AC 2007-14: ASSESSMENT OF ETHICS MODULES IN AN ENGINEERING CURRICULUM

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Abstract

Decisions made by engineers have a profound effect on the quality of life for citizens of the entire world. As such, their actions and decisions need to be governed by honesty, integrity, impartiality and fairness. Public health and safety considerations should dictate their professional behavior. (Unger, 1994). Engineers are expected to demonstrate that they adhere to the highest principles of ethical conduct. About 5% of questions on the F.E. exam correlate to engineering ethics.

At Texas A&M University, evidence of this interest in professional ethics culminated in the creation of a new course in engineering ethics, as well as a project funded by the National Science Foundation to develop material for introducing ethical issues into required undergraduate engineering courses. Case Western Reserve University has created an *Online Ethics Center for Engineering and Science.* University of Virginia School of Engineering and Applied Science and the Darden School of Graduate Business Administration have created a web site that is dedicated to the dissemination of engineering ethics case studies and supporting resources for students and faculty. The *Ethics Updates* site of the University of San Diego is another widely cited example. Illinois Institute of Technology's *Center for the Study of Ethics in the Professions has* made significant strides in promoting ethics amongst engineering societies.

All these are very strong signals that educators have been prompted to introduce, integrate and incorporate engineering ethics scenarios into college curriculum, both at the two year and at the four year levels. (Schlager, 1994). Furthermore, it is very important to recognize that such activities promote the critical thinking abilities of students and sharpen their oral and written communication skills. (Whitbeck, 1996). In this paper, the authors describe how they have incorporated and assessed several modules and exercises that can help students get a good exposure into this important area of engineering ethics. In addition, they also provide an analysis of the data they have collected.

Introduction

At the Annual Meeting of the Pacific Southwest Section of the American Society for Engineering Education, Professor Tim Healy presented a paper entitled *Teaching Ethics and Teaching Engineering - Some Parallels.* Professor Healy is a Scholar of the Markkula Center for Applied Ethics at Santa Clara University, California and is very active in the teaching of ethics to engineers. (Healy, 1997).

Professor Healy indicates that there are strengths and weaknesses in using case studies while teaching ethics to engineering students. Regardless, it is important to recognize the fact that when ethics scenarios are discussed with students, in a classroom environment, case studies do offer a smooth vehicle and thereby constitute a very valuable resource data bank. (Northouse, 2001).

Experts are of the opinion that if the students can correlate the scenario with something they have learned in the classroom, it will indeed be a very effective and efficient learning tool. The methodology is to use *Socratic Inquisition* techniques and create a learning environment instead of a lecture based teaching classroom. (Snyder, 1987). Professor Healy also mentions: *The limitations of models should be a part of our teaching in engineering and in ethics alike. Engineers should always have a strong sense of the strengths and weaknesses of their engineering models. This can be done through a general discussion of the nature of the modeling process.* (Healy 1997).

Learning Modules

Ethics modules have been incorporated into course syllabi and content of several courses within the engineering technology program at Miami University. These learning modules were designed to introduce concepts, enhance understanding, and broaden student knowledge in the area of engineering ethics and ethical behavior. (Appendix A) The inclusion of these modules within the content of engineering technology courses was initiated by the authors about five years ago. They have been successfully used in a first year freshman course and assessment data have been compiled, analyzed and tabulated. There are plans to generate similar modules for use in sophomore, junior and senior level courses. Appendix B provides an example of an Ethics Module that was used by the authors. (Henthorn, 1994 – 2004).

Students were encouraged to participate in classroom discussions. There were no lectures. On the contrary, *Socratic Inquisition* techniques were utilized in the classroom to create an atmosphere identified as *Learning Paradigm.* (McKendall,1993) Students were asked to summarize their thoughts in a written report, which was later analyzed, graded, assessed and tabulated. The results were analyzed using *Washington State University's Rubric* (Appendix A) and categorized using a *Likert Scale.* Data were plotted using a bar chart shown in Appendix B.

Scales of Measurement

It is important to recognize that statistical data takes many forms so that the analysis method used to present findings may be properly matched to the data type. Scientists encounter many types of data. One method of classification would be : *Discrete Data, Continuous Data, Sampled Data, Ordinal Data, Derived Data,* etc. However, some other scientists classify in a different manner and they list four types of data (scales of measurement) that are very common and more frequently used. (http://www.math.sfu.ca/~cschwarz/Stat-301/Handouts/node5.html)
Among the widely accepted scales of measurement are: *Nominal, Ordinal, Interval, and Ratio*. It is important to recognize that only certain procedures and recommended operations are preferred and legitimately acceptable for each measurement scale. (Cann, 2003). In certain cases it may not make any sense to calculate the average and create a histogram. Calculation of mean value or determination of the standard deviation may not be a valid operation. (http://academic.emporia.edu/mooredwi/rda/notes1.htm)

Using *Nominal Scale* data one is permitted to examine if a nominal scale datum is equal to some particular value or to count the number of occurrences of each value. For example, gender is a nominal scale variable. One could examine if the gender of a person is male or female or count the number of females in a sample. One could examine whether disposable plates are made from plastic or cardboard/paper stock or whether beverage containers are made from glass or Styrofoam. (Cann, 2003).

