

Evaluation of PhD course Theory of Science and Ethics (MNF990) 2021-2023

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The course is mandatory for all MATNAT PhDs, is 5 ECTS, and addresses key topics in theory of science and ethical questions of direct relevance for scientific practice. Examples are: the social organisation of science; academic integrity; the role and ethical responsibility of science in society; dilemmas in contract research; moral dilemmas created by modern science; how science can deal with complexity and uncertainty; and the consequences of training that can shape scientific thinking in an ethics-free and amoral way. The course offers students an arena and opportunity to reflect critically upon their own research.

The 32 contact-hours of the course are concentrated in a block of 3 weeks. The course has a core part of seven 2-hour lectures and six 2-hour discussion seminars in smaller break out groups of about 6 to 7 students per group. The groups are made such that they have a mixed composition with regard to disciplines. In addition, the course offers nine elective modules (2 contact hours each) addressing specific topics or cases in theory of science and ethics of which each participant has to select three. These topics are chosen such that there is something relevant for all MATNAT disciplines, ranging from mathematics and informatics to geoscience and marine biology to name a few. The topics of the modules can vary from semester to semester. We often ask professors that are visiting our group to teach a module in the MNF990 course on a topical issue they are working on. This strengthens the link between teaching and the research front.

The main learning outcomes and objectives of the course are for participants to increase their ability to:

- Reflect critically upon the epistemic foundations of the sciences, as well as the implications for their own research;
- Understand what science can, and cannot, deliver, and to understand how, and why, this is so;
- Provide an overview of general debates about the theory of science, as well as perspectives on the relation between science/expertise and society;
- Relate the debates on the theoretical and epistemic foundations of the natural sciences to similar debates within the humanities and the social sciences

- Identify ethical questions of general relevance for their research field
- Explain and prioritize ethical questions of specific relevance for their own projects.
- Develop an overview of epistemological, ethical and societal aspects of a study/research project in their field.

In addition to a written pre-conception assignment in the first week, a 2500 words argumentative essay about an epistemological or ethical problem of relevance to their own research field must be completed within three weeks after the last course lecture. The assignments and the essay form the basis for assessment. The final grade is "passed" or "failed".

The academic approach to the course has been documented in a recent scientific article (Fjelland, 2021 <https://doi.org/10.1007/s11217-021-09802-8>).

In the 3-year period 2021-2023, the course has been offered six times. In this 3-year period a total of 256 PhDs attended the course of which 243 passed the course and 13 failed (5% compared to a 10 year average of 3% failing).

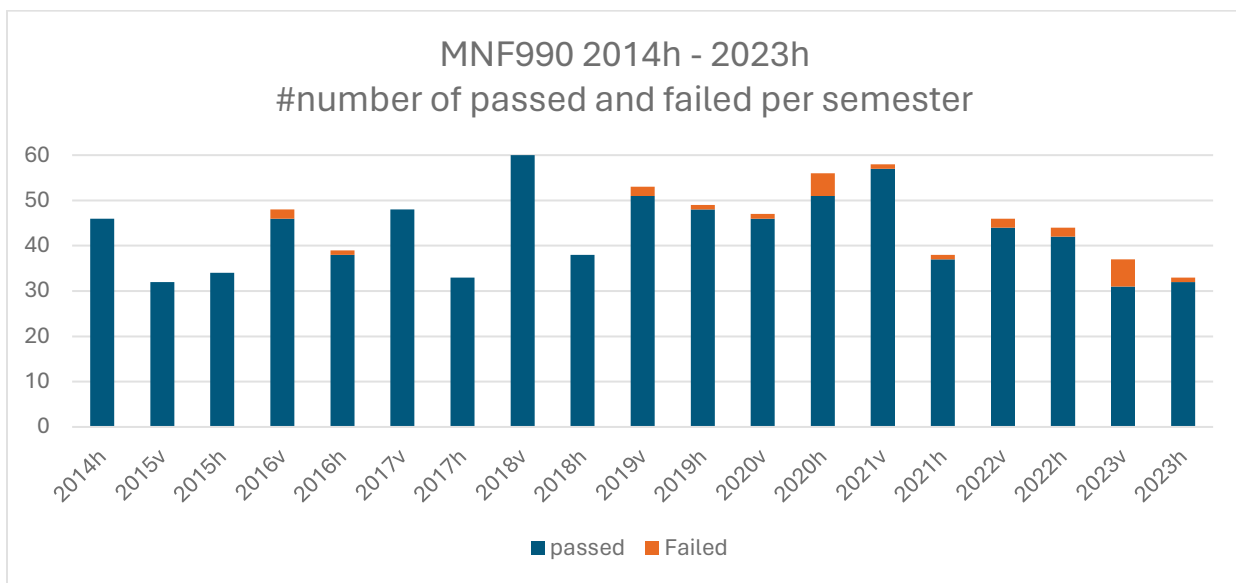


Figure 1 statistics of course participants, pass and fail per semester

In the evaluation period during 2 of the semesters (2022h and 2023v), Gunilla Öberg was the coordinator because coordinator Jeroen van der Sluijs was on a sabbatical leave.

