Studies on Mathematics Education and Society

BREAKING IMAGES

ICONOCLASTIC ANALYSES OF MATHEMATICS AND ITS EDUCATION

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20. Societal perceptions of mathematics and mathematics education

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That 'people are naturally bad at mathematics' or that 'mathematics is reserved only for people with higher intellect' are naturalised discourses rooted in the image and belief about mathematics and mathematics education. This chapter focuses on mapping societal perceptions of mathematics and mathematics education. These perceptions are tracked within naturalised discourses circulating on social networks, such as YouTube and Twitter, and in the media, such as newspapers and TV shows. We unpack the ways of thinking and understanding mathematics and mathematics education in peoples' comments based on their daily experiences as humans navigating modern society and news websites that have published articles related to mathematics and mathematics education in order to map and take a critical position on societal perceptions circulating about mathematics and mathematics education among the public.

Introduction

> Now, look, we're gonna be dealing with some real serious stuff today. You might have heard of it. It's called math! And without it, none of us would even exist, so let's jump right in. (Mr Goldenfold in *Rick and Morty*, 'Pilot', season 1, episode 1)

Nowadays, it is possible to find many references to mathematics and mathematics education on social networks – YouTube, Facebook, Twitter (now X) – and in the media – newspapers, TV shows, and so on. For

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example, in the sitcom *The Big Bang Theory*, mathematics appears in the form of complex formulas located on whiteboards, whether in the offices of Caltech University or the apartments of the characters Leonard and Sheldon. The formulas are drawn from applied and theoretical physics, which puts mathematics at an unreachable level in which even the physicists themselves are not sure about what they are doing – for example when Leonard needs Sheldon's help and draws a symbol that ends up being Charlie Brown's hair instead of a mathematical notation. Ordinary people, such as the character Penny, an 'average' American, are typically portrayed as people that find mathematics hard and rely on the rest of the characters to help them. This issue is not restricted to gender bias. The character Stuart, an art major from the Rhode Island School of Design and owner of the comic bookstore, The Comic Center, also struggles with complex calculations. Being a scientist, or having a PhD in a STEM (Science, Technology, Engineering, Mathematics) field, seems to guarantee a character's high intellect and interests bordering on geekiness, exemplified by many characters from *The Big Bang Theory* or Ross Geller from *Friends*. Well, except if the character is a woman, apparently. *Futurama* is an animated science fiction sitcom in which the character Amy Wong, a Martian, has a PhD in engineering from Mars University. Her interests are more related to social and fashion topics. She more rarely contributes to her field or engages in scientific discussions than her male peers. However, there are a few exceptions where this pattern does not happen (see, for example, the animated sitcom *The Simpsons*).

That mathematics is challenging and that only smart people can understand its working seem to be common assumptions. 'I'm not a mathematician' is a recurring response when someone is asked to perform any type of calculation that requires even the basic operations of addition, subtraction, multiplication, and division. An example of this phenomenon occurs in *Friends* when the character Joey faces a situation that unfolds as follows:

Joey: Full name.

Cliff: Clifford Burnett.

Joey: Date of birth?

Cliff: November 16, 1968.

Joey: Age?

Cliff: Can't you figure that out based on my date of birth?

Joey: I'm a doctor, Cliff, not a mathematician. (*Friends*, season 8, episode 23)

In movies and TV series, mathematics is portrayed as a highly complex subject. Mathematics is beyond reach, as, for example, in the film *A Beautiful Mind* about the mathematician John Nash. And this is not only for mathematics but extends to mathematics education as well. Even superheroes are nonplussed by mathematics. In the movie *Incredibles 2*, Dash must do his mathematics homework and his father Bob (Mr. Incredible) starts helping him. Dash corrects Bob by saying 'That's not the way you're supposed to do it, dad. They want us to do it this way'. Here Bob replies with a reaction most parents could relate to nowadays: 'I don't know that way. Why would they change math? Math is math. Math is math!' From examples like this, styles of teaching school mathematics have become a common subject of discussion. After watching several movies and TV shows, it becomes natural to begin wondering if mathematics is restricted only to brilliant minds.

When it comes to understanding the struggle with mathematics, it is possible to posit several hypotheses. For example, Neil deGrasse Tyson, a contemporary physicist, elaborates on why most people are bad at mathematics (Cosmology Today, 2017). He asserts that 'I've looked at how much trouble people have with mathematics typically because any one subject that the most people say, "I was never good at…" concerning a topic, it's gonna be math'. His hypothesis deals with how our brains work: 'I say to myself: If our brain were wired for logical thinking, then math would be the most, easiest subject, everything else would be harder. So, I am kinda forced to conclude that our brain is not wired for logic'. Here the apparent fictional reality of movies and TV series becomes an actual hypothetical phenomenon of generalised low academic performance in school mathematics. Being not good at mathematics

is, apparently, a shared experience for most people. A Google search on 'why math is hard' gives 667000000 results. The majority are articles addressing why people struggle with mathematics, with titles like 'Why so many students struggle with math', 'Top 6 reasons math is hard to learn', 'Why is math so hard for some children', 'Why so many students hate math (and how to fix it)', and so on. A Google search on 'Why is math easy' gives 593000000 results, within whose titles there is still the stigma of mathematics being hard, such as 'How to learn mathematics easily', '3 ways to make math easy', 'How I rewired my brain to become fluent in math', 'If you can't learn math, maybe it's not your fault', 'How to succeed in math', and so on.

