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Synopsis

Although people's ideas about mathematics and mathematicians often develop from their school and home experiences, such ideas also are influenced by interactions with popular media. In this article, I report on findings from a study in which I analyzed magazine advertisements for representations of mathematics and mathematicians. Data collection took place in two phases, approximately a decade apart. In each phase, I reviewed a year's worth of issues in each of six diverse, popular magazines for mathematical representations in advertisements. The frequency of mathematical advertisements decreased from Phase 1 to Phase 2, but the initial frequency was already extremely low, indicating mathematics' invisibility in popular media. This lack of representation may be due to mathematics not being seen as a "cool" way to sell a product or service since mathematics is linked to many negative stereotypes. The representations were similar in the two phases, with mathematics often depicted in stereotypical ways, such as being difficult or stressful. People rarely featured in the mathematical advertisements, which serves to further dehumanize mathematics. Generally, the findings were consistent with those from studies of other popular media, such as movies and books.

1. Introduction

Messages about mathematics, mathematicians, and mathematically proficient people (i.e., those who are good at mathematics; herein, for the sake of brevity, the term "mathematicians" will be used to refer to both mathematicians and mathematically proficient people) can be found in many places

outside of the classroom. These messages can complement, supplement, or challenge the messages to which people are exposed during their time in school, and can come from a range of sources, such as friends, family, and popular media. The latter is of particular importance as a source of messages due to its ever-increasing role in our lives. From the pre-school years to adulthood, people are highly connected to popular media, particularly via digital devices and social media [23, 34, 49]. Media play a powerful role as a socialization agent, due to three interrelated reasons:

> First, the media have an unparalleled ability to disseminate information about the culture ... Second, individuals typically spend a considerable amount of time attending to the narratives of the media. Third, there is discernible homogeneity in many of the media's stories, which results in a degree of consistency in what individual audience members can learn about the social environment. [7, page 243]

Popular media may provide information about mathematics and mathematicians to which people are/were not exposed when in school. For instance, many people do not have "real life" exposure to mathematicians, so their ideas about mathematicians typically arise from media portrayals [36, 37, 39].

It is important to understand the mathematical representations to which people are exposed, as they are a key factor in influencing people's views of and attitudes toward mathematics [19, 26, 33]. Many researchers (see, for example, [6, 27]) have shown that people's attitudes toward mathematics influence their achievement and participation in the subject area. Although such research has typically been conducted with students, the same ideas can arguably apply to adults who are not in school: If adults have negative attitudes toward mathematics, then they presumably will not voluntarily engage with mathematics. Such attitudes and outcomes are particularly damaging for adults who are parents, as they may pass along such ideas to their children and may struggle to assist and support them with mathematics [18, 29].

In recent years, researchers (see, for example, [20, 35]) have examined mathematical messages in popular media sources, to consider what representations are present and what ideas are disseminated to media consumers. Here, I report on a research project conducted in two phases, approximately a decade

apart, in which I analyzed representations of mathematics and mathematicians (herein "mathematical representations") in advertisements in mainstream magazines targeted at a range of audiences. Although advertisements are not the focus of magazines, they are present in nearly all magazines, and their messages are consumed by readers [24].

2. Review of Literature

Research about mathematics in popular media dates back to the 1980s, such as Jacobs and Eccles' research [22] about how parents were influenced by media reports about the links between mathematics ability and gender. Although some researchers (see, for example, [1]) continue to focus on popular media reports, such as newspaper articles, about mathematics and mathematics education, other researchers who investigate mathematics in the media instead focus on fictional popular media sources. In the past twenty years in particular, many popular television shows, movies, and books have featured mathematicians, such as *A Beautiful Mind*, *Numb3rs*, and *Proof*. Such media sources may "have helped to make the general public aware of some of the most outstanding personalities or problems in the world of mathematics" [44, page 117], but they have also disseminated many stereotypical, and thus harmful, messages about mathematics and mathematicians. By examining these sources, researchers are able to understand the messages about mathematics and mathematicians that are disseminated to the general public about these topics.

An influential study about popular media representations of mathematics and mathematicians was conducted by Mendick and colleagues with over 650 high school and university students in the U.K. (reported in such publications as [30, 31, 32]). The participants were asked to provide two examples of mathematics and/or mathematicians in popular culture. Indicative of mathematics' invisibility in popular culture, approximately half of the participants could not provide two examples. Mendick and colleagues analyzed the provided examples and found that mathematics was often portrayed in stereotypical ways, such as simply being numbers and calculations and/or being difficult and mystifying. There were also examples of mathematics being depicted as aesthetically beautiful (e.g., patterns in nature) and utilitarian (e.g., used to solve problems). Mathematicians were depicted as geniuses and socially awkward geeks.

Other researchers have also analyzed popular media sources (e.g., television shows, movies) in which mathematics and mathematicians are featured, with similar findings to those of Mendick and colleagues. Mathematicians are often portrayed as being geniuses with a "natural" gift for mathematics [20, 35, 42, 46]. Although the link between mathematical ability and general intelligence may seem like a positive portrayal, it makes mathematics seem like a discipline that is only for a "select few" who have mathematical gifts, rather than being for everyone. Concerningly, mathematicians are often portrayed as being mentally ill, with an obsession with mathematics depicted as the cause of these issues [17, 25, 35, 42]. More generally, mathematicians are represented as socially awkward nerds who are unattractive as romantic partners [20, 25, 33, 35]. With respect to gendered portrayals, media mathematicians are far more likely to be men than women, but women mathematicians tend to be portrayed in a more positive manner: less frequently portrayed as mentally ill and/or socially inept [20, 35, 42]. Stereotypes about mathematics and mathematicians have also been found in less "mainstream" media sources, such as internet memes [3] and comic strips [5]. Hence, these ideas appear to be ubiquitous in Western culture.

