Overview of the Ethical Dimensions of Scientific Research

Module One

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Series: Ethical Dimensions of Nano Science and Technology

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Author: Erich W. Schienke

MODULE INTRODUCTION

- This educational module provides users with concepts and examples for the development of ethical tools for analysis. Ethical tools are used to identify and design towards optimal solutions that satisfy a wide variety of ethical dimensions.

- Users of this module, and any module within the Ethical Dimensions of Scientific Research series, are enhancing and refining their moral literacy.

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- We present here a unified approach for understanding, engaging, and responding to questions concerning ethical and moral behavior encountered in the production and application of research. A unified approach, though, does not mean that it is universal and applicable to all contexts.

- One issue always worthy of consideration concerns addressing, "who bears the burden of intended and unintended consequences of our research?"

RESEARCH ETHICS

- *Scientific research* comprises more than just studies within a lab setting.
- The production of scientific research is tied to politics, social needs, public funding, venture capital, human health, environmental security, and economic development, as well as many other concerns of human society.

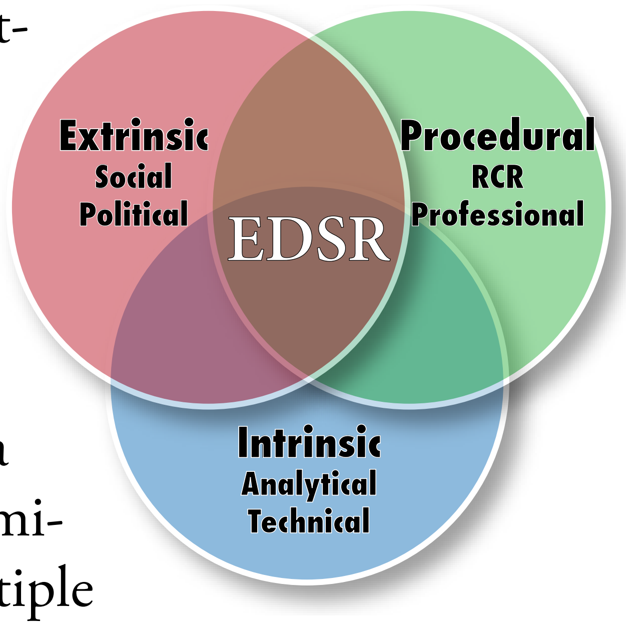
- Research ethics as broadly defined, thus, are a matter of:
  - responsible professional conduct fitting to the norms of a research community (procedural ethics);
  - require a consideration of the broader social, political, and economic impacts (extrinsic ethics);
  - and, point to where (social, personal, institutional) values and preferences become embedded in the analytical inputs and outputs of research itself (intrinsic ethics).

Consequences

- Choices made during research have ethical consequences.
- It is not always obvious what is right and wrong behavior in certain situations.
- Understanding how to make good choices as practitioners and leaders in the field of nanotechnology will require both scientific knowledge and an awareness of the various positions along with projected trade-offs.
- Tenured jobs are lost over research ethics violations, foreign nationals can be deported over non-compliance when researching on government funds, entire labs have been closed due to ethics violations.
- The key is to learn both about ethics by improving your ethical and moral literacy and where to go to learn more–find someone you can talk with.

Not paying attention to ethical norms and proper research conduct can impact careers.

Ethical Dimensions



- Research ethics is not a matter of memorization of rules about proper behavior. Rather, it is important to approach learning research ethics as the skill of being able to derive the ethics of a given situation, by asking similar key questions across multiple situations.
- As developed in the EDSR approach, three main categorical distinctions for research ethics used here are:
- broader social and political impacts of research (extrinsic ethics);
- research practice and conduct (procedural ethics);
- and embedded values within research (intrinsic ethics).

PROCEDURAL ETHICS

- There are ethical considerations of how to proceed in the course of conducting any manner of scientific research.
- These are referred to as procedural ethics and signify the typical areas of responsible conduct of research, including issues such as falsification of data, fabrication of data, and plagiarism, as well as considerations around conflicts of interest, research misconduct, treatment of human and animal subjects, and responsible authorship.
- *Every job occupied, every grant received and every paper published by someone who engages in misconduct deprives at least one honest scientist of an opportunity to which he or she was entitled." Herbert N. Arst, Jr., Imperial College School of Medicine, London. Nature 403:478, 2000.*

Nine main areas to consider in the Responsible Conduct of Research:

- **Data Acquisition, Management, Sharing and Ownership**
- **Conflict of Interest and Commitment**
- **Human Subjects**
- **Animal Welfare**
- **Research Misconduct**
- **Publication Practices and Responsible Authorship**
- **Mentor / Trainee Responsibilities**
- **Peer Review**
- **Collaborative Science**

Falsification, Fabrication, Plagiarism

- Known as the three "cardinal sins" of research conduct, **falsification, fabrication,** and **plagiarism** (FFP) are the primary concerns in avoiding research misconduct.
- *Falsification* is the changing or omission of research results (data) to support claims, hypotheses, other data, etc.
- *Fabrication* is the construction and/or addition of data, observations, or characterizations that never occurred in the gathering of data or running of experiments.
- *Plagiarism* is using or representing the work of others as your own work. Not properly citing sources is one of the most common forms of research misconduct.

