

Effectiveness and Utility of a Case-Based Model for Delivering Engineering Ethics Professional Development Units

LA-UR 14-20045

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ABSTRACT

This article describes an action research project conducted at Los Alamos National Laboratory (LANL) to resolve a problem with the ability of licensed and/or certified engineers to obtain the ethics-related professional development units or hours (PDUs or PDHs) needed to maintain their credentials. Because of the recurring requirement and the static nature of the information, an initial, in-depth training followed by annually updated refresher training was proposed. A case model approach, with online delivery, was selected as the optimal pedagogical model for the refresher training. In the first two years, the only data that was collected was throughput and information retention. Response rates indicated that the approach was effective in helping licensed professional engineers obtain the needed PDUs. The rates of correct responses suggested that knowledge transfer regarding ethical reasoning had occurred in the initial training and had been retained in the refresher. In FY13, after completing the refresher, learners received a survey asking their opinion of the effectiveness and utility of the course, as well as their impressions of the case study format vs. the typical presentation format. Results indicate that the courses have been favorably received and that the case study method supports most of the pedagogical needs of adult learners as well as, if not better than, presentation-based instruction. Future plans for improvement are focused on identifying and evaluating methods for enriching online delivery of the engineering ethics cases.

Keywords: Case Studies in Education, Ethics Case Studies, Engineering Case Studies

1. INTRODUCTION

As one of the premier research laboratories in the United States, Los Alamos National Laboratory (LANL) employs many engineers who have become credentialed within their discipline either by attaining a Professional Engineer (PE) license or through certification conferred by a professional society. Generally, maintaining such licenses and certifications requires participation in continuing education to obtain professional development units or hours (PDUs or PDHs). PEs registered in the State of New Mexico (NM)

are required to obtain at least four PDHs in ethics biennially [1].

As part of its contractual obligation to the US government, the Laboratory provides a mandatory one-hour general ethics course (on topics such as conflict of interest, raising and resolving ethical issues, and standards of conduct and business ethics) online to all workers annually. These courses enable PEs to claim two PDHs biennially, leaving a gap of two PDHs every two years.

LANL is located in rural Northern NM, approximately 100 miles from the nearest commercial airport. There is little in the way of vendor-provided engineering-specific ethics training available in the area, and budget constraints have made supporting travel for training difficult. Distance education courses, while widely available, do not address company-specific ethics policies or federal requirements impacting the practice of engineering at LANL.

Given the large target population (about 120) who need ethics PDHs on a biennial basis, it was decided that in-house delivery of engineering-ethics training that could be used to fulfill PDH requirements was the preferred solution. Because of the recurring nature of the requirement and the static nature of the information (i.e., the core principles of engineering ethics are relatively constant), it was determined that workers should be exposed to an initial, in-depth training followed by annually updated refresher training (which is defined as a “short-term course aimed at recall and reinforcement of previously acquired knowledge and skills” [2]).

Developed in accordance with the Systematic Approach to Training (SAT), the initial training covers the elements of the NM *Code of Professional Conduct – Engineering and Surveying* (NMAC); ethical obligations to the engineering profession and other professionals; and various federal legal requirements, most especially export control law, that have the potential to impact the practice of engineering at the Laboratory. It has been delivered both in classroom and online settings. Although the initial training does incorporate some case-based “test your knowledge” exercises, it is primarily a lecture- or presentation-based pedagogical model.

Research in the field of “andragogy” (the art of teaching adults [3]) dating back to the 1970’s, however, suggests that lectures, and especially lectures in which the same information is repeated, may not be the ideal instructional model for adult learners. Therefore, as we designed the engineering ethics refresher training, we looked to other instructional designs.

