Soft skills for Mathematicians

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Contents

Preface **5**

5 Popularizing mathematics **7**

5.1 Writing popular texts 7

5.2 Giving popular talks 10

5.3 Contacts with media 11

6 Writing applications in academia **13**

6.1 Writing an application 14

6.1.1 Preparation 14

6.1.2 Summary 15

6.1.3 Research plan 16

6.1.4 Connect to research environment in department or topic in research 18

6.1.5 Feedback 19

6.1.6 Other attachments 19

6.2 Cover letter 20

6.3 Writing a CV and List of publication 21

6.3.1 List of Publications 24

6.4 Interviews 25

7 Career building **29**

7.1 Research topics, publications and authorships 29

7.1.1 PhD studies 30

7.1.2 Post Doc employment 31

7.1.3 Career reflection 32

7.2 Active attending workshops/conferences and networking . . . 32

7.3 Building on your CV: publication impact, grants and more . . 35

7.3.1 Publication impact 35

7.3.2 Financial support 35

7.3.3 Choosing affiliation 36

7.3.4 Teaching merits 37

7.3.5 Other merits 37

7.3.6 What to down-prioritize 37

Preface

This book has been written when giving a PhD course at the Department of Mathematics and Stockholm University on 4 occassions between 2014 and 2026.

Thanks to ...

Chapter 5

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.

5.1 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. Is is also recommendable to describe the prerequisits 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 id 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.

5.2 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.

5.3 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 6

Writing applications in academia

In this chapter we give some advice when applying for grants or academic positions. How to write applications for jobs outside academia lies outside the scope of this text, furthermore I don't have much experience of it. So even if some things mentioned below surely apply for such applications as well, I would recommend you to seek advice elsewhere.

Writing an academic job application is somewhat different from writing a grant application. However, since there are equally big differences between different grant applications and between different job applications, I treat the two jointly. We start with the general application and then treat the CV and list of publication separately.

It is very important for your academic career to apply for (and of course also to receive!) grants, and this experience will in itself improve your ability to write applications. As for academic job positions I would not advice you to change positions as frequent as is recommended outside academia, but in the beginning of the academic career you will typically apply for several positions, e.g.: PhD position, one or two Post Doc positions, Assistant professor followed by a tenure position.

When deciding to apply for a position or grant you should aim high. Perhaps you can apply to a couple of different donors or positions, but the only way to get a prestigeous position or grant is to apply for it! And even

if you are not successful you will learn from the experience. When it comes to applying for grants you can, and probably should, also apply for grants which are easier to get. However, usually the more prestigeous grants give more funding, and such grants are also important for your CV.

6.1 Writing an application

6.1.1 Preparation

I start with my best advice, which does not have to wait until it is time to apply for some grant or job: ask some colleagues that have *successfully* applied to positions and/or grants if you can read their applications (and promise you will not spread it further). Consider what aspects of the application are particularly strong, and also if you think something could be improved even further and how. If you plan to apply to something specific, it is of course even better if the application you read was aimed for the same grant/position or at least similar.

Before starting to write the application you should read the announcement carefully – usually there is a link to where more details can be found, and usually a web page where the application and attachments should be uploaded. It is *very* important that you follow instructions!! If it says your CV should not be more than two pages, or your project description should not exceed 5 pages you must obey this. It could very well happen that applications not obeying the instructions, in particular in calls receiving many applications, will simply be rejected without further consideration. This advise could seem superfuous, but I still get surprised by how many applications that don't follow the instructions.

Before starting to write the application you should try to find out who will evaluate it, at least what competences they have. This information might be available in the announcement or it might be known through some official chanel (such as members of a research council or similar), but if not you can write an e-mail asking about the scientific background of the committee that will decide who gets the grant/position.

From my own experience I would say that it is nearly always a mixture of competences. There are usually a couple of experts that know your general

research area, together with a panel with much wider competences (within all of mathematics or often even wider, such as all of natural sciences). There are some exceptions to this mixture of experts making up the panel; one is if applying for an externally funded temporary position. In such a situation the PI (hopefully working in an area close to yours) will have most of the saying and they are typically then expert in the area.

Most common is still the situation where your application is read both by experts in your field and a panel with wider competences. Typically the experts spend more time reading your application and often write a short report on your application for the panel members, and possibly rank your application compared to other related applications. Other members of the panel read your application only briefly and look in the expert(s) report(s), and compares your application with the other applications in quite diverse areas, and try to agree on a final ranking of the top candidates.