With respect to research involving representations of mathematics and mathematicians in advertisements, Evans and colleagues (reported in such publications as [9, 11, 12, 13]) conducted a multi-phase study in which advertisements in British daily newspapers were analyzed for mathematical representations. The initial phase of the project involved newspapers from 1997 to 2003, whereas the later stage of the project involved newspapers from 2006 to 2008. In the earlier stage, very few (1.7%) of the newspapers featured any mathematical advertisements, and none of the "popular" newspapers contained any mathematical advertisements. Similarly, in the later stage, there was a lack of mathematical advertisements (4.7%), and the social class of the readership correlated with the incidence of mathematical advertisements. In both phases of the study, the mathematics in the advertisements was quite basic and was sometimes nonsensical. Furthermore, many of the products in the mathematical advertisements were targeted at men (e.g., cars, business services), and reinforced gender stereotypes.

Although there are some examples of researchers exploring representations of mathematics and mathematicians in television shows, movies, and books, there is a paucity of research in which researchers have investigated these representations in magazine advertisements. Magazine advertisements,

although not comprising the core content of the magazine, are indicative of societal views and stereotypes. Both advertising in general, and magazines in particular, have been shown to create ideologies, reflect society, and influence socialization (see, for example, [8, 28]). Similarly, as discussed by Mendick *et al.* [30] and Morge [33], people's views of mathematics and mathematicians, and perceptions of themselves as mathematical beings, are influenced by popular media representations of mathematics and mathematicians. Hence, by analyzing representations of mathematics and mathematicians in magazine advertisements, I hoped to be able to understand the messages that are disseminated to the general public through this medium.

3. Theoretical Framework

For the purpose of this research, I drew on two complementary conceptions of representation [2, 21]. Barker defined representation as "a set of processes by which signifying practices appear to stand for or depict another object or practice in the 'real' world" [2, page 177]. However, Barker argued that this one-way definition is not fully constitutive of all that representation encompasses. Rather, representations can also act in the opposite direction: They can constitute "reality" by constructing meaning for real objects, processes, and individuals. Therefore, in my research regarding mathematical representations in magazine advertisements, the representations come from conceptions of mathematics and mathematicians that exist in the "real world," but the advertisements' representations can also act to construct meaning for these concepts that are subsequently adopted by the real world.

Hall defined representation as "using language to say something meaningful about, or to represent, the world meaningfully, to other people" [21, page 15]. He further argued that representation can be viewed as a system comprised of "different ways of organizing, clustering, arranging and classifying concepts, and of establishing complex relations between them" [21, page 17]. One important aspect of organizing this system is the ability to discern what similarities and differences exist between concepts. Hall noted that individuals understand and make sense of concepts in the world in unique ways, although there are similarities between the conceptual maps that individuals build. Without these similarities, we would not have a shared culture of meanings about the social world, and we would thus have difficulty communicating.

Hence, relevant to my research, advertisers rely on magazine readers having a shared culture of meanings about mathematics and mathematicians; otherwise, the advertisers' references and representations would not make sense to readers.

I conceptualize magazine readers as active audience members, per active audience theory, which was proposed in the early 1980s by Brunsdon and Morley [50]. In this framework, viewing is conceptualized as an "*interpretative* activity, taking place over time" [50, page 20, emphasis in original]. Hence, interactions with media (i.e., viewing) are mediated by each viewer's life experiences and existing cognitive schemas. In this conception, there is no one "true" meaning in a media source; rather, individual viewers construct meaning through their own lenses, based on their own experiences and in relation to their sociocultural situations, in unique ways. These theories were used in this study to frame my understanding of mathematical representations in magazine advertisements, as well as the readers of magazines who are exposed to these advertisements.

4. Methodology

This study was completed in two stages, approximately a decade apart. In Phase 1 (late 2008), I selected six monthly magazines that were aimed at a variety of audiences in terms of gender, age cohort, socio-economic status, and topic of interest, plus were widely circulated and readily available in Canada. The selection of magazines was limited by those for which an entire year's worth of issues was available at the public library in the Canadian city in which the research took place. Information about the selected magazines is provided in Table 1.

Table 1: Information about the Magazines Analyzed in the Study

Title	Target Audience	Country of Publication
Parents	Mothers with young children	U.S.A.
Popular Science	Men interested in science and technology	U.S.A.
Report on Business	Businessmen	Canada
Runner's World	Serious runners of any gender	U.S.A.
Seventeen	Teenage girls	U.S.A.
Vogue	Women interested in haute couture	U.S.A.

My justification of the target audiences was based on an analysis of the magazines' content, as well as, where available, information about the magazines

provided on their websites (e.g., mission statement, subscription information). For example, although *Parents* is titled in a gender-neutral manner, the content of the magazine (e.g., advertisements for women's toiletries, covers mostly featuring mothers and children, articles about losing "baby weight") indicated that the target audience was mothers, rather than fathers or non-binary parents. Advertisers, of course, are well aware of magazines' audiences, with "advertising sold on the basis of the demographics of the audience expected to view the advertisements" [51, page 111].

