

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 2026.

Thanks to ...

Chapter 1

Research ethics and the use of AI in research

1.1 Good research practice

Responsible conduct of research concerns the complicated question of what is right and wrong when it comes to conducting and publishing research. Some such concepts have been discussed in other chapters of the book, but here we try cover most aspects in one go. Responsible conduct of research consists of two parts: Research ethics and Research integrity (Steneck, 2006). Research ethics involves moral principles which requires researchers to pay due attention to the effects on their subject group, including also animals, as well as to wider society and to minimize harmful effects on their research subjects. Research integrity, on the other hand, is guided by the rules imposed on the research community by itself (see for example The All European code of conduct for research integrity, by the All European Academies at www.allea.org). Since the current book is aimed for mathematical scientists I will not go into ethics related to experiments, or when dealing with sensitive data – here we focus is research integrity.

An natural question is: *Why* do we at all need to set up such guidelines? I would say there are (at least) three reasons. The first reason is to admit that not all research is performed with high research integrity standards. So the problem exists! More about this in Section 1.2. Secondly, it is only

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when some guidelines are formulated that we know how to act, but also that such guidelines should be discussed and modified over time. And third, but perhaps most important: if we don't maintain high standards in terms of research ethics and integrity, society will not trust us. If trust is lost, what we do becomes useless and research funding will disappear. Currently (2026), researchers (57%) together with medical doctors (58%) have highest trust among all professions – government politicians (17%) and AI Chatbots (23%) being at the other end of the scale (see www.ipsos.com). It is extremely important to maintain this trust, and preferably to improve it. My strong personal opinion is that this should be achieved by openly discussing research integrity as well as being open with scientific misconduct, rather than hiding it.

Some goals to, as well as means for, achieving high research integrity include (cf. Nature, Vol 570)

- Conducting research so others have trust and confidence in methods and findings
- Meeting professional standards
- Should boost quality, relevance and reliability
- Something we should all strive for
- Needs attention and continuous training for improvements
- Probably requires some control system (which also needs to be improved continuously)

The *European Code of Conduct for Research Integrity* (2011), published by the European Science Foundation and ALLEA (All European Academies), formulates the goal with science: Science is expected to enlarge mankind's knowledge base, provide answers to global challenges, and guide decisions that shape our societies. In the most recent edition of the European Code of Conduct for Research Integrity (from 2023) this code is based on 4 principles:

- **Reliability** in ensuring the quality of research, reflected in the design, methodology, analysis, and use of resources.

- **Honesty** in developing, undertaking, reviewing, reporting, and communicating research in a transparent, fair, full, and unbiased way.
- **Respect** for colleagues, research participants, research subjects, society, ecosystems, cultural heritage, and the environment.
- **Accountability** for the research from idea to publication, for its management and organisation, for training, supervision, and mentoring, and for its wider societal impacts.

How should we apply these principles to maintain and improve research integrity, with focus on research in the mathematical sciences? The perhaps most important control mechanism is social interactions. In particular between senior researchers and their peers (post docs and PhD students). Showing strong research integrity for the younger generation is essential, but also between colleagues on equal footing, be it between professors or between PhD students. Our peer review system (for scientific papers as well as in applications for grants and positions) also serves this purpose: someone not showing research integrity will usually not be successful. Another means to maintain high research integrity is to regularly discuss ethical issues and good as well as bad examples, for example in the research group or department meetings. More and more, courses in research ethics are part of higher education programs, but also in promotion programs for Faculty members at universities. Finally, it is our responsibility as researcher to take suitable action when research codes are violated.

So how should one act if discovering some type of questionable research practice is happening? Such a situation is not very pleasant, implying that it is tempting to simply neglect it. But this is of course not recommendable, since all of us loose on problematic research integrity, and the person in question in particular. One obvious possibility, in particular if the person in question is not your superior and the problem is not too serious, is to bring it up for discussion directly with the person. You could for example say that you would discourage from manipulating a figure even if it does not alter conclusions, that reference xx need to be inserted when using that result, or to acknowledge that AI tools were used (and how) in the research in the Acknowledgments.

