

## **AC 2009-2183: CASE ANALYSIS: A TOOL FOR TEACHING RESEARCH ETHICS IN SCIENCE AND ENGINEERING FOR GRADUATE STUDENTS**

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# Case analysis: a tool for teaching research ethics in science and engineering for graduate students

## Abstract

Training in Research ethics should be central to the education of graduate students in science and engineering. Unfortunately, there have been several cases of serious research misconduct. Because research touches upon important aspects of human life, research misconduct can seriously and negatively influence society as a whole. For this reason, it is necessary to introduce graduate students in science and engineering to basic issues in research ethics. At the University of Puerto Rico, Mayaguez campus (UPRM), an interdisciplinary group of investigators created **Graduate Education in Research Ethics for Scientists and Engineers (GERESE)** to integrate research ethics into the graduate curriculum in science and engineering. Funded by the National Science Foundation, this project has developed four workshops directed toward graduate students to provide them with decision making tools for reaching ethical decisions. The workshops which build upon one another, (1) help graduate students become aware of issues and problems in research ethics, (2) outline a method of moral deliberation to help them analyze problematic situations, (3) provide students with tools and practice in analyzing real world ethics cases in the research context, and (4) offer a capstone activity in which the students give poster presentations on a case connected to their research interests.

This paper focuses on the third of the series, the **Case Analysis Workshop**, where students analyze ethically problematic situations in the research environment. This workshop prompts them to deploy skills acquired in previous activities toward the solution of fictional and historical cases. This paper will outline the elements out of which cases are built, methods for analyzing them, and novel techniques used in workshop assessment. It concludes by summarizing outcomes from instantiations carried out with student groups at the University of Puerto Rico at Mayaguez. A sample case in research misconduct will be used to highlight the workshop's central activities, illuminate a step by step analysis program, and outline the special techniques of moral deliberation.

## Introduction

Instances of research misconduct have caught the public's attention sufficiently to dramatize the importance of developing effective strategies to teach research ethics. **GERESE** (Graduate Experience in Research Ethics for Scientists and Engineers), funded by the National Science Foundation, responds to these public concerns by means of a comprehensive model program designed to introduce research ethics into the graduate curriculum. GERESE synthesizes standalone courses in research ethics with micro-interventions that integrate ethics into the mainstream graduate curriculum in science and engineering. Three workshops and a capstone activity provide the skills to deliberate critically and successfully on moral problems in research ethics. A **Graduate Awareness Workshop (GAW)** introduces students to basic issues in research ethics by using a double axis framework that locates ethical issues in axes of pursuing the truth and accomplishing social responsibility [1]. In the **Moral Deliberation Workshop (MD)** students learn methods of ethical deliberation including deontological and teleological approaches (Kant, Ross, and Mill). A **Case Analysis Workshop (CW)** confronts students with

actual and hypothetical situations. Here, students come to understand the social consequences of research misconduct through the discussion and analysis of hypothetical and historical cases. Finally, an **Ethics Banquet** (EB) allows students to synthesize the knowledge and skills they have learned by giving poster presentations that analyze cases in research ethics chosen to fit their specific disciplinary focus. Because each workshop builds on skills and knowledge presented in earlier workshops, these form a progressive series. The expected result after completing this series is a group of graduates who are ethically motivated investigators in the scientific and engineering disciplines and are committed to responsible and ethical research.

Workshop leaders (project PIs and graduate student ethics mentors) have used four cases to create ethical awareness in the research areas: the Tuskegee case [1], the Hwang Woo-Suk case, [2], the Poehlman case [3] and the Aberdeen Three case [4]. These cases exemplify the profound social consequences and impacts of research misconduct and dramatize the urgency of incorporating ethics into and throughout the science and engineering curriculum. Because they are high profile cases, they help to engage science and engineering faculty as well as students. They also dramatize to these constituents the importance of integrating research ethics into the graduate student curriculum.

A double axis framework that classifies research ethics problems in terms of their impact on the pursuit of truth and their implications for social responsibility arises out of consideration of these classic research ethics cases. Objectivity, accuracy, fabrication, falsification, and plagiarism are examples of issues that pertain to the axis of truth. Ethical treatment of humans and animals who are subjects of research projects as well as concern for the impact of research on the natural environment reflect issues that pertain to the axis of social responsibility. This double axis framework responds to the ethical objective of stimulating moral awareness by helping students to classify and identify ethical issues in research.