After selecting the six magazines, I retrieved a year's worth of issues for the most recent year available at the city's public library (2008 for *Popular Science* and *Report on Business*; 2006 for the four other magazines). Although I could not locate the most recent year's issues for four of the magazines, I felt that 2006 was sufficiently recent to be acceptable for my analysis. Each magazine had monthly issues, save for *Report on Business*, which had a joint July/August issue; thus, I searched for advertisements in 11 issues of *Report on Business* and 12 issues of the other magazines.

For each magazine, I skimmed every page of each issue, looking for advertisements that would be relevant for my analysis. Although many advertisements include quantitative data, such as the cost of a product or the number of calories in an item, I only selected advertisements that I felt portrayed a mathematical message. Certainly, using quantitative data to increase the clout of an advertisement is a message in itself (see, for example, [14]), but that notion is beyond the scope of this project. Hence, I only selected advertisements that featured a mathematical message — that is, a message pertaining to mathematics and/or mathematicians. The selected advertisements were analyzed with regard to a wide variety of aspects, which will be discussed shortly.

In late 2017, I repeated the process by retrieving a year's worth of issues for all six magazines that were used in the first phase of the study; these issues were all from 2017. As the issues that were examined in Phase 1 were from 2006 and 2008, the issues that were examined for Phase 2 were therefore approximately a decade newer than those in Phase 1 were. Since the Phase 1 data collection occurred, some magazines' publication became less frequent. For example, *Seventeen* moved from monthly publications, as seen in Phase 1, to six publications per year, beginning in 2017. This decline has been attributed partly to cost-cutting measures, in an era with

declining use of print media, and partly to a focus on more online content [47]. The number of magazine issues analyzed is listed in Table 2.

Table 2: Number of Magazine Issues Analyzed in Phase 1 and Phase 2 of the Study

Title	Number of Issues in Phase 1	Number of Issues in Phase 2
Parents	12	12
Popular Science	12	6
Report on Business	11	10
Runner's World	12	11
Seventeen	12	6*
Vogue	12	12
Totals	71	57

(*) This number includes the December 2016/January 2017 issue. There was no February issue for *Seventeen* or *Runner's World* in Phase 2. In Phase 1 and Phase 2, there was a joint July/August issue of *Report on Business*. In Phase 2, there was no January issue of *Report on Business*.

The study was guided by the following research questions:

1) How frequently are mathematical representations present in magazine advertisements? Are there differences by magazine type?
2) What types of mathematical representations are present in magazine advertisements?
3) What differences in mathematical representations exist between advertisements for mathematical products and advertisements for other products? Are there differences in the types of products advertised by magazine type?
4) What gendered and racialized portrayals exist in mathematical advertisements?
5) Have the mathematical representations in magazine advertisements changed in the past decade?

To address these research questions, each selected advertisement (i.e., an advertisement involving a mathematical message) was analyzed with regard to the following aspects:

- Explicit mathematical messages
- Implicit mathematical messages

- Types of mathematical content
- Use of text
- Use of images
- Use of colour
- Inclusion of people
  - Gendered representations
  - Racialized representations
- Location of the advertisement

Using a table, detailed notes were taken about each aspect, with verbatim quotations copied into the table where relevant. Once each advertisement was analyzed individually, comparisons were made within each magazine and between the two phases of the study, as well as between advertisements for mathematical products (i.e., mathematics DVDs) and advertisements for other products (e.g., deodorant, cars).

5. Findings

In the following sections, I present the findings from the two phases of the study — Phase 1 (2006/2008 data) and Phase 2 (2017 data) — separately with respect to the following themes: (1) frequency of mathematical representations, (2) types of mathematical representations, (3) differences in mathematical representations by product and magazine, and (4) gendered and racialized trends. To conclude each thematic section, I draw comparisons between the two phases of the study to consider any changes in mathematical representations in magazine advertisements over the past decade. In the final section of the findings, I summarize trends across the two phases of the study.

5.1. Frequency of Mathematical Representations

In the following sections, I discuss the frequency and patterns of mathematical representations in the magazine advertisements, first in the Phase 1 sample and then in the Phase 2 sample. I begin by addressing the overall frequency of mathematical advertisements and then discuss the distribution of mathematical advertisements across the different magazines. I conclude by comparing the findings from the two phases of the study.

5.1.1. Phase 1 Findings

When searching for mathematical advertisements in Phase 1, I viewed approximately 10,000 pages of six different magazines (Note: I did not keep track of the number of pages in each issue of each magazine in Phase 1, but I was able to make an estimate using the Phase 2 data). Presuming that the selected magazines contained advertisements in the proportion common to the magazine industry (nearly 50% [45]), I may have viewed close to 5,000 pages of advertisements. The proportion of each magazine that was composed of advertisements varied widely. For instance, *Vogue* featured many advertisements (dozens of pages before the magazine's content began) whereas *Report on Business* had very few advertisements (10 or fewer pages per issue).

Even with such a large selection of advertisements, I only found 12 advertisements that contained any messages about mathematics and/or mathematicians. One advertisement was published in three issues and another was published twice; hence, mathematical advertisements were published 15 times across the Phase 1 sample. This paucity of mathematical advertisements was not a surprising finding, as mathematics and mathematicians tend to be marginalized in society, and are not usually viewed as "cool" or "trendy" (see, for example, [36, 37, 48]), messages that advertisers are frequently trying to convey about the products or services that they are trying to sell.

Unsurprisingly, the magazines about business and science/technology, fields related to mathematics, had several more mathematical advertisements than the other magazines did. Specifically, *Report on Business* had four advertisements (none repeated) whereas *Popular Science* had five advertisements (none repeated). Conversely, there was only one relevant advertisement in each of *Parents* (not repeated), *Runner's World* (published in two issues), and *Seventeen* (published in three issues). There were no relevant advertisements in *Vogue*.