2. RATIONALE FOR SELECTION OF THE CASE MODEL APPROACH FOR CONTINUING EDUCATION

Knowles’ model, which has evolved over the years (his seminal work is now in its seventh edition [4]) contains six core andragogical principles that influence instructional design decisions for adult learners:

- 1) the adult learners’ need to know not only the subject matter, but also to understand the underlying why, what, and how
- 2) the tendency toward movement from dependency upon an instructor to greater autonomy and self-directedness as learners age
- 3) the prior experience of the learner – particularly their mental models – and the need to use techniques that incorporate the adult learners’ experience base as an integral part of instruction
- 4) the adult’s orientation to learning being problem-centered and contextual
- 5) the dependency of adults’ readiness to learn on the developmental phases associated with the various roles that they play/have played in their (professional) lives
- 6) the basis of adults’ motivation to learn being in intrinsic value and personal payoff

Case studies are an ideal method for adult instruction. In the case method, knowledge is acquired while dealing with a real-life problem and not in isolation of its context [5], consistent with the fourth of Knowles’ principles listed above. “Although the case method does not actually provide real experiences, it is personal as it puts the burden of thinking on the learners and arouses their interest by making them active participants [6].” This characteristic is responsive to both the adult learner’s need for self-directedness and for engaging his/her own experience base. While development of skills generally requires an element of actually doing the skill-based activity, the case method provides the opportunity for skill development through presentation of different cases that exercise the same skill over a period of time [5]. Finally, because cases involve real people with real problems, they are also more likely to stimulate adult learners than are subject matter-based lectures or texts [7]. The narrative format encourages learner engagement [5].

3. DESIGN OF THE ENGINEERING ETHICS CASE STUDIES

Clark [6] describes case studies as being of one of two forms. The first type uses short and specific situations in which the problem is apparent. The learner is asked to demonstrate his/her problem solving ability by applying principles that have been taught previously. The second type focuses on appreciating different perspectives on a situation. This type provides complex information that requires deep analysis and focuses on problem identification as well as finding solutions. The Food and Agriculture Organization of the United Nations (FAO) (see reference [5]) refers to these two types as “caselets” and “comprehensive cases,” respectively.

The case studies used in the LANL project are more like Clark’s [6] first type, as they are typically short and require the learner to apply the knowledge gained from the initial training. Many of the case studies used in the refreshers do, however, share one characteristic of Clark’s second type, namely, the need to consider multiple perspectives on the problem. As the case study unfolds, the learner may be asked to take the position of the involved worker, coworkers, consultants, or managers, exercising Knowles’ [4] principle regarding an adult’s readiness to learn being dependent upon the learner’s phase of development in various roles.

Because the refreshers are delivered online, one of the integral aspects of the case method, discussion with a group of co-learners [5], is lost. Recognizing that much of the value of the discussion is in the feedback provided to the learners to positively reinforce learning [5], the courseware was designed with branching, which takes the learner to different paths through the material. Selection of the “best” response leads either additional segments of the case or to a new case. Selection of a non-optimal response leads to feedback as to why the response is not the best option and, in some cases, the opportunity to further explore the rationale underlying the “best” response by answering additional questions.

Learning Objectives

Cases were selected to reinforce the learning objectives developed for the initial training. These included:

- Enhancing learners’ knowledge of ethical conduct expected of engineering professionals and of how to apply this knowledge in situations requiring ethical judgment; subject matter associated with this objective specifically addressed the NMAC *Code of Professional Conduct* as well as the codes of conduct of the major engineering professional societies

The NMAC rules address five topics:

- 1) Protection of public safety, health, welfare, and property

- 2) Specialization and the performance of services only in specific areas of competence
 - 3) Issuing public statements
 - 4) Professional relationships with an employer or client
 - 5) Solicitation of professional employment
- Familiarizing learners with business ethics principles
 - Familiarizing learners with ethical conduct regarding authorship and publication
 - Enhancing learners' knowledge of how to use and protect information in an ethical manner
 - Providing learners with information on where to go for additional resources on ethics and ethical conduct

Adapting the Cases

While we tried to stay true to the details of the cases, it was sometimes necessary to adapt them to bring out salient features of the NMAC, LANL policies, or relevant laws and regulations. Generally, we begin by presenting a high-level, factually accurate summary of the case, with the only adaptation being removal of the names of involved individuals and substitution of names like "Eddie Engineer" and "Mike Manager" to enable students to track the participants through successive presentation of the case without compromising individual privacy.

Additional details about the case are presented in subsequent "frames." The case is doled out in small increments, with questions probing various ethical principles embedded within each segment. Fictitious situations or characters may be introduced to allow the scenario to explore aspects that were not present in the real case. Introduction of fictitious characters also facilitates having the learner take the position of actors other than those who were directly involved.

