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ORIGINAL PAPER

The Role of Professional Knowledge in Case-Based Reasoning in Practical Ethics

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Abstract The use of case-based reasoning in teaching professional ethics has come of age. The fields of medicine, engineering, and business all have incorporated ethics case studies into leading textbooks and journal articles, as well as undergraduate and graduate professional ethics courses. The most recent guidelines from the National Institutes of Health recognize case studies and face-to-face discussion as best practices to be included in training programs for the Responsible Conduct of Research. While there is a general consensus that case studies play a central role in the teaching of professional ethics, there is still much to be learned regarding *how* professionals learn ethics using case-based reasoning. Cases take many forms, and there are a variety of ways to write them and use them in teaching. This paper reports the results of a study designed to investigate one of the issues in teaching case-based ethics: the role of one's professional knowledge in learning methods of moral reasoning. Using a novel assessment instrument, we compared case studies written and analyzed by three groups of students whom we classified as: (1) *Experts* in a research domain in bioengineering. (2) *Novices* in a research domain in bioengineering. (3) *The non-research group*—students using an engineering domain in which they were interested but had no in-depth knowledge. This study demonstrates

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that a student's level of understanding of a professional knowledge domain plays a significant role in learning moral reasoning skills.

Keywords Cognitive science · Case-based reasoning · Practical ethics · Bioengineering · Expert knowledge · Professional knowledge · Assessment · Responsible conduct of research · RCR

Introduction: Why Teach with Cases?

The importance of using cases to teach moral reasoning has been agreed upon for some time (Arras and Rhoden 1989; Brody 1988; Caplan 1980; Harris et al. 2009; Jonsen and Toulmin 1988). Since the National Institutes of Health (NIH) issued its first set of guidelines for the Responsible Conduct of Research (RCR) in 1989, the field of applied professional ethics has reached a consensus regarding best practices in teaching. Two of these "best practices" are highlighted in the November 2009 NIH guidelines for RCR: the usefulness of using case studies and face-to-face discussion to teach RCR to scientists. This focus on specific pedagogy challenges the sole use of *online* modules that were created to enable researchers to efficiently master topics in ethics pertinent to their research. NIH made it clear that such modules alone would no longer satisfy its requirements. A minimum of 8 h of case-based ethics discussion was to be adopted.

Furthermore, such education cannot be a onetime event. It is to occur throughout all stages of the scientist's career, from graduate school and postdoctoral work to junior and senior faculty years as well. Ideally scientists will become expert in both their knowledge domain and in professional ethics. They then can teach peers and students alike (NIH 2009).

This emphasis on teaching ethics using case studies invites deeper reflection. Scholars in the field of medical ethics have long recognized that cases are constructed to teach a variety of pedagogical lessons. In bioethics, for example, case studies written by analytical philosophers are often short and stylized to stress the learning of a specific principle or theory, or they can be "rich, thick, complex, messy" cases that depict real-life situations (Arras 1991, p. 29). These can be used to teach students to recognize morally relevant facts (known and unknown) as well as concepts, and also to identify ethical dilemmas. Various stakeholders' perspectives can be identified, in addition to the ranges of values held by these stakeholders. Critical of the analytical cases fellow philosophers were using to teach practical ethics, Caplan (1980) recognized that "practical ethical dilemmas do not come served neatly on a platter!" (p. 24).

Scholars in engineering ethics also focus on a case-based approach and identify various ways the cases can be used. Charles Harris, Michael Pritchard, and Michael Rabins' popular text, *Engineering Ethics: Concepts and Cases* includes more than forty cases. When used in conjunction with the methods of moral reasoning presented in the book, the cases can help students engage in what the authors label "constructive analysis" (Harris et al. 2009, p. 18). Students' moral imaginations come into play as they offer justifications for possible alternative resolutions to a moral dilemma (p. 23).

This consensus on using cases in ethics teaching is tied to the reintroduction of casuistry, a method of moral analysis that dominated moral reasoning until the sixteenth century, when it lost favor to analytical philosophy. Resurrected by Jonsen and Toulmin (1988) in the 1980s, casuistry is a *bottom-up* method of moral analysis that emphasizes the importance of practical or tacit wisdom. Similar cases are compared and contrasted with a negative or positive limit or paradigm case that has defined characteristics. The goal of this process is to discern underlying rules for resolving the case at hand.

Casuistry has been contrasted with "principlism," popularized by Beauchamp and Childress (2001), which introduced the four principles of medical ethics: autonomy, beneficence, non-maleficence, and justice. Unlike the theory-driven approaches, which are defined by specific principles, casuistry analyzes concrete cases and then incrementally develops moral knowledge (Arras 1991, p. 31). Case studies, in sum, can be written to encourage students in the classroom to envision issues that occur every day in the practice of a profession. Alternatively, they can focus students' attention on the use of a theory or principle for analysis and resolution. In planning ethics workshops or seminars, one needs to identify the particular goals for each session and select case studies to meet those goals.

The Role of Professional Knowledge in Ethical Problem-Solving

Anecdotal evidence from experienced ethics professors describes students' enhanced ability to discuss ethical dilemmas and resolutions when they use scenarios based on their own experience. Todd Chambers, an ethics professor at Northwestern Medical School, observes that in the clinical years he draws upon the students' own experiences for teaching material. His rationale for doing so is linked to the level of professional experience of the students. "The moral challenges students face," relates Chambers (1995), "are unique to their stage of development within the profession of medicine, so one must be able to comprehend their stories of moral challenges within the context of the daily ethos of their lives" (p. 191). He and his colleagues encourage students to tell the stories they encounter in the clinic and then reflect upon the moral content of those stories, rather than present students with philosophical texts to analyze. He uses this approach because it fits into the "ongoing rituals of the natives and communicates with them in their own language" (Chambers 1995, p. 191).