5.1.2. Phase 2 Findings

In Phase 2, I kept track of precisely how many pages were in each magazine, with a total of 7,769 pages examined. Only five different mathematical advertisements were located, with one of the five repeated. Hence, less than 0.08% of the pages (6 of 7,769) of the magazines contained mathematical advertisements.

The five advertisements were published in three magazines, each with a different focus. Namely, there were two relevant advertisements (one repeated) in *Popular Science*, two relevant advertisements (not repeated) in *Parents*, and one relevant advertisement (not repeated) in *Vogue*. There were no relevant advertisements in *Seventeen* or *Runner's World*.

5.1.3. Comparison of Findings

To summarize, in Table 3, I provide a comparison of the number of issues examined in each phase of the study and the number of relevant advertisements located therein. In order to give a sense of readers' exposure to mathematical messages, the counts for the advertisements are the number of times that mathematical advertisements were present, rather than counts of different mathematical advertisements. For instance, in *Runner's World* in the Phase 1 sample, there was one mathematical advertisement, but it was published in two issues, so it is counted as two in the table.

Table 3: Frequency of Mathematical Advertisements per Issue, Phases 1 and 2

Title	# of Issues in Phase 1	# of Math. Ads	Math. Ads Per Issue	# of Issues in Phase 2	# of Math. Ads	Math. Ads Per Issue
Parents	12	1	0.08	12	2	0.17
Popular Science	12	5	0.42	6	3	0.50
Report on Business	11	4	0.36	10	0	0.00
Runner's World	12	2	0.17	11	0	0.00
Seventeen	12	3	0.25	6	0	0.00
Vogue	12	0	0.00	12	1	0.17
Totals	71	15	0.21	57	6	0.11

As shown in Table 3, mathematical advertisements were published 15 times in the 71 issues examined in Phase 1, compared to 6 times in the 57 issues examined in Phase 2. Hence, the ratio of mathematical advertisements per issue is higher in Phase 1 than in Phase 2 (0.21 vs. 0.11), which means that readers of these magazines approximately a decade ago would have seen mathematical advertisements more frequently than recent readers would.

In both phases, mathematical advertisements occurred most frequently in *Popular Science*, a magazine focused on the related fields of science and technology. In Phase 1, *Report on Business*, a magazine focused on another field related to mathematics, had the second most frequent occurrence of mathematical advertisements. In both phases, magazines with little mathematical

focus, *Runner's World*, *Seventeen*, and *Vogue*, had very few mathematical advertisements. It was somewhat surprising to see so few mathematical advertisements in *Parents*, a magazine that frequently focuses on educational topics.

5.2. Types of Mathematical Representations

Here, I begin by discussing the ways that mathematics and mathematicians were represented in the magazine advertisements located in each phase of the study. As part of this discussion, I address the amount and type of mathematical content that was present in the advertisements. I then draw comparisons between the two phases of the study in terms of mathematical representations.

5.2.1. Phase 1 Findings

Several of the messages about mathematics in the advertisements in Phase 1 were negative and reinforced stereotypes, such as the advertisements shown in Figure 1.

Figure 1: Ban deodorant advertisement (left; *Seventeen*, April, June, and July 2006 issues) and Gluskin Sheiff advertisement (right; *Report on Business*, July/August 2008 issue).

In the deodorant advertisement from *Seventeen* magazine, a young woman is shown doing mathematics on a chalkboard, with the phrase "BAN STRESS" overlaid. Hence, mathematics is depicted as something that causes stress. Problematically, the "mathematics" that is on the chalkboard is just a mish-mash of symbols and numbers. Nonsensical, "math-like" writing is often seen in popular media representations of mathematics; such representations make mathematics seem confusing and inaccessible to readers [20, 35]. In the second advertisement, for a wealth and risk management company, from *Report on Business*, numbers — and, by proxy, mathematics — are depicted as being "dry and dull." Thus, in both examples, mathematics is shown in a negative light, as stress-inducing and boring, respectively. Similarly, in an advertisement for probability DVDs from The Teaching Company (*Popular Science*, April 2008), it is implied that probability is typically boring and inaccessible: "Probability has never been more interesting and accessible than in these 12 lectures from The Teaching Company." Thus, even in a purportedly positive advertisement, negative ideas about probability are present.

In a few advertisements, mixed messages were provided about mathematics, such as an advertisement for a mathematics DVD (The Teaching Company: The Joy of Mathematics DVD, *Popular Science*, November 2008) in which mathematics was described as a subject that has "fun and beauty," but also where various facets of mathematics were described as "magically connected." As with the nonsensical "mathematics" in the *Seventeen* ad, describing mathematics as "magical" serves to make it seem impenetrable by the average reader.

Only the advertisements for building blocks and luxury cars featured clearly positive messages, with mathematics linked to being intelligent and successful. Namely, in an advertisement for Mega Bloks (*Parents*, December 2006), a child's arm is shown holding a spaceship made of Mega Bloks, and positive messages are provided: "Kids learn skills like math, problem solving, science and focus, while also building confidence. So one day, your child might achieve great things, whether it be in outer space or right here on earth." Hence, playing with blocks is depicted as a way to develop mathematical (and other) skills, which will lead to success in adult life. Likewise, a positive link to mathematics was seen in two similar advertisements for Saab cars (*Report on Business*, June 2008 and July/August 2008).