The reaction of people to mathematics is not that distant from what deGrasse Tyson stated. If 'mathematics' is searched on YouTube, the most-watched video with, almost fifty million views, is '15-year-old Yaashwin Sarawanan is a human calculator!' (Asia's Got Talent, 2019). On this video, one of the most 'liked' comments is: 'Q. What is 4+5? Me: I think that should be 9. Pulls out a calculator just to ensure' (22000 likes and 133 replies). At least twenty-two thousand people can relate to this situation, not trusting themselves in performing simple mathematical tasks. On the video 'The surprising beauty of mathematics' (TEDx Talks, 2014), with over six million views, one of the comments with more replies is: 'I used to be great at math until I was taught the "proper" way to do it. Now I pretty much hate math' (375 likes and 61 replies). One reaction for the previous comment refers to the style of teaching his teacher had when he was a student and how it influenced his thoughts about mathematics:

> I had the same problem all my life. I used to be really bad at math, at least I thought so, because of the reasons you gave, teachers wouldn't accept my work either, and worse, sometimes they would say that I just played with numbers without making sense, and copy the result from somebody else, especially, when I didn't know how to explain, how I got my results. And I used to feel so lousy, and a total idiot.

These discourses seem to be part of the common sense of people. For instance, that mathematical problems have only one right answer or that mathematics is so abstract that it is not useful in day-to-day life and impractical due to rote memorisation of formulas (Colagrossi,

2018). Such discourses elevate mathematics to a supra-level of Platonic ideas far from the reach of mundane, average people, not being part of everyday life, and belonging only to mathematical geniuses. A parody of such discourses can be seen in *The Simpsons* (season 14, episode 7) when a math teacher teaches teenage gang members that 'differential equations are more powerful than bullets'.

Mathematics is often portrayed as a highly relevant subject: Without mathematics, humankind, and life as we know it would not exist, but how many people do see mathematics as important? Apparently not so many. For a long time, research on the teaching and learning of mathematics and educational policies have tried to include 'all' people within the practices of school mathematics by arguing that people fully use it in their daily lives and that it should be enjoyable to work with (Pais, 2018). Some dominant narratives around mathematics have become highly recurrent within society, dealing with the value of mathematics (Pais, 2013). For Stephen Lerman (2014), such perceived value performs a role that has resulted in putting mathematics in a privileged position.

In this chapter, we seek to map and take a critical position on societal perceptions circulating about mathematics and mathematics education among the public. The study is relevant because it may critically rethink the role the media have in constructing meaning and the circulation of naturalised discourses about mathematics. The aim is to trace what has been said outside academia, often tropes that propagandise mathematics, offer salvation narratives, and (re)produce myths about, and dehumanise, mathematics. Therefore, the attention is not going to be on the places where mathematics education is taken as a scientific discipline, namely academia, but where the teaching and learning of mathematics stop being virtual.[1] By placing the attention outside the field, we are aiming to break the predominant tendency within mathematics education research, which is to focus on internal issues of the teaching and learning of mathematics (Lerman, 2014), to (re)produce successful experiences (Gutiérrez, 2013), and to promote solutions (Pais, 2012).

1 'Virtual' in the sense of Deleuze (2007).

Mapping social media's discourses

That 'people are naturally bad at mathematics', or that 'mathematics is reserved only for people with higher intellect' are common assumptions found in social discourse. School mathematics has been one of the leading causes of anxiety (math anxiety) and fear (math phobia). How people approach mathematics depends on several factors coming from their previous or present experiences and preconceptions.

As humans, we encounter a plethora of social stimuli in our environments every day and utilise a series of highly adaptive systems (e.g., attention, perception, memory) to make sense of incoming information. Together, these systems systematically alter the information in order to make it interpretable. Ultimately, the aim of using these systems and, more generally, of social information processing is to allow us to make attributions about others. Such attribution-making processes vary interpersonally in that two people may perceive the same event yet conjure up two different attributions. The bases of individual differences in perception are preconceptions, or 'schemas', that are acquired with experience as people encounter people, objects, or events (Garrido, 2020, p. 5071).

Perception becomes an adaptive process through which people sometimes make inaccurate interpretations of the social world (Garrido, 2020). According to David Dunning (2001), research in the field of social perception has been focused on three key aspects: (i) debates regarding the types of information people pay attention to, (ii) tracing the cognitive processes people follow when receiving this type of information, and (iii) the types of judgments people can reach. Our interest in this chapter is how ordinary life's language reveals the circulating and dominant narratives around mathematics and mathematics education. As Philippe Chassy (2014) contends, language provides a systematically biased perception of what is taken to be 'reality'. In this regard, 'the perceptual filters superimposed by language on social realities bias how individuals build a representation of the situation' (p. 36). Along these lines, we approach mathematics through language, which is submerged into linguistic relativity (Sapir, 1929). He states that humans are 'very much at the mercy of the particular language which has become the medium of expression for their society' (p. 210). We cannot free

ourselves from bias about mathematics and mathematics education within social activity.

This chapter focuses on mapping societal perceptions of mathematics and mathematics education. Within mathematic education, perception has been addressed mainly in relation to students or teachers and their relationship with some mathematical topics or roles of mathematics in society (see Chan & Wong, 2014; Ikeda, 2018; Leung & Lee, 2013). Toshikazu Ikeda (2018) asserts that how students perceive the role of mathematics in society 'should be distinguished from student appreciation of mathematics' utility in society (p. 261). This is because 'some students might not appreciate the utility of mathematics in society, even though they can recognize its roles'. Aiming to unpack the ways of thinking and understanding mathematics and mathematics education, we search for circulating and naturalised discourses on online news and within expressions of people's opinions. The search involves places where people comment about mathematics and mathematics education in their daily experiences as humans living in modern society and news websites that have published articles related to mathematics and mathematics education.