The 2021v, 2021h and 2022v semester editions of the course were taught entirely online. The 2022h and 2023v semesters were a mix of physical and online teaching. Since the 2023h semester the course is entirely physical again.

To increase engagement, we introduced a discussion forum on canvas (mitt.uib) where the students have to react to a discussion prompt for each lecture and module of the course. In

order to pass the course, it is a requirement that students respond to at least 80% of these discussion prompts. Students can also react to each others' posts and quite often do that, leading to very interesting and animated discussions on core topics of the course. After going back to physical teaching, we kept the online discussion forum because of its' success in creating higher engagement. Before the start of the course, we ask students to post their expectations and wishes regarding the course and we use their responses in the teaching. Last semester we gave more attention to publication ethics and authorship practices in response to expectations and wishes expressed by the students.

Each semester, participants evaluate the course using a survey. Traditionally, the survey was handed out on paper and completed in-class in handwriting, which leads to a high response rate. The online and hybrid editions of the course were evaluated by an electronic survey and had a much lower response rate. Two semesters (the semesters where the coordinator was on sabbatical leave) were not evaluated due to capacity problems.

One of the questions we ask is would you have taken the course if it was not mandatory? On average around 20% answer this question with yes. We continue and ask if you answered no, according to what you know now after having followed the course, would you have taken the course if it was voluntary? On average the percentage that would have taken the course increases to about 65%.

For the 2023h semester the response rate was 71% (23 out of 32 participants responded to the electronic evaluation survey). The percentage of participants that would have taken the course if it was not mandatory went up from 34% to 70% according to what they knew about its contents after having followed the course. Parts of the course that are highly appreciated include the discussions in break-out groups and the freedom of choice in the module week (where they choose 3 modules from a menu of 9 optional modules). Every semester there are some students choose to follow all 9 modules, as they find all of them interesting. There were mixed opinions of the concentrated format of the course. Most students like the concentrated form (all 32 contact hours in a block of 3 weeks), others would have preferred to have it spread out over the entire semester. Most participants find the course interesting (Fig 2) and relevant to their PhD work (Figs 3 and 4). The course's general approach is appreciated by the vast majority of respondents. The lectures (fig 6) were perceived as more helpful than the digital reader (fig 7) in understanding the topics of the course. Most participants agree or strongly agree that 5ECTS is reasonable in relation to the workload (Fig 8).

Box 1 provides evaluative statements by 27 different course participants and Box 2 provides evaluative statements by 6 of the other teachers involved.