In each advertisement, a positive phrase (e.g., "Grip + Fun") is shown in parentheses, raised to the power of x. The description of the car relates to being smarter and faster: "evolved exponentially."

In terms of mathematical content, very little was shown in the 12 mathematical advertisements, with seven having no written (or other, such as graphical) mathematics shown. As mentioned, the two Saab advertisements featured exponents, but the mathematical equations, such as $(\text{Grip} + \text{Fun})^{\text{x}}$, don't actually make mathematical sense. Similarly, the "mathematics" in the Ban advertisement was nonsensical. In the two remaining advertisements, both for mathematics DVDs, the mathematics shown involved stylized numbers (The Teaching Company: The Joy of Mathematics DVD, *Popular Science*, November 2008) and a single-variable, worked out algebraic equation (The Teaching Company: Probability DVDs, *Popular Science*, April 2008). Although it is solved correctly, the equation does not involve standard conventions (e.g., $p \times 5$ is used instead of $5p$), and it is not clearly linked to probability. Hence, even in these mathematical advertisements, there is very little mathematical content.

5.2.2. Phase 2 Findings

In Phase 2, there were fewer mathematical advertisements located than in Phase 1, which may be partly related to the fact that *Popular Science* and *Seventeen* moved from monthly to bi-monthly publication in the time period between the phases of the study. Hence, 14 fewer issues were reviewed in Phase 2 than in Phase 1. Nonetheless, some interesting mathematical representations were present in the advertisements. Stereotypical ideas about mathematics were present in two advertisements from *Parents* magazine, shown in Figure 2.

In the Krusteaz pancake mix advertisement, a mathematics test is positioned as a difficult challenge to be overcome (with which pancakes will help). More specifically, the "difficult" topic selected was fractions. Although fractions are a known area of struggle for many students (see, for example, [4, 15]), it is notable that another subject area (and topic within that subject area) was not selected. The advertisers are drawing on the cultural trope of "Math is hard!", assuming that readers have shared experiences and views of the subject area (and a particular topic within it), rather than another subject area.

Figure 2: Krusteaz pancake mix advertisement (left; *Parents*, April 2017 issue) and Goodness Knows bars advertisement (right; *Parents*, January 2017 issue).

Although the message in the advertisement about Goodness Knows bars is subtler, it too draws on (assumed) shared cultural understanding: mathematics as proof/truth. By making the statement "We did the math," the advertisers are drawing on the idea that mathematics provides authority to claims, which is an idea raised earlier regarding the use of numbers and statistics in advertising [14]. Another interpretation of this statement is that the people at Goodness Knows did the mathematics so that the consumer did not have to do it, which is a negative message about mathematics avoidance.

Vogue featured one mathematical advertisement. In the last two pages of a seven-page spread for the high-end fashion manufacturer, Hermès, with the phrase "Objects come alive," a cone and an icosahedron were present with a variety of other items, as shown in Figure 3.

The cone appears to simply be a resting place for a magnifying glass, whereas the icosahedron — one of the Platonic solids — is floating above some jewellery. Presumably, most readers would simply see these three-dimensional shapes simply as regular objects, like the shoe and spinning top that are

Figure 3: Two-page advertisement from Hermès, published in the September 2017 issue of *Vogue* (pages 128-129).

also shown in the advertisement, rather than thinking of them as explicitly mathematical. Also, since *Vogue* has an extremely high proportion of advertisements, compared to the other magazines, it is possible that little attention would be paid to this one, particularly since it does not feature any models wearing clothing (like many of the advertisements in *Vogue*) and only features stylized versions of Hermès products.

In terms of mathematical content, three of the five advertisements had none shown. As noted, there were three-dimensional shapes in the Hermès advertisement, alongside several "everyday" items. In the final advertisement (The Secrets of Mental Math DVD, *Popular Science*, May/June 2017), the DVD case featured stylized numbers and symbols (e.g., addition sign, square root sign). Hence, very little mathematics was actually shown in these mathematical advertisements.

5.2.3. Comparison of Findings

Although the datasets from both phases of the study contained some advertisements with positive (or neutral/mixed) messaging about mathematics, negative stereotypes were also present. In the Phase 1 sample, such stereo-

types were more overt than in the Phase 2 sample. For instance, mathematics was explicitly linked to stress in the Ban deodorant advertisement in Phase 1, whereas mathematics was depicted as a challenge to overcome in the Krusteaz pancake mix advertisement in Phase 2. In 10 of the 17 advertisements (58.8%), no mathematical content was shown. In the remaining advertisements, the mathematical content was nonsensical, decorative (e.g., stylized numbers), or unrelated to the product.

5.3. Representations by Type of Product Advertised and Magazine

Throughout the process of analyzing the data for the study, I noticed that there were clear trends in the advertisements by type of product advertised. I therefore separated the advertisements into those for "mathematical products" and those for "other products." The former category contained advertisements for products that were explicitly mathematical (i.e., mathematics DVDs). The latter category contained advertisements for products that were not explicitly mathematical, such as deodorant, building blocks, cars, banking/financial services, and computer processors. Although some of these products are linked to mathematics, they are not products expressly about mathematics, like the mathematics DVDs.

In the following sections, I discuss the trends in mathematical representations by both product and magazine, as these two categories are strongly linked. Namely, all of the mathematical products (mathematics DVDs) were advertised in *Popular Science*, whereas the other products were advertised in the other magazines (with one such advertisement in *Popular Science*).