We set some parameters to delimit the data. We started with sites where people verbalise their opinions without being asked to do so, such as a YouTube video comment box. There are plenty of YouTube channels related to the teaching and learning of mathematics and scientific topics engaged with mathematics. Therefore, social media sites, YouTube, and Twitter in particular, are the first places to look for societal perceptions. Facebook is not part of the sample since many pages dedicated to mathematics or mathematics education are not public. The second source of data is online news in English through the search engine provided by Google at news.google.com. After data were collected, they were further analysed using the big data software Nvivo, and then the analysed results were compiled and graphed using Gephi. The gathered data consist of 1500 YouTube comments, 1250 tweets, and 846 pieces of online news.

On the one hand, social media study is based on: (i) YouTube video comments, and (ii) Twitter posts. Using the YouTube search tool, we identified the five most popular channels regarding mathematics – including mathematics teaching or dissemination of specific

mathematical topics. These five channels are the result of triangulating a YouTube search with the keywords: 'math' and 'mathematics' and the filters 'Channel' and 'View count'. Additionally, we considered only the channels that enable posted comments (some channels have disabled the comment section for the most-viewed videos; these were therefore not part of the sample). The channels included: *Numberphile*, *Khan Academy*, *Professor Leonard*, *PatrickJMT*, and *3Blue1Brown*. We selected only the comments from the five most-watched videos of each channel. Using the Chrome extension Twitter Archiver, we collected Twitter posts referring to math, mathematics, and mathematics education. This extension – the free version – enables saving up to one hundred tweets per hour by keywords. The tweets collected are a sample of a significant number of tweets published around the world. We selected only tweets posted in English.

On the other hand, the study from online news is based on a search at Google news. We gathered news regarding mathematics and mathematics education published between 2015 and 2019. We know this methodology can be affected by the search algorithm from Google, that prioritises some news over others. Multiple factors – a lot of these are beyond our control – are key for showing what is more 'appropriate' for each user. However, it is plausible to see a sort of saturation regarding the published online news despite this bias.

The strategy for studying YouTube video comments and Twitter posts is based on saturation of discourses around mathematics and mathematics education. We decided to approach the sample with this strategy given the nature of the data and the number of possible comments and posts we could gather. Saturation becomes helpful since it 'is a term used to describe the point where you have heard the range of ideas and aren't getting new information' (Krueger & Casey, 2014, p, 64). In other words, at some point, the selected samples should become repetitive in their content and purpose. And although some readers may consider this review superficial or general due to the nature of the sample and its limited volume, we may cite social network analytics' recurrences.

The media, societal perception, and mathematics education

It is not rare to encounter news headlines such as 'The myth of being "bad" at maths' (Wen, 2012), published by *BBC News Online*. This article reveals that, according to a study by Silke Luttenberger, Sigrid Wimmer, and Manuela Paechter (2018), around 93% of US adults experience some level of math anxiety. Thus, people unable to understand mortgage interest payments are advised not to feel alone anymore. The article also elaborates on how mathematics has become the school subject of the one-right-answer or the right-or-wrong conundrum, so teachers should emphasise to students that mistakes are part of mathematics learning. And so, math anxiety is naturalised as a cause of bad performance (or, at least, an essential part). This means that only 7% of US adults do not experience math anxiety; such people are not part of the myth of being 'bad' at mathematics. As for young children, they are not exempt from math anxiety. The news article '"Maths anxiety" causing fear and despair in children as young as six' (Weale, 2019) released by *The Guardian* exposes math anxiety as a possible cause of physical symptoms and behavioural problems in class, leading students into a cycle of despair and suffering, harming their mathematics performance. The article asserts that this phenomenon may be contributing to a growing mathematics crisis in the United Kingdom, given that there is a general sense of mathematics being hard compared to other school subjects, which is implicated in students losing their confidence. Here, the way the media decide to present some studies by researchers and international organisations (such as the Organisation for Economic Co-operation and Development, OECD, or the United Nations Educational, Scientific and Cultural Organization, UNESCO) in laypersons' terms plays an important role in circulating certain dominant narratives. The media's power and impact have been an interesting topic for research in modern societies, specifically on consumer goods, services, and election campaigns (see Udanor, Aneke, & Ogbuokiri, 2016). The media – such as online news, social networks, non-Internet-based written news such as newspapers – have enabled a larger and quicker distribution of information, providing the possibility of reacting in real time to events happening anywhere in the world.

According to the data gathered for this analysis, one of the main kinds of circulating and naturalised discourses around mathematics and mathematics education on social media consists of biased opinions based on people's particular experiences, mostly with school mathematics or encounters, whether good or bad, with their school mathematics teachers. Statements such as: 'After watching this, I am convinced that school is not necessary' (YouTube comment), 'My current math teacher makes me worried. You restore my confidence. You have no idea what that means to me' (YouTube comment), or 'Why is math so hard ... maybe its just me being dumb' (Twitter post) reveal the prejudices people have about mathematics and its teaching. For example, someone decided to post on a YouTube video's comment section that the number of dislikes was due to mathematics instructors/teachers feeling deficient while watching the video: 'The dislikes must have been from calculus instructors, who feel inadequate after watching this' (YouTube comment).

Another kind of circulating discourse is about math phobia, the fear of mathematics: 'As a kid I really struggled with math. I just had a flashback of my mom trying to help me with math homework [...] I can't imagine being a kid right now having to do school from home. Me: about to say the wrong answer again Mom' (Twitter post). Another type is built around failure narratives. For instance, 'This test is so hard that I didn't even understand the question' (YouTube comment). Also, about the lack of utility of mathematics in day-to-day life. For example, on a YouTube video that explains how to cut a cake scientifically, a person posts: 'Science needs to know its place and stay away from cake baking and eating [...] I've baked plenty of cakes in the 90s with my Kenwood mixer and without needless advice'. In the same vein, on a video that explains probabilities, a person commented: 'The probability i am ever using probability is 0%'.