It also happens quite frequently when applying for grants with many applications that the *Assessment criteria* are stated explicitly. Quite often they include (mathematical) Novelty, and some times also high risk - high gain. If assessment criteria are stated it is very ímportant to convince the evaluation panel that you possess the criteria after having read (or even skimmed through) your application.

Whether or not stated explicitly, I think that a good application should address the following three questions: Why this problem, why you and why now? The first part means that you need to motivate why the problem (area) to be considered is of interest. The second part implies you need to argue why you are suitable to solve the problem, for example that you have already made some progress or that you are expert in some relevant mathematical area. Finally, it is also good to motivate the timing. Perhaps the problem itself is new and not addressed earlier, there is an application in need of the solution, or that some other new result can be used as an important building block when aiming to solve the problem.

6.1.2 Summary

The combination of readership makes it important to write the application such that it is informative both for the experts, as well as for the panel with wider competences who spend less time on your application. Quite

often you are in the application asked to write a *Short Summary* of your research and future research plan. This part should aim for a wider audience, so avoid too much technicalities. Focus on explaining the question(s) you are addressing and why it is important, using as low mathematical level as possible, followed by a short low-level description on your approach to solve the problem, perhaps adding some statement of preliminary results. End by explaining how your results would be useful in case you are successful.

6.1.3 Research plan

The research plan should have a title and this is of course important. In some situation it is the whole application that bears the title and within the application the research plan is only denoted "Research plan". Either way, the title is important. It should be evident from the title that it connects to the call for the application. If the call is in *Computational mathematics* an expert, and preferably also a non-expert, should understand your application fits in. The title should also sound interesting and relevant for the call.

The Short Summary should connect to your *Research Plan*, which is nearly always a separate document of specified maximum length (2-5 pages or so). When you have a separate Short Summary you can write the Research Plan more directed towards the experts. Having said this, I still discourage from being too technical in the Research plan, and to instead focus more on a general description and ideas.

Quite often the Research plan should start with a short description of your previously obtained results. If this is the case you can briefly describe some of your research achievements, focusing on those you are most proud of together with those that best fit to your future research plan. You should try to argue in what way your results stand out, both in terms of the problem they addressed, how you solved it, and the impact they have had on the research community. When you then start writing about the future plan it is important to emphasize what is different from earlier results.

Writing a good research plan (including a description of earlier work) is extremely important for the outcome of your application. Before you write it you should think through its content. You should write a first draft at least a month in advance, then let it rest for a few days before you go through it once more.

When you write your research plan you should address the following points

- Why is the proposed problem(s) important/interesting?
- Why you? How do you plan to solve it?
- How is this different from your ealier work?
- Why are you suitable for working on this problem?
- What is the expected result/output?
- What are the consequences of solving the problem(s)?
- Why now? What makes the timing good?

Clearly you have to motivate why the problem you plan to study is important. It could for example be posed by some others in the literature, a new method that can be applied to an old problem, or if in applied math, that a new research question has arosen in the application area. If you write about some application you should not give more details than you are comfortable with. If you write unclear, or even incorrect, things about some application this might be discovered by panel members thus putting you in a bad position.

After the problem motivation you should write some about your plans on how to solve the problem. It is important that you have thought about this in advance, and that you have some ideas. It could very well be that you have made some partial progress or even have a close to ready manuscript dealing with part of the research plan. Do not include things in the Research plan that you have already submitted, or even worse, published – these should be referred to as preliminary progress and be cited. But it is perfectly fine to include some things where you have made partial progress or even started to write a manuscript on, in your research plan. But don't *only* include things you have partly solved already – other parts of the plan should contain parts you haven't worked on but where you have an idea on how to approach it.

When you describe your research plan it is important to show what are the new and original ideas in the research plan. Of course most of us base our new research on methodology we have learnt and used earlier. However, in

the application you should emphasize what is new. I would not be impressed by an application saying that "We will extend the result of Britton et al. (2024) to higher dimensions using similar methods.". If, for example, your problem has been formulated by other independent researchers you should cite them. Similarly, if you plan to use methods from a couple of different areas you should cite important contributions (other than your own) in these areas. When it comes to arguing why you are suitable to solve the problem, then you might however include some citations to yourself. The reference list of your research plan can (and preferably should) hence contain items where you are an author, but not the majority of the references.

After the description on how to approach the problems you can state some expected output: what do you expect to show, how many papers do you expect and perhaps a bit on the consequences of your result. The latter could for example be that you expect that the result can open up a new approach for solving other problems, or that it will be used in some applications solving a more specific problem.