Ruth Macklin, a philosopher and pioneer in teaching applied medical ethics, recognizes the usefulness of students' professional knowledge to frame issues. "When cases are drawn from students' current or recent experience on the wards," explains Macklin (1993), "it brings a sense of relevance and immediacy to the discussion." Speaking to the dual use of case studies, she further reflects that "cases can help future professionals learn about ethics in practice while still allowing for the introduction of ethical principles and theories" (Macklin 1993, p. 202).

Sociologist Renee Fox agrees with Macklin. Interviewed in 2007 for the *Penn Bioethics Journal*, she was asked where and how bioethics should be taught in the medical school curriculum. She responded, "… the most appropriate place would be during medical students' clinical years when they are in direct contact with ethical issues that arise in situ with regard to patients, their families, and members of the medical and nursing staff. And it should include attention to experiences that medical students are having that they feel are ethically troubling…." (Han et al. 2007).

Philosopher Caroline Whitbeck discusses case-based instruction specifically in engineering ethics, in terms of "agent-centered" learning. The cases she favors are written with the goal of preparing "students to address moral problems that are likely to arise in their work as engineers and scientists" (Whitbeck 1995, p. 300).

Using detailed primary historical documents from the National Aeronautics and Space Administration (NASA) history museum, Rosa Lynn Pinkus, Larry Shuman, and colleagues created a set of technically complex cases that present ethical dilemmas faced by frontline engineers as they tackled the building of the main engines of the space shuttle. In analyzing technical materials to write these cases, they identified three ethical concepts—competency, responsibility, and safety—as being prevalent in both individual and organizational ethics dilemmas. They defined these concepts and combined them to create a two-tiered framework to assist practitioners in identifying the obligations of an ethical engineer and an ethical organization (Pinkus et al. 1997).

Moral philosopher Mark Kuczewski observes that *all* methods of moral reasoning (theory-based, principle-based, and casuistry, also known as case-based reasoning) require one to write a story. He convincingly argues that, taken together, theory-, principle-, or case-based methods have a commonality that can provide a guide to teaching ethics reasoning. He begins by stating firmly that there is no such thing as applied ethics in the traditional sense. Ethics does not first work out a theory and then apply it to experience. So in practical ethics, theories per se have a minor role in problem solving. When one engages in practical ethical analysis, one proceeds by *looking* at ordinary practice and *reflecting* upon the implicit assumptions and dilemmas. The dilemma already exists—it is not created by the theory or the principle (Kuczewski 2004).[1]

In addition, Kuczewski points out that because all methods in professional ethics presuppose a kind of narrative construction, they also require skill in framing the case. "How we tell the story of the case will help us to interpret the meaning of the principles in the case. In many ways, becoming a good ethicist means becoming a skillful narrator of cases" (Kuczewski 2004).

Finally, the comparison of responses below demonstrates the importance of professional knowledge both in resolving a case dilemma and in the way that an ethical dilemma is framed. In analyzing 14 student responses to one of five ethics case studies students had to resolve, Pinkus was struck by the contrast between 2 students' verbal responses (transcribed below) to questions about a case that involved a potential conflict between an engineer and a corporate manager. In the case, the bioengineer had identified a material that could be substituted in the manufacture of an artificial hip that cost less than the one originally proposed. It had

[1] The paper can be obtained by contacting the author Mark Kuczewski directly at <mkuczew@lumc.edu>.

all of the same characteristics except that long-term testing had not been done on it. The engineer wanted to do the testing, but the manager wanted to use the material and not disclose the switch to the customer.[2] Both students (quoted verbatim) recognize the specific dilemma:

Question:	What do you see as the problem there, if there is a problem?
Student #1:	They have decided to use a different material than was originally agreed upon, which will make them more *money*, but they do not have long-term data on this material. So they're running the risk of it having be less long-term, less reliable than the present material
Student #2:	Well, they found this new material for an artificial hip implant, and it costs less than the material that they were planning to use. So the management decides to change it and use this new material instead

Here, both students identify additional "morally relevant" facts:

Question:	Would any other factors be important here?
Student #1:	Yeah, that they are not telling the customer that they are changing the material
Student #2:	Just the fact that they haven't really done much testing on it, so they cannot be sure of the reliability of this product, and that they had made an agreement with Smith Co. to give the best quality material to make these parts

In the exchange below, the first student is beginning to frame the ethical dilemma in professional engineering terms. The second student is starting to take the manager's perspective but recognizes the dilemma and is "uncomfortable" with it:

Question:	If you were Christine [the engineer], what would you think of Vernon's [the manager's] decision not to inform Smith Co. of the change? What would you do now?
Student #1:	Well, I see he's "got dollar signs in his eyes," and that could lead to more money for me too, but I'm wondering if this is unethical. We do not have reliability data on the current material; that's bad. Also, by not telling our customer about this, we're risking future business with them
Student #2:	It seems like looking from Vernon's perspective, I would agree that it's probably better for the company because they're saving money—or she would ultimately save more money, but for this one [thing] it would cost less to actually manufacture and they would make more money from this. But because this new material hasn't been tested, then I don't feel comfortable about [its] being used instead of the material that they *know* actually works and has real good quality

[2] This case, "The Price is Right," is a modified version of a case with the same name found in the text by Harris et al. (2009, p. 335). Technical issues related to bioengineering were added to that generic engineering ethics case.

