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Writing about mathematics

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1. Introduction

Writing about mathematics and explaining it to a layperson is difficult - especially in the mass media. Many professional mathematicians in Germany are disappointed at the newspapers that publish only a few news stories about mathematics. This does not correspond to the importance of mathematics in the natural sciences and the economy, they say and emphasize the slogan: "High technology is always mathematical technology." In some sense they are right: a CD player, computer tomography or the quick delivery of goods all around the world were not manageable without mathematics.

In the following I want to present some ideas and results on which I work in my dissertation thesis. My goal is to describe with linguistic methods why it is so difficult to explain mathematics to a wider audience. My corpus includes papers that were published in mathematical journals, textbooks that are used at school and at university, popular science books and articles that appeared in science magazines like "Scientific American", newspaper articles and children’s books. In a first step I arrange these texts in text classes called "Textsorten" (text types). The second step is to determine the different professional degrees (Fachlichkeitsgrade) of these text types.

In the 1980s linguists have started to ask the question of how to describe the linguistic structure of texts that were written for experts or laypersons. Since today there are no empirical studies on this topic. As a mathematician and journalist my goal is to determine how to write about mathematics in a good style. Since I work as a freelance science writer I am steadily searching for good strategies to sell mathematics to newspaper editors. Here, I will present some theses I found by analyzing newspaper articles about mathematics.

Two main questions lead to the discussion: How does mathematics get into in the newspaper? How does it look like when it appears in the newspaper?

2. How mathematics gets into the newspaper

The articles I have collected in the corpus appeared in German daily and weekly newspapers from 1993 to 1996. I collected 216 texts, among them news stories from the weekly newspapers "Die Zeit" (25) and "Der Spiegel" (12), from the national daily newspapers "Frankfurter Allgemeine Zeitung" (42), "Frankfurter Rundschau" (17), "Süddeutsche Zeitung" (37), "Die Welt" (34) and two local newspapers from the Würzburg area in southeastern Germany, "Main Post" (41), "Volksblatt" (8). I did mix daily and weekly newspapers as well as national and local newspapers, because I hope to notice differences between their reporting. As I know, this collection of news stories is complete in the sense that the corpus includes all articles that appeared in the given period of time in the newspapers I took into consideration.

Although I have no data with which I could compare the reporting on mathematics with the reporting on other sciences, I conceive the number of 216 texts as low. This supports the suspicion that mathematics do have a shadowy existence in the mass media.

The different numbers of texts about mathematics in the different newspapers is a direct consequence of different concepts of science reporting. Perhaps the rumor that the editors of "Der Spiegel" do not like mathematics is not true. But obviously "Die Zeit" cultivates a high-level reporting on mathematics. The science section of "Frankfurter Rundschau" encompass only one page per week; the weekly science section of "Frankfurter Allgemeine Zeitung" has up to three pages. Even the way of reporting science news differs, too. In the local newspapers one can find more news about the mathematical life at the university than articles about new mathematical results. In the national newspapers it is the other way around.

I arranged the 216 articles in eight text types that can be distinguished by text internal criterions; among these are for example the headline structures, the numbers of columns, the number of paragraphs, the use of pictures, intertextual references and stilistic features. I distinguish - now in german - "Bericht" (130), "Reportage" (1), "Meldung" (53), "Kurzmeldung" (20), "Bild-Text-Kombination" (7), "Interviews" (3), "Glosse" (1) and "Serie" (1).

It is important to mention that this division is due to linguistic methods and differs from usual arrangements made by journalists. For example, I do not seperate news from commentaries. This is reasonable because all articles in the corpus do have commentary paragraphs. As a consequence book reviews are seen as variants on "Berichte" or "Meldungen".

It is interesting to look at the topics of the articles. They stretch from pure mathematical results to personal news. 56 articles are about mathematical achievements. Topics are for example a new proof of a theorem or a recently found large prime number. There are also articles about applications of mathematics like chaos theory or signal processing (55). I have chosen those of these news stories for my corpus that explicitly quote mathematicians or mention mathematical research. The subject of no less than 46 articles is the lively mathematical community. New appointments, honours, birthdays and deaths are reported. Science policy is the main topic in 19 articles. Mathematical congresses are reported in 5 articles. And finally there are 35 book or CD reviews.

