

Soft skills for Mathematicians

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Preface

This book has been written when giving a PhD course at the Department of Mathematics and Stockholm University on 4 occasions between 2014 and 2024.

Thanks to ...

Chapter 1

Popularizing mathematics

Chapter ?? dealt with writing of scientific papers aimed for being published in internationally peer review journals in the mathematical sciences. In the current chapter we discuss how to write and present popular texts, still containing mathematical material. It is worth pointing out that there are many other ways to popularize mathematics, for example interactive softwares, YouTube-clips, games and more. The Section is devoted to writing popular texts mainly because I have too little knowledge about how to create interactive software or other mathematical "edutainment". It is my hope and belief that some of the ideas of the current section applies also to these more modern methods. But surely there are also differences and I encourage the interested reader to search for advice for such popularizing means from other sources.

1.1 Writing popular texts

There are of course many similarities between writing a mathematical paper and a popular math text, just like any scientific writing share many recommendations. But there are also differences. Below I try to describe what is similar and what is different.

You should have three main goals when writing a popular text in mathematics. First, the reader should learn some mathematics, so something should be shown/derived. Secondly, this should make the reader understand some new concept or similar, so the reader should realize the usefulness of the result. Finally, you should aim at making the reader want to learn even more,

for instance you can end by asking new questions that are not addressed in the current text.

Suppose you want to write a text containing mathematics but aimed for a more general public. The first thing to specify is, as when writing a scientific paper, what do you want to say, who is the reader and how to structure the paper (Halmos, 1971). Even for a popular text, the intended readership should affect both the presented mathematical depth as well as the chosen examples and illustrations. This is clear if you for instance compare texts aimed for highschool mathematics teachers, children between 10-12 years old, or seniors wanting to learn more about research in mathematics. So, beside having some mathematics you want to write about, the readership is the second most important factor when you write the text.

For popular texts it is even more important to have some interesting content early in the paper. To include lots of preliminary computations before coming to the main part in a popular text is out of the question. So the outline should have a motivation, some type of result and its consequences, early in the text, followed by more mathematical parts giving heuristic derivations of different mathematical conclusions. It is also recommendable to describe the prerequisites for reading your popular text, e.g. high school level or knowing only addition, subtraction, multiplication and division. These may be the same for the whole text, or more basic for the most part of the text and specifically stated additional knowledge needed for a separate section. This will help readers to decide what to read and what not to read.

In a popular text the first task is to attract interest from the reader – usually the reader only read for pleasure and if the paper doesn't catch interest of the reader they will go on to another text. Catching interest can be done in several ways, for example by stating a challenging question, provoking the reader, or surprising them with a counter-intuitive result. Quite a lot of readers, but not all, are also interested in the usefulness of a results, so when possible it is recommended to explain how a result can be useful either for other parts of mathematics or some application. Illustrating the result in some figure can also help the reader to better understand. Finding an interesting title, perhaps being a bit provocative or at least surprising, is also more important when writing a popular text.

A big difference between writing a math paper and a popular text is the level of mathematical rigour. In popular texts it is often not suitable to give complete proofs of anything. I recommend to include heuristic arguments for showing a result only when they are enlightening to the reader, and to

completely skip derivations that give no new insights. It is perfectly fine to write "it can be shown that the conjugate of x equals y ", and somewhere in the text you should give some reference to where more of the theory is explained. The idea when writing is that the reader, at their suitable level, should gain some new insights and a feeling for the mathematical arguments leading to the results, but unless the result is basic you will not be able to give the complete derivation/proof. The mathematics in popular texts will often be demanding for many readers even when having simplified it, but make sure that the reader is also awarded frequently when reading, for example by showing the usefulness of a result or pointing out something surprising. Before explaining some phenomenon you can for example ask a (not so mathematical) question and once something has been shown you return to this question showing that the solution can help to answer the question.

Another aspect to have in mind is that you don't have to be as precise when stating the results, for example with regards to assumptions. Nor do you have to state the result in its most general form – stating the result for a canonical example is usually much more informative. This may be hard for mathematicians since we are used to being very precise and to work hard to obtain the most general form of a mathematical result. Similarly, I would not recommend to give all definitions and assumptions in every detail. Preferably, what you state should still hold true, but leaving out some unpleasant facts is perfectly fine. Further, the language used in the text may very well be less formal and precise compared with the language used in scientific papers. Just like with regular papers, but perhaps even more important, I recommend to end the paper with a summary about what has been shown and why the results are of interest.