Next, the first student uses her professional knowledge of materials testing and her assessment of the high risk of implanting an artificial hip. These facts enable her to stand firm in the decision not to use the untested material. The second student lacks specific, professional knowledge about materials testing and defers to his manager even though he is not personally or professionally comfortable with the decision.

At the same time, student #2 explicitly identifies the distinct stakeholders' multiple perspectives, and moves flexibly among them. By this point, one can see that the students have framed the issue in different ways and one can begin to see how they will reach their conclusions.

Question:	So what would be some of the consequences of taking that line of attack? What would you do if you were Christine?
Student #1:	I would not implement this material without the long-term data because an artificial hip is very [dependent] on long-term reliability. The current good ones *fail*, we know that. And if [it] is [an] alloy—which usually means increase in strength—but you don't have the data to prove it, then, as a company, you don't want to use it, especially something that's going to be implanted in the human body. So, I definitely would not do it. But I would start the testing. They have ways of testing these materials for long-term reliability
Student #2:	[pause] I don't know. There's not much I can do, I guess, because the decision is up to the management and I guess I've shown them all the points about this case: that it hasn't been tested and that it's probably not fair to the customer that they don't know that there's going to be a change to this new material

Next, student #1 is clear about the possible consequences of refusing to use an untested material and is willing to accept them. The second student has not thought through potential consequences:

Question:	Okay. What do you think is the consequence of thinking like that?
Student #1:	The manager would try to override me, but if they fire me, they fire me
Student #2:	(*Interviewer prompt: So basically your stance is you're just going to let it go?*) I think so

In response to the following question, student #1 continues to provide evidence of her deep understanding of the technical/professional knowledge related to the issue. Student # 2 has nothing further to add.

Question:	Let me ask the same question as before. Are there any other facts that might be relevant here?
Student #1:	Well, we know that the quality of this material is not any better. Generally, when you refer to *quality* that would include long-term strength versus fatigue, as in being a little more susceptible to wear-damage. So, you need to consider that it's a different material, it's going to behave differently under circumstances. So from an engineering point of

Question:	Let me ask the same question as before. Are there any other facts that might be relevant here?
	view, you can look at the lattice structure of this alloy and you can know its behavior to a certain extent because of past research, and, if your material is engineered, you know how to [access/assess] that. And I think that when you get down to the nitty gritty of material, those are important facts in making this decision. Also, if you can basically [disclaim] this quality of the new material in a number of steps, it sounds like you can convince the manager not to use it
Student #2:	[pause] Um. [No]

Below, we see that *both* students reached the same ethical conclusion that signing the document would be wrong, not professional. Interestingly, their answers correspond with the Code of Ethics of the National Society of Professional Engineers, provision III.2.b, regarding not signing a report that includes false information (National Society of Professional Engineers 2007).

Question:	Okay, so if you were Christine then would you sign the document?
Student #1:	Uh uh. [No]
Student #2:	I probably wouldn't because, knowing that no test has been done, they really cannot say that this new material is better than the other one that they were planning to use. And if they want to, they can probably find somebody else maybe to verify it, or [sign for it]

Next, each student can think of an analogous case. Note that their selected cases resemble the way the students had framed the ethical issue:

- The first student identifies similar technical cases in which a product was not safe because of a defect in the long-term reliability of the material. Patients were harmed and the product was recalled.
- The second student, who deferred to the manager, cites the case of the decision to launch the Challenger. This choice points to the dangers of case-based reasoning if not used correctly; that is, while this is an appropriate analogous case in terms of deference to the manager, the fact that the Challenger exploded after the launch should have prompted the student either to choose a different analogous case or to reconsider his reasoning in the case at hand.

Question:	Okay. Can you think of any cases similar to this?
Student #1:	Well, there are a lot of medical products that have gone out without the proper testing, I'm sure. The J-lead has come up a number of times that we've learned about—its *lack* of long-term reliability testing and fatigue. That's happened a lot, especially in the early development of implants. I'm reminded of the guy who discovered the bio-compatibility of Teflon. And uh—I'm sorry not the bio-compatibility, but the friction performances of Teflon as a, you know—well anyway, it had a good performance in the body for certain implant areas. And so they implanted the Teflon, and when it eventually wore down and different particles leached and were toxic, they killed a lot of people
Student #2:	I think the Challenger case? There was also a conflict between the engineers and the management on whether or not they should launch the space shuttle

In addition to illustrating the role that professional knowledge has in ethical reasoning, the students' responses also illustrate the importance of framing an ethical dilemma. Identifying and articulating how a student frames a moral dilemma is an important step in teaching and assessment. The "frame," for example, will influence a student's choice when considering precedents or analogous cases. It acts as a prompt for a student to articulate the case as a professional/technical dilemma, as a moral one, or both. It also helps an instructor to identify the gaps as well as the strong points in a student's analysis skills. The lack of or inappropriate reference to professional codes, the misuse of an analogous case, or the lack of tacit bioengineering knowledge and experience in the decision-making toolkit may mark a shallow analysis. These specific issues can then be addressed in individual assessment.