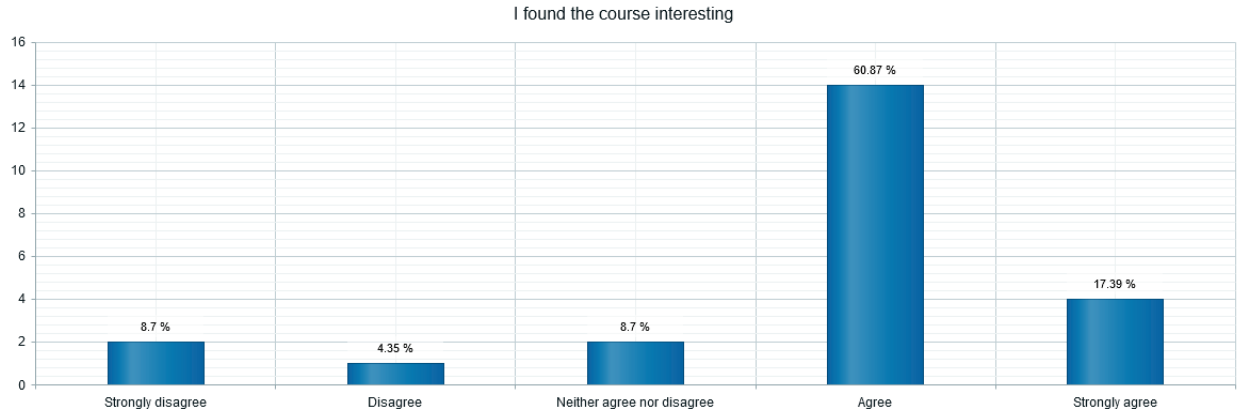


Figure 2 Responses of 2023h cohort on whether the course is interesting

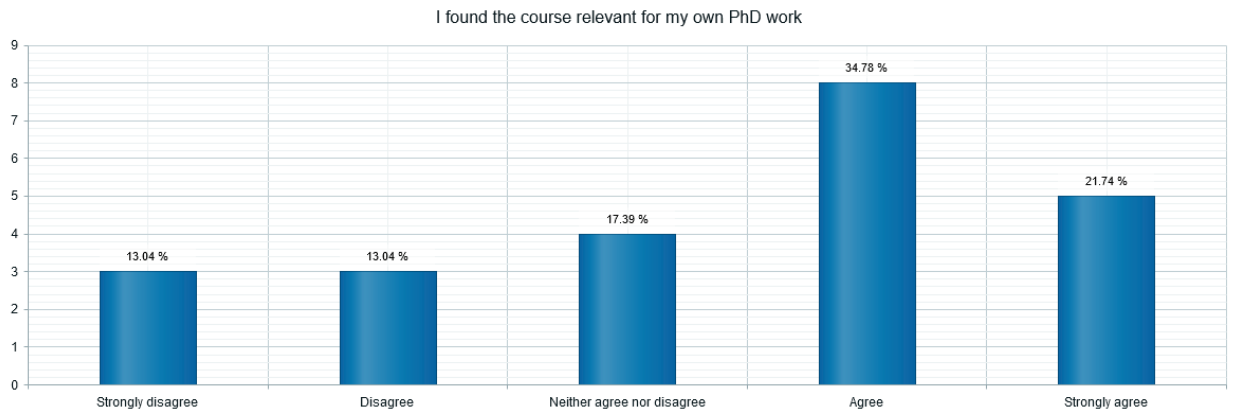


Figure 3 Responses of 2023h cohort on whether the course is relevant to their project

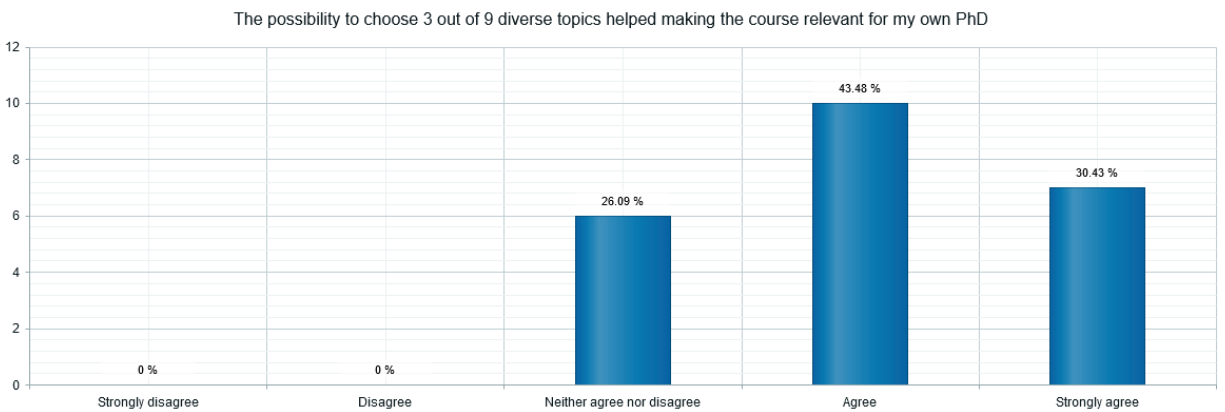


Figure 4 Responses of 2023h cohort on whether the modules increase relevance to their project