Let’s have a look on the references that appear in the newspaper articles. In each of the articles about the mathematical life the occasions of reporting is mentioned. (for example a new book that is published or the birthday of a scientist). The articles about mathematical results often seem not to have a special occasion (35 of 111 texts). 42 articles of them do not mention a printed reference but name mathematicians, or it is obvious that the journalist used a reference that is not mentioned. 34 texts contain an explicit reference to a more scientific publication. Most of these articles refer to the popular science magazines "Scientific American" (7), "New Scientist" (6) and "Science" (10). This is interesting because articles in these magazines are already written in a popular style. In addition, these magazines are not specialized in mathematics. Some of the articles about applications of mathematics refer to physical or other technical journals. Mathematical journals are not mentioned. Perhaps they are to complicate to be understood by journalists. But even more popular mathematical magazines are not often named (twice the Notices of the German Mathematical Union, one time the "Mathematical Intelligencer").

To sum up: About the half of the articles about mathematics talk about the mathematical community. The other half report on mathematical results and their applications. If references are mentioned they do not name any mathematical journals. Topics are taken mostly from popular science magazines like "Scientific American" or "New Scientist".

3. How mathematics looks like in the newspaper

Journalists want to tell stories. Therefore, even mathematics must become a surprising story. A first look at the newspaper articles proves that all these stories have a similar structure. The first sentence leads the reader to the topic of the article. After this, the news is told: for example a new result, a new proof or a gap in an existing proof. Then the journalist explains some mathematical facts and the scientific landscape around them. The articles close with a commentary and a conclusion.

The first sentences mostly reveal the story the journalist wants to tell. Let us call these first sentences "lead". The leads can be classified in ten different classes. I would like to mention some of them.

Most articles begin like a classic news story (69), most of them are about birthdays or honours (31), some of them report on new scientific achievements (14). Another strategy is to start with a recent development in mathematics, for example the conclusion that the chaos theory is booming or that randomness recently gets a wide attention among mathematicians (16). Long articles often start with some kind of wisdom or proverb (23), examples: 'To share must be practiced early.', 'The proof of the pudding is in the eating.', 'A picture tells more than thousand words.'

The most characteristic way to begin articles about mathematics is to name a prejudice on mathematics followed by a counter-evidence (21). The stories told are like the following: 'To explain mathematics is not possible - but here is a beating counterexample.', 'Mathematics produces sad people - here I show you somebody that loves maths.', 'Most people have bad experiences with mathematics - here is a piece of maths that everybody can enjoy.', 'Mathematics is the most objective science - but sometimes there are bad arguments.'

One conclusion might be possible: The leads mirror the stories that are around mathematics. Journalists who have a collection of these leads in mind will find more easily mathematical topics that can be explained in the newspaper.

4. Formulas and terms

The language of mathematics is like each language for special purpose characterized by precision and economy. These properties are mirrored in mathematical terms that have a strict definition, in the formulas and in the mathematical proofs that consist of chains of logical arguments.

4.1. Formulas

From a linguistic point of view, mathematical formulas are alien elements in a text. They are not words and can be seen as a different semiotic structure. Nevertheless formulas often take up the syntactic function of nouns. In order to have a unified vocabulary I regard numerals and letters as formulas of least complexity.

The meaning of formulas is determined by a strict syntax and some strictly defined components. In newspaper articles their meaning can completely change. A reader that cannot grasp the meaning of a formula will see it as a symbol of the incomprehensable mathematics. Roland Barthes called this phenomenon mythic, although he had different linguistic structures in mind.

Let’s have a look at the following sentences.

(1) Aber was soll der Laie mit der Kenntnis anfangen, daß die Mathematiker in einer Abstimmung "eipi=-1" zum schönsten mathematischen Satz erkoren haben? Normalmenschen können daraus nur schließen, daß Mathematiker in einer Formelwelt leben, die ihnen unzugänglich ist.
[Zeit, 12.7.96 'Unterhaltsames Bauwerk Mathematik']

(2) Die exakte Zahl verschiedener Springerkreise wurde nun erstmals an der Universität Dortmund von Martin Löbbing und Ingo Wegener mit Rechnerhilfe bestimmt. Sie beträgt 33439123484294.
[FR, 18.5.96 'Springerkreise erstmals berechnet']

(3) Die Gleichung xn+yn=zn notierte der Richter am Toulouser Parlament, habe, wenn x, y und z ganze Zahlen ungleich null sind, für ganzzahlige Exponenten größer 2 keine Lösung. Wenn die Hochzahl 2 ist, gibt es beliebig viele Lösungen. Generationen von Schülern kennen diesen Fall als den Lehrsatz von Pythagoras, wonach die Quadrate über den Seiten eines rechtwinkligen Dreiecks sich immer schön addieren: a2+b2=c2. Bei 32+42=52 beispielsweise geht die Gleichung auf, denn 9+16=25.