Empirical Studies and Professional Knowledge

Select empirical studies support the intuition that professional knowledge does play a role in professional, ethical problem solving. Micki Chi's work in cognitive psychology concerning the nature of expertise sheds light on this issue. "During the 1970s," Chi explains, "general memory strategies (such as rehearsal or method loci) and problem-solving strategies (such as means-ends analysis) dominated the experimental studies in psychology and simulation research in artificial intelligence" (Chi 1978, p. 73). It was then thought that using such a strategy facilitated memory retrieval. Thus, it was believed that children's memory improved with age because their strategies improved, and that experts were experts because they used the strategies. Chi and her colleagues challenged this view and successfully demonstrated "that people with expert knowledge in a particular domain did not necessarily acquire more skillful strategies; rather, their domain knowledge actually bypassed the need for general strategies. "Children" for example, "were shown to remember or recall just as many items as adults if the domain they were tested on was one they were familiar with, such as dinosaurs or chess" (Chi 1978, p. 94). By 1980, it was increasingly recognized that experts had a "richly organized knowledge of the problems that allow[ed] them to represent the problem in such a way that the solutions [became] transparent." In Chi's words, "experts were not solving problems successfully because they applied and saw strategies skillfully; rather, the solutions become apparent as soon as they represented problems correctly. Thus, how well one represents a problem depends on a person's domain-relevant knowledge rather than strategic skill" (Chi and Koeske 1983, p. 31).

In a preliminary report Pinkus and Claire Gloeckner presented a study[3] that assessed 48 student-authored and -analyzed cases to examine how each student learned the methods of moral reasoning taught in a 14-week applied graduate and undergraduate bioengineering ethics course (Pinkus and Gloecker 1999). A total of 48 student papers (12 undergraduate and 38 graduate students) were assessed for

[3] This was a preliminary study to the one reported here, which is discussed in detail below.

"depth of understanding" of individual concepts taught in the course. Students' papers were divided into two groups: those by "experts" and those by "novices":

- Students who authored a case study based on their thesis research (graduate students) and those who used their senior design project (undergraduate students), were labeled "experts."
- Students who authored a case study *not* based on their research or their senior design project were labeled "novices."

The 42 concepts that were taught in the course were listed on a scoring grid. A measure of moral reasoning (MMR) was constructed to assess students' use of these concepts. Three factors were taken into account: whether a student *labeled*, *defined*, and/or *used* a concept correctly. Coding in this way provided evidence for a clear trend toward increased learning of concepts when a student both wrote about a familiar domain and then analyzed the case study from that perspective.

Matthew Keefer and Kevin Ashley reported "a systematic analysis of the cognitive processes required for acquiring skill in practical ethical reasoning in a professional domain" (Keefer and Ashley 2001, p. 377). They used a web-based experimental design and found "striking differences in the students' and ethicists' use of knowledge and reasoning" (p. 377). The differences were found in the application of principles. Experts used professional knowledge and role-specific content, while novices "made significantly more use of common knowledge and applied more general ethical principles or appealed to consequences in the justification of their responses" (p. 377). When asked to identify additional moral issues, assess the moral implications of actions, and provide alternative practical resolutions to conflicts, experts showed greater skill than novices. These findings point to the importance of professional knowledge and role-specific professional obligations in resolving professional ethical conflicts.

Bioengineering Ethics: Concepts and Cases

After many years of teaching a required graduate-level bioengineering ethics course, lead author Pinkus had an opportunity to statistically examine her impression (and that of her colleagues) that professional knowledge played an important role in learning moral reasoning skills. Specifically, did students who used their declared area of expertise as a basis for writing a case study—the capstone assignment in the course—learn the methods of ethics analysis taught in the class better than students who authored a case study in a topic in which they had no in-depth knowledge, and may or may not have had an interest. The study reported here was carried out over a four-and-a-half-year period within the context of a semester-long, required graduate course in bioengineering ethics taught by Pinkus. During this time, a broad research agenda defined in a multidisciplinary

National Science Foundation (NSF) grant[4] clearly influenced her teaching practices. Following is a brief description of the course in which the study reported here took place, and then the study and its results.

The bioengineering ethics course is a 14-week required class for all graduate students in the Bioengineering Department at the University of Pittsburgh. It is designed to supplement students' traditional bioengineering education in three specific ways:

- To teach the conceptual tools needed to identify, articulate, and resolve ethical dilemmas inherent in the practical, professional work that they take part in daily.
- To enable students to recognize that engineering and medicine each have unique demands related to professional practice, but each practice also reflects the general societal values in which the practice occurs. Given that there are many foreign national students in the department, this is an important concept to grasp.
- To provide a learning environment where practical ethics can best be understood. This includes group discussion of relevant ethics cases, off-site field trips so students can observe professional ethics in action, and peer-reviewed, in-class, group projects.

During the first few weeks of the course, students engage in small-group, case-based discussion. They identify the ethical dilemma(s) and the morally relevant facts and concepts in their assigned case, discuss alternatives resolutions, and justify a resolution. The next portion of the course also employs small-group discussion while introducing students to a variety of methods of moral reasoning. These methods are used as students discuss complex, technical bioengineering cases, and classic paradigm cases in bioethics, tailored to their professional domains. The course concludes with students (some individually and some in teams) authoring their own case study, analyzing it, and presenting it to their peers for review.

A student's final grade is based on:

- Attending and participating in class (15 %).
- Completing one critique/analysis of an out-of-class activity (10 %). This may include observing the Unified Presbyterian/Shadyside Hospital University of Pittsburgh Medical Center's (UPMC's) Ethics Committee Meeting or UPMC's Children's Hospital Ethics Committee Meeting; attending University of Pittsburgh's Center for Bioethics and Health Law's Bioethics Grand Rounds; or taking advantage of other offerings in the ethics programs at the University of Pittsburgh or Carnegie Mellon University. An option also exists for students to attend a Federal Drug Administration (FDA) Panel Meeting in Washington, DC and observe, firsthand, the process by which a device is evaluated for market approval. The activity is funded by the Bioengineering Department at the University of Pittsburgh and coordinated by course-director Pinkus.

