Tentative Syllabus for a course "Ethics in Chemistry" [by Jan Mehlich]

Introductory remark

The comments and recommendations made in the following on planning and carrying out a course on ethical and social aspects of scientific activity (here: in particular chemical research) are based on my experiences with a course "Philosophy and Ethics of Science and Technology for Researchers and Scientists", held at Tunghai University, Taichung, Taiwan. It was offered for 40 students of all science majors and consisted of 16 lessons a 100 minutes plus a midterm and a final written exam. The course was taught in English. The suggestions made in this document are adapted to the requested conditions, such as a specification for Chemistry students. Moreover, it is obvious that a course like this should and most likely will be given in the local language of the respective university. Also, according to the preferences and taste of the lecturer, the literature list will be modified and refined with items in the language of the course (here, only English books are listed).

A major conclusion from previous experiences is that a course "Ethics in Chemistry" should not focus solely on ethical aspects of science conduct itself (good scientific practice, fraud, issues in publishing, conflicts of interest, mentoring, etc.), but equip the students with skills in overseeing "the larger picture of chemistry" by spending considerable course time on the societal and environmental impact of chemical activity. If the goal of such a course is "sustainable education of chemistry students as our society's future scientists and researchers", it needs to provide the students with:

- Concepts and praxis of Good Scientific Practice,
- A clear idea of the responsibilities as a professional chemist
- An understanding of the role of chemists and chemistry in society, culture, economy, politics, etc.
- Discourse skills

It is, furthermore, of utmost importance to make clear to the students at every section of the course how the presented and discussed issues relate to their actual daily (lab) activity and their (future) role as members of the scientific community! It must neither be a course on ethics and moral philosophy nor on sociology and politics. These disciplines inform and underlie the course content, but the more important point is the clear connection between the reflection on the course content and the professional conduct of chemical research.

Course Titel:

The course title should reflect these considerations. "*Ethics in Chemistry*" is misleading and might lower the acceptance for such a course, both among institutional decision-makers and students. A title like "*Research Methodology, Science Conduct and Social Implications of Chemistry*" might serve the purpose better. If that is too long, "*Chemistry, Ethics, and Society*" might serve the purpose well, too.

Course description:

The course shall equip the attendants with competences and skills in basic research methodology and its philosophical foundations on the one hand, and in overseeing, understanding, evaluating and assessing contemporary ethical and social issues arising from scientific and technological activity and progress on the other hand. The course is designed and planned in particular for Chemistry students and their related fields, requiring no philosophical or ethical background knowledge. The course content is strongly related to the students' daily research activity: Science conduct, logic and theory of science, experimentation, writing publications, dealing with uncertainty, social impact of scientific activity. Applying the fundamentals in philosophy of science and research ethics to the particular conduct of science and its internal and external domains of responsibility is expected to sharpen and solidify the students' awareness for the theory of research practice, their knowledge of Ethics and their ability to exploit ethical thinking for the application in the social sphere "science and technology" as a field of human activity that impacts the quality of life of people all over the planet. As a major field in "Applied Ethics", Science and Technology Ethics touch the domains of Bioethics, Medical Ethics, Environmental Ethics, Profession Ethics and Business Ethics. With the help of countless examples from chemistry, science in general, research, engineering, R&D, etc. in the history of societies worldwide, the students will get a sense for the "Ethos" of science conduct on the one hand, and of the ethical and social implications of S&T on the other hand. While the former is a matter of "internal responsibility" of individual researchers and their institutions, the latter topic will address risk issues, responsibility for outcome of S&T progress, and the social construction of technology. The overall objective of this course is to contribute to a more "complete" education of young researchers and scientists as important enactors of progress and influential decision-makers in the future. It shall provide them with the skills to reflect on and deal with the major contemporary challenges in society and environment with a higher degree of sustainability.