6.1.4 Connect to research environment in department or topic in research

In the research plan you should list people you expect to collaborate with. If applying for a position, it is highly suitable to relate to the environment you wish to join, explaining why those competences can be useful for you and your research plan, and how you can be useful to them. If applying for a grant, you should specify how to use the money in order to materialize the Research plan. Will the money be used for your salary, will you employ a PhD student or Post Doc, will you publish in open access journals, will you go to conferences presenting results from the project, ...?

Your actual research plan can be more or less independent of the specific position or grant you are applying for, but these latter aspects (the environment or use of funding) should be written with specific focus on the position/grant. Further, if the grant or position has some specific focus connecting to parts of your research plan, then you should naturally highlight these parts of your research plan more than you would have otherwise.

Research organisations often talk about grant applications in terms of

"risk" and "gain". It is quite often stated that they accept high risk (meaning that part of a research project may fail) if there is also high gain should the project be successful. My advice is to include a bit of both high and low risk in the research plan. You can for example state that you are quite confident to obtain some sub-result. Perhaps even some preliminary result point in this direction. Other parts of the project can be a bit more visionary. There your approach to tackle the problem can be less precise, but you should then also argue why a breakthrough would make a bigger difference in case your efforts are successful.

6.1.5 Feedback

As mentioned above you should prepare the application well in advance for the deadline, and go through it again after letting it rest for a few days. After this I recommend that you should ask some other suitable person to read your application, preferably one expert and one non-expert having background corresponding to panel members. The former could very well be your supervisor or Post Doc mentor who should support you in getting a good job or grant. Ask them to give input and give them a deadline which gives you enough time to modify according to their comments. Once you have received their comments you should read through the manuscript again with their comments on the side, and revise it. Since the research plan is usually quite short my recommendation is to rewrite full paragraphs where changes are suggested rather than making smaller changes. The reaction you want the readers to get is: this seems like highly interesting and relevant research problems and it seems like the applicant has a big chance of making progress in the area.

6.1.6 Other attachments

Beside a Research plan, and CV and List of publications discussed below, you are sometimes asked to submit other documents. This could for example be copies of PhD exam and courses you have taken and passed, including pedagogic and supervision courses, and Support letters.

If applying for a teaching position you are sometimes asked to write a short text on your views on pedagogics/didactics. There you can describe

your earlier experience and courses you have taken. The more different experiences you have the better. So, mention for example different courses you have been involved in, different levels (BSc, MSc and PhD) and different course structures, e.g. assistant teaching, lectures, online courses, practicals, computer labs, various examination forms, ... If you have developed some course or written some course material this should clearly be mentioned as well. It is also welcome to write a bit on your teaching philosophy and your development as teacher. It is perfectly fine to write about earlier negative experiences if you have learnt from them. You may include some references to publications connecting to your ideas – this will indicate that you are both interested in pedagogics and willing to read about progress of didactics of mathematics.

In some situations you are requested to list a fixed maximum number of papers you have published. They can ask for your "Most important publications", or for the "Most relevant publications" for your research plan. When you do this I recommend you to include several *recent* publications, some possibly not even published or accepted yet. It does not give a good impression if all such papers are more than e.g. two years old, even if they then typically have higher citation numbers.

6.2 Cover letter

Usually you are requested to write and upload a cover letter. This should be running text and preferably not more than one page. The cover letter should be like a summary of your complete application: what are your strengths and future research plans, why are you applying for the position (or grant) and why are you suited for it. When you explain why you are suited for the position you should mention things that make your application a bit special.

The cover letter can have a more personal style than the CV and Research plan, and it should be dated and signed by you. You can end by stating that you look forward to receiving their response.

6.3 Writing a CV and List of publication

Beside having a strong novel and original research plan, your CV and list of publication are of course very important. The application for a position or grant is for work you will do in the future, but even so, the CV and list of publications are the main indicators for how likely you are to be successful in the future.

The CV and list of publication can look more or less identical for different applications, so a good idea is to have two files that you add things to whenever you have "achieved" something. For instance, I have a very long and detailed CV-file and a long complete list of publications, which I update regularly. When I apply for a grant I extract a shorter CV from the long file – or if I have a not so old short-CV I start from that and check if something needs to be udated (but please note that what are important experiences may differ between calls/positions. For grants/positions aimed to junior scientists the CV and list of publications should sometimes be merged into one document. The CV and List of publications are both very important documents in your application: they will be read by both the experts and the other panel members having wider competences.