Conflicts of Interest

- Personal obligations, connections to other institutions, participation in other research programs, or drawing from competing pools of funding can influence one's capacity to be impartial in a given situation.

- Knowing when we are or are not able to think outside of our other interests is crucial to understanding how to avoid possible conflicts of interest.
- The key to avoiding possible conflicts of interest is transparency of plausible interest in a given situation. Reveal all relevant connections to the case at hand.
- Recuse oneself from the case at hand if necessary.

Care for Data

- Data are the core of research. The recent requirements by federally funded grants to develop data management plans summarizes the imperatives here, including long-term storage of data, sharing of data, and other aspects of assuring data integrity, continuity, and federation.
- Interoperability of data, particularly across research institutions is crucial in conducting collaborative research across a large network.
- Paying attention and adhering to meta-data standards (information about data types and data structures) is of growing importance in sharing data between research communities, across disciplines, between regulatory institutions, governmental offices, and NGOs.

National Science Foundation (NSF) Data Sharing Policy:

Investigators are expected to share with other researchers, at no more than incremental cost and within a reasonable time, the primary data, samples, physical collections and other supporting materials created or gathered in the course of work under NSF grants. Grantees are expected to encourage and facilitate such sharing.

Responsible Authorship

- The identification of authors, the ordering of authors, the speed of publication of research findings, modes of research dissemination, acknowledgements, relevancy, and other aspects of publishing and disseminating findings.
- It is extremely important to adequately and accurately cite literature to give credit to those who have conducted research before you.
- It is better to be cautious and cite when unsure to avoid even the appearance of plagiarism.

"Authorship and collaboration problems are a serious threat to the research enterprise and to the motivation of young scientists, especially when they involve misappropriation of ideas and data." Floyd E. Bloom. Science 287:589, 2000.

- Authorship credit should go to anyone providing a substantial intellectual contribution to the paper.
- It is worth discussing authorship at the beginning of a project to avoid conflicting expectations when it comes time to publish.

EXTRINSIC ETHICS

- Nanotechnology presents significant challenges and opportunities to questions concerning the broader impacts on societal (economic, political, cultural) and environmental (ecological, biological, land-use) domains.
- Further considerations of issues around the distribution of benefits and harms of nanotechnology need to also be taken into account, to assure, for example, that nanotechnology does not benefit only already well-off sectors of society.

Issues to consider about the extrinsic ethics of nanotechnology:

- **What are the public policy and/or legal implications of research?**
- **Are there questions around intellectual property?**
- **Is the research potentially transformative of society and/or economy?**
- **Are there dimensions of social justice that need to be considered?**
- **Are there educational dimensions to the research?**
- **Does the research take into account underrepresented groups?**
- **Are there issues about privacy that need to be considered?**
- **Are risks to health and environment being adequately considered in a precautionary manner?**
- **Have long-term considerations about future impacts been taken into account?**

Policy Implications

- Scientific research can and often does impact public policy in a manner of ways. Understanding that one's research may be applicable to informing public policy decisions or be subject to regulatory mechanisms is crucial.
- There are many three main intersections between policy and research that need to be considered, such as:
    - policy and regulation about the scientific research and/or technology (policy of science, or science policy);
    - scientific research and technological capacity often informs crucial decision-making processes, such as determination of risks and evaluation of responses (science for policy);
    - and, institutional policies in support of funding and conducting research (research management policy).

Intellectual and Personal Property

- Nanotechnology will present some of its own unique legal challenges, particularly where regulatory issues cross paths with property rights, ownership, public domain, surveillance, and privacy.

- Nanotechnology, unlike other similar technical areas (such as biotech or microelectronics) is undergoing the patenting of many fundamental processes.

As of June 28th, 2011, the US Patent Office has granted 7,000 nanotechnology (Class 977) related patents.

- As nanotechnology is really really small, certainly working below the detection of normal human perceptions, it provides significant opportunities for the development of undetectable monitoring systems, which can bring up significant issues around molecular privacy, awareness of surveillance, and ownership of molecular information gathered from monitoring.