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[4] "Learning and Intelligent Systems: Modeling Learning to Reason with Cases in Engineering Ethics: A Test Domain for Intelligent Assistance," 1997, National Science Foundation award # 9720341.

- Analyzing at midterm one complex technical case (10 %)—the Teletronics Pacemaker Case Study (Pinkus and Bates, unpublished casebook, University of Pittsburgh, 2005).
- For the capstone assignment, writing and analyzing a case study based on the student's research area (40 %) and presenting the case in class (25 %).

For the capstone project, students are encouraged to work in teams of two to four and are coached on various ways to combine their knowledge domains, so that the final case represents a blend of their real-life experiences as well as a deep understanding of a technical/professional area in bioengineering. The case may be written using *moral imagination*; that is, if a student is working on a device that is years from going to market, he or she can "fast-forward" it and foresee possible dilemmas that might occur after it is in use. If it is based on an actual dilemma, the facts are changed so that confidentiality is preserved. Analysis of the case must use moral problem-solving methods discussed in class. The goal of this assignment is to provide students with the experience of applying the methods learned in class to their own work. It also encourages them to view their work through an ethical lens.

The goal of the in-class case presentation is to provide students with the opportunity to engage fellow students in a discussion of their work, encouraging them to identify the ethics issues and suggest resolutions to the case. A peer-review system is used during the presentation to provide each student/group with constructive comments. Christopher Schunn's SWoRD program, a web-based instructional system that supports reciprocal student authoring and student peer reviewing, has been adapted to the task of writing, reviewing, and rewriting ethics problem analyses.[5] The adaptation provides peer reviewers with written guidance for reviewing a peer's problem analysis, focusing on important ethics criteria.

What did Students Learn, and was Professional Knowledge Important?

The evolving nature of the class assignments over a four-and-a-half-year time span enabled the study to be done. The capstone assignment in the course always required the writing and analyzing of a case study, but students in the first two semesters were free to choose any topic in bioengineering that interested them to write their case study. Retrospectively, we classified students according to whether they chose to use their own area of research (*research group*) and those who did not (*non-research group*). Interestingly, we found that students who used their own research universally earned higher grades than students who did not. The third time that the class was taught, students had a choice regarding the topic of their case study but were encouraged to use their own research area. Again, students were categorized into *research* and *non-research* groups. During the fourth and fifth semesters, students were *required* to use their research as the domain from which a case study would be written. All of these students were counted in the *research*

[5] Scaffolded Writing and Rewriting in the Discipline (https://sites.google.com/site/swordlrdc/directory, accessed January 29, 2015).

Table 1 Classification of student-authored papers in the study (n = 61)

Category	Number of students
Expert	13
Novice	36
Total research group	49
Non-research group	12
Total	61

group, although some of them were not committed to a research domain for their thesis and had been assigned earlier to work in a specific research lab as they clarified their final goals. These students were identified as the *novices in the research group*. In the fifth semester, 13 MS and Ph.D. students who were one term away from defending their thesis were enrolled. We classified these students as being *experts* in the *research* group.

Table 1 shows the classification of the 61 students whose case studies were coded for the study reported here.

Assessment: Measuring Students' Use of Methods of Moral Reasoning

Students' papers were coded using an assessment grid that tracked the ethical concepts students used in their analysis, as well as how they applied them (see "Appendix"). The assessment of a student-authored paper was focused on evidence that a student had grasped analytical tools labeled as higher-level moral reasoning skills (HLMRSs). The five higher-level moral reasoning skills were defined in the process of conducting an NSF study (noted earlier) investigating how students adapted conceptual tools for ethical reasoning as they resolved case-based dilemmas in class over an extended period of time.[6]

The five measures are whether a student:

1. Employs professional/technical knowledge to frame the issue.
2. Views the problem from multiple perspectives.
3. Flexibly moves among multiple perspectives.
4. Identifies analogous cases and articulates ways the cases were analogous.
5. Employs a method of moral reasoning in conducting the analysis.

These are not stand-alone criteria. Taken together, they allow for various ways that students will frame an ethics dilemma, analyze it, and resolve it. Each criterion is fully defined below.

[6] That work was performed under NSF award # 9720341, " Learning and Intelligent Systems: Modeling Learning to Reason with Cases in Engineering Ethics: A Test Domain for Intelligent Assistance", 1997.

1. *Do students use professional/technical knowledge to frame the issue?* To meet this criterion, students should be confident in their domain knowledge and be aware of what they do *not* know. This is tied to the concept of competence, defined as being a "knowledge expert specially trained to design, test, and assess the performance characteristics of technologies within his or her realm of expertise" (Pinkus et al. 1997, p. 34). Students in the *research group* reported here all used their professional knowledge to frame their cases.
2. *Do students view the problem from multiple perspectives?* This is the ability to put oneself in the shoes of others. Using multiple perspectives indicates that students can move beyond their own viewpoint and see the problem through different lenses. For example, in a case involving a question of the reliability of the US Food and Drug Administration (FDA) testing requirements for a novel pacemaker lead, students could identify with the patient receiving the device. If it malfunctioned, what would be the consequences in lives? In monetary costs? to the company? Some students might question what the physician who implants the device would do if there were a problem with it. Physicians, after all, have a Hippocratic ethic of doing no harm. And what about the FDA? Is it an authoritative protector of the community? How were its testing guidelines set? Being able to view a problem from multiple perspectives encourages the students to use their *moral imagination* and create alternative scenarios. These differing perspectives and alternative scenarios, in turn, raise questions that need to be answered and direct students to seek additional facts.
3. *Do students have the ability to move flexibly among multiple perspectives?* As students seek the facts that their questions have elicited, they begin to examine the interconnections among all the stakeholders. This provides a check to their individual resolution. But this type of examination requires what is termed "adaptive expertise" (Fisher and Peterson 2001; Martin et al. 2005). Can students start with a question based firmly in their technical/professional knowledge and then move into an *ethical* realm to question safety for the patient? Do they have the ability to comprehend the stresses on others and the dilemmas they might face? Changing perspectives requires a cognitive shift in thinking that must be learned; it typically requires a deep understanding of one's own knowledge domain and its limits to be carried out successfully.
4. *Do students use an analogous case*, *and do they use it correctly?* This of course, speaks to case-based reasoning, or casuistry, the formal method of moral reasoning and an approach to practical problem solving typically used by professionals on the front lines.
5. *Do students use methods of moral reasoning?* Students' use of a method of moral reasoning indicates that they have looked at the case in yet another perspective: an analytical one. Paraphrasing one definition of ethics, students have "critically reflected on what they did and why they did it" (Pinkus et al. 1997, p. 23).