Summarised course objectives:

- Understanding basic Philosophy of Science and applying it in daily research activity
- Increasing knowledge on theory, conduct and communication of science
- Applying Ethics to "Scientific Practice" and "S&T Assessment"
- Learning concepts of "responsibility" and "sustainability" in S&T
- Acquiring skills for interdisciplinary normative discourse

Textbooks and References as accompanying course reading material

Listed here are monographs on research ethics, science ethics and technology ethics. Not included is distinct material on particular topics, such as Publishing Guidelines, position papers from Chemical Weapons Conventions, regulations on animal experiments, etc. Some of the listed books include extensive reference lists that contain that kind of documents. Here, again, it is important to include material that is relevant for the students, preferably in their mother tongue. Macrina 2014 and Shamoo, Resnik 2015, for example, mostly refer to regulations and guidelines enacted in the USA, which might be irrelevant (in some cases) for students in the EU. Hansson 2017 provides - unlike the title suggests - a great introduction to sustainability, risk, responsible research, and other societal dimensions of scientific activity.

<u>Recommended:</u>

- P. Pruzan, *Research Methodology. The Aims, Practices and Ethics of Science*, Springer, Switzerland, **2016**
- J. Kovac, *The Ethical Chemist: Professionalism and Ethics in Science*, Prentice Hall, Upper Saddle River, **2003**
- F. L. Macrina, *Scientific Integrity: An Introductory Text with Cases*, 4th edition, American Society for Microbiology Press, Washington, **2014**

- E. Shamoo, D. B. Resnik, *Responsible Conduct of Research*, 3rd edition, Oxford University Press, Oxford, **2015**
- C. Russell, L. Hogan, M. Junker-Kenny, *Ethics for Graduate Researchers. A Cross-disciplinary Approach*, Elsevier, London, **2013**
- S.O. Hansson (ed.), *The Ethics of Technology. Methods and Approaches*, Rowman & Littlefield Intl., London, **2017**

Further Reading:

- Committee on Assessing Integrity in Research Environments (CAIRE), *Integrity in Scientific Research*, The National Academies Press, Washington, **2002**;
- S. Loue, *Textbook of Research Ethics - Theory and Practice*, Kluwer, New York, **2002**;
- National Academy of Sciences, *On Being a Scientist: Responsible Conduct in Research*, 3rd Edition, National Academy Press, Washington DC, **2009**;
- D. B. Resnik, *The Ethics of Science - An Introduction*, Routledge, London, **1998**;
- K. S. Shrader-Frechette, *Ethics of Scientific Research*, Rowman&Littlefield, London, **1994**;
- Smith Iltis (Ed.), *Research Ethics*, Routledge, New York, **2006**;
- R. E. Spier (ed.), *Science and Technology Ethics*, Routledge, London, UK, **2001**
- Mitcham (ed.), *Encyclopedia of Science, Technology and Ethics*, Thomson Gale, Famington Hills, **2005**

Online sources:

- http://research-ethics.net
- http://poynter.indiana.edu/teaching-research-ethics/tre-resources/
- http://pages.towson.edu/ladon/ethics/ethicsyl.htm

Who can teach?

No general answer can be given on this question. It is a matter of circumstances at the particular university.