The CV typically starts with your name and contact details, web-page address, nationality, gender, and date of birth if you want. Then comes a number of headings, for example:

- Employments
- Education
- Publications statistics (# publications, h-index, ...)
- List of publications (but more often a separate document)
- Presentations
- Grants/Awards
- Teaching and supervision experience
- Miscellaneous

The contents below each heading should all be dated and listed in reverse chronological order, the rationale being that more recent contributions are more relevant. Quite often the years are listed in the left column, where it is also made clear if the most recent activity is finished or still ongoing.

Under Employments you should list your employments with dates (month and year suffices). If there are any gaps between employments and/or education you should definitely comment on this. If you were on sick-leave, parental leave, or even unemployed or travelled around the world, this will typically not be heald against you, whereas an empty time-space in your CV makes any reader suspicious.

Under Education you should list your bachelor level studies, master level studies and PhD studies (university, subject, study years and years of exam, and supervisor/thesis when relevant). Here you can list longer visits at other universities during your studies as well. Education is also the best suited place to list information about any pedagogic and/or supervision courses you have completed.

Education, and Employments unless you are still a PhD student, should always appear and come first in the CV. What other headings to choose should depend which areas you have experience in. For example, if you have received several major grants and rewards you should have this as a separate heading, whereas it could be listed under Miscellaneous if you have received few and/or minor grants. The same applies to the other headings.

Listing some grants gives a good impression on both experts and panel members. In particular if you have obtained some substantial grants (always specify total amount received, and if you were PI, i.e. principal investigator=main applicant) in high competition. Make sure to clarify such information by e.g. giving success rate. But, even if you only have received some smaller travel grants, this shows you have been active in applying, which is well worth mentioning rather than not listing anything.

Quite often your list of publications should be a separate document (see separate subsection). Still it could then be worthwhile summarizing your publication record. If you are requested to do so then you have no choice, but otherwise it only makes sense to include publication statistics if you think they put you in a good position. There are several different sources for attaining citation statistics: MathSciNet, Web of Science and Google Scholar

perhaps currently being the three most frequently used. I recommend you to choose the one that gives you highest citation numbers. Either way you should state which source you are using and the date at which the citation statistics were collected. When it comes to summary statistics for all your publications, the most common to include in your CV are: total number of publications, total number of citation, h-index (your h-index equals the largest integer h for which you have at least h publications cited at least h times), and i10-index (publications with at least 10 citations).

Teaching and supervising experiences are always worth mentioning. This is obvious if applying for a teaching position, but even when applying for a research grant it proves that you are contributing to the training of younger generations to research. Additionally, any completed supervision confirms the important academic skill of supervising. Be specific regarding teaching in terms of number of courses/hours, and if you had examination responsibility or even developed the course.

When you list presentations you have given, you should start with any invited conference talks, followed by contributed conference talks and then invited department seminars. Clearly, any invited conference presentation is impressive, but even contributed talks show a willingness to actively participate in the scientific community. Department talks are highly relevant as well, and can be denoted "invited" even if you had a close colleague working there and you were the one proposing to give a talk.

Under Miscellaneous you can list quite a lot of different things, for example: language skills, administrative tasks, programming skills, referee or other expert assignments, comissions of trust (e.g. elected PhD representative on Department board), outreach activities, and more. It is good to include something here that makes you special. This could for example be that you have been active in coaching in highschool math-competitions, have taught a course in a developing country, or have appeared in media popularizing mathematics.

A CV often ends by giving contact details to 2-3 reference persons that the experts and panel may contact for additional information about you. After each name you should briefly describe their relation to your academic life, which could be: your supervisor, a director of studies, a Post Doc mentor, or a senior collaborator. If you have the possibility to choose some well-known scientist as a reference person that can sometimes impress the panel. You

should of course not list someone that you think might have a bad impression of you, and before listing them you should send them an e-mail asking if they are willing to act as reference person for you. You don't have to ask each time you submit an application, once is enough unless a long time has passed since you asked. But, I recommend to inform them each time you submit an application so that they know what you have applied to.

A CV should not be very long. Two or at most 3 pages is a suitable length. When you go through your CV you should make sure that the lengths of the different parts correspond to their importance: if you for example are applying for a research grant your pedagogical skills should make up 20% or less of your CV.

In the Appendix of these lecture notes you can see a 2-page CV of mine.