The “Aberdeen Three” case [4] provides another example of how ethical issues arise during research in engineering. Three engineers, with important R&D positions in a chemical weapons plant, ignored inspections on the handling and disposal of toxic wastes. One of the tanks in the plant containing sulfuric acid leaked onto the soil and percolated into a nearby water reservoir. Mishandling these toxic substances endangered the life of plant employees and local residents.

The Aberdeen Three case fits nicely onto the double axis framework. It uncovers the axis of truth by highlighting individuals and the conflicts that confront them in their respective situations; this axis touches on what others have called microethics [5]. This case also raises the general problem of the social responsibilities of researchers. In this way it shines a spotlight on macroethical issues in research [5]. Thus, the double axis framework develops moral awareness and imagination by showing systematically how cases such as the Aberdeen Three raise ethical issues.

This Case Analysis workshop incorporates the frameworks and principles in the Responsible Conduct in Research (RCR) approach. In addition it goes beyond it in the following four ways: (1) by helping students to understand the ethical reasoning beneath RCR rules, (2) by helping them to acquire skills pertinent to moral deliberation, (3) by providing students with tools to deal with ambiguity and disagreement without abandoning the pursuit of clarity and agreement, and (4) by helping students distinguish between morally conflicting situations, moral disagreements,

and moral problems. Building these objectives onto RCR rules, thus, responds to concerns expressed by the Council of Graduate Schools [6]:

*“...the problem with limiting RCR training to training in professional standards is that the latter does not offer a greater promise for changing the behavior of students than training more broadly in ethics. In fact, it may well offer less. The teaching of professional standards as rules to be followed may have little persuasive value if the standards are not carefully and explicitly justified in terms of their ethical rightness.”(p.8)*

### **Conceptual Framework**

More and more, educators in practical and professional ethics are turning to skills-based approaches in moral pedagogy. The Hastings Center provides an excellent and remarkably comprehensive list of skills that elicit moral conduct [7]:

1. A practiced and refined moral imagination.
2. The ability to recognize moral issues even when these are tightly embedded in complex real situations.
3. Developed and refined skills in analyzing basic and intermediate moral concepts.
4. A finely tuned sense of responsibility.
5. The ability to deal with moral ambiguity and disagreement while remaining focused on moving toward clarity and agreement.

These skills are admirably developed through classroom activities that involve the use of realistic (whether historical or fiction) ethics cases. For example, the cases mentioned above (Tuskegee [1], Hwang Woo-Suk, [2], Poehlman [3] and Aberdeen Three) all give students the opportunity to practice recognizing moral issues, analyzing moral concepts, and dealing with the ambiguity and disagreement. Moreover, when students work with short, thinly structured scenarios, they can refine these skills through practice in the realistic scenarios that well written cases can deliver. Thus, cases turn the ethics class into an ethics laboratory. More complex cases encourage students to practice different modes of structuring and framing complex situations. These framing and structuring activities have been identified by Werhane [8] and Johnson [9] as key elements to moral imagination. Finally, having students practice decision-making and problem-solving through cases and scenarios and then having them explain and justify their decisions to teachers and peers starts the process of developing the virtue of responsibility. Cases represent the best pedagogical strategy for responding to the Hastings Center objectives.

In this way, the Case Analysis Workshop plays a key role in the workshop series that forms the heart of the GERESE project. Its role has been to develop a practical context in which students practice and hone the knowledge imparted to them through the earlier workshops, namely, the **Graduate Awareness Workshop** (which introduces basic themes in research ethics and outlines general moral approaches) and the **Moral Deliberation Workshop** (which provides a more advanced exposure to moral approaches and outlines a method of deliberating about moral problems). The Case Analysis Workshop helps students to develop and refine knowledge about ethical approaches and ethical decision-making as well as heightens their sensitivity to the ethical import of situations typical of research-related activities.

## Methodology for the Case Analysis Workshop

The CAW typically lasts four hours. Its parts, described in detail below, include a pre-test, a review of the ethical concepts presented in the GAW (Graduate Awareness Workshop), a presentation on moral deliberation, cases that detail instances of research misconduct, and a post-test.