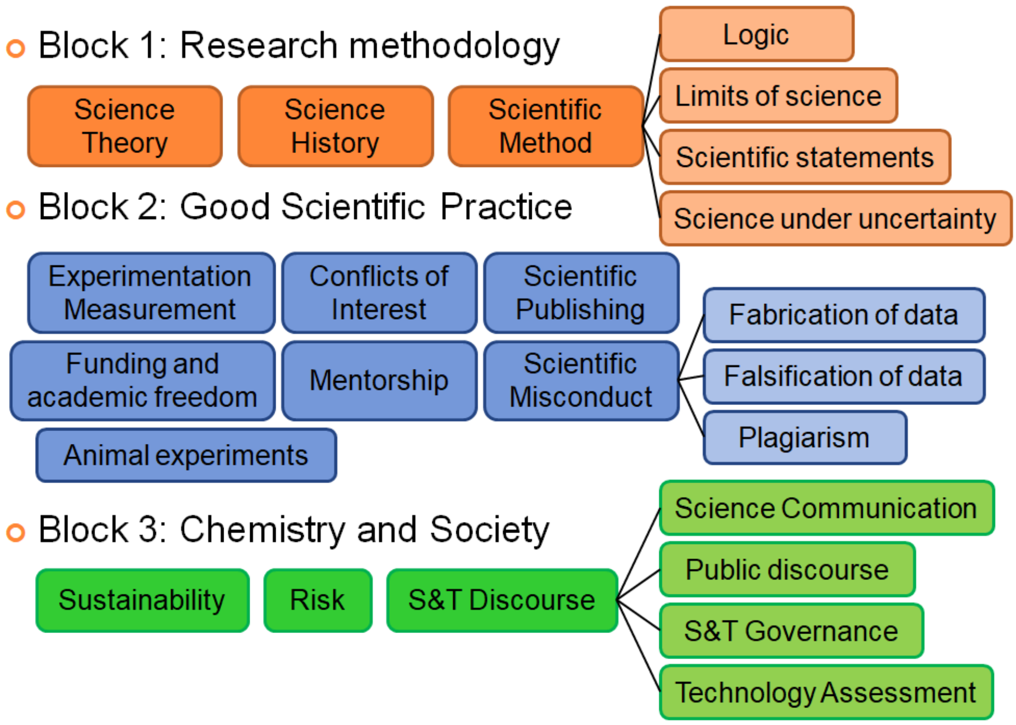
- Option 1: A faculty member of the Chemistry department teaches the course. It must be someone who feels competent to teach research methodology and who is familiar with ethical aspects of scientific activity. This either requires a particular qualification in this field (e.g. a degree in Applied Ethics, work experience in ELSI projects, etc.) or the willingness to elaborate a knowledge base from extensive literature study. Both might be a challenge.
- Option 2: The Chemistry department establishes a cooperation with a respective institute within the same university, e.g. Philosophy (science ethics) or Sociology (Sociology of Technology). It must be made sure that the lecturer has experience in working with Chemists or even has a knowledge background in Chemistry and practical experience with chemical research.
- Option 3: Invited speakers. If a lecturer can't be recruited from the academic staff of a university, it can be attempted to invite a scholar from another university. It should be avoided, however, to split the course into a compilation of related topics, each taught by a different speaker. This would have negative impact on the meaningfulness and usefulness for the students who would have bigger difficulties to identify themselves and their work with the course content. If one single lecturer is dedicated to the course, he or she has much better chances to deliver this potentially "dry" topic in a more personal and inspiring way (knowing the students' research topics, addressing their particular questions and issues).

- Option 4: Assigned "Ethics in Chemistry" experts by the EuCheMS member societies prepare and teach the course (as suggested in a EuCheMS task group meeting). I am not sure how this can be organisationally and logistically feasible. One way could be the preparation of an online class (recorded videos) by one particular expert. That could be a "last resort" if the other options don't work out.

In any case, the requirements and options for such a course vary from university to university, especially the available time framework. An outline for a general syllabus for such a course necessarily needs to be flexible and "open" in the sense that a lecturer may take its suggestions and construct his or her own syllabus with little effort. Therefore, a modular approach is followed.

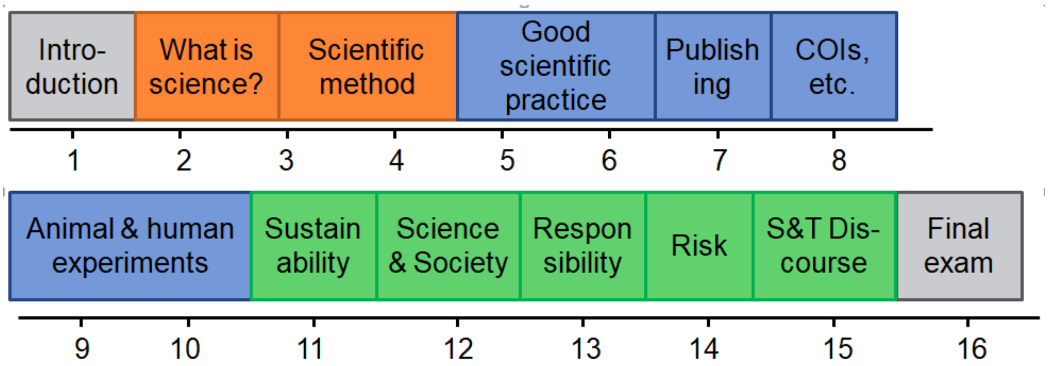
Modular course schedule

Three blocks that cover the three fields of inquiry mentioned above (scientific methodology, good scientific practice, social dimensions of chemistry) are suggested:



Please keep in mind that the main objective of the first block is to sharpen the students' awareness of the methodological pitfalls of scientific practice and the importance of compliance with guidelines of *good scientific practice*! It is included in this course for the pragmatic reason that - according to frequent observation - there is no other chance for science students to learn science theory, even the most basic rules of logic, hypothesis formulation and argumentative reasoning of conclusions. However, since it shall not be a class in philosophy of science, the topic must be condensed into a meaningful and significant introduction into science theory. Several academic journals (e.g. HYLE; Science & Education) provide valuable suggestions and strategies for lecturers to tackle this demanding task. [In case it is of interest, find the way I managed it in the transcript of the course, provided here: https://magagpa.wordpress.com/st-ethics/]

This introductory block is followed by the two blocks in research ethics (a field of profession ethics) and social dimensions of science (mostly informed by aspects of technology ethics). I am aware of the fact that most scientists deny the relevance of the latter and would like to reduce "science ethics" to the profession ethics part. I have, as I believe, provided good reasons for adding the field of external responsibility (the social implications) to this syllabus [see also: J. Mehlich, "*Is, Ought, Should - The Role of Scientists in the Discourse on Ethical and Social Implications of Science and Technology*", *Palgrave Communications* **2017**, *3*, 17006]. Lecturers may choose to put greater weight on the former part. Yet, the latter shouldn't be omitted entirely since it teaches the concepts of sustainability, risk governance, precaution and others that will be outspokenly important and valuable in the students' future job life. Roughly, a course schedule that includes all the suggested modules could look like this:



It is obvious that this outline is a very rough orientation and must be specified and refined according to the given circumstances (actual number of lessons, institutional needs, preferences of the lecturer, etc.). For example, many courses on research ethics set a focus on "experiments with humans", which might be of lower relevance for Chemists so that it can be skipped.

The first lesson should give a clear overview of the course objectives and why the lecturer chose to discuss certain topics. Here, the chance must not be missed to trigger students' attention by linking the course content to their research activities and expected roles as scientists. I made good experiences with explaining the differences between top-down and bottom-up ethics approaches and their "middle way", by depicting the scientist as a member of the society with a particular role (justifying the call for a "science ethos") and an impact on society, and by structuring the course according to two different levels of responsibility. The next lessons should go through all elements of "the scientific method" so that it becomes clear for the students where ethical pitfalls can arise. The application of logic and statistics, the formulation and verification/falsification of hypotheses, the interpretation of data in view of established knowledge, theories, etc., all these aspects have an ethical content and are subject of discourses in philosophy of science. This overview will facilitate the further teaching of research ethics by structuring it and outlining the links between scientific activity and its ethical problems.

The following lessons should be devoted to "good scientific practice". This block may start with the elaborations of "virtues of scientific practice" that are the elements of a "science ethos". Then, these virtues can be discussed in view of the common ethical "hot topics" in science: Fraud (fabrication, falsification, plagiarism), publishing of science, mentorship issues, conflicts of interest, academic freedom, collaboration and interdisciplinary research, intellectual property.

A special focus (one lesson) must be put on research that includes animals. This is recommended even if none of the course attendees actually does animal experiments, because it delivers important knowledge on a certain type of ethical implication of scientific activity.

After these topics in the dimension of "internal responsibility", it can then be proceeded to the broader aspects of societal and environmental impact of chemistry. This section shall start with a lesson on the (political, economic, societal) concept of sustainability and how chemical activity (research, industry) relates to these considerations. After elaborating on the connections between chemistry and society and various approaches of responsibility, the focus can be turned towards risk issues, covering more narrowly defined "scientific" elements as well as broadly understood "societal" implications. In a next step, the students should learn about existing established practices of S&T related ethical discourse (e.g. ELSI debates, RRI, technology assessment) and the scientists' particular role in it. For this purpose, they may also be confronted with common argumentation strategies and reasoning patterns that emerge in such a discourse.

Again, it must be pointed out that the presentation of cases and real-life examples are the most important element of this course (rather than mere theoretical reflections). In each module, the lecturer is advised to choose illustrating cases that can easily be anticipated by the students as they address situations that they may potentially find themselves in. The literature is full of case studies and compilations of such that may be exploited for teaching purposes. It may be a good choice to dedicate the last class of the course to one or two particular examples of technoscientific systems (e.g. biotechnology, nanotechnology, energy-related S&T, food industry, etc.) and discuss all the relevant issues of it. This choice can be made according to the thematic focus of the attendees or their particular department. Here, the students shall learn how to apply the content of the other lessons to a particular branch of S&T. It sets all aspects into a useful perspective and summarises the course aptly in order to let the students realise how its objectives relates to them personally.