6.3.1 List of Publications

As mentioned earlier, the List of publications could be contained in the CV, or make up a separate document, and this is often specified in the instructions. Either way, the list of publications should list all your publications in reverse chronological order. I recommend to also include submitted but not yet accepted manuscripts, possible under a separate heading. You can refer to them as "Submitted" and give a link to its ArXiv-adress. Papers that have been accepted, but that are not yet published, should be listed as "To appear in Journal X" or "Accepted for publication in Journal X", and given a link to the ArXiv pre-print. Published papers/book chapters/monographs should be given in full detail: all authors, year, journal, volume and page numbers, plus a digital doi-address when applicable.

In pure mathematics authors are often listed in alphabetical order, which is not the case in most other disciplines or in applied mathematics. At the top of the List of publications you might hence explain this, for example by writing "Authors are listed alphabetically except when marked with $\star$". If there are only few publications and several of them contain many authors, then you might after each publication specify your contribution to the paper in terms of formulating the problem, deriving the results and writing it. You should of course not leave out any contribution of yours, but on the other hand you should write about your contributions in such a way that you would not be embarrassed if your coauthers would see it ... . There is less

need to specify your specific contributions if there are few coauthors or many publications.

6.4 Interviews

When applying for academic positions it is quite frequent to call a short list of top applicants to interview, either virtually or in real life. If you are called to such an interview you should be happy, since the majority of applicants were *not* called to interview. When called to interview you will at the same time receive information about the interview: how long it will take, who will be attending and their mathematics background, and how you are expected to prepare. It is perfectly fine to ask for this information if not given to you – this shows you take the interview seriously.

Often an interview will consist of a short presentation by you, followed by an interview where you respond to some questions. As for the presentation you should receive information on what to talk about and for which audience. The people interviewing will have access to your application and should have glanced at it before you enter for interview. I recommend that you start by describing any news or additions on your CV from when you applied. For example, you might have given another talk, an earlier submitted manuscript might now be accepted for publication, or a new manuscript has been submitted. This is new information to the panel which puts you in a better position. If you are asked to talk about your research plans you can do this at a low technical level, emphasizing the relevance of the problem, novelty in solution approach, and expected impact. Don't go into details but describe your short and long term goals in general terms. You can also include other future goals (see below).

Quite often you are asked to describe what you would like to have achieved academically within e.g. 5 years. You can then mention some long term goals in research, but this should not contain any details. Equally important are other type of long term goal, such as: establishing yourself as an independent reseacher, supervise a PhD student (if applying for tenure (track) position), apply and receive a major grant that can support a small research group of yours (for some reason employers always want to hear this ...) and initiated research collaboration with local colleagues. If you are applying for a

teaching position you should probably also want to have developed some new course and to have supervised at the bachelor/master level within 5 years. If applying for a more junior position one goal might be to have obtained a faculty position, and another to have established a new research direction involving new collaborations.

There will always be time for questions from the interview panel. You can prepare responses to some common questions (beside your goal for the future discussed above):

- Why did you apply to this position?
- Which is your best research result so far?
- Mention one strength and one weakness you have
- How will you fit in our department?
- Do you have any questions to us?

It gives a good impression if you know who is working in the department you apply to, in particular close to your own research area, and you can mention that you want to learn the methods of X to perhaps make use of in your research. Similarly, it gives a good impression if you have some questions to them, e.g. what teaching duties are connected to the position, if you would get a travelling budget and/or other support, if other recruitments are in the pipeline, questions about housing (if applying to a different city).

I think it pays in the long run to be honest, so don't try to give a different impression from who you are, and try to be relaxed at the interview, without talking too much.

To be added

Follow instructions. If novelty assesed - inform the panel what is novel

Read successful applications

Read assessment criteria, and convince panel that you fulfill them

Give catchy title to research plan

In pop-summary: not only the area, but also what you plan to do

If applied work: be certain an expert from the applied area would agree to what you write

Chapter 7

Career building

This final chapter aims at giving advice on how to build a successful career in mathematics academia. Perhaps some advice apply also for mathematicians outside academia, but probably other things do not, so here the focus is on career building in academia. The advice is mainly meant for mathematicians early in their career, like most of this text, for example someone being close to defending a PhD or doing a first or second Post Doc.

Some issues have already been discussed in other sections, but here we discuss them in terms of career building. I don't claim to have followed all pieces of advice myself – probably no one has. It is important not to do anything against your own will, so each piece of advice should only be followed if it also agrees with your personal will. I divide the advice into your scientific papers, conference/workshop attendance and networking, and other important issues.

