching the YouTube video to solve a mathematical task involving solving the integral $\int_0^4(-x^2+4x)\,dx$ (see Aguilar & Esparza Puga, 2020).

In the study by Esparza Puga and Aguilar (2023), the general characteristics of the mathematical help students obtain through YouTube videos are explored, particularly regarding the qualities of the sources they prefer and trust. Using a popular channel of videos on school mathematics called "julioprofe" as a reference (see http://youtube.com/julioprofe), we interviewed first-year engineering students who used these videos. The interviews aimed to identify (1) the characteristics of the mathematical help that students obtain through these videos, and (2) the criteria for reliability that students use to trust—or not trust—the mathematical information obtained from these sources.

The results reveal general characteristics of the mathematical help students obtain through this type of video:

- *It is multifunctional*. Through these videos, students get multipurpose mathematical help. They can use it when they have attended class but have doubts and want to clarify them, or they can use it to introduce themselves to a new mathematical topic. They can use it when they cannot attend class and want to catch up on lessons. In addition, the mathematical help they get from these videos could cover different school mathematical topics, from the most basic to the most advanced.
- *It is always available*. Another prominent feature of this mathematical help is that it is available anytime, anywhere—as long as the student has internet access. Students can turn to

this source of mathematical help in and out of school and, as one student put it, "if you are doing the assignment at 3 in the morning, it [the help] is always there."

- *It is private*. Students can refer to this source of help privately, without revealing their doubts to their classmates or the lecturer. Some studies suggest that students may feel 'dumb' in front of their peers when asking for help or expressing doubts in mathematics class (Newman & Schwager, 1993). The mathematical help obtained on YouTube eliminates these inconveniences because it can be consumed privately.
- *It is easy to use and self-paced*. Some of the interviewed students highlighted the brevity and simplicity of the videos by julioprofe, as well as the presenter's step-by-step explanations. In addition, the students have personal control over the pace since the video can be stopped, skipped, or repeated as many times as needed.

As for the criteria students use to trust the mathematical information contained in these videos, the findings suggest that trustworthiness is based on three elements:

- *People close to them recommend it*. Several students describe how their lecturers, parents, or classmates recommended that they look for mathematical help on YouTube or the julioprofe channel. We think that the fact that authority figures such as their lecturers or their parents recommend it—in addition to their classmates—promotes students' trust in this source.
- *It works*. Another element that we believe increases students' confidence in this source of mathematical help is that it has helped them to solve assignments and even pass exams—as some of the students interviewed report. We think that when students receive positive notes and evaluations after using julioprofe's videos to study, they interpret it as tangible proof of the effectiveness of those videos as study support.
- *It gets 'likes' and positive comments*. Students pay close attention to the 'likes' and comments that the videos receive from other YouTube users. Some interviewed students analyze the number of 'likes' and the kinds of comments a video receives to weigh its quality. In the case of julioprofe, the videos receive thousands of 'likes' and positive comments.

Concluding discussion

In this paper, two points have been illustrated. Firstly, social media serves as a space where individuals express their emotions related to school mathematics. These online social spaces can be used as a window into people's attitudes and feelings about school mathematics. Researchers and educators can better understand how individuals feel about school mathematics and how they engage with it by analyzing public sentiment on social media. This approach can lead to developing effective strategies and interventions to improve attitudes towards mathematics and enhance learning outcomes. The use of Twitter as a tool for monitoring and analyzing public sentiment toward school mathematics has the potential to advance our understanding of this important subject area.

Secondly, this paper has highlighted how the internet and social media have changed how students search for mathematical help and validate mathematical knowledge. We are witnessing a shared epistemology among new generations of students, in which mathematical knowledge is independently obtained beyond the walls of the mathematics classroom. Its certainty or truth is validated not based on its intrinsic mathematical qualities but through indicators of the authority of the sources and other social indicators such as recommendations, comments, or the number of likes obtained by the source of

mathematical information. This transformation in acquiring mathematical knowledge and validating its certainty has significant implications for mathematics education and calls for new approaches to teaching and learning mathematics that consider the role of social media and internet resources.

The emergence of a new epistemology in which mathematical knowledge is validated through indicators of authority on social media, such as likes, comments, and recommendations, is a significant shift in how students perceive the value and reliability of mathematical information. This new way of validating knowledge transforms the traditional notion of mathematical authority and expertise. Students increasingly look beyond traditional sources of authority, such as teachers and textbooks, to validate their understanding of mathematical concepts. In this new epistemology, the trustworthiness of mathematical knowledge is based on the collective judgment of a community of users on social media platforms, who provide feedback on the quality and relevance of the information shared. This has implications for how we understand the nature of mathematical knowledge and the role of authority and expertise in the field of mathematics. Furthermore, it highlights the importance of digital literacies in mathematics education. Students must learn how to evaluate and critically assess the credibility of mathematical information found on social media platforms.

While this new epistemology challenges traditional approaches to teaching and learning mathematics, it also offers opportunities for innovation and collaboration in the field. By embracing the power of social media and digital technologies, educators can engage students in new and exciting ways, facilitating meaningful and authentic learning experiences that align with the changing nature of mathematical knowledge in the digital age. Therefore, mathematics educators need to recognize and address the emergence of this new epistemology, developing pedagogies that encourage critical reflection and evaluation of mathematical information found on social media platforms while also promoting a deeper understanding of the nature of mathematical knowledge and the role of authority and expertise in the field.

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