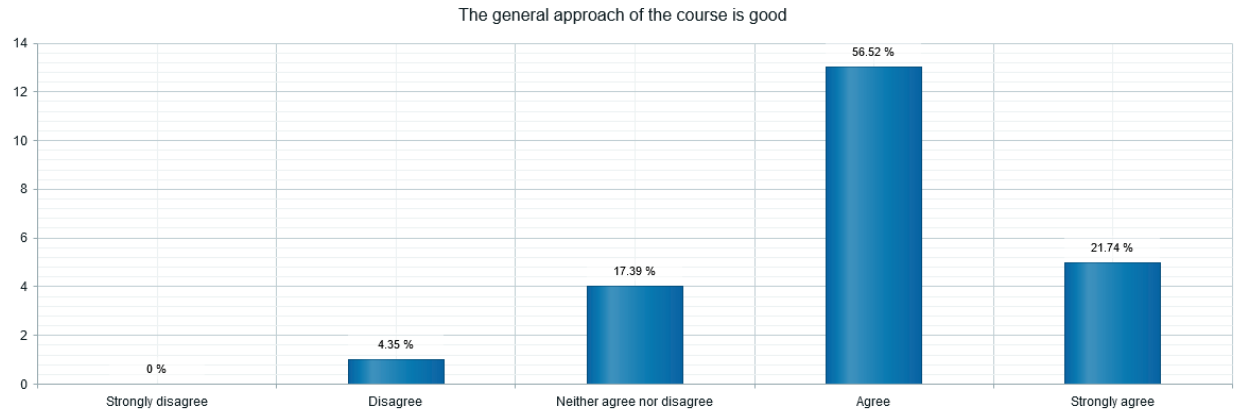


Figure 5 Responses of 2023h cohort on whether the course's general approach is good

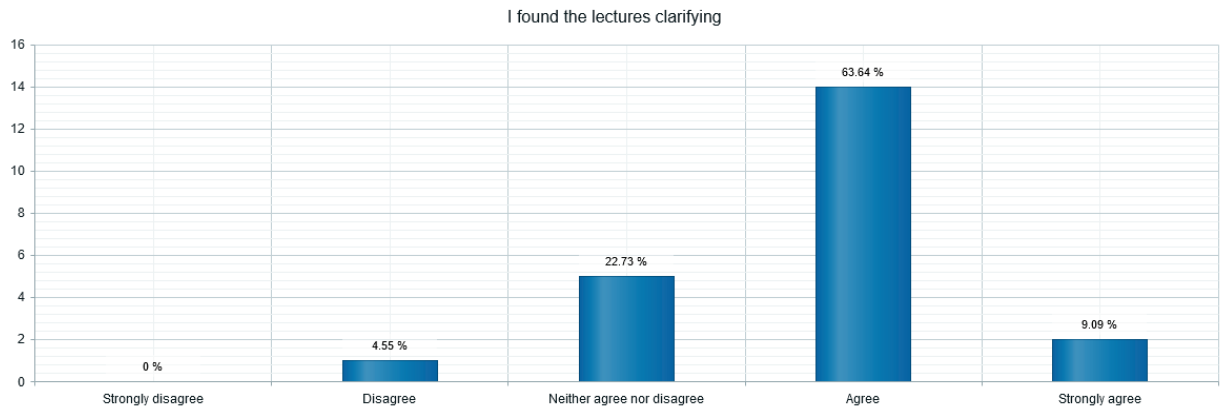


Figure 6. Responses of 2023h cohort on whether the lectures are clarifying

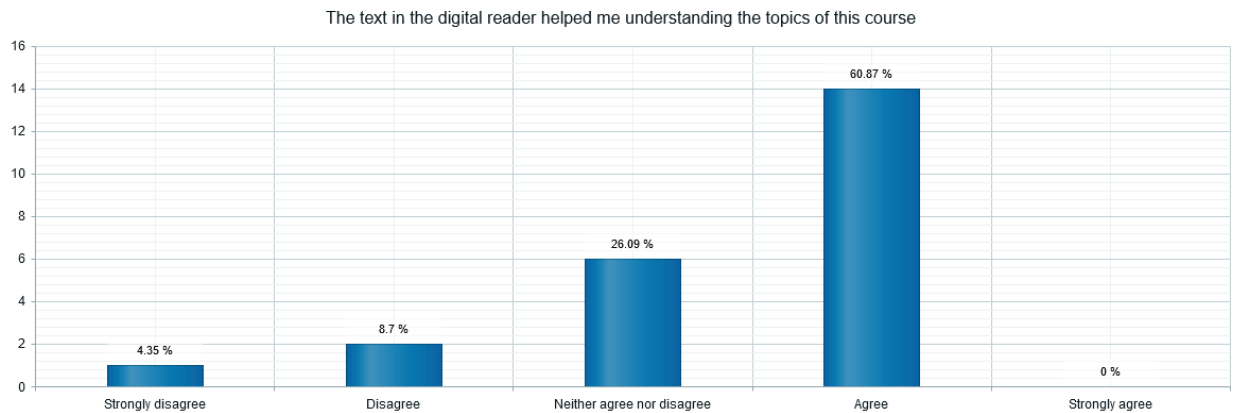


Figure 7 Responses of 2023h cohort on whether the reader helped to understand the topics