Of these five higher-level moral reasoning skills, this paper reports on the first (professional knowledge) and the last (use of moral reasoning). Use of moral reasoning was objectified, measured, and reported here as a moral reasoning proportion. (The other three higher-level moral reasoning skills were qualitatively measured but are not reported here.)

Computing a Student's Moral Reasoning Proportion

A student's knowledge of a "*concept*" could be demonstrated in three ways: by labeling, defining, and/or applying it. An ethics concept is said to be "labeled" if the term for the concept is present; "defined" if a dictionary-like definition of the concept is present; and "applied" if the concept is brought to bear appropriately using facts of the particular case. Each of these could be done correctly or incorrectly.

We measured student understanding by constructing a Methods of Moral Reasoning (MMR) proportion, c/(a + b + c). The denominator (a + b + c) consists of the number of times the student:

(a) only labeled the concept
(for example, "Jake was concerned that the patient had not given full *informed consent* when she agreed to have a total hip replacement.")
(b) defined the concept without labeling it
(for example, "After being fully and completely informed of the risks, benefits, and alternatives to a total hip replacement, Martha discussed this with her husband and her family physician and then told her surgeon that she had decided to have the replacement.")
(c) labeled the concept, defined it, *and* used/applied it correctly
(for example, "When Barney Clark received the first artificial heart in 1982, he gave his *informed consent* for the procedure. As time went by, however, it was clear that he had not fully understood the risks that the procedure entailed, and there was definitely some concern that his consent had been coerced.")

The third measurement, (c), is also the numerator. So, for example, if a student labeled, defined, and/or used the concepts of *informed consent*, *autonomy*, *risk disclosure*, and *safety* then she received a score of 4 for the denominator. If she correctly labeled, defined, and demonstrated understanding of each term except *informed consent*, then she received a score of 3 for the numerator and her final score would be ¾ or 0.75. Using this method, the highest score a student could achieve is 1, which indicates that every time a term was used, it was labeled, defined, and applied correctly. We suggest that this proportion represents a student's depth of understanding of the concepts of moral reasoning that were taught in the course. As shown in Fig. 1, this MMR proportion correlates to students' familiarity with the knowledge domain in which their case was based. All 61 papers (written across all classes as described above) were scored by two independent coders and then compared and summarized in the graphs below.

The first bar in Fig. 1 represents the scores of 12 student-authored papers that were *not* based on students' research. The second bar includes *all* 49 student-

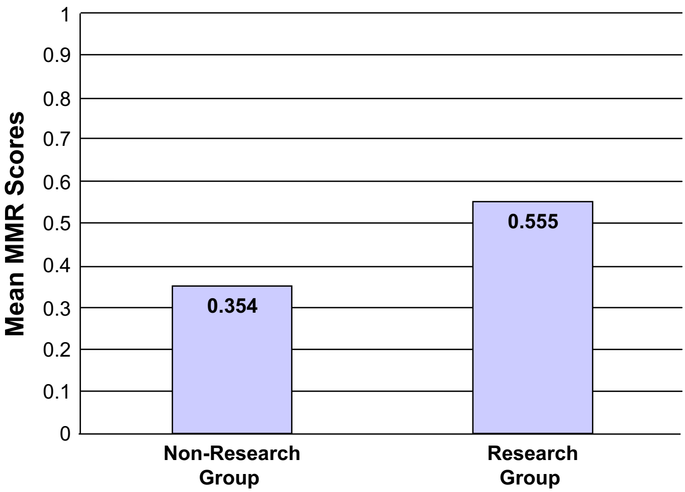

Fig. 1 Comparison of mean MMR scores for students using a topic outside their research domain (*non-research group*) with mean MMR scores of students using their own research (*research group*, including experts and novices) to author an ethics case study

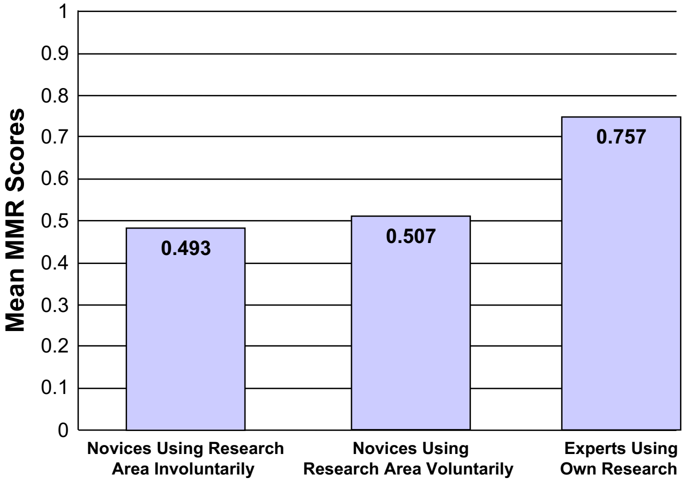

Fig. 2 Comparison of mean MMR scores within the research group: novice students *required* to use a topic within their research domain (and having had little exposure to it thus far); novice students who *voluntarily* chose to use their research area; and expert students using their own research to author an ethics case study

authored papers directly pertaining to students' research. A two-sample t test with unequal variances determined the p values and conclusions. Students who used their research topic for their case study did significantly better than those who did not use their research topic (p value = .03). Expert students in the research group did significantly better than those who did not use their research topic (p value = .01).