It is possible to find opinions stating that people have learned much more from a YouTube video than from their formal classes in school: 'You're a god. I've learned more from you in the last few hours than I have in my math class during the last few months' (YouTube comment). Other comments imply that mathematics is generally beyond human understanding. When this happens – to have learned something considered impossible to learn or to have understood a particular topic or problem – it deserves a celebration: 'AT 35:28: Me screaming...;

roommate: did you win the lottery?; Me: no, I just did my first calculus problem' (YouTube comment).

Figure 20.1 shows frequencies of the categories found within all the YouTube comments collected from the saturation strategy used to approach the gathered data. The statements found on YouTube are based on, and related to, a particular watched video. In this light, videos become a source that evokes past or present experiences with mathematics or mathematics teachers and personal feelings and opinions that help reveal people's perception of math and math education. Likewise, Figure 20.2 shows the frequencies of the categories found within all the Twitter posts collected. Here, opinions are not based on, or related to, a specific video; instead, they are based on people's willingness to post a comment. Although the source that provokes posting a Tweet is not revealed in most of the cases, the comments can also reveal societal perceptions of math and math education.

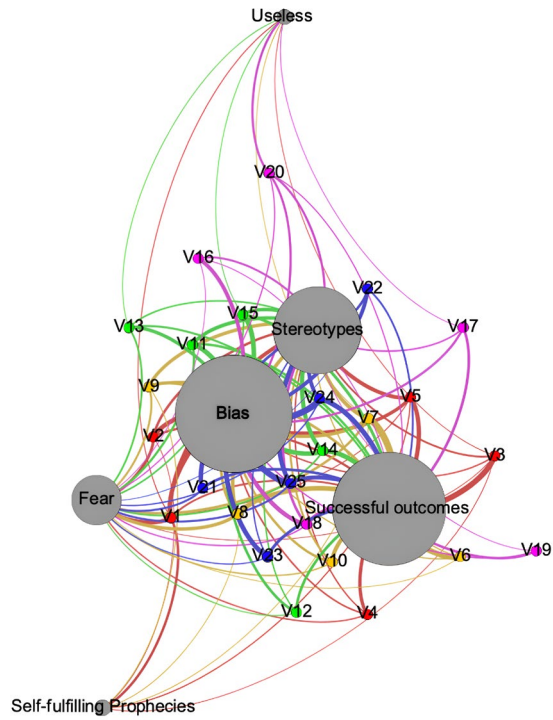

Fig. 20.1 Frequencies of YouTube comment categories. Figure created by authors, using Gephi software.

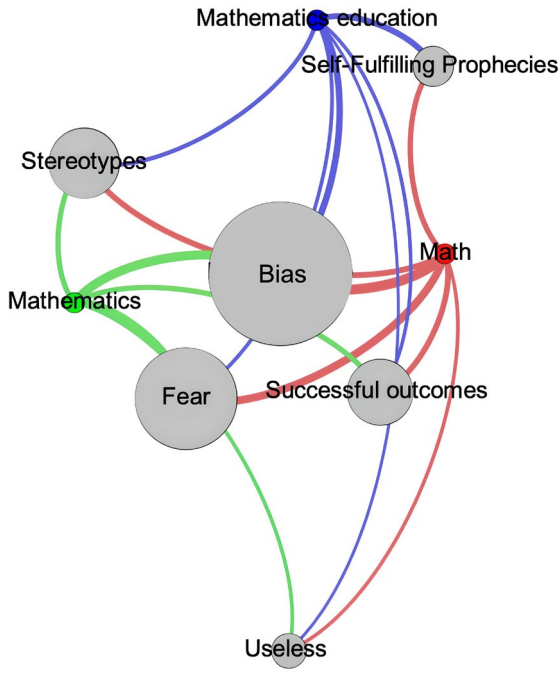

Fig. 20.2 Frequencies of comment categories in Twitter posts. Figure created by authors, using Gephi software.

As previously mentioned, the first category of comments gathered from YouTube and Twitter comprises *biased opinions* regarding school mathematics practices. These comments heighten the narrative that mathematical concepts taught in school are pointless, that teaching styles need attention, and that mathematics education, in general, should be revised.

> This kind of math is the one needed to be taught in classroom. so fun, entertain. (YouTube comment)

> I could not imagine a better way for learning and loving Math <3 Thank u So much for that! (YouTube comment)

> Talking about math is essential. It's what mathematicians do. While students may think that mathematicians simply sit around working out computation problems, that's not at all an accurate picture. Mathematicians ask big questions, come up with ideas, ... (Twitter post)

> my math is so bad 😭😭 10 weeks to get both of these to 160 at the very lowest though we got this (Twitter post)

> I have a question Is it just the topic or math in general that was the problem? (Twitter posts)

A second category comprises comments built around what we take to be *successful outcomes* from mathematics teaching and learning. These comments reveal the difficulties people have while learning mathematics. Certain events – such as watching a video – have a positive impact on their understanding of mathematics or their mathematics tests. Also, overcoming these difficulties is something worth sharing.

> I will now put 'knows how to solve the hardest problem on the hardest test' on my resume (YouTube comment)

> This is legit the only time I've ever enjoyed math in my entire life, ur works beautiful bro (YouTube comment)

> Thank you Bro! I got B+ on exam! You helped me!; I wish you all the best! Sory for my bad english=) thanks from Kyrgyzstan! (YouTube comment)

> i overthink everything but at least i got the answers to da math test now🦕🦕 (Twitter post)

> i have a b+ in math call me the math queen i love algebra (Twitter post)

A third category is composed of comments dealing with *stereotypical* visions of mathematics and its teaching and learning. This understanding of mathematics is based on people's unfortunate experiences of school mathematics that have developed into particular stereotypes of believing that mathematics occurs only in one form. It also includes the beliefs that mathematics is not for all, and that only a certain type of person is mathematically competent – drawing on harmful distinctions regarding race, gender, nationality, etc.

