Communications

Targeted identities of the mathematics learner: Now it's getting personal!

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An image (Figure 1) popped up in my Facebook feed recently. Undoubtedly it was sent to me, specifically, as a result of some algorithm, perhaps due to my having searched 'Mathletics' on internet search engines (I am currently researching the phenomenon of online mathematics instructional platforms); or Facebook could 'know' that I am a parent of school-age children, although the advertisement seems more directed at teachers than parents. Regardless, I was immediately struck by the words and images embedded in this post. Five learner identities were depicted, together with gendered illustrations; there were certainly specific messages about what it means to be a learner of mathematics.

I begin with the premise that advertisements such as this are powerful because they produce discourses about learning mathematics and about being a mathematics learner. This particular advertisement is additionally powerful due to the form and method of delivery (sent directly to the potential consumer) and because the platform Mathletics already enjoys a high level of market share in New Zealand (Darragh, 2021) and worldwide: "trusted by over 5 million students in over 14,000 schools in almost every corner of the world" [1]. Due to this wide-ranging and targeted influence, it is worth examining the messaging in the post.

In this communication I first examine the five learner identities depicted in the advertisement, both the identity labels and their corresponding emojis, to consider their production of the mathematics learner. Second, I note the gendered depictions of these five learners in the illustration. Third, I give other examples of producing mathematics identity in the media. Finally I argue that we must be vigilant of the ways in which data analytics can both create personalised advertisements and potentially differentiate what it means to be a learner of mathematics for different groups of people.

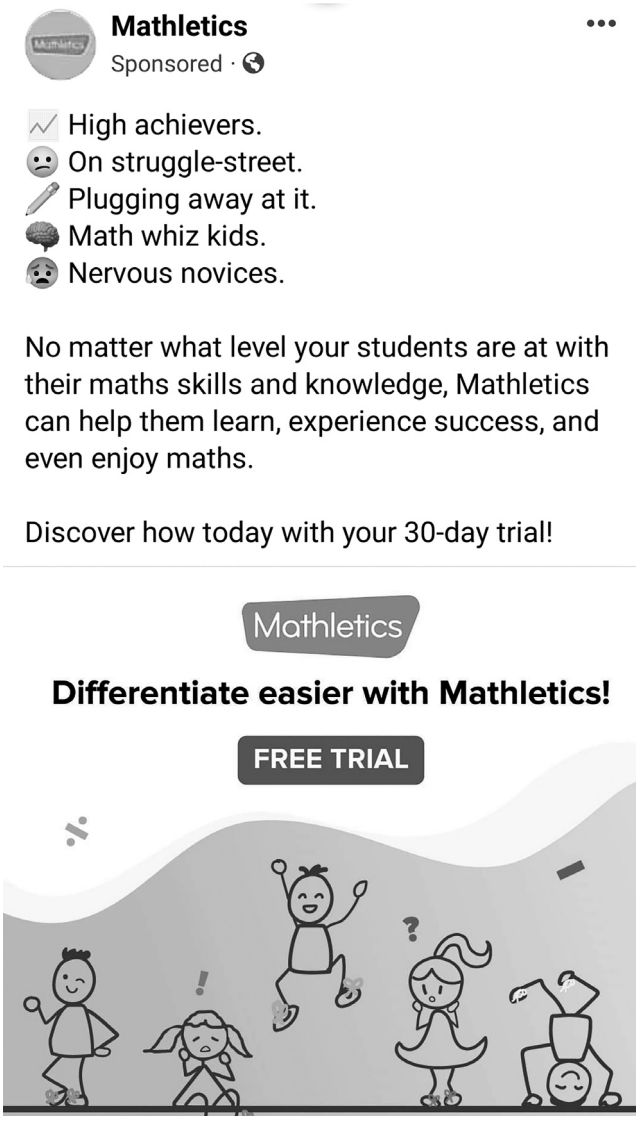

Figure 1. Facebook advertisement received in 2022 (from Mathletics [1]).