### *Case Presentation and pre-test.*

The workshop starts with a presentation of an ethical case in video format [10]. A Spanish translation handed out with the video presentation ensures that all of those in the typically bilingual audience understand the case's content. After showing the video, a question and answer session clarifies both the details of the case and the relevant technical issues. The case and the question and answer session set the stage for administering a pre-test that is used for workshop assessment. During the pre-test, the participants are divided into interdisciplinary groups. They are given 20 minutes to apply the deliberation methodology to the case and argue about the morally justifiable decision.

### *Presentation of a moral deliberation method*

After the pre-test, the workshop leaders help participants review the ethical concepts discussed in previous workshops. Among the topics reviewed are ethics and morality, philosophical approaches to ethical decision-making including strict consequentialism (Mill), strict deontology (Kant), and moderate deontology (Ross). A moral deliberation method developed by Ferrer [11] is presented and discussed. This method is used as a conceptual tool to guide students through the moral deliberation process in a systematic way. The method consists of the following seven steps:

- (1) **Determination of facts:** Students practice identifying the situations, people and environment through which the case unfolds. A good understanding of facts is essential for the this deliberation procedure.
- (2) **Identification of morally problematic situation:** There are usually several morally problematic situations that require attention. This step provides students with an opportunity to improve their sensibility to the situation causing the ethical problems.
- (3) **Identification of possible courses of action:** Usually there are several possible courses of action. Some result in misconduct while others effectively and ethically solve the problem(s).
- (4) **Distinguishing “moral questions”, “moral disagreements”, and “moral conflicts.”** A moral question is a situation in which moral duties are clear to the subject, although they may be in conflict with other issues of interest to the agent such as financial and political interests. These situations do not require moral deliberation so much as moral courage. Moral disagreements arise when the agent feels subjectively certain, but holds a point of view in conflict with other persons' moral judgments. These situations call for moral dialogue and argumentation. Finally, moral conflicts (or moral problems) arise when agents face conflicting moral duties. These instances clearly call for moral deliberation [1].

(5) **Establish a hierarchy of values related to the morally problematic situations.** If there are moral conflicts, the students are required to examine the relative hierarchy of values in conflict in order to determine the overriding duty or duties in the situation.

(6) **Consequence analysis:** If the previous step is not enough to identify the preferred course of action, a further step is required consisting of analyzing the foreseeable consequences of each course of action. The analysis of consequences depends on a good determination of the facts. It should include foreseeable consequences related to the persons involved, the working environment, the external environment, and society at large.

(7) **Justification of the moral choice:** After analyzing different possible courses of actions, the students identify those that are morally justified.

Once this method is set forth, they turn to practicing its application using appropriate examples taken from real and hypothetical cases.

#### *Presentation of research misconduct cases*

Considering that powerful cases are remembered by the students while those less impressive are forgotten with time [12], students turn to discussing two highly publicized cases of research misconduct in this next stage of the workshop. The Tuskegee and Dr. Woo-Suk Hwang cases have been used with success. These are “black and white” cases because they present situations in which the moral and immoral options are clear to the audience. These “black and white” cases (clear cut in terms of moral issues) serve to dramatize the serious social implications of research misconduct. A summary of these cases is presented in the Appendix.

In addition, a set of cases is used to analyze and apply the concepts and steps of the deliberation process. For this part of the workshop, the cases express various shades of gray. In particular, they set forth hypothetical situations progressively laid out to simulate dynamic situations in which one act or decision leads to a chain of events that require further interventions.

#### *Post-test*

A post-test is administered after students have practiced moral deliberation to gain a sense of how their ethical awareness has changed. They form the same groups as in the pre-test and revisit the case used in the pre-test. This provides them the opportunity to deliberate and think from a richer standpoint on cases, facts and morally problematic situations. Post-test results are compared with the pre-test to determine if there has been a change in moral awareness, and, if so, the extent of this change.

### *Workshop Assessment*

The assessment was performed using the pre- and post-test described just above. Included in the comparison was an assessment of the quality of the arguments used during the deliberation process and the completeness of the identification of each one of the steps included in the method of deliberation presented.

A rubric has been developed to assess this **Case Analysis Workshop**. The dimensions, levels and scale used during the evaluation are presented in Table 1. Each dimension was evaluated with a number from zero to three (0 to 3) where zero represents insufficient command of the dimension evaluated and the maximum score, three, represents a high level of mastery of the skills of ethical analysis under evaluation. The rubric allows the qualitative evaluation of each level of analysis that is further translated to numerical values using the linear scale presented in Table 1.