> me: I like math, not my favourite but it's cool; these kind of problems: *appear *; me: wow I'm going to study philosophy and never look at a number ever again (YouTube comment)

> Teacher: there will only be 3 questions; Me: thank god; Test: 1,1A,1B,1C, 2, 2A, 2B, 2C, 3, 3A, 3B, 3C (YouTube comment)

> Asian parents when their kids finish this test: 'That was an improvement, but it's not hard to improve on garbage. *DO IT AGAIN*' (YouTube comment)

> Normal people: im going to major in neuroscience/biology/engineering/ business/etc everyone: oh!! thats so cool!! me: im gonna double major in physics and math. everyone: oh . .. . thats .. . . cool. (Twitter post)

> Rewatched Jurassic Park and i've decided the only acceptable way someone can flirt with me is by using mathematic theories (Twitter post)

A fourth category is composed of narratives about *fear and hate.* These narratives are built on people disliking specific experiences they had or still have with mathematics and notions of math phobia. It also includes jokes people make as a way of mocking particular aspects of mathematics. Most comments entail narratives of failure in the practices of learning mathematics and of encountering not-so-good experiences with different teachers and styles of teaching.

> This test is so hard that I didn't even understand the question (YouTube comment)

> Me: not understanding anything; Also me: yes, big brain indeed (YouTube comment)

> I try to solve the tasks; My Brain: don't even think about it (YouTube comment)

> Math keeps making my brain hurt in ways I never thought it was possible. thanks for the video! I freaking love this channel. (YouTube comment)

> oh god, Im still just as lost, I'm screwed! thanks though (Youtube comment)

> apparently i lost my mathematic skills someone please teach me (Twitter post)

> i suck at math woop woop😔😔 (Twitter post)

> im doing math work but i dont know how to do any of it im going to fail school cause of this virus (Twitter post)

A fifth category is composed of comments about the *useless* nature of mathematics. Most comments within this category entail narratives of perceiving mathematics as lacking meaning and coherence. For many people, mathematics is pointless and without any practical use outside the boundaries of school. It is possible to evidence discourses around the lack of sense school mathematics has in daily-life practices. These discourses come from particular experiences people have when

engaging with day-to-day tasks without using the formal mathematics they learnt at school.

> notice how everyone is learning this because they use it at school but no adults that are using this at work (YouTube comment)

> useless as always; Thx you for wasting my time (YouTube comment)

> Does Mathematic still needed? (Twitter post)

> We especially need imagination in science. It is not all mathematics, nor all logic, but it is somewhat beauty and poetry. (Twitter post)

> The best math you can learn is how to calculate the future cost of current decisions (Twitter posts)

A sixth category is built around notions of *self-fulfilling prophecies*. These commentaries reveal how certain beliefs people have regarding mathematics and its teaching become materialised, such as a mathematics test grade. Most comments deal with a low expectation that people will perform well at mathematics tests, or a belief that people will accumulate bad experiences when encountering something related to mathematics. These narratives intertwine with auto-exclusion from mathematics practices.

> Me: thinking I studied well for a test; Putnam: so you've chosen death (YouTube comment)

> I failed Calculus, I not surprising... from now on, I'm watching these videos (YouTube comment)

> Sometimes I wonder why I felt so bold and decided to choose a science major,,,, I ain't good at science nor math and I have to take so many courses for the two uGH. (Twitter post)

> LMAOOOO i definitely failed my math exam: D.D. (Twitter post)

From the frequency graphs for YouTube comments and Twitter posts,[1] it is possible to notice that: (i) Twitter Posts' Frequency Network, TPFN (see Figure 20.2), is more compact in comparison with YouTube Comments' Frequency Network, YCFN (see Figure 20.1). This compactness shows that the peripheral vertices (nodes) – namely the categories of *self-fulfilling*

1 The algorithm Force Atlas 2 from Gephi was applied to visualise both graphs.

prophecies and the *useless* nature of mathematics – in TPFN are most distant from the network. The compactness of a network indicates that discourses within its categories are more balanced. Thus, the dispersion of ideas and discourses about mathematics and mathematics education is less in TPFN than in YCFN. We also notice that (ii) YCFN shows a concentration of discourses built around two categories: *bias* and *stereotypes*. This exhibits the dominant narratives circulating on YouTube comments. *Successful outcomes* and *fear* form the second largest group of categories within the spectrum of dominant narratives. And (iii) the dominant discourses in TPFW occur in a different distribution than those in YCFN. Most Twitter posts are built around narratives of *bias*, this category being the most prominent. Narratives of *fear* and *successful outcomes* are the second-largest circulating discourses. The differences between YCFN and TPFN could be explained by each platform's nature and use. YouTube has become a platform from which people seek virtual help (see, e.g., Aguilar & Puga, 2020). This is not the case for Twitter, which people might use for informative purposes and to post their opinions on diverse subjects.

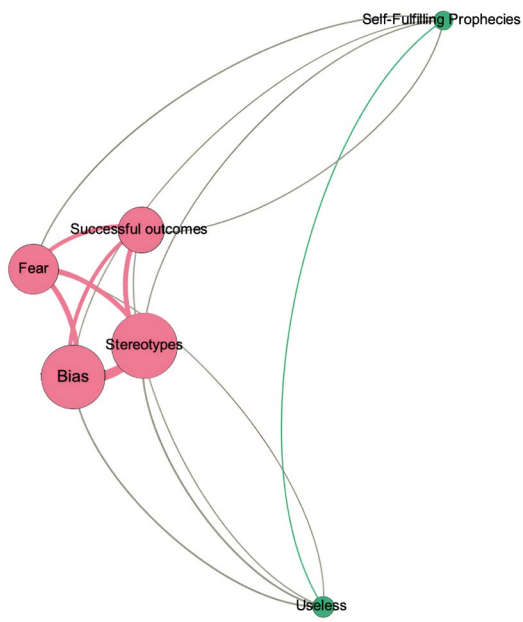

Fig. 20.3 YouTube comments' co-occurrences. Figure created by authors, using Gephi software.

