Responsible Conduct of Research in Engineering

Sara Wilson, Associate Professor
Mechanical Engineering
University of Kansas
KU RCR efforts

What is done at KU?

- A newly developed, modular, Blackboard-based, web course departments can use in a cafeteria fashion to fulfill RCR training needs within their area (the catch all)

- Within introductory graduate courses (Biology)
  - GS 804 Ethics in Science and Engineering
    1 cr hour (focused on sciences – taken by Chem, Pharm Chem, Med Chem, Pharm & Tox, Nursing)
  - BIOE 801 Responsible Conduct of Research in Engineering
    1 cr hour (my course – required in Bioengineering MS and PhD programs)

- Online tutorials for some specific subjects (human subjects)
What is unique about engineering RCR at the graduate level?

- Engineer as a ‘science’ researcher
  - Hypothesis-driven research
  - Typically experimental research attempting to prove a hypothesis in order to advance understanding
  - Why? questions

- Engineer as different from a scientist
  - Design: Creating a device/system/construct to solve an identified set of problems using scientific principles
  - Forensics: Using scientific principles to answer questions about how events occur
  - Modeling: Developing a simplified, mathematical/computational representation of a system that could be used to examine hypothesis or as a basis for design or forensics
  - How? questions
Engineering MS and PhD Graduates Careers:

- Ongoing survey of KU faculty and their student’s careers (13 faculty)
## Survey of Faculty

<table>
<thead>
<tr>
<th>Topic</th>
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<th>Somewhat</th>
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RCR/RCE topics

Engineering Topics:
- Modeling (simplifying assumptions, validation, computational error, extrapolation)
- Human health and welfare in the design of devices/structures/constructs
- Working within areas of competence
- Client/Employer agent and avoiding conflicts of interest in professional practice
- Business practices
- Public statements
- Global/social impact of engineering design

Science Topics:
- Data Integrity and Appropriate Reporting of Statistical Methods
- Conflicts of Interest in Review and in Financial Rewards of Research
- Publication and Openness
- Allocation of Credit
- Authorship Practices
- Confidentiality
- Falsification, Plagiarism, Fabrication
- Mentorship
- Human/Animal Subjects
Students In Computational Modeling

- While some RCR topics are appropriate to these students:
  - Authorship Practices
  - Plagiarism
  - Confidentiality in Peer Review
  - Mentorship

- These students often find their research is not part of the normal RCR discussion
  - What is fabrication and falsification when it comes to a model?
  - Some are pretty far from the human health and welfare implications of research
Experimental Methodology

Sampling → Experiment → Double-Blind

Hypothesis → Experiment

Data Integrity (fabrication, falsification) → Experiment

Statistical Analysis (appropriate inclusion of all data) → Experiment

Communication of the Experiment and its Results
Modeling Example - Meteorology

- Understanding patterns of air and weather motion is a complex problem, difficult to obtain experimentally and well suited to modeling.
- Impact the general public in many ways:
  - weather related evacuation
  - global warming/ air pollution effects
  - crop related decisions
Assumptions

Range of Validity

Sensitivity Analysis

Input Conditions

Discretization

Computational Model

Communication of the Model and its Results (Visualization, Extrapolation, Use of Model Methods by Others)

Experimental Validation
Students Working In Design

- Human health and welfare in the design of devices/structures/constructs
- Global/social impact of engineering design
- Sustainability
- Issues in Manufacturing (byproduct creation, pollution, efficiency)
- Business Ethics
- Intellectual Property
- Confidentiality and Classified/Restricted Research
Graduating Students Heading to Industry

- Professional Practice:
  - Human health and welfare in the design of devices/structures/constructs
  - Working within areas of competence
  - Client/Employer agent and avoiding conflicts of interest in professional practice
  - Business practices
  - Public statements
  - Global/social impact of engineering design (including sustainability)
  - Intellectual Property
  - Issues in Manufacturing (byproduct creation, pollution, efficiency)
My Course

Week 1: Basic Ethical Principles, Societal Roles of Engineers and Scientists
- Moral reasoning
- consequence-based reasoning (utilitarianism),
- duties/rights/justice-based reasoning (deontological),
- virtue-based reasoning
- Integration of methods of analysis
- The roles of scientist and engineers in society
- Codes of ethics (ASME, NSPE, and ACS).

Weeks 2-7: Scientific Practices
- The next section of the course focused predominately on traditional responsible conduct of research topics.
  - Week 2: Best Practices in the Laboratory: Lab Notebooks, Data Handling, Fabrication/Falsification, Statistics
  - Week 3: Working relationships: Advisor/Student, Colleagues
  - Week 4: Papers and Conferences Presentations, Authorship Issues
  - Week 5: Writing a Grant, Peer Review
  - Week 6: Human Subjects/ Animal Subjects
  - Week 7: Conflict of Interest
My Course

Weeks 8-14: Engineering Practice and Integration

- The third section of the course focused on engineering and business ethics, design and manufacturing, societal and global impact and integration of research and engineering practice.
  - Week 8: Research with Industry and the Military, Issues in Confidentiality
  - Week 9: Medical Devices and Engineering Design
  - Week 10: Intellectual Property, Copyright and Patenting
  - Week 11: Professional Practice and Business Practices
  - Week 12: Engineering Modeling Issues
  - Week 13: Social Justice and Sustainability
  - Week 14: Whistleblowing and Managing Issues
My course

Weekly preparation assignments
Short lecture for 10-15 minutes each class
Case studies/Discussion for remainder of the time

Final Project
The final project for this class was for each student to create a case study based on what they learned in the class and their research and engineering experiences. Students worked in teams to edit and analyze each other’s cases. Students were required to write a commentary on their own case and their partner’s case describing the ethical issues and possible ways to manage the issues.
What works and doesn’t

- Having students discuss cases, their own lab experiences, etc.
- Sending students back to labs with questions:
  - Example: Assignment to ask a professor (preferably their advisor if they have one) what the authorship policy is in their lab.

- I have had to step back and add coverage of some “assumed knowledge”:
  - What is plagiarism exactly?
  - What is academic misconduct and what are the consequences?
  - Engineering undergrads sometimes have less knowledge of how science is done than science students (what is a hypothesis, how does one read a research paper)
  - International students have less experience with professional practice and academic conduct expectations in US.

- This is more material in a very short time.
Example Cases (Modeling/Forensics)

- Professor and student asked to model airplane crash using previously developed model of crashes for court case
  - Court case involves showing some damage was not caused by crash
- Student is concerned that model was not validated for the conditions of the crash (swamp)
- Model was not created to rule out damage but rather to describe possible damage

Example Cases (Global/Design)

A New Dialysis Machine

- You are an engineer, working for a company, designing dialysis equipment for worldwide use. You are interested in designing both for economically-developed countries and third-world countries. In the economically-developed countries there are working dialysis systems, but your design would be an improvement. In the third-world, access to dialysis equipment is limited.

You have two choices in the design:

- A design using disposable filters that would be replaced with each patient
- A design involving a 100 times more expensive, reusable filter that could be cleaned, autoclaved and reused with each patient

Issues:

- Purchase of disposables in the third-world is difficult and not typically funded by charitable organizations that might be willing to purchase or donate the equipment
- The reusable filter would require more training, autoclaves and be more expensive initially
- The first design would be more profitable for your company as hospitals would continue to buy disposable filters
- Manufacturing and FDA approval costs are such that your company can only move forward with one design
Thank You

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The Responsible Conduct of Computational Modeling and Research, Michael Loui (PI)

contact: sewilson@ku.edu