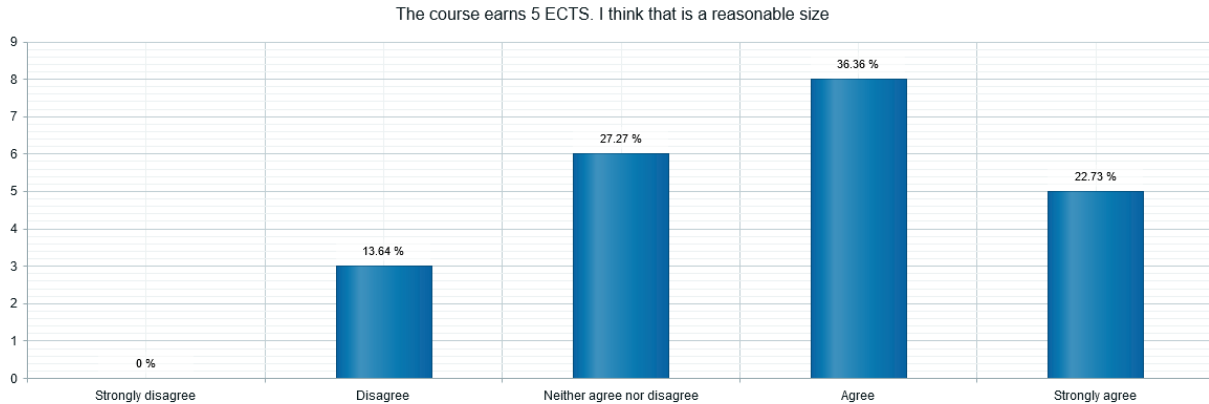


Figure 8 Responses of 2023h cohort about the size of the course

Box 1 participants' answers to the question "Do you have any general comments or suggestions for improvement?"

- *"I really liked the discussions as it helped me to understand and get the main points of the topic, and I also could learn from other student's projects. Overall, I found the literature useful (e.g. precautionary approach, post-normal science, values and research ethics), however it would have been good to have other examples for Alternative knowledge systems (as Bremer's paper was repeated twice) and sensitivity analysis."*
- *"I did not find the discussion prompts to be useful. I think it would be more useful (and would make the engagement higher) to rate each other's statements, in terms of how much we agree with that specific statement. This would make everyone more aware of which are the opinions that are controversial and which are common opinions."*
- *"I almost forgot about the course (mainly my fault) since it did not show up on the main dashboard of MittUiB for me. I am not sure why, but it would be nice with an e-mail notification, say 1 or 2 weeks before the course starts."*
- *"It was a great course by its lecturers and topic contents. However, I'm afraid I have to disagree with the final evaluation. To pass or fail the course only by an essay without accounting for other course activities is not the best approach from my perspective."*
- *"The concentrated lectures hours makes it nearly impossible for people in applied science, conducting experiments to actively work, which then leads to be behind at work. Moreover, just because the contact-hours are done doesn't mean that we are completely finished with the course as we have an essay to write, which, between finding a relevant topic, finding the references, and writing the paper, is also quite a time consuming task."*
- *"Really good course. One of the best I've attended at the university."*
- *"While I can understand why, the obligation in the essay to cite sources based on the files in the digital readers really does limit the topic one can choose to write on."*
- *"Loved it! It was definitely a brain teaser. If I could, I would take more classes about it because it really triggered my interest. I will definitely consider it when I am done with my PhD."*