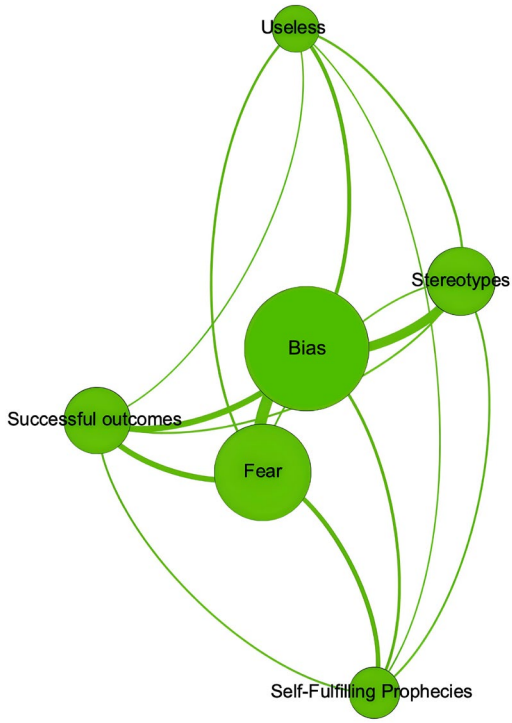

Fig. 20.4 Twitter posts' co-occurrences. Figure created by authors, using Gephi software.

When observing the co-occurrences of such categories, it is possible to note how they relate. From YouTube comments (Figure 20.3), narratives about *bias* intertwine with *stereotypes*, *fear and hate*, and *successful outcomes* – building a community[2] – more than with the *useless(ness) of mathematics* and *self-fulfilling prophecies*. Communities are visible according to the colour of the nodes. *Useless(ness)* and *self-fulfilling prophecies* are in a different colour than the rest of the categories. This exhibits how comments intertwine amongst these four categories to (re)produce dominant narratives about mathematics and mathematics education. For example,

2 The tool Modularity helps in detecting communities. These are displayed by the use of different colours for each community. Nodes that are connected with higher density belong to the same community.

> Calc II is the last thing standing between me and my degree (It's already been 4 loooong years). You are the only reason I'm graduating. I can't thank you enough! (YouTube comment)

> professor, you are my hero. I started learning with you since my calculus 1. Now I am in calculus 3!!! (YouTube comment)

> The class: A minute has 60 seconds; The homework: calculate how many minutes has the day.; The exam: Calculate the exact amount of seconds there are till the Sun dies, taking into account the seconds you lost reading this question, and then calculate the equivalent hours. (YouTube comment)

Within the dominant narratives circulating in YouTube comments, it is possible to evidence a closer connection – proximity – between *bias* and *stereotypes* categories. This is composed of comments such as*:*

> It would take me the rest of my life to understand this level of maths (YouTube comment)

> When you understand the main idea of Fourier Transformation finally in a youtube video instead of in a whole semester in university. (YouTube comment)

> Oh.. My.. God; This thing just taught me more math that 2 yrs of Engineering lectures couldn't teach me (YouTube comment)

When it comes to Twitter posts (Figure 20.4), all categories built one large community – this is visible given that all the nodes are displayed in the same colour. However, some connections between categories are denser. The density is visible through the weights of the edges – some lines connecting two categories are visibly thicker than others. Here, it is possible to evidence the dominant narratives that arise from what people decide to share and showcase when posting their *bias* and *fear* related opinions regarding their past or present experiences with mathematics and mathematics education. Within such posts, plenty of statements circulate around people's low expectations for their mathematical skills and performance. Often, people consider themselves as 'bad at math' or 'not good enough or are not meant to do and engage with mathematics'. Opinions such as:

> Why is math so hard... maybe it's just me being dumb. (Twitter post)

> When I read this for the first time in the textbook my mind exploded (YouTube comment)

> Now I have a grudge against that math teacher for life, no offense but I hope he goes to hell or something. He singlehandedly made the bullying worse and gave me anxiety n an irrational fear of people (Twitter post)

> I couldn't even do math in class, how the fuck they think ima be able to do it online? (Twitter post)

> I've been going through finals, failed my math final, and am having an existential crisis about whether or not I wanna be an engineer anymore. but I'm trying. After tomorrow, I should be on more for plotting and writing. (Twitter post)

These narratives shed light on societal perceptions of mathematics and mathematics education as a disciplinary field inserted in school practices. Most people's views on mathematics are entangled with the useless nature of this knowledge in practical daily-life activities. It seems that the apparent impracticality of mathematics instantiates feelings of anger, anxiety, frustration, and discomfort.

Dominant narratives from international organisations, educational policies, and stakeholders acknowledge mathematics as key knowledge for modern society. The salvation themes arising from such discourses involve notions of 'mathematics for all' (see Pais, 2018), in which everyone needs mathematics proficiency to secure their future. Then, people's perceptions of mathematics align with elaborations produced by the media, of mathematics being difficult and inaccessible for people with average IQ. For example, *The Conversation* published an article entitled 'Maths: six ways to help your child love it' (Johnston-Wilder & Penazzi, 2018), which deals with two types of engagement with mathematics: one by mathematicians and the other by everybody else.