Table 1. Characteristics of the rubric used as assessment tool.

<b>Dimensions</b>	<b>Levels</b>	<b>Scale</b>
1. Determination of facts	0. Beginning	0 %
2. Identification of morally problematic situations	1. Poor	33 %
	2. Good	67 %
3. Identification of possible courses of action	3. Excellent	100 %
4. Identification of moral disagreements and problems in each course of action.		
5. Determination of the values at play and the hierarchy of principles and duties		
6. Consequences weighting		
7. Decision justification		

### **The Development of Additional Cases**

Several additional cases were used and prepared as part of the initial phases of preparation for both the Moral Deliberation and the Case Analysis Workshops. Some of them were adaptations from the existing literature on case analysis in research ethics and others developed by the researchers and research assistants of the GERESE project. These cases have been published on the internet on the platform provided by Connexions®: [www.cnx.org](http://www.cnx.org).

## Initial Results

A Case Analysis workshop was conducted at the University of Puerto Rico, Mayaguez Campus. Thirty-two graduate students from sciences and engineering participated. The pre and post tests were evaluated using the rubric previously described. The results are depicted in the next figure.

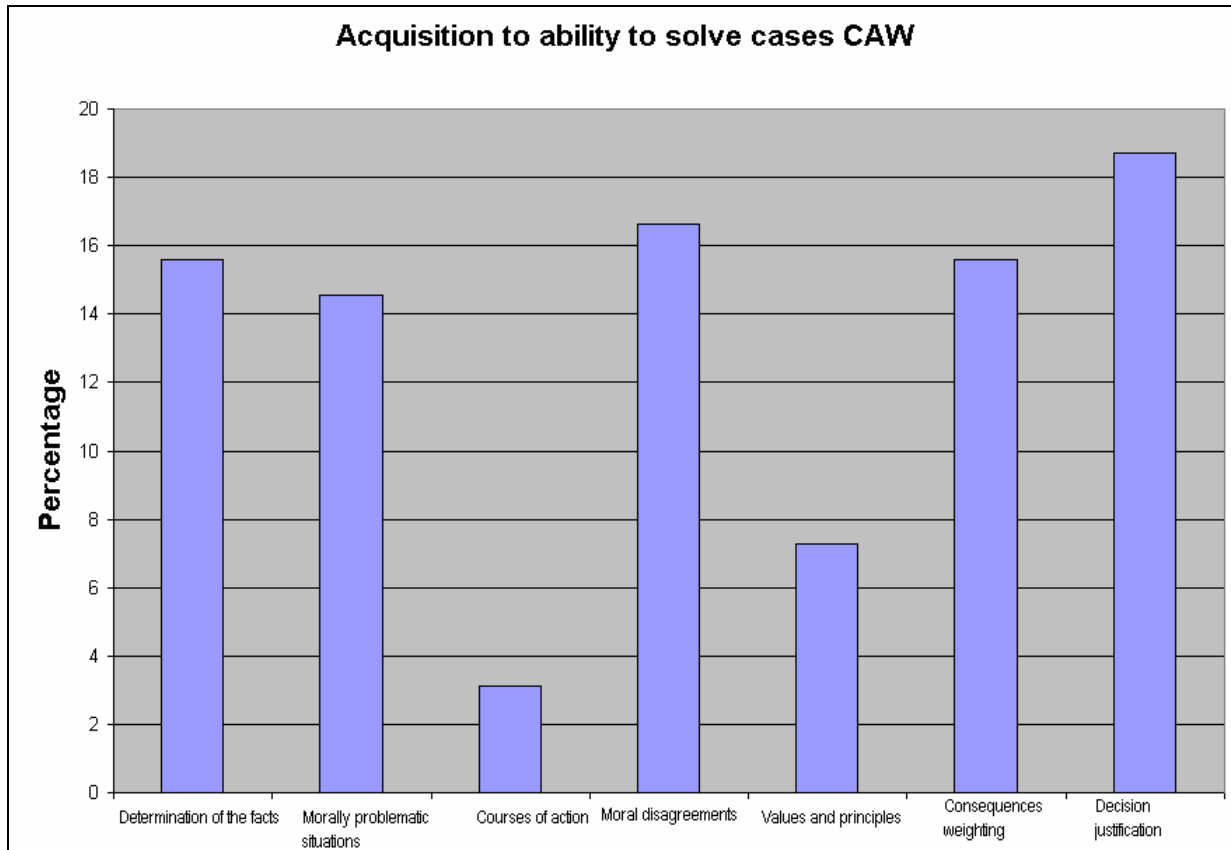


Figure 1. Acquisition of ability to solve cases in CAW

According to the data obtained, a general improvement occurred in the skills depicted in the first figure. In fact, each dimension shows at least some improvement. The greatest improvement accompanied **decision justification** (18.6%), a crucial skill given the importance of explaining and validating professional decisions in today's pluralistic society. The dimension with the smallest improvement (3.1%) was the **identification of course of action**. This small improvement probably reflects the fact that this theme was emphasized in an earlier workshop devoted to Moral Deliberation. Another dimension showing smaller but still significant improvement (7.3%) is the **determination of values at play**. Again, this smaller rate is due to the covering of this theme in a prior workshop.

Significant improvements can be found in four other areas. First, in the **determination of fact**, participants showed a 15.6% rate of improvement situations, disagreements and actual or true



moral problems, demonstrating that they did not initially take into account the entire situation and its participants but later incorporated these into their analysis. Second, with the **identification of moral disagreements**, a 16.6% improvement shows that students learned through the course of the workshop to distinguish between moral questions, moral disagreements, and moral conflicts. Third, in the **identification of morally problematic situations**, a 14.6% rate of improvement demonstrates that student improved their ability to recognize situational conflicts in morally problematic contexts. Finally, a 15.6% **improvement in consequence analysis** shows that students began to take into account a larger range of consequences in their decision-making including long range impacts in such macroethical areas as the natural environment and future generations. In conclusion, improvements in the first six steps composing this conceptual framework in decision-making show that the workshop has helped students to make good ethical choices and to accompany these choices with strong critical, justificatory arguments.