- *"Some powerpoint slides had a lot of text, which makes it hard to follow."*
- *"The course is really cool. I am glad I attended this one. Thanks to the lecturers!"*
- *"Thank you for a nice course. I think it still should be mandatory."*
- *"Either have the course over lager time, or that it is very time consuming and advice to take it in a flexible semester."*
- *"This course should be very useful for people designing policy or for people doing assignments to guide policy."*
- *"Some topics were discussed too much, or in too detailed."*
- *"More and different topics of ethics in science should be mentioned"*
- *"In general a very good course."*
- *"Making the course intensive (3 weeks) may have various disadvantages (overlap with other courses)."*
- *"Maybe the time to write the assignment was a bit short."*
- *"One of the strengths of the course is PNS. I was heavily critical to reading the corresponding articles in the beginning, but it grew on me and helped me in the lectures. A++ would read again. Very interesting approach."*
- *"Maybe more feedback on the assignments?"*
- *"Most of the lectures provide additional reading as seminal or controversial books; this was excellent (have already read 2 of them)."*
- *"Very interesting to discuss ethical and cultural issues with a wide range of participants. Example: Discussion of traditional knowledge."*
- *"I really liked the course!"*
- *"The lectures on ""Big Science"", ""Philosophy of Science"" and ""Alternative ways of knowing"" were by far the most interesting ones, and I wished more time would have been dedicated to them. They actually forced the reflection and I genuinely actually learned something new."*
- *"This course gave me insights about ethical consideration and I decided to assess my own research papers on the parameters I learned."*
- *"It was really nice to meet PhD students from other research fields and to work together with them in the break-out group sessions."*
- *"Overall, a very good course. Good range of different speakers and topics. I like the 3-week format. This makes it fit well with other commitments."*
- *"I would like to see more examples and cases about Norway during the lectures. The discussions in smaller groups were fruitful."*

Box 2 Evaluative comments provided by six other teachers involved in the course:

- *“What I might chip in, is that I see a development over time, having sporadically taught this course since, well, 1998 or 1999 actually. The development is that in my opinion, participants more easily see the relevance of ethical reflection. For example, this year, nobody posted or said something like “There are no ethical issues in my research”. 10 or 20 years ago, a good deal of science phd candidates uttered such things. I commented this change to the group this year, and by their facial expressions it is clear that they find this a refusal of ethics an obsolete attitude. I think the mix of plenaries and modules work well and still defends it place.”*
- *“I have been teaching one lecture in MNF990 on the social organisation of science for several years now. It is a 2-hour lecture and its content has changed (slightly perhaps) in the course of the years. In general, I have had many positive experiences with the students. They are mostly very eager to engage and even to discuss some fo these topics. Unfortunately, the time limit constrains the discussions significantly. Ideally I would wish for a follow up lecture based on at least one particular case (in my case the studies from continental drift to plate tectonics to illustrate the more abstract points about the dynamics in scientific developments). I am aware that one cannot expect the students to read relevant literature beforehand since the whole program is quite dense, though this would be even better. - One of the issues I cannot cover in my lecture – though I would like to – is the more general issue about science and ethics. This would not be about scientific integrity but more about social responsibility (RRI). I teach a similar course in Gothenburg where I have the opportunity to engage the students in both role play and small discussion groups based on ethics cards. Some such element I would deem beneficial, though I do not know how the group work of the students functions.”*
- *“It seems to me that the course is working well and that you have done a really good job with the MittUiB setup and interaction there. My two classes on Popper and Kuhn have worked well with many engaged discussions. I think perhaps the candidates could have benefitted from even more conceptual “theory of science” tools for discussing their work and discipline. A brief lecture on realism and various forms of constructivism, perhaps (e.g. Hacking’s social construction of what?)? Or even, what is distinctive of the sciences as compared to humanities and social sciences? Some of the “best” students last year had never heard of “hermeneutics” for instance”*
- *“I am a big fan of this course and always say to whomever would listen that all PhD programs should have one like this. Here in Barcelona, I give lessons for Pompeo Fabra University and for a PhD program funded by Caixa, a Catalan socially oriented bank, that are inspired by MNF900. The students in Bergen are great and the interaction we have before and after the lessons is very well organized and always instructive. Suggestions for improvement: share with teachers the students evaluation of the course - we do it here and it is quite useful. ”*
- *“Here is some input for the evaluation:*

- *The facilities are always well organised – the room, projector etc. There is nothing more to do than turn up and teach. This noted, last time I taught it was a bit difficult to find the room in the høyteknologisenter/Bio building*
- *I haven't used the online platform for the course, but as far as I can tell I don't need to.*
- *Students I have mainly found to be engaged and interested in the session I teach. I leave room for discussion and this is usually quite animated. Some have emailed me afterwards to get tips for their essay.*
- *I don't usually give much in the way of advance reading, but when I have I'm not sure it was read.*
- *It can be difficult for some students to relate to my session on alternative ways of knowing, because their work is so technologically or theoretically specialised, and in a way 'detached' from people's lived experience, that they struggle to see how local knowledge (for eg) could be relevant. I've adapted the session a bit to reflect on scientists' own ways of knowing they juggle in themselves, and how this affects their research.*
- *I don't recall students frequently drawing links between my session and other sessions on the course. This might be a weakness, that modules are a bit siloed and don't cohere very well together?*
- *Last time I taught there was some confusion over how many core and elective sessions they needed to take. That it wasn't clear on the course outline. This could be something to attend to/make even clearer."*
- *"I think the course is great, and it is nice to see that most of the students seem to enjoy it despite some initial hesitation. The course seems to be a rare opportunity for them to get out from their lab and discuss with students from other disciplines, and to think about the general and overarching issues of science and research. In my experience, the students use this opportunity well and engage and discuss a lot. Thus, it is enjoyable to be one of the course instructors. And I also think the course is important for them, not only for learning about things, but for being more prepared for overarching challenges and ethical and moral dilemmas that they may encounter during their PhD."*