> There is a widespread perception that mathematics is inaccessible, and ultimately boring. Just mentioning it can cause a negative reaction in people ... For many people, school maths lessons are the time when any interest in the subject turns into disaffection. And eventually maths becomes a topic many people don't want to engage with for the rest of their lives... At the opposite end of the spectrum, professional mathematicians see mathematics as fun, engaging, challenging, and creative.

Although there have been multiple efforts to make mathematics more accessible to students (including the variety of theories, methods, and

materials produced by mathematics educators worldwide), school mathematics seems to be bounded by the alchemic process that produces the mathematics curriculum (see Popkewitz, 2004). This alchemy of the school mathematics curriculum might explain the different nature of the mathematics of professional mathematicians and the mathematics of school practices. Within the media, the apparent spotlight is on the decreasing performance of students. On the one hand, research engages with making mathematics accessible to all to achieve certain standards. In contrast, the media highlight that mathematics-learning standards are not close to being achieved. For example, the French news site *The Connexion* uses the phrase 'catastrophic maths' to describe students' performance (Connexion journalist, 2018): 'A new report that found the level of mathematics among French students today to be "catastrophic" has recommended 21 possible solutions, including the so-called "Singapore method"'.

Another example comes from *The Conversation*, an article titled 'Challenging the status quo in mathematics: Teaching for understanding' (Rakes, 2017). This news story outlines the minimal changes achieved by the national reforms in the United States intended to improve students' performance in mathematics: 'Despite decades of reform efforts, mathematics teaching in the U.S. has changed little in the last century. As a result, it seems, American students have been left behind, now ranking 40th in the world in math literacy'.

The media have also covered stories highlighting the emotions students experience as a result of the impact that teaching and learning school mathematics has on them. These deal with various negative side-effects that arise from engaging with mathematical tasks, such as anxiety, fear, and even physical symptoms (see Weale, 2019; Henry-Nickie, 2018). Within this type of news, mathematics is presented as damaging and scary, with statements even asserting that not all students should be obliged to learn this school subject.

> Children as young as six feel fear, rage, and despair as a result of 'mathematics anxiety', a condition which can cause physical symptoms and behaviour problems in class, according to a study [...] Pupils in both primary and secondary school can find themselves locked in a cycle of despair, suffering from anxiety which harms their maths performance, which in turn leads to increased anxiety. (Weale, 2019)

> The mathematics discipline usually strikes fear into the hearts of most students and working-age adults in the U.S. (Henry-Nickie, 2018)

Along similar lines, there is also a cluster of news stories that deals with disseminating mathematics updates. These news types are focused on the accomplishments in the field, for example, awards or improvements on students' performance worldwide. *ScienceAlert* emphasises the recognition of the first woman awarded the Abel Prize, Karen Uhlenbeck (Starr, 2019):

> For the first time, a woman has been awarded the prestigious Abel Prize. Karen Keskulla Uhlenbeck of the University of Texas at Austin will receive the annual prize for her tremendous contributions to the field... The news is notable because historically, most of the mathematics and science prizes have been awarded primarily to male recipients. Of the 904 individual Nobel laureates, only 51 have been women. (Starr, 2019)

The *Baltic News Network* (Baltic News Network, 2019) elaborates on the positive results of Latvian students in PISA (Program for International Student Assessment), within which low performance has decreased in mathematics by 2.6 points since 2012. *The Telegraph* (Gurney-Read, 2016) highlights the countries with high achievement in mathematics international tests, such as TIMSS (Trends in International Mathematics and Science Study):

> The average results of Latvian pupils were scored 496, which is statistically higher than the average OECD level – 489. Authors of the study say this is the highest result in mathematics Latvian pupils have achieved in seven cycles of the Programme for International Student Assessment (PISA). (Baltic News Network, 2019)

> Singapore, Hong Kong, Korea, Chinese Taipei, and Japan continue to dominate international rankings for maths and science, the latest league tables have revealed. (Gurney-Read, 2016)

Mathematics is perceived as a school subject in which students struggle the most. Sometimes, it is presented as scientific approximations to situations for ordinary life that need more assistance, for example, in finding love. The *Daily Mail* (Gray, 2015) discusses how a mathematician calculated a formula for finding true love. There is also a mathematics formula, according to *Greek Reporter* (Kokkinidis, 2019), to select the most beautiful woman on the planet.

> Mathematics is probably not a subject that many people find sexy, but it could hold the key to finding true love [...] Mathematicians have developed a series of theories that can help people find the perfect partner. (Gray, 2015)

> British scientists have recently determined exactly who is the most beautiful woman on the planet – according to a mathematical formula used by ancient Greeks. (Kokkinidis, 2019)

The media also gather news that focuses on debunking myths around mathematics and mathematics education, such as gender disparities in students' performance. The use of research to build such arguments is a common factor of this type of news. *Genetic Engineering & Biotechnology News* (Genetic Engineering & Biotechnology News, 2019) highlights one piece of neuroscientific research that found no differences between boys' and girls' neural development.