5.3.1. Phase 1 Findings

The advertisements for the mathematics DVDs were located in the back "advertisements" section of *Popular Science*, so they may have been overlooked by readers. Conversely, the advertisements for the other products were featured throughout the magazines, plus contained bright colours and large images. There were no images of any people in the DVD advertisements, whereas people (entire people or body parts) featured in four of the other advertisements (i.e., half of the advertisements for other products), as will be discussed in detail in the next section. As shown in Figure 4, the DVD advertisements tended to lack colour and images. These advertisements contained a substantial amount of text, far more than the other advertisements.

Advertisement

We've Got the Right Equation: Learning Algebra I

30 Recorded Lessons from The Teaching Company

Teaching algebra in most of today's classrooms is not significantly different from what it was 50 years ago. Certainly, there have been some attempts to change algebra instruction, such as the "new math" reform movement of the 1960s. But the changes that persist in today's algebra curricula as a result of that movement are more superficial than substantial.

On the other hand, mathematics and its applications have changed spectacularly in the past 50 years. The advent of technology, for example, in both applied and pure mathematics, has changed the way mathematicians, scientists, and social scientists do and use mathematics.

It is high time for classroom instruction of algebra to reflect some of these changes. This is why, in some exciting, interactive, hands-on algebra classes, we are beginning to see changes in what, how, and to what ends mathematics is being taught.

Our **Algebra I** course is on the cutting edge of mathematics teaching and learning for the many reasons stated below.

The Approach to Algebra in a Technological World

Inspired and informed by research on the teaching and learning of algebra, Dr. Monica Neagoy gives functions a more major role in her **Algebra I** course design.

After a historical overview of the evolution of algebra, she explores the various families of functions in a logical and motivating order from linear to quadratic to rational and, finally, to the family of exponential functions. Each family serves as the building block for understanding the following, and more advanced family of functions.

The penultimate section addresses systems of equations and inequalities—taken from among the families studied in previous sections—and the final section looks to the future by giving a taste of fascinating, factual and captivating civics.

Algebra I has a well-established reputation as one of the primary gatekeepers for access to college, and for access to competitive public and private institutions.

Dr. Neagoy uses historical anecdotes, stories, and myths about mathematicians to humanize their work and the problems they were trying to solve. Concrete models such as prisms, cubes, and discs are employed to help students connect algebraic expressions with the shapes and quantities they describe. Finally, graphing calculators are used throughout this course to illustrate key concepts and enhance student understanding.

About The Teaching Company

We review hundreds of top-rated professors from America's best colleges and universities each year. From this extraordinary group we choose only those rated highest by panels of our customers. Fewer than 10% of these world-class scholar-teachers are selected to make The Great Courses. We've been doing this since 1990, producing more than 4,000 hours of material in modern and ancient history, philosophy, literature, fine arts, the sciences, and mathematics for intelligent, engaged, adult lifelong learners. If a course is ever less than completely satisfying, you are welcome to for another or we will refund your money promptly.

Lecture Titles

1. An Overview
2. The Evolution of Numbers
3. The Language of Algebra
4. Exploring Functions with (Or Aid of) Graphing Calculators
5. Linear Functions—Introductory Explorations
6. Multiple Representations of Linear Functions
7. The Geometry of Linear Function Graphs
8. Words, Equations, Numbers, and Graphs
9. Problem Solving with Linear Equations
10. Modeling Real-World Data with Linear Functions
11. Linear Functions and Geometry
12. Quadratic Functions—Introductory Explorations I
13. Quadratic Functions—Introductory Explorations II
14. The Geometry of Quadratic Function Graphs
15. Words, Equations, Numbers, and Graphs
16. Problem Solving with Quadratic Equations
17. Modeling Real-World Data with Quadratic Functions
18. Polynomial Expressions (Degree Greater than Two)
19. Rational Functions—Introductory Explorations
20. The Geometry of Rational Function Graphs
21. Working with Rational Functions and Equations
22. Exponential Functions—Introductory Explorations
23. The Geometry of Exponential Function Graphs
24. Working with Exponential Functions and Equations
25. Systems of Linear Functions and Equations
26. Using Matrices to Solve Linear Systems
27. Systems of Functions and Equations
28. Systems of Inequalities
29. Inverting Functions—Looking at Them in Reverse
30. Using Intuition as a Problem Solving Tool

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Figure 4: Advertisement for algebra DVDs (*Popular Science*, March 2008).

The differences in advertisement styles may be because the companies that sell mathematics DVDs do not have the advertising budget of major corporations; thus, they cannot afford prime locations in the magazine or colour advertising. Nonetheless, a black-and-white, text-heavy advertisement surely is not engaging to a reader, and does not help with mathematics' image as dull and boring. Furthermore, if readers view mathematics as irrelevant and outmoded, such views may be reinforced by the DVD advertisements, since the content is being sold in an outdated medium (particularly by the time that the Phase 2 sample was collected), a DVD.

In terms of the messaging by product, the advertisements for the mathematics DVDs were mixed, with some presenting mathematics as an exciting field and others presenting mathematics as a difficult field. Similarly, mixed messaging was present in the other advertisements, with some depicting mathematics as difficult (Ban deodorant ad) and others depicting mathematics as a useful, beneficial subject (Mega Bloks). Hence, there were no clear trends by product type (i.e., mathematical or other) in terms of the messaging of the advertisements.