If the questionable research practice is performed by a superior of you, and/or if it is very serious, confronting the person(s) in question may not be

commendable. I would then talk to some other superior person, such as a Head of Department or similar. Typically, line managers have a code of conduct not to reveal whom such information comes from if brought forward. It might feel a bit frightening to talk with a superior regarding suspected questionable research by a colleague or superior. If so, consulting with a reliable colleague not involved can be a first step. Alternatively, nearly all universities have some type of ethical board to which employees can anonymously file a suspected case of questionable research, and contacting them is another option. As mentioned, these are not pleasant issues to deal with, but not acting may very well lead to future problems down the road, in particular if the problems are within your own research group. In the worst case you may even end up on the accused side if you are part of the research group and co-author. Fortunately, on the individual level, these type of problems are quite rare (but not so on the University level).

One particular problem discussed earlier is that of authorship (Section ??). Who should be authors of a paper? Someone who has contributed with essential ideas leading to a research project should preferably be asked to join a project and to be an author even if less active later in the project. If this is not possible, the person should then be given credit in other ways, by citation (even if nothing is published ideas may be cited as *Personal communication*, and/or in the Acknowledgements.

1.2 Research misconduct

Bad research practice may have different magnitude, and if it is serious it is often called research misconduct. Research misconduct is typically divided into three different categories:

- **Fabrication.** Means that some research output is simply created without any underlying empirical or theoretical underpinning.
- **Falsification.** Is instead used for the situation where a research output has been modified, often to make the result look more convincing
- **Plagiarism.** Occurs when a research result is taken from another source (e.g. scientific paper or researcher) without giving proper credit

to this source. It is worth pointing out that plagiarism may also be applicable to when a researcher uses results of him/herself without proper reference.

Jointly, these are often abbreviated ffp or FFP.

I am currently a member of the Swedish National Committee against research misconduct (NPOF), which deals with suspected research misconduct performed by Swedish scientists. This is a board of senior scientists covering various scientific fields, with two judges being chairmen, and with 6 full time staff members, all holding PhD's in different subjects and with experience in research ethics. For researchers to be found guilty of research misconduct (FFP) we require that the misconduct must be severe (so no single mistake) and that it must either be done intentionally or with gross negligence.

The most common forms of misconduct that we experience is data manipulations and/or figure manipulation. This is rarely relevant for pure mathematics but may very well happen in applied mathematical sciences. In order to be convicted the misconduct has to be done intentionally or with gross negligence. It is of course hard to prove that something is done intentionally, but my impression is that the researchers are most often aware of their misconduct. A different quite frequent accusation we deal with is when someone claims that a result published by a group of authors is in fact stolen other researcher(s), so suspected plagiarism. It could for example be that a PhD student finds out that the supervisor at a later state publishes results based on ideas of the supervisor (or vice versa), or that some collaborator who has left a research group is left out from publications where they should have been an author, or the opposite, that they publish a result from the former group without them as coauthors. In such cases it is often hard to evaluate if the accusation holds true so that someone can be convicted. This would require some documentation that the ideas/results were actually obtained by the person left out. Another new type of accusation that we have seen more of the last 1-2 years is where scientific papers are accused to having been written by AI tools. It is hard to prove this beyond doubt and so far the only convicted cases are those with numerous fake references, when fabrication can be confirmed.

A common defense when being accused for research misconduct is to respond that they have not been involved in the specific parts of a paper where misconduct is suspected. It is important to remember that being

author of a paper means that you are responsible for *all* parts of the paper. You must also read the remaining parts of the paper, beside the parts of the paper where you have contributed. You should also convince yourself that the research has been conducted with integrity. It may not always be easy to understand all parts of a paper, in particular in applied papers, but this should be the ambition.