[Spiegel, 26/1993 ’Griff nach dem Gral’]

(4) "Zeige, daß der Bruch (21n+4):(14n+3) für keine natürliche Zahl n zu kürzen ist" [...]
Der oben gefragte Beweis für n (internationale Mathematik-Olympiade 1959) findet sich natürlich in der jüngsten Ausgabe des Monoids.
[Zeit, 15.1.93 'Sekt, Gold und Mathematik']

(1') What is a layperson supposed to do with the fact that mathematicians elected "eipi=-1" as the most beautiful mathematical theorem? The average person can only conclude that mathematicians live in a world of formulas that is inaccesable for him.
[Zeit, 12.7.96 'Unterhaltsames Bauwerk Mathematik']

(2') The exact number of different knight circles has been computed with electronic help at the University of Dortmund by Martin Löbbing and Ingo Wegner. It is 33439123484294.
[FR, 18.5.96 'Springerkreise erstmals berechnet']

(3') The judge at the parliament of Toulouse wrote, that the equation xn+yn=zn has no solution for integer exponents larger than 2 if x, y, and z are nonzero integers. If the exponent equals 2, there are infinitely many solutions. Generations of students know this case as law of Phythagoras, which says that the squares of the sides of a right-triangle add up nicely: a2+b2=c2. For example, with 32+42=52 the equation works out, because 9+16=25.
[Spiegel, 26/1993 'Griff nach dem Gral']

(4') "Show that the fraction (21n+4):(14n+3) cannot be cancelled down for any natural number n." [...]
Of course, the proof for n asked for above (International Olympic Games of Mathematics 1959) can be found in the new volume of Monoids.
[Zeit, 15.1.93 'Sekt, Gold und Mathematik']

In example (1) the formula is not explained. It is written down and put into quotation marks. This indicates a distance between the author and the formula. In addition, the sentence includes a commentary that makes sure that the formula is understood as a symbol showing the incomprehensable mathematics.

The formula in example (2) is a number. It is part of the news, because it names the number of knight circles recently found. But this number also demonstrates something different. By its length it is a kind of picture and shows how large this number is and that the calculation is obviously exact.

In example (3) the formulas are part of an explanation. First it is mentioned, then it is deconstructed step by step. The author explains the letters in the formula. After this, a special case of the formula is written down and numbers are put in. Now we have reached a formula of zero complexity.

Example (4) is of particular interest. The first sentence appeared in the first paragraph of the quoted article. The second sentence is the last sentence of the news story. The letter "n" is a part of the formula in the first sentence and serves as a reference to the formula above. Many journalists try to connect the first and the last paragraph of a news story. Here, this is carried out by a formula and one of its parts. The first sentence is a question. The last sentence refers to its solution.

4.2. Terms

Mathematical terms are based on definitions. These definitions fix the properties of the mathematical objects and determine how mathematicians have to work with them in logical arguments. These definitions cannot be reported in the newspaper; it would be too complicated. But it is wrong to think that only definitions shape the meaning of mathematical terms. There are also theorems describing their properties, and - most important in our case - the mathematicians do have an intuition about their objects. These intuitions are often part of a deeper understanding of the mathematical structures that is hidden by formulas. Of course, it is not possible to do mathematics in the newspaper, but it is possible to explicitly write down the intuitions of mathematicians. Four examples:

(5) Am Ende des achtzehnten Jahrhunderts hat er [Charles Babbage] sich mit sogenannten elliptischen Kurven beschäftigt.
[FAZ, 5.10.94 'Der Computer rechnet mit']

(6) Er [Lions] wurde für seine Arbeiten zu nichtlinearen partiellen Differentialgleichungen gewürdigt: Mit derartigen Gleichungen werden etwa turbulente Strömungen von Gasen und Flüssigkeiten beschrieben. Sie spielen bei der Konstruktion von Automobilen und Flugzeugen eine wichtige Rolle, lassen sich aber meist nicht exakt lösen.
[SZ, 18.8.94 'Zahlenkünstler unter sich']

(7) Die fraktale Geometrie, ein Zweig der Chaosforschung, erhitzt die Gemüter. [...]
Die Fraktale Geometrie ist populärer als die Mathematik wohl jemals in ihrer viertausendjährigen Geschichte war. Jeder Gymnasiast kennt ihr Aushängeschild: eine bizarre, sich bis ins Unendliche verästelnde Computergraphik namens Apfelmännchen oder Mandelbrot-Menge (so benannt nach ihren Entdecker Benoit Mandelbrot).
[Zeit, 20.5.94 'Streit ums Chaos']