5.3.2. Phase 2 Findings

In the Phase 2 sample, the five mathematical advertisements were fairly balanced between mathematical products and other products — mathematics DVDs (two advertisements), pancake mix (one), granola bars (one), and fashion accessories (one) — and all were in colour. However, the advertisements for the mathematics DVDs had far more text than the advertisements for the other products. Only one of the advertisements (pancake mix) contained a person. The advertisements for the mathematics DVDs were at the back of the magazine (*Popular Science*), in a section with many other advertisements, which most readers would presumably skip over. In contrast, the advertisements for the other products were within the body of the magazine, so would more likely be noticed by readers.

The advertisements for the mathematics DVDs were mixed in terms of their messaging. The Math Tutor DVDs (*Popular Science*, January/February 2017 and March/April 2017) were focused on people having problems with mathematics, implying that such a situation was common and that everyone needed help with mathematics. In contrast, the Secrets of Mental Math DVDs (*Popular Science*, May/June 2017) had a message about mathematics being an advantageous ability in various aspects of life: "This powerful ability to perform mental calculations will give you an edge in business, at school, at work, or anywhere else that you encounter math."

The messaging about mathematics in the advertisements for the other products was less positive: It was neutral for the fashion accessories, mixed for the granola bars, and negative for the pancake mix. It is concerning that negative messages about mathematics are targeted at parents with young children, as the advertisement that included negative sentiments about mathematics was in *Parents* magazine. As noted earlier, many parents have poor relationships with mathematics, and they can pass along these feelings, such as mathematics anxiety, to their children (see, for example, [18, 29]). Exposure to such messages about mathematics through magazine advertisements can reinforce such views.

5.3.3. Comparison of Findings

In both phases, the advertisements for mathematical products were very text-heavy and, in the Phase 1 sample, devoid of colour. In both phases, no people were featured in the mathematical product advertisements, possibly signify-

ing mathematics as a dehumanized subject area. These advertisements, all in *Popular Science*, were at the back of the magazine, amongst many other advertisements, and likely would not have been noticed by most readers. In contrast, the advertisements for the other products were prominently placed amongst the magazines' content and were colourful, often with large images. Some of these advertisements featured people, in whole or in part. There were no clear trends in terms of the messaging for the mathematical products or the other products.

5.4. Gendered and Racialized Trends

In this section, I discuss the gendered and racialized trends in the mathematical advertisements. Beyond the images, the language used and the information included (e.g., names of professors for mathematics DVDs) were also analyzed for gendered and racialized representations.

5.4.1. Phase 1 Findings

In Phase 1, only four of the 12 advertisements (33.3%) featured images of people. A summary of these four advertisements, with regard to gendered and racialized images, is shown in Table 4. I acknowledge that attributing gender and race to images of people is a challenging and sometimes contentious practice. Where possible, I used contextual clues (e.g., names) and clothing (e.g., business suit) as signifiers to make this practice as accurate and transparent as possible.

As detailed in Table 4, there were girls, boys, men, and women present in the images of the advertisements. However, people were typically not the focus of these advertisements — either just body parts were the focus (e.g., the hand holding the beaker) or just a small photograph of a whole person/people was provided. The only advertisement where a person featured prominently was the Ban deodorant advertisement, which showed several photographs of the same young woman; as noted earlier, though, this advertisement linked mathematics with stress, a negative representation. In terms of racialized representations, the people and body parts were all White.

In the advertisements that did not feature images of people, no clear racialized information was provided, although gendered information was provided. Namely, in the Gluskin/Sheff Wealth and Risk Management advertisement (See Figure 1; *Report on Business*, July/August 2008), both of the contact names provided are those typically associated with men.

Table 4: Gendered and Racialized Images in Phase 1 Advertisements

Advertisement	Magazine	Issue(s)	Gendered Representations	Racialized Representations
Ban deodorant	*Seventeen*	April, June, and July 2006	Young woman	White
Canada's Credit Unions	*Report on Business*	October 2008	Man's arm holding a beaker	White
Citi	*Runner's World*	January and March 2006	Father with daughter and son	White (all three people)
Mega Blocks	*Parents*	December 2006	Little boy on box (corner of advertisement); non-gendered bare arm holding blocks (main portion)	White (boy and arm)

Similarly, in the three mathematics DVD advertisements featuring names (The Teaching Company: Learning Algebra 1 DVDs, The Teaching Company: Probability DVDs, and The Teaching Company: The Joy of Mathematics DVDs; all from *Popular Science*, March, April, and November 2008), two of the three names provided are those typically associated with men.

5.4.2. Phase 2 Findings

In Phase 2, only one of the five advertisements (20.0%) featured images of people. Namely, the advertisement for Krusteaz pancake mix (*Parents*, April 2017) included an image of a woman, whose head was not included in the image (see Figure 2). The woman has light brown skin and curly hair, so her racial identity is unclear. The woman is serving pancakes to help an unidentified child "crush" a math test focused on fractions. Hence, the woman is portrayed in a traditional caregiver role, providing food for her child.

In the advertisements that did not feature images of people, the only advertisement that had any relevant information about gender was an advertisement for four different educational DVDs from The Great Courses. One of these DVDs was entitled "The Secrets of Mental Math" and featured Professor Arthur T. Benjamin as the instructor. All four DVDs in this advertisement (for a variety of topics) featured men as instructors.

5.4.3. Comparison of Findings

Across the two phases of the study, only five advertisements (29.4% of the entire dataset) contained images of people, either whole people or simply body parts. This lack of people in the mathematical advertisements may be related to conceptions of mathematics as dehumanized [10, 16]. Nearly all of the people who were shown were White, which could be indicative of an over-representation of White people in popular media generally [40, 41] rather than a stereotype regarding White people and mathematics. Typically, girls and women were shown in stereotypically gendered roles, like homemaking and having mathematics anxiety, whereas boys and men were featured in advertisements where the messaging about mathematics was more positive.