As shown in Fig. 2, when differences among students' MMR scores are compared according to their level of expertise, the 13 "expert" students who wrote and analyzed a case study based on their thesis or dissertation work scored highest of all groups (mean score 0.757). As a group, the 36 "novice" students who wrote a case study using their research area performed below that, with mean scores of 0.507 for those 12 students who voluntarily used their own research when given the choice and 0.493 for those 24 who were required to use their research area. These findings further support the claim that *expert* students, those who had a deep understanding of a professional domain, demonstrated the methods of moral reasoning taught in the class significantly better than *novices*, who had a shallow understanding of a domain.

Recall that the *novice* students were ones who had not committed to their topic for their thesis; rather they had been assigned to work in a specific research lab as they clarified their long-term goals. Those who used the topic "voluntarily" presumably had some interest in it and some command of facts and concepts. Those who were "required" to use the research topic may have faced issues similar to the non-research group. For example, they may have had to research professional domain facts and concepts in addition to learning and applying methods of moral reasoning as they constructed and then analyzed their case study.

Conclusions

This paper reports the results of a study designed to investigate the role of professional knowledge in practical, moral problem solving. An observation common among those teaching practical ethics is that those students who have a foundation in a professional domain seem to grasp methods of moral reasoning better than novices. Sixty-one student-authored case study papers, written as a final assignment in a 14-week required bioethics engineering graduate course, were categorized and scored by independent coders. Forty-nine students (experts and novices in the research group) used their research area as a focus for the case study, and 12 students (non-research group) wrote a case study outside their field of professional expertise. We concluded that case-based instruction in practical ethics that attends to a student's deep understanding of a specific professional domain contributes significantly to student learning of methods of moral reasoning.

Work in both analytical philosophy and cognitive science explains this finding. In the field of practical ethics, while there is a consensus that case studies are key in teaching, there is still a contentious debate regarding the methods of moral problem solving that characterize the field. None of these methods offers sound resolution to a practical dilemma (Brody 2003; *Kennedy Institute of Ethics Journal* 2007). This includes the common top-down theories and principles as well as the bottom-up method of case-based reasoning. All methods of moral reasoning require a fair amount of maneuvering to be applied to a case, and even then a gap exists between method and resolution. When students use a professional domain in which they are expert, their tacit knowledge, professional judgment, or praxis helps them resolve the dilemma. Larry Churchill stresses that when the problem-solving task of practical ethics is assigned to theory, it "makes us overlook the way persons *using* theory (and other human skills)… solve problems. Thus, we confuse a tool (ethical theory) with the skillful use of a tool. Theories don't yield answers," he contends; "moral agents use theories to strive for an answer. But theories don't do the striving for them. The process is not automatic and there are lots of ways it goes wrong" (Churchill 1992, p. 23).

We suggest here that when a student frames an ethical dilemma using deep knowledge of a specific domain, an understanding of the morally relevant facts and concepts—as well as possible familiarity with analogous cases—is already at hand. These are important first steps in analyzing a case and require skill. These skills are sometimes referred to as clinical judgment or practical or tacit wisdom.

This practical wisdom is also embedded in professional knowledge. Students analyzing a case they constructed in a domain with which they have no practical experience and little in-depth knowledge do not have these advantages. First, they need to research the domain to isolate the morally relevant facts and concepts, which can be a daunting task. Second, as they apply the methods of moral reasoning to resolve the dilemma they identified, they face the gap between method and resolution but have no way to bridge it. This disconnect prompts them to gloss over important facts and fit the resolution into an abstract moral/ethical frame. In Jonsen's (1991) words, they use theoretical, abstract constructs or "balloons" of moral reasoning, but there is no connection to the practical terrain or tacit wisdom that the professional uses to navigate successfully every day.

The conclusions in this paper are tentative. The study does not meet the very narrow definition of "research" that is described in the federal regulations governing research with human subjects [45 CFR 46 102 (d)]. Over a long period of time, various types of information were used to improve the way ethics was taught to the bioengineering students in this study, but this process occurred in the absence of any kind of formal, systematic protocol or plan. The goal was to improve teaching and develop more salient case materials, not to test specific hypotheses. During the time the class was taught, observations were made regarding students' use of professional knowledge and its relationship to learning new concepts in ethics, and there was an attempt to assess those observations.

Many variables could explain the correlation found here between in-depth professional knowledge and the learning of ethics reasoning skills. The significant correlation found, however, moves the field of assessment further along. If one were to devise a new study based on the findings presented here, students could be grouped according to their Graduate Record Exam (GRE)[7] scores or their previous expertise in ethics reasoning.