Changes in Economy and Society

- Nano science and technology present possibilities which could potentially transform the shape of economic production, output, market arrangements, etc.

Nanotechnology - which some scientists and business leaders hail as ushering in the next technology-driven Industrial Revolution - promises to be one of the critical foundations for this new innovation economy.

- It is crucial to ask whether the research could impact how society functions on a day-to-day basis, for example, such as how we grow food, produce energy, etc.
- The public understanding of nanotechnology presents significant challenges, particularly in trying to communicate risks, challenges etc.
- The full arrival of a nanotechnology based manufacturing will have profound effects on traditional modes of fabrication and production.

Social Justice

- Most people would tend to agree with the stance that our developments in science and technology should adhere to, or at least not be entirely counter to, our notions of the common good, not harming others, not causing further hardships, etc.
- Distributive Justice (equity): are the costs, harms, and benefits of nanotechnologies being distributed equitably over society?
- Procedural Justice (due process): how are decisions about nanotechnology regulation being taken into account and who is making the decisions and choices.
- Intergenerational justice (long-term): choices made now about infrastructure, investments, longevity, and risk can have implications for generations to come.

Risk and Precaution

> "Molecular manufacturing and nanotechnology are not one technology, but rather a spectrum of technologies, with radically different risk profiles." (Foresight 2006)

- Approaching any new territory in science and technology can present great payoffs and public goods, but they can also present daunting challenges that can change and shape international relations.
- Understanding and fully defining the risks of a given technical scenario require both an analysis of the science itself (see intrinsic ethics issues on handling of uncertainty), and a projection as to how the technology could potentialy cause harm or otherwise negatively impact human well-being.
- Precaution in the face of risk needs to be considered and taken into account in any case, and certain aspects of nanotechnology can present an exceptional risk to human and environmental health.

INTRINSIC ETHICS

- While considerations of procedural ethics require a framework of responsible research behavior and extrinsic ethics requires an explicit consideration of broader impacts, intrinsic ethics requires a deeper analysis of how the research itself is constructed and where certain choices being made in the line of research embed value judgements and can impact real-world outcomes.

Some issues to consider about the intrinsic ethics of nanotechnology:

- **How are standards of proof, errors, and uncertainties handled in a given analysis?**
- **What constitutes empirical adequacy and how consistent are results, over how many runs?**
- **What is the scope? Are some dimensions of the analysis oversimplified?**
- **What classification typologies are being used (ontologies)?**
- **How / what methods were selected?**
- **What went into the choice of research questions?**

- The basic idea of intrinsic ethics concerns choices that seem to be only considered in mathematical or within the terms of the art, yet can embed certain values and result in different implications as to the application or future direction of the nano-knowledge.

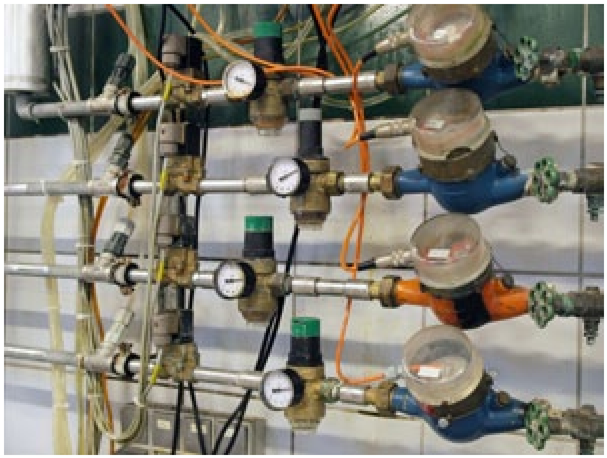
Framing Research

- Values and ethics become embedded within the production of research, often times, at the very decision about research topic and question.

- Choice of Research Questions: research results are inevitably impacted by the scope and range of research questions.
- Frameworks and Global Assumptions: interests of the researcher are reflected in accepting certain framework conditions, such as the representational limits of an analysis, or in choosing the values of certain variables, within a model, as being "more" representative of reality than a different variable, model, or limit.
- Causal Explanations and Narratives: causal explanations produce a conception as to what is happening within a given nanotechnology model or analysis.

Empirical Adequacy & Simplicity

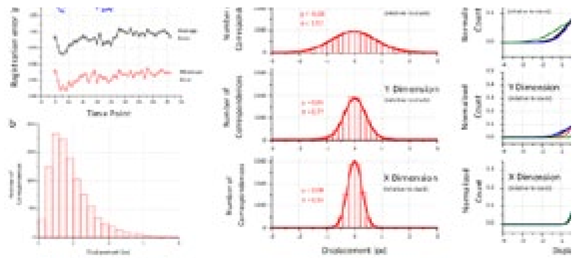
- How do we determine what we are seeing adequately supports our claims?
- Empirical Adequacy and Consistency: were adequate tests conducted to assure the phenomena observed is consistent, is the study reproducible, or is the instrumentation working within viable parameters and/or limits of observation.