## Conclusions

The Case Analysis Workshop was developed as a tool for graduate students to practice moral deliberation. Using cases, it builds upon theoretical knowledge of ethics to encompass the skills measured by pre- and post-tests described in the first figure above. Through judicious case selection, it provided a tested (and further testable) way to think about research ethics and to envision it in pluralistic, global, and social contexts. Finally, its seven-step method of moral deliberation provides tools to sharpen reflection on research ethics and research misconduct.

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## APPENDIX

### VIDEO: ENGINEERING GUESSTIMATION

Characters:

- 1- Steve Cashman, the boss
- 2- Pamela Marketer, a recently graduated doctor
- 3- Lauren English, her friend

Pamela Marketer, a recently graduated Ph.D., is being interviewed by a potential employer. He offers her a part-time job while she starts her academic career. Lauren, her friend, is working on a stream model for the Snake River and he asks her to help her with the modeling process.

She begins working with her friend, looking at the process that she has followed. Lauren explained the trouble that she has had collecting the data needed to develop the model. Doctor Marketer asks Lauren for the re-oxygenation calculations.

However, Lauren looks distressed because she did not do those calculations. When she asks how she would model the river without the re-oxygenation constants, Lauren simply stated that she would use the data that she had already collected. However, the recently graduated doctor realizes that the collected data was useless without the re-oxygenation constants unless they had the river's velocity and depth amongst other parameters.

Lauren: Is everything worthless without that data?

Doctor: Let me think...

Lauren: What are we going to do?

Doctor: Hold it, let's just think about this.

The doctor keeps on searching for solutions to the problem amongst the already collected data in an open book, a quadrangle, and a map.

Two months later...

The doctor turns in her report to her employer. He thanks her for her job well done and wishes her well in her new teaching position, telling her that she will be a great role model for her students.

As she is leaving, Lauren asks her how she got the re-oxygenation constants. The doctor simply shrugs and answers that she made them up based on models from other rivers that she found in old textbooks for the constants based on river type. She matched the models of the rivers in the textbooks to the Snake River's type as best as she could and then plugged in the data. However, when Lauren asks whether she acknowledged her methods, she answers that not

exactly with a wide smile and replies that careful wording is everything. After all, she tells Lauren, no one would ever know. Lauren replies guiltily that they would know.