Considering the dataset more broadly, it is important to note that, in both phases of the study, the advertisements for mathematical products were all in *Popular Science*, a magazine targeted at men. Of the advertisements for other products, the more strongly mathematically-linked items (e.g., banking/financial services) were in *Report on Business*, another magazine targeted at men. Thus, women readers typically would have less exposure to mathematical advertisements, based on typical readership of the magazines, and many of the advertisements in the magazines targeted at women (i.e., *Parents*, *Seventeen*, and *Vogue*) had negative messages about mathematics.

5.5. Comparison of Mathematical Representations by Phase

In general, there were very few mathematical advertisements in the dataset, but such advertisements were more common in Phase 1 than in Phase 2. In both phases, magazines focused on the related fields of science and business (i.e., *Popular Science* and *Report on Business*) had more mathematical advertisements than did the other magazines, and all of the advertisements for mathematical products (i.e., mathematics DVDs) were in *Popular Science*.

In Phase 1, negative stereotypes about mathematics were more explicit than they were in Phase 2. In both phases, a variety of messages (positive, negative, and neutral/mixed) about mathematics were found in the advertisements, and there were no clear trends in messaging by type of product advertised (mathematical or other). Very little mathematical content was present in the mathematical advertisements, and the content that did exist was nonsensical, decorative, or unrelated to the product.

In both phases, the advertisements for mathematical products were text-heavy and featured at the back of the magazine, likely not to be noticed by readers. The advertisements for the other products were more centrally located and were full colour advertisements, with little text.

Again, findings were similar in both phases when considering gendered and racialized representations. Few people were shown (in whole or part), and when they were shown, the gendered representations tended to be stereotypical. The racialized representations were typical of the broader media landscape in terms of the overrepresentation of White people.

Therefore, the datasets from the two phases of the study were marked by more similarities than differences in terms of the messaging about mathematics and mathematicians that was shown. The main difference was the decreased frequency of mathematical advertisements from Phase 1 to Phase 2, but the initial frequency was already a very low baseline.

6. Discussion and Conclusion

Not only are negative stereotypes about mathematics and mathematicians being perpetuated in advertisements in mainstream magazines, but mathematical representations are sorely lacking in this type of advertising. Only 17 different mathematical advertisements were located within 128 magazine issues, which contained approximately 18,000 pages. Mathematics is often treated as an invisibility in our culture [30], and this conception is reflected in the magazines' advertisements. Such findings regarding a lack of mathematical advertisements were also present in Evans *et al.*'s [9, 11, 12, 13] analysis of advertisements in newspapers. Advertisers of mathematics-related products and services may not feel the need to advertise in popular magazines whose readers do not see mathematics as relevant to their lives, even in applied contexts. Even *Parents* magazine, which features many educational products for children, only contained three mathematics-related advertisements across the two phases of the study. Another possible explanation for the lack of mathematical advertisements is advertisers' desire to make their products and services seem trendy and desirable, characteristics that are rarely linked to mathematics [48].

In the magazine advertisements that contained mathematics-related representations, mathematics was typically presented as difficult and/or boring.

As discussed, most of the mathematical advertisements (12 of 17; 70.6%) were completely devoid of images of people. Such representations may be indicative of a common perception of mathematics as dehumanized subject area [10, 16]. With regard to racialized representations, generally, magazine advertisements have been shown [38, 43] to be overpopulated with White people, relative to their proportion in the population. Hence, the lack of representation of people of colour in the mathematical advertisements may be part of a broader advertising landscape in which White people are overrepresented, rather than a particular association between Whiteness and mathematics (e.g., the "old, White guy" mathematician trope).

With regard to gendered representations, the mathematical advertisements were often for products targeted at and fields dominated by men (e.g., investment banking, business) and in magazines typically read by men (e.g., *Popular Science*). The mathematical advertisements that were targeted at women typically had gender-stereotyped messages about mathematics and about broader societal roles. Although magazine advertisements may be a marginal type of media source, my gender-related findings align with those of researchers who explored television shows, movies, and books for representations of mathematics and mathematicians (see, for example, [20, 31]). This very alignment, even in such a marginal media source, shows how deeply entrenched mathematics stereotypes are in North American popular culture and society.

The mathematical representations in these mainstream magazine advertisements are part of a larger cultural milieu surrounding mathematics and mathematicians, and there were representative examples in the non-advertisement portions of the magazines. For instance, the May 2017 issue of *Runner's World* (which did not have any mathematical advertisements in the Phase 2 sample) featured an article about a mathematics professor who is also a marathon runner. The title of the article was "Fleet Geek," and the professor was referred to as a "running nerd." Thus, even though there were no mathematical representations in this magazine in the Phase 2 sample, readers would be exposed to mathematical stereotypes through the magazine's content, even though it was not a mathematics-focused magazine.

Although magazine advertisements are a marginal media source, exposure to their negative, stereotypical messages serves to reify the tropes therein and to reinforce negative images of and attitudes toward mathematics.

Examining factors that may influence attitudes toward mathematics is a significant undertaking because several researchers (see, for example, [6, 27]) have shown that students' views toward mathematics influence their achievement and participation in the subject area. In other words, if negative images of mathematics and mathematicians in the media and society are internalized by students, they may want to dissociate themselves from the subject area. Thus, this may lead to avoidance, negative attitudes, and ultimately, a lack of success in mathematics.

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