The following table provides a more structured overview. It is divided into 10 sections, but may be expanded into more lessons (for example, a typical lecture at a German University consists of 15 lessons). The overview does not include exams or time for student presentations. However, it is recommended to let the students participate actively by preparing reports on particular ethical topics of their research work. This could be written homework or group work with in-class-presentations, according to the preference of the lecturer.

Section	Course content
1	Why Philosophy of Science? Why Research Ethics? For whom? Does it make a difference? Definitions of "Science", "Technology", connections to "society". Responsibility in Science • Internal and external domains of researchers' responsibility • Role responsibility, actor responsibility, consumer responsibility • Individual vs. institutional responsibility, shared responsibility Short Self-introduction of course attendees (important for the selection of topics throughout the course → must be linked to students' actual work)
2	What is science? What is not science? Science ←→ Society Limitations of science Realism and Anti-realism, constructivism Scientific Statements: Their justification and acceptance Description, Causality, Prediction, Explanation Hypotheses, Theories and Laws Deductive, Inductive and Abductive Logic in Science → Uncertainty in research, risk
3	Science ethics as virtue ethics • "Scientist" as a social role → Expectations

	• What is the "ideal scientist"? • Virtues of "good science". Scientific integrity. Measurement and Experimentation, Scientific Method Processes, Instruments, Operationalisation Measurement errors Validity and reliability in experimentation, design of experiments Safety issues • How many experiments? • How many resources? • How much risk? For whom? Scientific misconduct: • FFP definition: Fabrication of data, Falsification of results, Plagiarising of research. • Reasons for fraud: Institutional pressure, conflicts of interest, pride, etc.
4	Science Communication Doing science vs. writing science Publication of research Ethics of publishing • Writing science: trivial? Ethics of science communication. • Publishing practices: o Peer reviewing, o Impact factors, • Citation practices. Communication with non-experts
5	Further Issues of scientific practice: a) Mentorship issues b) Research funding and academic freedom c) Collaborative Research, Interdisciplinary research d) Conflicts of Interest e) Intellectual Property
6	Experiments with animals • Animal rights? • "3R" regulations • Legal issues Alternatively: Topics closely related to the students' actual research
7	What is sustainability? • Sustainability as the "call for ethics" in science and technology assessment. • History, definitions, normative foundations. Scientific and technological progress • Determinism or constructivism? Historical cases, current views. • Impact on society, impact on S&T governance and institutions. • Neutrality claim?
8	Responsibility of Chemists 4 Dimensions of responsibility: • Who? (Individual, shared, collective responsibilities) • attributed by who? (The chemist as a social role) • for what? (Implications of chemical activity) • concerning what factor? (Chemical knowledge and expertise) Risk Governance • Definition of risk, risk assessment, risk management. • Ethical dimensions of risk: normative frameworks for risk governance. • Precautionary Principles

9	Professional arenas of S&T-related ethical discourse • S&T governance, Science policy • ELSI commissions, interdisciplinary expert roundtables Argumentative patterns • Consequentialism, Deontology, Justice (Contractarianism), Virtue Ethics in the evaluation of "emergent technologies".
10	Discussion of a topic related to the students' interests, e.g. Biotechnology, Nanotechnology, Energy, Food, etc. • Viewpoints of different stakeholders and public, conflict potentials • Social and environmental impact • Cultural differences?

What can be offered?

There is not much use in offering ready-made presentation slides or lecture transcripts. Lecturers will need to prepare their own classes. In order to support this, in addition to this modular syllabus suggestion, the following items can be prepared and offered through electronic sources (for example, the EuCheMS webpage):

- Literature data base - A list (with links, if possible) of text material (books, articles, essays, etc.) that may be used as course-accompanying literature or as inspiration for the lecturer for the preparation of the course.
- Collection of cases - A compilation of the cases that are commonly used to illustrate the ethical pitfalls of scientific (and particularly chemical) activity.
- Teaching tool suggestions - A collection of images, videos, slides, etc. that have been proven useful in explaining complicated issues in a clear, simple, understandable and/or brief way, based on the experiences of previous such courses, alongside literature links to didactic instructions for teaching ethical and social aspects of science conduct.