Ordinal Scale data permits one to examine if an ordinal scale datum is less than or greater than another value. Thus, you are able to 'rank' ordinal data, but you cannot 'quantify' differences between two ordinal values. Preference scores such as the *rating of restaurants* where 7 = excellent, 1 = unacceptable but the difference between an establishment with a 7 ranking and one with a 5 ranking can not be quantified. This is an example of the use of ordinal scale. (Cann, 2003).

Interval Scale measurements are allowed to quantify the difference between two interval scale values but there is no natural zero. Temperature scales are examples of interval scale data with 70^0F sensing warmer than 35^0F and a 35^0F difference in temperature has some physical interpretation. 0^0F or 32^0F is arbitrary so that it does *not* make sense to say 70^0F is twice as hot as 35^0F. Materials hardness scales such as Rockwell and Brinnel are also examples of the use of *interval scaling.* That is, it is *not valid* to say that iron is twice as hard as aluminum because the numbers associated with Brinnel Hardness Test or Rockwell Hardness test are measured with respect to an arbitrary datum. (Cann, 2003).

Finally, *Ratio Scale* data permit ratios to be made between scaled variables. Physical measurements of height, weight, and length are typically ratio variables. Thus it is meaningful to say that 100 yards is twice as long as 50 yards. This ratio holds true regardless of which scale is used to measure the length (e.g. yards or meters) because there is a natural zero for length. (Cann, 2003). Another example of such a scale would be one that would measure speed. It would be meaningful to say that 30 kilometers per hour is exactly half the speed of 60 kilometers per hour. This ratio is also true regardless of which scale is used to measure the speed (e.g. kilometers per hour or miles per hour)

Likert Scale

Rensis Likert, the American educator and organizational psychologist was the founder of *University of Michigan's Institute for Social Research.* Likert is best known for his research on management styles, development of Likert Scales and the Linking pin model. (Likert, 1932). Just like W. Edwards Deming, Likert's books on theory of management were very popular in postwar Japan during the sixties and seventies. A Likert scale is often used in research surveys and questionnaires. It is a type of psychometric response scale. Likert Scale is perhaps the most widely used instrument in sociology research. Likert scaling is referred to as a bipolar scaling method. Presented with a statement, Likert scale attempts to measure and record either the positive or the negative response provided.

While addressing and responding to a statement presented on a Likert scale questionnaire, respondents indicate whether they

Strongly agree (5),
Agree(4),
Remain undecided (3),
Disagree(2)
Strongly disagree(1).

It is important to emphasize the fact that these responses, 5 – 4 – 3 – 2 – 1
represent what is known as *ordinal level of measurement.*

The Likert Scale represents a built-in, inherent order or sequence. For example:

Strongly Agree to Strongly Disagree.
Biggest to Smallest.
Maximum to Least.
Strongest to Weakest.
Tallest to Shortest.
Heaviest to Lightest.
Largest to Smallest.
Etc.

Numbers (1 to 5) are assigned to the responses received, however these numbers do not indicate the magnitude of difference between the responses. One may recall that in case of ratio scale or interval scale the magnitude of difference, indeed has a specific meaning attached to it.

The data is not continuous. Therefore it must be interpreted carefully. It is not appropriate to generate or create a histogram using the data collected. Mean (average) values do not have any meaning for interpretation. Furthermore *standard deviation* does not convey anything. Therefore, the data are normally summarized using a median or mode. The authors prefer to use *mode.*

Analysis of Results and Conclusions

In this exercise seven items were selected for "Primary Trait Analysis" according to *Washington State University's Rubric.* Appendix C shows how grading was administered. It may be observed from Appendix D *Bar Chart* that the students have acquired adequate knowledge in five of the seven areas selected for analysis. Items 1, 2, 3, 6 and 7 show respectable mode values of 4. It would be excellent if one could achieve mode values of 5 for all the seven characteristics listed, however this may be unrealistic.

Items 4 (*Assesses the key assumptions and characteristic*) and Item 5 (*Assesses the quality of supporting data*) record mode values of 3 thereby suggesting that there is room for improvement.

New modules are being developed for use in other courses at different levels. The ultimate objective is to achieve a situation wherein the students have achieved a good grasp of the importance of engineering ethics in a realistic environment.