4. METHOD

For the 2010 and 2011 courses, "success" was defined in terms of the participation rate among members of the target audience (throughput), percent of correct responses (as a surrogate for knowledge transfer/retention), and informal feedback from participants. Due to a limitation in LANL's course delivery mechanism, no formal feedback was obtained.

Throughput and correct response rate were also monitored for the 2012 refresher, and formal feedback was solicited as well. The survey used was a modified version of Thalheimer's [9] learner survey. Unlike many "smile sheets," which ask general questions about the learning experience, this survey format asks learners to respond to specific learning points covered in the learning intervention. We used the learning objectives for the refresher training (shown in Table 1) as the key learning points to survey

against. Note that these learning objectives are a roll-up of the objectives used in the initial training; for example, the initial objectives related to authorship and protection of information are included in the more general topic of business ethics.

Capturing data about the *value* of individual key concepts provides more meaningful information about changes that should be made in future learning interventions [9]. In addition to addressing general ratings, the evaluation form also asks two critical questions related to how likely the concepts learned will be utilized on the job and how likely the concepts will be shared with others. This provides information regarding whether the training is likely to have an impact where it was intended.

Modifications to Thalheimer's [9] basic structure included questions related to participant preferences regarding case-based learning as compared to other instructional methods along the andragogical factors suggested by Knowles [4] and questions related to the utilization and value of asynchronous discussion augmentation of the online cases. It was hoped that this would allow us to validate our conclusion that a case-based model is the most appropriate method for delivering the educational experience to our target population and to gauge the effectiveness of threaded dialogue in improving the richness of the learner's experience and the quality of the feedback provided.

5. RESULTS

Throughput and Correct Response Rate

Throughput and correct response rates for the 2010 and 2011 refreshers have been discussed extensively elsewhere [10] and are not repeated here. The participation rate for 2012 was similar to that of past years (~49%). The correct response rate was significantly lower (at 68.8%, $F = 4.41$, $p = .019$) for the 2012 refresher than was observed in 2010 or 2011. Two of the 2012 questions had particularly low percent correct rates – one with just 25% correct and the other with 33.9%. With these removed, the 2012 results are still lower than in previous years, but the result is not statistically significant (mean correct response rate = 75.9%, $F = 1.82$, $p = 177$).

Course Evaluation

Of the 59 trainees who took the 2012 refresher, 29 completed the survey, for a response rate of 49%. Table 1 shows participants' ratings of the value of the specific information contained in the learning objectives. Data in each cell is the percentage of respondents providing the response. The most common response across all learning objectives was that the materials "provided a nice reminder."

When asked to rate the overall value of the learning experience, 72.4% rated it as valuable or very valuable; only 3.4% provided a rating of little or very little value.

TABLE 1. VALUE OF SPECIFIC INFORMATION

Learning Objective	Rating				
	<i>Most people already know this</i>	<i>I already use these concepts regularly</i>	<i>Provided a nice reminder</i>	<i>Deepened earlier understanding</i>	<i>Concepts were new to me</i>
Making better decisions when faced with ethics-related situations	3.6%	7.1%	57.1%	32.1%	0.0%
Being knowledgeable regarding the Rules of Professional Conduct that apply to Professional Engineers licensed in the State of New Mexico	3.4%	13.8%	41.4%	41.4%	0.0%
Knowing how to identify and resolve business situations requiring ethical judgment	3.4%	13.8%	48.3%	31.0%	3.4%
Knowing where to go to get help when I am unsure about my best course of action	0.0%	17.2%	41.4%	34.5%	6.9%

The questions aimed at assessing the likely impact of the training each provided a range of likelihoods from 0% to 100%, and advanced in increments of 10 units. For the question regarding using the information on the job, 65.4% said that they were at least 70% likely to use the information on the job; only 10.2% gave a likelihood rating of 30% or less. For the question about sharing the information with a coworker or friend, the results were less positive – 48.1% expressed a 70% or greater likelihood of sharing, while 13.8% said that they were 30% likely or less.

Value of the Discussion Board

Survey respondents were also asked about their participation in and valuation of the discussion board that was introduced in 2012. While only 20.7% reported visiting the discussion board, 100% of those who did visit rated the experience as being of average or greater value.