The structure of a popular text in mathematics can vary depending on length, readership and topic. If the paper is very short you need not even have different sections, but if the text is more than around 2 pages I strongly encourage you to have some visible division of the text into separate units. Your first section might present the problem without revealing the answer. Then a section explaining how to solve the problem, and ending with a section describing the solution and its consequences. It is also recommendable to give a reference to a source where more information can be found, preferably written for a wider audience. The title of your paper is perhaps even more important than when writing a scientific text. It is not necessary to have an abstract of your paper, even if it is clearly a possibility.

I end this section by recommending you to try to write a popular text in mathematics (or some other edutainment product). The best is of course if you have some specific use for it, but there are several options for this. For example, most countries have an organization for mathematics teachers and such organizations often have a bulletin which can contain popular texts in mathematics. Similarly, most countries also have magazines popularizing science, where a popular text of some area of mathematics can fit well. I think we mathematicians have an obligation to explain also to people outside the mathematics community what we are doing. The more people outside that learn about what we do, the more willing will the public be to support mathematics at all levels. Writing a popular text in mathematics that is published in a magazine or a teacher bulletin will also be a good addition to your CV. It shows your interest and ability for outreach activities, an experience much sought after both in academia and outside.

1.2 Giving popular talks

Giving a popular talk has many similarities with giving more scientific talks, and being modified in a similar way as when writing a popular text rather than a research paper. Since there is much less time as compared to a written popular text you need to reduce your material and skip many details. Even more important than when giving a scientific talk is to try to have interaction with the audience. Ask questions and engage the audience in other ways, for example by responding to questions with their mobile displayed on the screen (Kahoot or similar). In the start it is often a good idea to pose a question, connecting to your presentation, to the audience to catch their interest and maybe wanting to guess the answer. At the end of the talk you can return to the initial and explain what conclusions to be drawn from your presentation. It is also nice to then pose some additional questions which are not solved in the presentation, making the audience realize that there is more to learn.

What is particularly nice in a popular presentation is when the answer to a question is at first surprising, but then when adding some explanation the conclusion makes more sense. Another feature to possibly consider is where unexpected, or several different, mathematical methodologies come into play, and also when the conclusions have impact on an important application.

Be prepared to skip some material in case you run out of time (never talk too long!). After all, if your talk makes a deviation due to questions from

the audience, you have instead discussed other things which the audience apparently found interesting.

1.3 Contacts with media

During the COVID-19 pandemic I had a lot of contact with Swedish and international media since mathematical and statistical models for infectious diseases is my main research area. Before this my media experience was limited, but during the pandemic it was often several interviews each day. The most common question was what would happen in the near future, and this type of question is of course different from the more common situation of explaining new research results for media. In my contacts I tried to always emphasize that there is lot of uncertainty in my, or any other, prediction since many things were not observed (asymptomatic cases, changing behaviour, disease severity, ...). For predictions longer into the future it is even harder since people's behaviour in the future is impossible to predict.

When presenting mathematical research results for media there is of course less reason to stress such uncertainties, but if the research concerns applied mathematics saying something about the real world, I think it is worth making the point that any mathematical model is a simplification of the real world. When it comes to purely mathematical research results another difficulty is more prominent. Just like when giving popular talks, this is try to explain your results without giving all details (e.g. assumptions and exceptions). The price to pay is hence that not all you say will be entirely true in all its generalization, but I think this is still the way you should do it. You can include some word such as "in principle" or "more or less all" or something similar, but giving all assumptions and criteria is out of the question.

I have experienced both interviews for journals, magazines and news papers, live interviews for radio and television, and recordings for radio and television. If interviewed for written text, my advice is to always ask to see the final text before it is being published. Quite often you then find that the journalist has misunderstood something or that they want to sharpen your statement more than you do, and then you should demand the corresponding corrections.

Live broadcast can make you a bit nervous, but since usually very few people are in the room this has not been my experience – I tend to forget that

many people are seeing/listening to me. Further, I have always been treated well in such situations, and what is good is that nothing of what you say will be removed when being broadcasted live. I have found the pre-recordings more troublesome. You might be interviewed for 10 minutes or more in front of a camera, but when it is later broadcasted the news agency usually only sends a minute or less of the interview, and then the contents of that minute can give a rather different impression than the whole interview would. For instance, at some interview occasions I had one or two negative comments about the Swedish Public Health Agency, but the majority of my comments about them were positive. But when the interview was broadcasted all they showed were my negative comments. Even if I clearly made these comments, only showing the negative ones gave an incorrect impression of my opinion about the Public Health Agency. As far as I know it is not customary to demand to see the shortened version of the interview to be shown, so I guess all one can do is to try to be aware of this at the interview. You might also point this out after the interview. Fortunately, when mathematical research is presented in media there is often few reasons why the journalists would try to tweak your statements.

Chapter 2

Literature

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