Every semester, improvements to the course have been made based on insights obtained from previous evaluations and experiences during the teaching. For instance, 3 new modules have been developed based on suggestions / wishes of the students. These are: Equity, diversity and inclusion in STEM; Ethics of mathematics; and values in science. Also, the assignments for the break-out group discussions have been improved following constructive feedback by the students.

Further, a rubric (appendix 1) has been developed for the grading of essays in order to increase transparency in the grading, clarify expectations as to what counts a good essay for this course and to provide clear feedback to the students regarding strong and weak aspects of their essays.

Based on experience with the use of the rubric by several of the teachers involved, the rubric has been improved over successive semesters.

The academic content is updated continuously and actively linked to the research front in the field. The mandatory reading consists of a mix of classic texts and very recent texts. Outputs from several recent Horizon projects on responsible research and innovation and on the precautionary principle in which the lecturers participated, have been directly integrated in the curriculum of this course.

Some of the classic texts in the reader seem a bit harder to digest for some of the participants. As we think the insights provided by these texts are important for the academic development of all PhD's in MATNAT, we keep these texts and use the lectures and discussion groups to make these more accessible.

The essays written by the students are mixed in quality, but every semester we have a substantial amount of excellent essays and in several cases we encourage the students to publish it on a blog or in an other suitable channel. Box 3 provides an example of essay topics developed by students. Gunilla Öberg is currently editing a collection of outstanding essays on ethics of mathematics, written by students of several semesters of this course.

The logistics of the course has been a challenge in recent semesters, due to the limited availability of suitable rooms. In many cases the rooms were in different buildings and not all buildings are suitable for the break-out group discussions. The preferred locations are the A/B and C/D rooms on the second floor of VilVite, because that building is well suited for the break-out groups discussions (we normally break out in 7 groups).

Box 3 Sample of essay titles from the 2023h cohort

- The ethics behind lethal decision making by Autonomous Weapons Systems (AWS)
- Patania II: testing polymetallic nodules extraction in the Clarion-Clipperton Zone
- Ethical thinking about the research of wireless communication
- PET Chemistry and Radiopharmaceuticals: Harmonizing Progress with Precaution
- Is it consistent with the ideals of science to protect or keep knowledge secret?
- Ethics and mathematics: the moral obligations of a mathematician
- Is it a scientist's obligation to do environmentally friendly research?
- Is the application of Carbon Capture and Storage ethically justifiable?
- Are biomathematical models a good basis for deriving decisions in health-related questions?
- Needs and dilemmas for an ethical energy transition to low and carbon-neutral solutions
- Can we continue abusing cleaner fish as a delousing tool to produce a luxury good?
- Does mathematics have a harmful effect on the world?

- What are the potential ethical issues that emerge from creating models in aquaculture and how can aquaculture models be improved to better serve our society?
- Should we reconsider the importance of science?
- The Interaction of Science, Economics, and Ethics
- Ethical issues of the publication system in research
- Gene editing: The best thing that has yet to happen for humankind?
- The dilemmas of building privacy in cryptography
- Innovation in the Anthropocene: The Ethical Imperative of Developing AI Tools for a Sustainable Future
- AI in Healthcare: Are We Jumping the Gun?
- Do pure mathematicians need ethics?
- Is CRISPR/Cas a threat to humankind?
- Is the use of CCUS ethically responsible?
- When does prediction of climate change become unethical? – Uncertainty behind climate projections
- Ethical considerations regarding research subjects in a mathematics education research project
- Are Big Data researchers properly equipped for their research?
- Who is responsible for Science Communication: A critique of the dialogue model
- How You Treat Dilemmas as a Petroleum Engineer?
- The introduction of CRISPR genetically modified organisms into marine ecosystems
- Noise Problems Caused by New Technologies and Policies
- Ethical Considerations in Data-Driven Research: A Comparative Analysis of COVID-19 Test Strategy and Wildfire Prediction Studies
- Improving Decision-Making Process by Deeper Integration of Numerical Simulations in the Post-Normal Science
- On the Necessity of a Mathematical Treatment of Modern Ethics