- Simplicity/Scope: what is the scope of the study under consideration, is the study significantly comprehensive to be relevant to various conditions?
- Complex phenomena require complex models and descriptions. Not adding enough complexity to a research hypothesis could result in oversimplification of a situation, leaving out crucial thresholds or other limits in the system(s) under consideration.

Standards of Proof & Uncertainty

- What constitutes certainty about a given observation? How many times must it be observed to be considered “valid proof” of a particular event? What is considered to be statistically significant for a given event to be occuring?
- Standards of Proof and Handling of Uncertainties: standards of proof often incorporate social values.
- Type I and II errors can have significant impacts in nano-applications and need to be considered by researchers and peer-reviewers.



Type I error: (false positive) where the test produces a positive result when the negative result is the case, such as in a medical patient testing positive for a disease they do not have. In terms of data analysis, new information falsely changes previous estimates of uncertainty.

Type II error: (false negative) where the test produces a negative result the when the positive result is the case, such as when a medical patient has an ailment that goes undetected by test(s). Regarding data, new informations does not correctly change previous estimates of probability of occurrence.

Both types of errors present different costs in different contexts, and result in a choice about values.

Methods & Classifications

- Methods selection itself, can shift over the duration of the experimental process (though, hopefully not during an experiment!) of a given investigation. As we travel through the research process, we gather data about observations. This data is shaped by our selection of methods, and also conforms to our classification schemes.
- Methods Selection: choice of methods for either data collection and/or analysis reflects the context of the researcher and impact significantly the intellectual merit and framework of the nanotechnology research.

- Classifications and Ontologies: the classification of an observation or phenomena, particularly when the classification strategy is being developed, the adequacy of certain definitions, granularity of classifications, etc., can have significant impacts in later developments, lead to certain oversights, and even lead to misleading conclusions.

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RESOURCES

The National Nanotechnology Infrastructure Network (NNIN) "is an integrated partnership of fourteen user facilities, supported by NSF, providing unparalleled opportunities for nanoscience and nanotechnology research. The network provides extensive support in nanoscale fabrication, synthesis, characterization, modeling, design, computation and hands-on training. in an open, hands-on environment, available to all qualified users." http://www.nnin.org/

NNIN Societal and Ethical Issues (SEI) Portal
"SEI is concerned with the social and ethical dimensions of nanotechnology research, development, and application. SEI challenges the assumption that nanoscience - and science and technology in general - are merely technical affairs, understandable and describable in the language of numbers, chemistry or mathematics. Instead, it is deeply embedded in the social world and in the context of issues such as potential benefits and risks of nanoproducts (i.e., health, safety, and environmental) and the "problems" these products are designed to "solve." Also of importance is how individuals - nanoscientists included - perceive and react to these issues. What are the perceived risks and benefits? Why do we emphasize certain risks and benefits over others? What "problems" are we most concerned about? Nanoscientists may not have all the answers if asked to describe the social or ethical implications of their research. However, beginning to think about them is an important first step." http://sei.nnin.org/

Institute of Electrical and Electronics Engineers (IEEE)
"Through its Ethics and Member Conduct Committee, IEEE aims to: foster awareness on ethical issues; promote ethical behavior amongst those working within IEEE fields of interest; create a world in which engineers and scientists are respected for exemplary ethical behavior."
Review the IEEE Code of Ethics. • Review ethics cases.

National Academy of Engineers (NAE)
"Founded in 1964, the National Academy of Engineering (NAE) is a private, independent, nonprofit institution that provides engineering leadership in service to the nation. The mission of the National Academy of Engineering is to advance the well-being of the nation by promoting a vibrant engineering profession and by marshalling the expertise and insights of eminent engineers to provide independent advice to the federal government on matters involving engineering and technology."
http://www.nae.edu/

Within the NAE
"The overarching mission of **Center for Engineering, Ethics and Society (CEES)** is to engage engineering leaders in examining the ethical and societal challenges of engineering and bringing them to the attention of the engineering profession and society."
http://www.nae.edu/26187.aspx

"The Online Ethics Center (OEC) is maintained by the National Academy of Engineering (NAE) and is part of the Center for Engineering, Ethics, and Society (CEES). The CEES started in April 2007 and plans conferences and other research and educational activities under the direction of the CEES advisory group."
http://www.onlineethics.org/

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