Instructional Delivery Using Case Methods

Respondents were asked to rate how well case methods support each of Knowles’ [4] andragogical principles when compared to traditional lecture- or presentation-based

instruction. Table 2 shows their responses to these questions; data in the cells is the percentage of responses. The methods were viewed as equally supporting most of Knowles’ principles by a plurality, if not a majority, of respondents. There were two principles for which the case method was seen by the majority of respondents as providing better support: the tendency toward movement from dependency upon an instructor to greater autonomy and self-directedness and the orientation toward learning as being problem-centered and contextual. In no case was the presentation-based method of instruction viewed as best supporting the andragogical principles by a plurality of respondents.

Comments on the case method received in response to an open-ended question were consistently positive:

- “The case method puts a real world perspective on the lessons and, especially when consequences of failure to behave ethically are demonstrated, it makes the lesson have meaning.”
- “For this subject matter, case studies seem to be more meaningful.”
- “For web-based instruction, I prefer case studies.”

TABLE 2. RATINGS OF INSTRUCTIONAL DELIVERY METHODS

Adult Learning Instructional Design Principle	Ratings		
	<i>Better supported by the case method</i>	<i>Supported equally well by the case method and by presentation-based instruction</i>	<i>Better supported by presentation-based instruction</i>
The need to know not only the subject matter, but also the why, what, and how underlying it	37.9%	44.8%	17.2%
The tendency toward movement from dependency upon an instructor to greater autonomy and self-directedness	58.6%	37.9%	3.4%
The need to incorporate the learner’s experience base as an integral part of the instruction	37.9%	51.7%	10.3%
The orientation toward learning as being problem-centered and contextual	55.2%	37.9%	6.9%
The need to incorporate the various roles that the learners play/have played in their professional lives	41.4%	51.7%	6.9%
The basis of the learner’s motivation being in the intrinsic value of the learning and personal pay-off	24.1%	69.0%	6.9%

The only negative comments we received had to do with learners being uncomfortable with the lack of a definitively right or wrong answer for many of the scenarios: “Ethics can be black/white, but sometimes it is gray (or striped or polka-dotted)... these gray areas are the hardest thing for engineers to come up with the 'right answer.'” These were consistent with comments that had been received informally in prior years.

6. DISCUSSION

Correct Response Rate

The question with the 75% failure rate in the 2012 refresher was a multiple choice question where more than one answer was correct; most respondents (66.7%) selected the more obvious of the two correct responses and missed the more subtle correct response. This may reflect a problem with the question stem, which is worded as follows: “Which of the NMAC 16.39.8.9 Rules of Professional Conduct **best** apply to this situation?” [emphasis added]. Use of the word “best” may have implied that there was a single correct answer, even though the answers themselves clearly conveyed the option of multiple responses (e. g., option d. in the response set was “a and c”). This result may also be reflective of lack of attention on the part of respondents, since the answer that was most often selected was option a. – respondents may not have read through the entire response set before selecting their answer. The 2013 version of the refresher contains several questions with similarly worded stems where the correct answer is an option having multiple answers and where the distractor most likely to be incorrectly selected is located somewhere other than at option a. We will examine patterns of responses in the 2013 refresher responses to determine if similar trends exist.

The question that had the 66.1% failure rate portrayed a situation in which a vendor had invited an engineer at a manufacturing firm to play golf at an exclusive country club. The initial question about the case simply asked if it would be ethical for the engineer to accept the invitation. The case files of the National Society of Professional Engineers (NSPE) contain many cases of this type, and the

NSPE Board of Ethical Review has uniformly deemed the offering and acceptance of such social exchanges to be ethical as long as there is no *quid pro quo* and the nominal value of the gift is not excessive in the context of the industry’s culture. Both conditions were considered to have been satisfied in the case as initially presented [11]. However, accepting such a gift would be a violation of LANL’s Code of Conduct, which prohibits the acceptance of gifts valued at more than \$20 per occurrence or \$50 cumulatively throughout the year. Our speculation is that respondents answered this question from the LANL point of reference. This hypothesis is being tested in the 2013 refresher, which contains a question about acceptance of a gift that makes explicit the frame of reference as the NSPE Code, then asks what the respondent would do if confronted with the same situation as a LANL employee.