Appendix: MNF990 Rubric for essay grading

	Unacceptable	Insufficient	Acceptable	Good	Excellent
Well-articulated central question (or claim), related to the course	Lacks a question, and/or subject	The question/claim is unclear and inconsistent. It may not be a claim but, rather, a statement of fact.	Essay has a question/claim, but it may not be clearly spelled out in the introduction, too broad or inconsistent (e.g. the essay argues a different claim than in the introduction)	The question/claim is clear and debatable but would be improved by being more specific. It is spelled out in the introduction and consistent throughout the essay.	The question/claim is clear, specific, and debatable. It is clearly spelled out in the introduction and consistent throughout the essay.
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Argumentative quality	Weak, invalid, inconsistent or no argument; perhaps a simple assertion; does not take a clear or defensible position or draw a clear conclusion.	Inconsistent argumentation. The author evaluates arguments and scholarly positions in question by stating whether they agree or disagree without explaining why.	Most parts of the argument valid and well-supported; describes, or begins to support/test/extend/critique a scholarly position.	Main argument valid, systematic, and well supported; thoroughly and effectively supports, tests, extends, or critiques an existing scholarly position	Argument both well-supported and genuinely compares conflicting explanations; develops their own clear and defensible position; draws a significant conclusion, shows self-reflexivity.
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Counter arguments and/or opposing positions not considered.	Counter arguments and/or opposing positions insufficiently considered, no or weak rebuttals.	Counter-arguments fact-checked, checked for the tenability of premises, rebuttals sufficient.	Counter-arguments fact-checked, checked for the tenability of premises and validity, and checked for argumentative fallacies. Strong and consistent rebuttals	Counterarguments and rebuttals are strong, detailed and convincing & address substantive aspects of the argument.
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Conclusion of the essay	No answer(s) to the central question or answer does not follow from the rest of the essay	The answer to the central question is not supported by the arguments and analysis presented in the essay.	Sufficient answer to the central question, sufficiently supported by the line of argumentation in the essay.	A clear and concise answer to the central question; follows clearly from the line of argumentation	A clear and concise answer to the central question; follows clearly and convincingly from the line of argumentation.
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Use of references and sources	The essay lacks citations and/or a list of references.	Many in-text citations are missing. Major errors in citation style. Overreliance on minimal sources / poor selection of relevant sources, or strongly biased sample of sources.	Some in-text citations are missing. Some major errors in citation style and/or inconsistencies in reference style. Acceptable selection of relevant sources	All in-text citations are listed in the reference list. Minor errors in chosen citation style. Good selection of relevant sources.	All in-text citations are listed in the reference list and all res in the list are mentioned in the text. No errors in style. excellent selection of relevant sources.
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Written expression	The essay has enough issues with grammar, sentence, paragraph and essay structure that the meaning in several places is lost.	The essay is difficult to read. Paragraphs may combine several ideas in confusing ways. Sentences have severe grammatical or word choice errors that inhibit understanding. The essay has no clear or incoherent structure.	Some paragraphs lack topic sentences, and some may address more than one reason in the argument. Sentences have major grammatical or word choice issues. They need editing for clarity and concision to enhance readability. Structure sufficient.	Each paragraph has a topic sentence and addresses one reason in the argument. Sentences are generally clear. They may be wordy or have minor grammatical or word choice issues. Clear structure.	The essay is concise, fluently written and easy to read. Each paragraph has a topic sentence and addresses one reason in the argument. Terminology is used correctly. Sentences are clear and grammatically correct. Clear and logical structure
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use and level of understanding of the content of the course	The essay unrelated to the course / does not meet the learning objectives associated with the course. Does not build on any material of the course.	The essay poorly related to the course and/or demonstrates a poor conceptual understanding of the course materials; insufficiently meets the learning objectives. Refers to < 2 texts from digital reader & module texts.	The essay demonstrates a grasp, but not a solid conceptual understanding of the course materials and sufficiently meets the learning objectives. Sufficiently builds on the course materials.	The essay demonstrates a good conceptual understanding of course materials and shows a good achievement of the learning objectives.	The essay demonstrates a thorough conceptual understanding of course materials, a high level of reflexivity and critical thinking. Excellent achievement of learning objectives
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
General comments					

Graded by:

Publication recommendation: Not publishable without major rewriting / Publishable; suggested journal, blog or magazine:

Date: Overall result: Fail / Pass