> A comprehensive examination of neural development in boys and girls has now effectively refuted this myth, and demonstrated that neural functioning is similar in both sexes. Findings from the study indicate that, at a neurological level, there should be no reason why girls would have less aptitude for maths than boys. (Genetic Engineering & Biotechnology News, 2019)

And even though gender bias and stereotypes did not appear in YouTube comments or Twitter posts, there are various places where the gender gap is addressed, mostly related to prejudices of women performing poorly within STEM fields. It is often visible in sitcoms and animated series, such as *The Simpsons*, in the episode 'Girls just want to have sums':

> Principal Skinner: You know, Juliana, it's no surprise you became such a success. You always got straight As in school.
>
> Juliana: Well, I remember getting a B or two in math.
>
> Principal Skinner: Well, of course you did. You are a girl.
>
> [Audience gasps.]
>
> Principal Skinner: All I meant was, from what I've seen, boys are better at math, science, the real subjects.
>
> Juliana: [To audience] Calm down, calm down. I'm sure Principal Skinner didn't mean girls are inherently inferior.
>
> Principal Skinner: No, of course not. I don't know why girls are worse. (*The Simpsons*, season 17, episode 19)

Discussion

Can't believe they gave me a math assignment in dental school (Twitter post)

Recalling Chassy (2014), perception of what is taken as real is strongly influenced by languages – that are relativistic, according to Edward Sapir (1929). From social science and social psychological research, it is clear that beliefs and expectations of people can distort perception in various forms, which influence the way of viewing objective 'social reality' (Jussim, 2012). Wendy Wood (2000) explores how social identity theorists have studied group influence as well as other aspects of group behaviour:

> When people categorize themselves as an in-group members, the in-group serves as a reference for social comparison, and people adopt the prototypical in-group attitudes and beliefs as their own [...] agreement from others categorized as similar to self enhances one's subjective certainty and suggests that the shared attitudes reflect external reality and the objective truth of the issue. (p. 557)

Within this taken-as-real context, the media and social networks contribute to fabricating an image for mathematics and shape how people decide to adopt specific beliefs about mathematics and mathematics education. Although there is little research on how the media influence the societal perception of mathematics and mathematics education, there exist some efforts, for example, regarding the learning of mathematics with the use of digital media (see Kynigos, 2008). The social media matrix has become a powerful 'magic wand' able to determine the structure of society as it 'forms a basis for polarization and dissolutions and also ensures mergers and agreements' (Gündüz, 2017, p. 91). And so, social media can reveal, reflect, and even shape, how society views mathematics, whereby stereotypical representations of mathematicians can actually be discouraging to a group of subjects.

Trying to read societal perceptions from a linguistic perspective implies understanding discourse analysis, building on Norman Fairclough's work (1995). However, the focus here is not on using signifiers to critically analyse YouTube comments and Twitter posts. Instead, it is on mapping the dominant narratives surrounding mathematics and mathematics education in order to unfold the particular spatiotemporal

conditions that enable a certain type of rationality – a system of reason – that shapes certain kinds of people. From this, the 'taken-as-truth' statements about mathematics and mathematics education circulate to evolve into societal perceptions about what a mathematician is believed to be. These 'taken-as-truth' statements become discursive formations (Jørgensen & Phillips, 2002) that have been produced and reproduced by the interaction of different spheres of modern life (Foucault, 1972) and are entangled in the practices of everyday life. Within this realm of societal perceptions, discourses regarding the relevance of mathematics for society and day-to-day life should be denaturalised. For instance, discourses that link, mathematical proficiency with intellect, enabling the belief that people not performing well in mathematics are cognitively deficient; and discourses that link mathematics proficiency with being male, socially inadequate, not good at sports, poor sight, and so on. Or discourses that link mathematics proficiency with success. Here, discursive frameworks shape the boundaries within which people can negotiate what it means to be good or bad at mathematics, to have or not have mathematical abilities, to enjoy or hate mathematics etc. When people take a position regarding mathematics or school mathematics, their perceptions based on dominant narratives about success, usefulness, and value of mathematics play a determinant role. In this light, circulating discourses about mathematics and mathematics education shape people's perceptions and predispositions towards mathematics, given that:

> Our perception of objects is formed within the limits of discursive constraints [Discourse] causes a narrowing of one's field of vision, to exclude a wide range of phenomena from being considered as real or as worthy of attention, or as even existing; thus, delimiting a field is the first stage in establishing a set of discursive practices. (Mills, 2001, p. 51)

People respond to mathematics and school mathematics in diverse ways. How people perceive mathematics and mathematics education will depend on their frame of reference, values, beliefs, experiences, interests, etc. These alter not only our perceptions of social reality but also of reality itself. Societal perception could be understood as a portrait of reality shaped by our beliefs, experiences, or interests; but also, as a way of constructing our reality and social order. Johann

Engelbrecht, Salvador Llinares, and Marcelo Borba (2020) assert that at the same time that humans develop and build new media, the media themselves transform and 'construct' a new kind of human. The media complex does more than represent or describe the world and its relations; it produces and reproduces narratives about mathematics and mathematics education. It seems natural to think that how people conceive of mathematics is determined and situated. However, subjects are not passive entities within a system. In this context, the media might be seen as having agency (see Butler, 1997).

Mathematics undergoes an alchemic process (Popkewitz, 2004) deeply rooted in spatiotemporal conditions that transform the mathematics curriculum. As Yip-Cheung Chan and Ngai-Ying Wong (2014) contend, 'social, political, and even economic and cultural/religious backgrounds of a period generate a social mood that affects the curriculum worldview' (p. 274). Under this light of 'social mood', mathematics becomes the epitome of modernism, whether by the intrinsic characteristics of mathematics itself (logical and rational), or the capacity of promoting the development of valuable competencies for humankind (such as problem solving and the capability of changing reality). School mathematics is structured to reach as much of the population as possible, materialised in political agendas such as 'no child left behind' or 'mathematics for all'. Educational policies are entangled within a system of reason in which mathematics becomes a powerful knowledge for securing people's future and, thus, it is framed as something that should be enjoyable to learn (see Pais, 2018). However, societal perceptions about mathematics and mathematics education, rooted in the same system of reason from which political agendas portray mathematics as useful and vital, differ entirely from educational aspirations and desires. This finding problematises the teaching and learning of mathematics as a means of self-segregation, by constructing categories of 'normal' and 'smart' citizens in contrast to 'abnormal' and 'undesirable' citizens.

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