7.1 Research topics, publications and authorships

As mentioned earlier in several places, writing interesting and important papers is the single most important factor to determine if you become a successful mathematician or not. But how is this achieved?

7.1.1 PhD studies

When you start as PhD, it surely helps if you have a good supervisor. I would say that three factors determine if a supervisor is good: their mathematical knowledge and in particular ability to find interesting problems, if they are willing to spend enough time with the student, and finally if the personal chemistry (and mathematical interest) between the candidate and supervisor fits well.

The first factor, being knowledgeable and good at identifying interesting problems, is most often satisfied with successful mathematicians employed by good universities. Having a well-known supervisor may also impress others later in your career, but this should not be over-rated. I would however also try to find out more about the tentative supervisor regarding the input they devote to supervision. The personal chemistry is harder to know about in advance, but often there will be an interview before being hired, and this can give a hint, and if you have the opportunity to talk to other PhD students of the supervisor you might get an impression, even if they are unlikely to explicitly state something clearly negative about their supervisor.

During the PhD studies the student is often lead by the supervisor who usually defines at least the first research topics. As the PhD studies evolve, the PhD student should take more and more responsibility over the research and writing of papers, some later papers may very well be on topics suggested by the PhD student rather than the supervisor. Exactly how the collaboration works vary depending on subject, university tradition, funding, supervisor and PhD student. I would recommend to write some, but not all papers with the supervisor. It is natural to write jointly in the beginning, but perhaps write on your own or with another colleague towards the end (see Section 7.2 for how to meet possible collaborators). This could lead to more variation in content, and also show your initial steps towards independence. Whether to write without your supervisor towards the end of your PhD studies is something you should discuss with your supervisor when having general planning meetings (which you should have once per semester or so). Some supervisors are happy for the student to take independent steps and others are not, depending on subject traditions and possibly on funding sources for your position.

As for topics in the different papers in a PhD thesis they are nearly always

related to each other. Still it is good if there is also some novelty in each and not just a straighforward extension. It could be that a new mathematical technique is used when solving the problem, focus lies on a different part of the same general problem, or similar. It is also important that you (and your coauthors) work hard on each project and on the writing, making each paper of high quality. As discussed in Chapter **??** (about writing papers) you should aim fairly high when submitting, and if rejected you may choose to go down slightly on the journal hierarchy scale. I also recommend that you don't publish all papers in the same journal – this doen not give a good impression, unless the journal is really a top journal of course.

7.1.2 Post Doc employment

The topic of the papers in the PhD thesis often have a common theme. Once you start a Post Doc it is important to come to a new environment, preferably a strong environment in a good university with good senior people (including the Post Doc mentor/supervisor). But also other Post Docs and PhD students are important for making the post doc environment inspiring. The Post Doc period is a chance for you to change direction in your research to some extent. This way your publications will span over a wider field, which is enriching for you, makes your overall production have higher impact, and shows your independence from the research field of your PhD thesis and independent from your PhD supervisor. Showing that you can work without your PhD supervisor, and later also without your Post Doc supervisor, is essential for showing independence – something which is highly valued when applying for grants and positions in academia.

When it comes to the actual papers, their contents should of course be as important and interesting as possible. Most mathematicians (including myself) value fewer but good publications compared to more but less interesting papers. When you have enough results for a nice paper you and your coauthors should work hard on making it interesting and rewarding to read. As mentioned in the Writing chapter (Ch. **??**) I recommend to aim quite high when submitting the manuscript to a (first) journal. There is always an element of chance if your manuscript gets accepted or not, and having publications in high quality journals is important for your career building.

Another important aspect for making a paper influential is to make math-

ematicians in the field know about it. Publishing in high quality journals is one way, and putting it on arXiv right after submission is another. If your work is closely related to some other publications it is also recommendable to make these authors aware of your new manuscript. You can for example send an e-mail describing your work with 1-2 sentences and that it closely relates to work of them, and give the arXiv-link. Another method for spreading information about your work is by giving talks, more about this in the next section.

The goal with research is a) to discover new insights, and b) to spread information about these novel findings. For b) it is important to write interesting well-written papers, but also to present research results at conferences and seminars (and possibly to media). As a bonus, this will also make your career elevate: giving presentations make you more known and your work more cited.

7.1.3 Career reflection

Once in a while you should step back, reflect and consider your work from a distance. Ask yourself: are you addressing the important research questions in the field, are there new directions your work can take, are there other scientists you would like to collaborate with? Over the career, you should on occasions change research focus. It is fine to return to earlier areas and to make use of earlier methods, but the problems you address should also change over time – otherwise you will not remain an original researcher with novel ideas.