Course Evaluation

The result that the most common rating of the value of the specific information contained in the learning objectives was that it “provided a nice reminder” is not surprising given that the case studies were intended to refresh knowledge gained through prior training. The results on the two questions related to the likely impact of the training were positive – trainees generally reported a high probability that they would use what they learned in their job and, to a lesser extent, that they would share what they had learned with their coworkers. The differences in the two sets of impact ratings were not statistically significant ($F = 4.47 \text{ E-}06$, $p = .998$).

Comments indicating discomfort with the “squishiness” of ethics cases validated our previous conjecture that trainees’ discomfort with the lack of a definitively right or wrong answer for many of the scenarios was due, not to an inherent weakness in the case method (as had been suggested by the FAO [5]), but to the nature of the ethical dilemmas.

Value of the Discussion Board

The low self-reported rate of visits to the discussion board was disappointing. Even more disappointing was the fact that the only comments posted on the board were the ones “planted” by the instructor. Breadcrumbs confirmed that the site had had visitors, but those visitors “lurked.” Knowles’ [4] principle, that the basis of the adult learner’s motivation comes from the intrinsic value of the learning and personal pay-off, had led us to speculate that learners would be motivated to participate in the discussion board if they found that it had intrinsic value. Although all those who visited the discussion board said that it was of average or greater value, they did not participate. Perhaps this was due to a lack of perceived personal payoff – learners did not receive any additional credit for participating, so may have opted to do the minimum amount of work required to get the PDUs. To test this hypothesis, we are in the process of developing an incentive of 1 additional PDU for substantive discussion board input for roll-out early in FY15.

Instructional Delivery Using Case Methods

Case methods were viewed as better meeting adult learners’ needs (as compared to traditional presentation-based instruction) in two regards:

- Moving from dependency upon an instructor to greater autonomy and self-directedness, and
- Having the learning be problem-centered and contextual

It is somewhat surprising that the methods were viewed as equally supporting two-thirds of Knowles’ principles by at least a plurality of respondents. We expected case studies to be better at meeting learners’ needs regarding incorporating their experience base as an integral part of the instruction and incorporating the various roles that the learners play or have played in their professional lives. The latter is especially true

in view of the fact that the case studies were explicitly designed to have the trainees consider the cases from a variety of points of view – involved worker, coworker, manager, etc. – reflective of different roles they may have played.

7. CONCLUSIONS

The selection of the case model approach was driven not by the subject matter to be taught but rather by the target audience – the adult learner. Therefore, there is the potential to apply case model-based learning in other professional disciplines, such as health care, law, and public accountancy, in which there are continuing education requirements placed on adult learners. In addition to sharing the characteristics of adult learners, like our target population these audiences are all motivated to complete continuing education for personal payoff – maintenance of the license or certification needed for continued employment in their profession – which reflects Knowles' final andragogical principle [4].

Because the engineering ethics refresher courses are delivered online rather than in a classroom, one of the integral aspects of the case method, namely discussion with a group of co-learners [5], is lost. As a result, online presentation of cases lacks the richness and feedback associated with cases presented in the classroom.. It was hoped that an asynchronous discussion thread could be added to the training experience to provide some of that richness. While our attempts at augmenting the online training with a discussion forum failed, we still believe that this approach is promising and are in the process of examining inducements that would encourage trainee participation on the discussion boards.

8. RESOURCES

- [1] American Society of Mechanical Engineers Ethics Center http://www.asme.org/NewsPublicPolicy/Ethics/Ethics_Center.cfm
- [2] National Society of Professional Engineers Board of Ethical Review <http://www.nspe.org/Ethics/EthicsResources/BER/index.html>
- [3] New Mexico State Board of Licensure for Professional Engineers and Professional Surveyors Disciplinary Actions <http://www.sblpes.state.nm.us/discipline.html>
- [4] Online Ethics Center for Engineering and Research <http://www.onlineethics.org/Resources/Cases.aspx>
- [5] The American Lawyer http://www.americanlawyer.com/current_issue.jsp
- [6] The Center for the Study of Ethics in Society <http://ethics.tamu.edu/pritchar/an-intro.htm>

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