Five learner identities

Over the past two and a half decades there has been a growing interest in learner identity within mathematics education (Graven & Heyd-Metzuyanim, 2019). Much identity research in mathematics education sees learner identity as enacted or storied and dependent on the situation (Darragh & Radovich, 2018), rendering a fixed idea of identity somewhat redundant. As such, I was certainly interested to see five identities so clearly labelled, and elaborated in the form of emojis. To my knowledge, there is currently no literature within mathematics education that connects emojis to learner identity. Elsewhere, research into emojis explores how meaning is interpreted (Jaeger, Roigard, Jin, Vidal & Ares, 2019) and claim that because emojis are used to "express, stress, or disambiguate", they are "potentially better local proxies for people's intended overall sentiment than textual cues" (Hogenboom, Bal, Frasincar & Bal, 2015, p. 37). In other words, we can look at the emojis to further understand the meaning behind the identity label. First, it is interesting to note the two negatively positioned identities—'On struggle-street' and 'Nervous novice' are the only *facial* emojis used. This suggests that emotion itself is something negative when it comes to mathematics learning. The emoji dictionary [2] names these two emoticons as 'confused face' and 'anxious face with sweat'. Given that emojis may be counted on as a better indicator of the intent of the message, then perhaps one intent of the advertisement is to emphasise the states of confusion and anxiety when learning mathematics.

The more positive identities, on the other hand, are not illustrated with facial emojis. First, depicting a graph next to the 'High achievers' identity perhaps sends a message of rationality (Evans, Tsatsaroni & Czarnecka, 2013); the emoji dictionary describes this image as 'metaphorically on the rise'. Such an identity might be considered the 'ideal learner' within 21st century discourse of the neoliberal educational technology industry (Darragh, 2021) as it produces the mathematics learner as someone who is deliberately improving themselves (investing in themselves) via mathematics. However, there is some irony in seeing the 'Plugging away at it' identity represented by a pencil when the advertisement is for a computer-based learning platform. Perhaps this identity disappears with the use of Mathletics—hard work will no longer be required. The emoji dictionary associates this image simply with schooling; here I understand it to be 'traditional' schooling, perhaps targeting a more conservative market. Finally the brain icon together with the 'Math whiz kid' identity evokes for me a student with 'natural ability', where the ability to do mathematics is innate, or in the brain, an identity which is often gendered (Solomon, Lawson & Croft, 2011). These three positive identities are not at all emotional; rather, they depict overlapping yet different identities of successful, hard-working, and brainy. Whilst the five identities are perhaps intended to capture a broad spectrum of learners, together they give a message of mathematics being confusing and anxiety-provoking, but with hard work and investment (in Mathletics), one could achieve like a 'Math whiz'.

Gendered identities

Given that five identities were named, I was motivated to connect each to the five drawings of children at the bottom of the advertisement. Whilst this was open to interpretation, each illustration, from left to right, seemed to connect to the corresponding labels: 'Plugging away at it', 'Nervous Novice', 'High achiever', 'On struggle-street' and 'Math whiz'. A few clues informed my assumptions. Jumping seems to connect to the word 'high' and flipping upside down seems like something a 'whiz' would be able to do. The negatively positioned identities gave additional clues—the question-mark connects to the emotion of confusion and the exclamation to anxiety. What is clear is that these two negative identities are gendered 'girl'—they are wearing skirts and have pink shoelaces (I read 'boy' in the final white shoelaces but perhaps this last image depicted non-binary gender). Further, while the girls in general are both stereotyped and marginalised through their positioning into negative identities, their fair hair suggests these girls are white, excluding girls of colour in this image. I suggest the advertisement forms a regression of some decades in terms of gender (and racial) equity in mathematics education. It reminds us that constructing mathematics learner identity is not solely in the domain of education; rather the media may also sway societal understandings of who gets to be the mathematics learner and who is left out.