7.2 Active attending workshops/conferences and networking

Attending conferences and workshops is important both for presenting new research results, but also for networking. Large conferences and focused workshops have quite different purposes, but both are worth attending.

International conferences covering all or major parts of mathematics, typically attract more participants than more focused conferences or workshops.

An advantage with such conferences is that you get to hear plenary overview talks on hot research areas by top international experts. You also have the oppurtunity to present research results of your own, typically with a contributed talk or poster presentation. If you attend a conference you should *always* submit a contributed talk (or poster) – very rarely are they not accepted. Most often you are grouped together with talks on related subjects, and by giving a talk, other conference participants interested in this area will hear about your work. At the end of the presentation you have the chance of receiving interesting comments and questions that might inspire new work. You will also hear talks about related work and have the oppurtunity to ask questions. It could very well happen that these type of questions/comments initiate discussions after the session, and might in the long run lead to new collaborations.

If you are ever personally *invited* to give a talk at a conference you should do your utmost to accept the invitation. "Invited" means that your presentation will be at a session called Invited Session (you typically still have to pay registration, accomodation and travel expenses, so it is not an invitation in that respect ...). Invited sessions usually attract more attendants than contributed sessions, since the speakers are more well-known, and the speakers are usually given more time to present. As invited speaker you will hence reach a wider audience, plus an invited talk at a conference will look impressive in your CV. When choosing which conferences to attend, whether you are invited or not should make a big difference. Other things to consider when selecting which conferences to attend, is if the topic of the conference fits your interest, if it is a well-recognized series of conferences with strong plenary/invited speakers, and of course private matters.

Attending workshops is a different thing. These are usually "by invitation only", and the topic of a workshop is usually much more focused. Here your supervisor can be instrumental in recommending your name to workshops they are invited to, or possibly arrangeing workshops themselves. It is perfectly fine to ask your supervisor about future workshops and that you would like to attend such in the field of your interest. If you hear about a seemingly interesting workshop some time in advance, then you may very well send an e-mail to the organizers, briefly describing your area of research and contributions, and ask if there are any vacant spots for junior people. Nearly all workshops are arranged by senior people who invite other senior mathematicians. But, junior scientisits are also requested, and the organizers

typically know fewer in this category, implying that an e-mail can be successful if sent early enough. The advantage with workshops is that they usually gather a moderate sized group of experts in a particular field, and attending such a workshop gives an excellent opportunity to make new acquiantances with experts in your field.

If you have the opportunity to present your own work at a workshop you should definitely use the option. By doing so, many experts in your field will get to know you and your work, and this stronly increases your chances to be invited to future conferences, workshops and seminar talks, beside spreading information about your research.

Giving departmental talks is another way to spread your research results, to get feedback on your work, and to get to know colleagues at other academic institutions (of course you can on occasions also present in your own department). I would say that it is quite rare to receive an invitation to give a departmental seminar, unless if you know someone in the department. But, another way to give a departmental seminar is to invite yourself! If you for example are going to another city/country for some other reason (conference, workshop or even vacation) you might check good universities nearby to see if there are mathematicians in your area, or perhaps you already know that there are. If you find such an institution you can write an e-mail to a suitable person there, or if you find out who is the seminar organizer, who is often a Post Doc. You can briefly explain your research area, that you will be in the neighbourhood during some specified dates and that you would be happy to visit their department and give a talk supplying also the title and abstract. It is perfectly fine to ask for one (or two) nights accomodation, but to state that the trip is already planned and no support is needed for travel. You might also add that you fully understand if the suggestion is not convenient for them. If you do this several months in advance, chances are good that they would welcome you to give a presentation, and even if they don't you have given a good impression on them.

By visiting departments and giving talks you will make you and your work known, but you will also meet colleagues at various institutions which will increase your network. A side-effect is that you will get an impression of different universities which might be useful at later stages in the career.

7.3 Building on your CV: publication impact, grants and more

There are several other ways to improve career opportunities beside writing good papers and presenting research results at conferences, workshops and departments. One way to see how your career proceeds and seeing where you might have gaps is to analyse your own CV.