In this study, we created and used an assessment grid to evaluate the ethics analysis in each of the 61 student-authored cases. The five "higher-level methods of moral reasoning" described above were developed within the context of teaching while author Pinkus was involved in an NSF grant ("Modeling Learning to Reason

[7] The GRE "is a standardized exam used to measure one's aptitude for abstract thinking in the areas of analytical writing, mathematics and vocabulary" (www.investopedia.com/terms/g/gre.asp). Many graduate schools in the US use these scores to determine an applicant's eligibility for a given graduate program.

with Cases in Engineering Ethics: A Test Domain for Intelligent Assistance", award # 9720341) to study cognitive aspects of case-based reasoning. These five higher methods of moral reasoning are not stand-alone criteria. When used together, they strengthen a problem-solver's reasoning and bring the student to a sound resolution. Justification for using all five methods rests on the authors' position that ethical reasoning is a pluralistic endeavor.

As the companion paper by Goldin et al. (2015) confirms, the assessment instrument is both reliable and valid. It focuses specifically on objectifying and making explicit the analytical methods of moral reasoning taught in the class and looks for a deep understanding and application of them. The other four higher methods of moral reasoning listed on the assessment are also taken into consideration in a *global* way. The exercise that we evaluated (having each student author and analyze his or her own case study) involves many other complex cognitive higher reasoning skills that are not captured in the objective portion of the assessment instrument. Taylor Martin and her colleagues have also contributed to the understanding of adaptive expertise in bioengineering (Martin et al. 2005). Objectifying and measuring all higher-level moral reasoning skills is a goal worth pursuing.

For those seeking to satisfy the NIH requirements for education and training in the Responsible Conduct of Research, this study can provide some practical guidance for designing workshops, seminars, or semester-long courses. In general, tailoring the subject matter in the case studies used in any of these venues to the expertise of the participants should facilitate their learning. If the goal of the workshop, seminar, or course is to teach methods of moral reasoning, adding a case-writing exercise to the workshop may be considered.

Finally, if questions about assessment arise, the grid referred to in this paper and instructions regarding its use are provided in the "Appendix". Computing a student's MMR proportion will provide an objective measure of learning.

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Appendix: Coding Instructions and Coding Sheet for Student Paper Analysis

Coding Instructions

In order to achieve the most accurate and consistent classification of respondents' papers, the same method must be used to code each paper. When reviewing the papers, all coders should follow the instructions below. They will take coders through the assessment form in the order it was meant to be used.

Fill in the classification information at the top of the assessment form according to the attached cover letter.

Analytical Components of Methods of Moral Reasoning

While reading the paper, look for these concepts. Write in the page numbers on the appropriate line next to the concept, noting if the respondent has done one or more of the following: labeled (L), defined (D), or applied (A) the concept. Examples:

- Label: "Jake was concerned the patient had not given full informed consent."
- Define: "A patient gives informed consent if he or she gives permission for a procedure, being fully and completely aware of all it entails and of all consequences. The consent must be freely given and not coerced."
- Apply correctly: "After she discussed the procedure with her doctor and had her questions answered, Emily freely agreed to have the operation done."

The attached glossary provides definitions and examples of all the concepts. Use it as a guide in coding. It should be particularly useful in the following two cases: (1) respondents may apply a concept without explicitly labeling it (as shown in the above example) or (2) if you find that there is a serious error in the respondent's definition or application of the concept. In the latter case, please make a note in the margin. For example: "L, D, informed consent. Incorrect D: the student discusses informing the patient, but does not discuss the meaning of consent."

If the paper contains a concept not on the list, then add it to the open spaces on the concept checklist.

Higher Order Criteria (Bottom of the Assessment Form)

The criteria listed here capture more abstract aspects of the ethical analysis. Use of these criteria can be indicated with a simple yes or no, but the coder should also provide a brief justification and page number(s) of when the criterion was used.

- *Professional knowledge* means that the case is set in the context of well articulated and relevant technical knowledge.
- Identify *different perspectives* means that the respondent has analyzed the case from different points of view.
- *Moving flexibly* among various perspectives suggests that the person has a deep knowledge of the different perspectives and can use these different domains as they analyze the case. A paper exhibits this by not only analyzing the case from the viewpoints of various case participants but also by explaining how these viewpoints and analyses relate to one another and to the overall ethical analysis.
- An *analogous case* can be a separate case cited for comparison. It can also be evident when a student changes the facts of the case, i.e. "What if the subject was your mother?"

Student Paper Analysis and Coding *Last revised February 27, 2015*

Student Name: ______________________ Term: ________ U G

Paper Title: ______________________

Topic: ______________________

Analytical Components of Methods of Moral Reasoning

Label Pages	Define Pages	Apply Correctly Pages	Concept	Label Pages	Define Pages	Apply Correctly Pages	Concept
			Autonomy				Justice
			Act utilitarianism				Line drawing
			Animal rights				Non-maleficence
			Beneficence				Paternalism
			Bribery				Perspectives
			Cicero's creed				Physician responsibility
			Common morality				Product liability
			Confidentiality				Research v. clinical ethics
			Conflict of interest				Respect for persons
			Convergence				Responsibility of bioengineer
			Cost/Benefit				Risk analysis
			Creative middle way				Risk/Benefit analysis
			Definition of death				Risk disclosure
			Divergence				Risk management
			Doctor-engineer responsibility				Rule utilitarianism
			Doctor-patient relationship				Safety
			Failure to seek out the truth				Universalizability
			Golden rule/ Reversibility				Utilitarianism
			Groupthink				Whistle-blowing
			Honesty				
			Informed consent				

Employed professional knowledge to frame issues:

Identified different perspectives:

Flexibly moved among these perspectives:

Identified analogous cases and articulated the ways the cases were analogous:

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