Clearly, I am against all forms of research misconduct. This might not be convincing enough for readers to avoid research misconduct . . . For this reason I also list some other hopefully more convincing reasons to avoid misconduct. In most situations where the Swedish board NPOF find an accused researcher guilty the performed falsifications, fabrications or plagiarism are quite obvious and the committee is often surprised by how crude the misconduct is performed. So are there many better cheaters that are never convicted? My guess is that there are, but that the majority are still caught, even if I don't know of course. My argument is that I believe that a cheater rarely cheats only once and then stops. Instead I think such researchers will continue this line, making more and more serious changes and doing it more and more sloppy, until one day when it is detected by someone who files a report. But perhaps a PhD student leaving academia after finishing the PhD can get away with e.g. falsification? I guess this is true. A serious downside is however, that the risk of being detected is not over when a result is published. In the case of Sweden, the accused research must be older than 10 years in order not be considered. So a PhD student who cheats a few times during the PhD is hence at risk of being accused and convicted for it long after the PhD is awarded. I would not sleep well for many years if I was such a PhD student – I would never take the risk.

So what can you do to avoid the risk of being accused and convicted for research misconduct? Here is my list of pieces of advice:

1. Save all data and keep it in neat order for at least 10 years.
2. Never manipulate data even if seemingly very innocent changes.
3. Never modify figures or tables.
4. Consider if all individuals that have played an important role in the research project are coauthors to the paper and all ideas of others are referred to.
5. Never leave out important facts in the paper.

6. Be open with your use of AI tools.
7. Are you familiar with all parts of the research project? (In principle you can be convicted even when the misconduct is performed by a coauthor – as author you are responsible for the entire project).

1.3 Using AI in research

At the time of writing this text (september 2023), Mathematical research using AI is going through a revolution, or even an earth quake. As a consequence, this piece of text may very well become obsolete within a year ...

For a couple of years, AI tools have been used in writing and modifying texts. For this type of use, I would say that the general guideline is that authors (people) should have written a first draft of a paper, or at least given input on all the main ideas of what some text part should be about, before AI (computers) come into action. It is hence not acceptable to ask an AI tool to write an introduction and background about some area. Instead one should ask for ideas and then read about them and synthesize, or write down a preliminary version and ask for feedback. A consequence of asking an AI tool to write some bigger text-part is that the authors of the paper will rarely have a deeper understanding of these parts of the text, and authors are always responsible for all parts of a text. And you should of course never include any text which you don't understand and can defend yourself! Irrespective of how AI has been used in the writing process, text production, text modification, language and grammar correction and more, it is very important to be open with this. In the Acknowledgements it is hence important to state what AI tool has been used, and in what way(s).

The new and even more tricky situation is where AI tools are used in the actual research. Some more innocent examples include programming, producing figures and tables, and numerics. Also these uses have been around for a year or so and I would say that they are not problematic, but also here the use of AI has to be declared in the Acknowledgements, and code and other output need to be saved and documented and preferably made accessible to other scientists.

A more delicate matter is where also ideas and proofs are produced by AI

tools, a much more recent phenomenon. To me it is unclear what will happen in the future and what use will be considered as recommended or at least acceptable usage, and which use is questionable or even misconduct. I would say that the most important thing is to be open in how the research has been performed. If some ideas are obtained using AI, this should be stated in the paper (or Acknowledgement). An opinion I have, at least currently ..., is that when using AI agents in research, it is important that these agents are assistants, and that human(s) are the main driver(s). If this is not fulfilled, it seems questionable that humans should be authors of the paper.

An important recommendation in this dynamical part of research ethics (usage of AI tools) is to look for guidelines. For example, you can look in guidelines in journals you plan to submit to, or in scientific organizations in your field. More and more scientific journals require that authors declare they have not used AI methods inappropriately, and so do many research councils and other donors. Similarly, many scientific organizations have declarations of proper and improper use of AI methods.

Is it easy to get caught if using AI improperly in research? The honest answer is that I don't know. There are of course examples where this has happened, e.g. when the AI tool produces seemingly plausible but non-existing references, but my expectation is that new tools will be improved, thus minimizing such obvious mistakes. Most likely, the methods to detect when a text is written by AI methods will also be improved. It will of course never be possible to formally prove that a text is written by an AI tool, but even suspicion could be very negative publicity for the involved researcher(s).

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