7.3.1 Publication impact

As pointed out several times, your research results are most important, but also which journals they have appeared in and how much attention they have received in the scientific community. When you apply for grants and positions, most people in the panel will not have time to read your papers. They will judge your research by the number of papers and, more importantly: which journals they appear in, how much cited your publications are, and whom your coauthors are. Publishing your papers in different high profile journals is what to strive for. With regards to coauthors it is good to write some papers on your own, but to write others with various collaborators. To write most papers with the same coauthors can give a bad impression, in particular if it is your former PhD or Post Doc supervisor. Receiving lots of citations shows your work has made impact. In the previous section we discussed how to make your papers more read, and this is the first step towards being cited.

7.3.2 Financial support

An essential part in becoming a successful mathematician is to receive grants. The only way to receive grants is to write grant applications, and this you can start with doing early in the career. During your PhD period there are usually funding donors to which you can apply for travel support, and bigger conferences also often have grants for junior participants. Once you are approaching the end of your PhD you can often apply to national research councils and other donors for Post Doc grants. You typically apply for such grants with a suggested host university and supervisor to visit. Nearly all

supervisors will welcome such initiatives, since they don't have to finance it themselves. But there are also many job announcements for specified Post Doc positions at different universities – make sure you find the suitable websites for such positions and start applying a year before you plan to defend your PhD thesis or before your first Post Doc period ends.

Later in your career when you have obtained a tenure or tenure track position, you can start to apply for funding to support your own research, such as funding PhD students and Post Doc positions. Receiving grants of any such kind is positive for several reasons. First and foremost, it allows you to do scientific work you might be able to do otherwise, and this gives you new experiences and shows your independence. Secondly, by receiving grants it shows that you have succeeded in the competition to receive grants. And, thirdly, it shows a will and energy to work towards becoming a successful mathematician. I would claim that a mathematician without any experience of receiving grants will not be considered very strong no matter how many good papers they have written.

Hardly anyone receive all grants they apply to. If your application is not successful you should not get too disappointed. Sometimes there is feedback that can improve your future applications, and often the application can partly be used for other applications. Writing an application is also a perfect occassion for reflecting on what you want to do in the future, and specifying your future plans is important also for yourself, as described earlier.

7.3.3 Choosing affiliation

Something all panel members will look at in your CV is your current and former affiliations. There is no doubt that prestigeous universities and well-known mentors will give a good impression. Another aspect is that you should preferably change affiliation during the early stages of your career, so doing MSc, PhD and Post Doc at different universities (or even different country) is recommendable.

When it comes to "Presentations" in your CV, having invited talks at major conferences really confirms that you are a recognised scientist. However, there is not much you can do to become invited except to attend workshops and giving contributed talks at conferences to make your name known. To give talks at good universities is however much easier to make happen as

described in the previous section, and this will also look good in your CV.

7.3.4 Teaching merits

Another competence not considered enough by many junior scientists is that of teaching. I strongly recommend to get involved in teaching both as a PhD student and Post Doc. The former usually involves being teaching assistant, but if you are given the opportunity to lecture on a course as PhD student or Post Doc you should definitely grab it. When you later apply for a tenure or tenure-track position, such experience will be highly valued and might put you in front of others with possibly stronger research record. Most universities have pedagogical courses for young academics. Documented experience of such a course makes your CV even stronger.

7.3.5 Other merits

There are many other things which can improve your CV. Overall, beside being a strong acknowledged scientist with teaching experience, you might want to have some experiences which make you unique compared to others. If you have been referee for several, preferably high profile journals, gives a good impression, as does experience of organizing a scientific meeting. If you have had some appointment of trust, such as student representative on department board, board member of some scientific organization or similar, shows both that you are willing to serve the community, and also that other individuals are happy with you representing them.

Other things that can make you look special (and which are also are interesting!) is to get involved in outreach activities such as school contacts, or to give a course in a developing country, but there are also other ways.

7.3.6 What to down-prioritize

From the description above it seems important to do everything, and to do it well. Since time is limited a relevant questions is therefore if there are things *not* to focus on. Many scientists may give different answers to this, but my answer is that it is important to complement the most important

factor, research, with some other strengths like giving talks/networking and teaching. Still there is a limit to how much time to put aside for other duties than research. One recommendation is therefore to not do too much of any specific side aspect. For instance, I would not recommend to get involved in numerous organizations/boards – one is enough. Similarly, teaching numerous courses during the PhD or Post Doc period may not be well spent time, and accepting too many referee assignments, in particular for the same journal, might take more time than it merits.

Don't forget to look at your CV on regular basis: what are your strengths and weaknesses? Areas of stength (beside research) can be given lower priority in the near future, in order to improve on areas where you have weaknesses.

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