(8) Yoccoz gelang es zu beweisen, daß fast alle Punkte einer Mandelbrot-Menge eine "lokal zusammenhängende Umgebung" besitzten, was in etwa besagt, daß die selbstähnlichen Gebilde im kleinen wie aus "einem Guß" aussehen und sich nicht auflösen.
[SZ, 18.8.94 'Zahlenkünstler unter sich']

(5') In the end of the 18th century Charles Babbage dealt with "so-called" elliptic curves.
[FAZ, 5.10.94 'Der Computer rechnet mit']

(6') Lions was honoured for his work on nonlinear partial differential equations: These equations describe for

example turbulences of gas and liquids. They play an important role in the construction process of cars and aircrafts, but they often cannot be solved exactly.
[SZ, 18.8.94 'Zahlenkünstler unter sich']

(7') The fractal geometry, a branch of chaos theory, whips up feeling. [...]
The fractal geometry is more popular than mathematics has been in its history of four thousand years. Each high school student knows its advertisment: this bizarre computer graphic that branches out into infinity and that is called 'little apple man' [Apfelmännchen] or Mandelbrot set (named after its discoverer Benoit Mandelbrot).
[Zeit, 20.5.94 'Streit ums Chaos']

(8') Yoccoz proved that almost all point of the Mandelbrot set have a "local connected neighborhood", that means more or less, that this pattern whose parts are always similar to the whole structure looks in the small scale like "a unified whole" and does not dissolve.
[SZ, 18.8.94 'Zahlenkünstler unter sich']

In example (5) the term "elliptic curve" is not explained, but it is marked as a technical term. This is achieved by the German adjective "sogenannt". To avoid a specific explanation the adjective "complicated" is used or remarks such as "this cannot be explained to a layperson".

The other examples show with which strategies it is possible to explain terms. In example (6) the term "nonlinear partial differential equation" is not really explained, but the author mention where these objects are used. In example (7) the term "fractal geometry" is characterized by several non-mathematical properties: the Mandelbrot set is mentioned as the most popular object of chaos theory. Its appearance is reported as well as its naming and its nickname.

Example (8) focusses on the properties of the Mandelbrot set. Here, the quotation marks show that the term is a technical term. Afterwards it is explained with help of the metaphor "as a unified whole". The german metaphor "aus einem Guß" can be translated as "like one casting". The journalist marks the explanation as vague by writing "more or less". The same is true for the quotation marks around the metaphor. The metaphors obviously reveals the intuition of mathematicians handling the Mandelbrot set.

Up to this we can conclude: Linguistic structures that characterize the language of mathematics can be used systematically in order to write about mathematics in a comprehensive way.

Formulas can be explained by analyzing them step by step and calculate them with numbers. Formulas can picture large numbers simply by their appearance. As incomprehensable alien elements in a text they even can symbolize the incomprehensible mathematics as a whole.

There are several strategies of how to explain mathematical terms. They can be marked as technical terms by using quotation marks or adjectives. Mostly, the exact meaning of mathematical terms cannot be explained, but it is possible to give a hint how to understand them. The journalist can use the history and naming of the term or its appearance as a mathematical object. Metaphors can make the intuition of mathematicians explicit.

5. Conclusion

The results out of this study of articles about mathematics that appeared in German newspapers could have helpful consequences for the work of journalists.

Mathematicians that often complain about the fact that there is so little mathematics in the media could help to improve the reporting on mathematics. Obviously there is a lack of popular science articles about mathematics that can be used by journalists. These articles should be on the level of the science reports in the "Scientific American" or the "New Scientist". Mathematical magazines published for a wider audience could be the right media for this, especially the notices of the mathematical societies or the "Mathematical Intelligencer".

There are linguistic strategies for journalists. A collection of probable leads help to make a story out of mathematical achievements. Some means are the disproving of prejudices about mathematics as well as wisdoms or proverbs that are related to a mathematical achievement. In addition, formulas and terms can be handled skilfully even in the newspaper. The best way is to formulate the intuition of mathematicians explicitly, for example with metaphors. This avoids trying to explain their mathematical meaning, that is not possible in a news story.

The results presented here are preliminary. My dissertation thesis should extend them. I also see the need of a wider empirical study. Newspaper articles are on a low level of complexity. I expect that there are several new linguistic structures and writing strategies in the popular science stories that appear in magazines like "Scientific American".

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