Media constructions of the mathematics learner

There is already a body of research in mathematics education that discusses how public media both reflects and shapes the way society perceives mathematics learning and the learner (Abtahi & Barwell, 2019; Andersson, Ryan, Herbel-Eisenmann, Huru & Wagner, 2022). This research is important because the portrayals are not neutral, rather, they reflect different societal discourses and political agendas (Abtahi & Barwell, 2019). Evans, Tsatsaroni and Czarnecka (2013) examined newspaper advertisements and argued the use of mathematics to lend rationality, certainty and authority to the products. Other popular culture depicts mathematics and mathematicians in particular ways, such as intellectual and logical, but also geeky and socially incompetent (Esmonde, 2013; Fellus, Low, Guzman, Kasman & Mason, 2022). The media do not simply give messages about mathematics but also "frame a structure to think with" (Abtahi & Barwell, 2019, p. 2) and are powerful in producing public notions of what it means to be a learner of mathematics.

Mathletics is, of course, motivated to make a profit, and one key way to maximise profits is to ensure a wide market share. As stated, I suspect the five identities depicted are an attempt to capture a wide range of learner types. The overt message is that regardless of whether you are anxious, confused, hard-working, successful, or a math whiz, Mathletics is still for you. This is also clear in the "No matter what level your student is at […]" and the "Differentiate easier […]" messages pitched at the classroom teacher. However, it is the covert messages that I am interested in here. These reinforce the idea of mathematical emotions as negative, a neoliberal, rational depiction of success and (white) girls as marginalised (other races as invisible) in mathematics learning.

Yet there is one further concern I have about this advertisement in particular. Although I build on other research about mathematics identity production in public media, this advertisement could better be called *private* media in that it was sent to me personally, via my Facebook account. We are now entering a new era. Data analytics enable targeted advertising and this means that different advertisements may be sent to different people—and therefore different learner identities may be promoted for different people. This development is crucial to acknowledge because the algorithms used in the data analytics produce biases that reflect the biases of the programmers, and we know that programming is an occupation already dominated by white ('geeky') males (Boninger, Molnar & Saldaña, 2019; Mendick, Ottemo, Maria & Silfver, 2021). However, we know little about how the hidden data analytics work. How was I targeted specifically for this advertisement? Was my teacher or parent identity known? Was my gender and race a factor? The issue here is that people may be defined in various ways by the hidden algorithms, and then targeted with different advertisements. The key question is: How might these personalised advertisements promote different mathematics learner identities?

Mathematics already suffers from the way in which it is depicted in society, and the way some groups of students are excluded from being recognised as legitimate learners of mathematics. It is certainly worth paying attention to the way in which profit-making enterprises contribute to the production of stereotypes about mathematics learners and position mathematics within the neoliberal project. Yet,

moreover, in the current era of increasingly sophisticated data analytics, we must be vigilant about the ways different persons might be differently targeted in various media.

Acknowledgement

Supported by the Marsden Fund Council from Government funding, managed by Royal Society Te Apārangi

Notes

[1] Mathletics, a product of 3P Learning, https://www.mathletics.com/nz/
[2] Emojipedia, https://emojipedia.org/

References

Abtahi, Y. & Barwell, R. (2019) Mathematical morality tales: mathematics education in Canadian newspapers. *Canadian Journal of Science, Mathematics and Technology Education* **19**(1), 48–60.

Andersson, A., Ryan, U., Herbel-Eisenmann, B., Huru, H. L. & Wagner, D. (2022) Storylines in public news media about mathematics education and minoritized students. *Educational Studies in Mathematics* **111**(2), 323–343.

Boninger, F., Molnar, A. & Saldaña, C.M. (2019) *Personalized Learning and the Digital Privatization of Curriculum and Teaching.* National Education Policy Center.

Darragh, L. (2021) The promise of online mathematics instruction programmes: producing the mathematics learner and school mathematics. *Research in Mathematics Education* **23**(3), 262–277.

Darragh, L. & Radovich, D. (2018) Mathematics Learner Identity. In Lerman, S. (Ed.) *Encyclopedia of Mathematics Education,* 582–585. Springer.

Esmonde, I. (2013) What counts as mathematics when "We all use math every day"? A look at NUMB3RS. In Bevan, B., Bell, P., Stevens, R. & Razfar, A. (Eds.) *LOST Opportunities: Learning in Out-of-School Time,* 49–63 Springer.

Evans, J., Tsatsaroni, A. & Czarnecka, B. (2014) Mathematical images in advertising: constructing difference and shaping identity, in global consumer culture. *Educational Studies in Mathematics* **85**(1), 3–27.

Fellus, O., Low, D.E., Guzman, L.D., Kasman, A. & Mason, R. (2022) Hidden figures, hidden messages: the construction of mathematical identities with children's picturebooks. *For the Learning of Mathematics* **42**(2), 2–8.

Graven, M. & Heyd-Metzuyanim, E. (2019) Mathematics identity research: the state of the art and future directions. *ZDM* **51**(3), 361–377.

Hogenboom, A., Bal, D., Frasincar, F., Bal, M., Jong, F. D. & Kaymak, U. (2015) Exploiting emoticons in polarity classification of text. *Journal of Web Engineering* **14**(1-2), 22–40.

Jaeger, S.R., Roigard, C.M., Jin, D., Vidal, L. & Ares, G. (2019) Valence, arousal and sentiment meanings of 33 facial emoji: insights for the use of emoji in consumer research. *Food Research International* **119**, 895–907.

Mendick, H., Ottemo, A., Maria, B. & Silfver, E. (2023) Geek entrepreneurs: the social network, Iron Man, and the reconfiguration of hegemonic masculinity. *Journal of Gender Studies* **32**(3) 283–295.

Solomon, Y., Lawson, D. & Croft, T. (2011) Dealing with 'fragile identities': resistance and refiguring in women mathematics students. *Gender and Education* **23**(5), 565–583.

Congruence theorems in the past, present and future

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Triangle congruence theorems are a central part of geometry teaching, but in spite of their familiarity, there is much to be learned about them, both for students and researchers. They form a collection of results that fit nicely together, so they constitute a small *mathematical theory;* they have what Freudenthal (1971) called 'local organization'. Moreover, they provide a playground for pupils to *distinguish truth from falsehood:* some sets of assumptions give a true theorem, others are not sufficient and lead to counterexamples. As it often happens for mathematical statements, in the classical congruence theorems none of the assumptions can be removed without invalidating the result.

Congruence theorems around the world

Everyone can list the 'triangle congruence theorems' (or 'properties' or 'postulates' or 'criteria'). But the list might differ according to who you ask. It is likely to include some, and perhaps all, of these:

> (SSS) Two triangles are congruent if three pairs of corresponding sides are equal in length.
>
> (ASA) Two triangles are congruent if two pairs of corresponding angles are equal in measurement, and the included sides are equal in length.
>
> (AAS) Two triangles are congruent if two pairs of corresponding angles are equal in measurement, and one pair of corresponding sides, different from the included ones, are equal in length.
>
> (AAcorrS) Two triangles are congruent if two pairs of corresponding angles are equal in measurement, and one pair of corresponding sides are equal in length.
>
> (SAS) Two triangles are congruent if two pairs of corresponding sides are equal in length, and the included angles are equal in measurement.
>
> (SsA) Two triangles are congruent if two pairs of corresponding sides are equal in length, and the pair of angles opposite to the bigger of these sides are equal in measurement (if the two sides are equal, then we can use any of the two sides).
>
> (HL) Two right-angled triangles are congruent if their hypotenuses and one pair of corresponding legs are equal in length.

All these ensure that two triangles are congruent, making use only of conditions involving the length of some of the sides and the measures of some of the interior angles. Within this description there are at least two other, less familiar, congruence theorems:

> (acuteSSA) Two acute triangles are congruent if two pairs of corresponding sides are equal in length, and one pair of corresponding angles are equal in measurement.
>
> (perimeterAA) Two triangles are congruent if they have the same perimeter and the same angles.

It is interesting to examine the list of triangle congruence theorems that one finds on Wikipedia (under 'Congruence (geometry)' in 2022) and how that list changes on the corresponding pages in various languages. Table 1 shows which theorems are listed. We can see that, although in mathematics what is true can be proved, what is important is a matter of choice.