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APPENDIX A : Classroom Worksheet Instructions

DISCUSSION OF ENGINEERING ETHICS

Name of the Student: Date Submitted:

Background: Study the NSPE Code of Ethics available at:

http://www.mtengineers.org/pd/NSPECodeofEthics.pdf

Methodology: You have been presented with four scenarios. Engage in a productive discussion of each scenario with your peers. Keep NSPE Code of Ethics in perspective while presenting your viewpoints. Take notes while the classroom discussion is taking place. Your written communication skills are also very important. The instructor will serve as a *moderator*. Devote approximately 15 minutes of interaction per scenario. 5 more minutes to gather your final thoughts and write them down.

Submission: Submit electronically a written report. Your responses should include:

(a) A summary that indicates that you have captured the spirit of classroom, peer-group discussions.

(b) Your own point of view as to how you would handle the *Ethics Scenario* presented.

Requirements: Approximately 100 words per scenario. 4 scenarios, 400 words total.

Commentary: Reflect on this classroom exercise and comment on the way it was organized and conducted. (No lectures, but peer-group discussions.) Indicate the importance of Ethics in Engineering Profession. What are your views about present day 'ethics situations' in the engineering field? Have you come across some interesting or objectionable scenarios? Comment on how this *module* has helped you in accomplishing some of your educational objectives. (Approximately 200 words.)

Grading:

Discussion of 4 Ethics Scenarios.	20% per scenario ✕ 4 =	80%
Reflective Commentary.		20%

APPENDIX B : Four Assignments (Courtesy of Grover Hnethorn)

Ethics Scenario # 1

You (student) were hired one year ago with a chemical company. While working on the night shift you see a supervisor and one of the employees dump a barrel of toxic material down the floor drain leading to the city sewer. What would you do?

Additional Information If this is reported to the EPA there is a good possibility the plant will be shut down.

Additional Information The plant is in a small town and is the major employer. A plant shut down would be a severe economic blow to the community. Your uncle, who has three children, is employed at the plant. In fact, he was the employee who was helping the supervisor dump the toxic material in the floor drain. Does this change your position? With this information, what would you do?

Ethics Scenario # 2

You are an avid deer hunter. You live in a state where doe hunting is against the law. The law was passed several years ago when the deer population was extremely low. While hunting one of your friends kills a doe. He knows the law, and knew the deer was a doe when he shot it. He did it out of frustration because it was the last day of hunting season and he had not seen a buck deer to shoot. What would you do?

Additional Information You are a corn farmer. Your total income comes from selling corn. Over the past four years you have noticed the deer population is totally overrunning your fields. In fact, you see physical evidence where they have caused several thousands of dollars of damage to your crop each year. Further, in your opinion, the deer population is not in danger such as it was when the doe hunting law was passed several years ago.

Ethics Scenario # 3

You are to be congratulated. You have accepted an offer from a leading company in a field you have wanted to enter since your freshman year at Miami. Company B has a great training program, high starting salary and is known for promoting from within. This opportunity was one of two that you received from well-known companies. Although the starting salaries were very close, you wanted to work in this industry. Company B's offer came in two weeks after Company A made you an offer so you decided to accept this offer and you send them a letter of acceptance.

Additional Information

Two weeks ago, after receiving the offer from Company A you gave the offer a lot of thought. You knew the company was a leader in its field, had a good employee relations reputation, the salary offer was acceptable, and the geographic area for employment, all fit your needs. You were somewhat concerned about delaying your acceptance and losing this position while waiting for other offers that you were unsure might materialize. With the positives of this job in mind, you had already sent Company A letter of acceptance. What would you do now?

Ethics Scenario # 4

You are a design engineer for an automotive company. Three years ago you were the senior design engineer on a door latch system. You were praised for your design by upper management and given a considerable salary increase for your contribution. Several complaints have been filed by car owners stating that the latch system has failed in accidents. Some testing companies have also stated the latch does not meet government safety standards. If the public becomes aware of the problem or the government stops the company from producing the product with its latch, it would be a severe economic blow to the company as the latch is a part of the two best selling models this year. You have been approached by upper management to be prepared to defend the product and the company reputation "at all cost." What do you do?

Additional Information

After being notified of the lawsuits and potential government intervention, you have run additional tests. Some of the test data has not duplicated the original test data. In fact, the latch has failed company test standards. Upon investigation you determine previous tests were falsified by one of your design engineers and test lab supervisor. What do you do?

Additional Information

You are called to the Division VP Manager's office. After discussing your recent findings, (test failures) you are instructed to remove all written data which will be "embarrassing" to the company and be prepared to defend the latch in court or before the government. After a few days you tell the VP you will not be part of any cover-up. You are reminded you are fifty years old with several long term financial obligations and if you don't place the company interest in proper perspective, you will be on the "outside looking in" What do you do?

APPENDIX C : A sample of how grading was administered.

STUDENT # X

THE CRITICAL THINKING RUBRIC

RUBRIC COURTESY OF W. S. U.

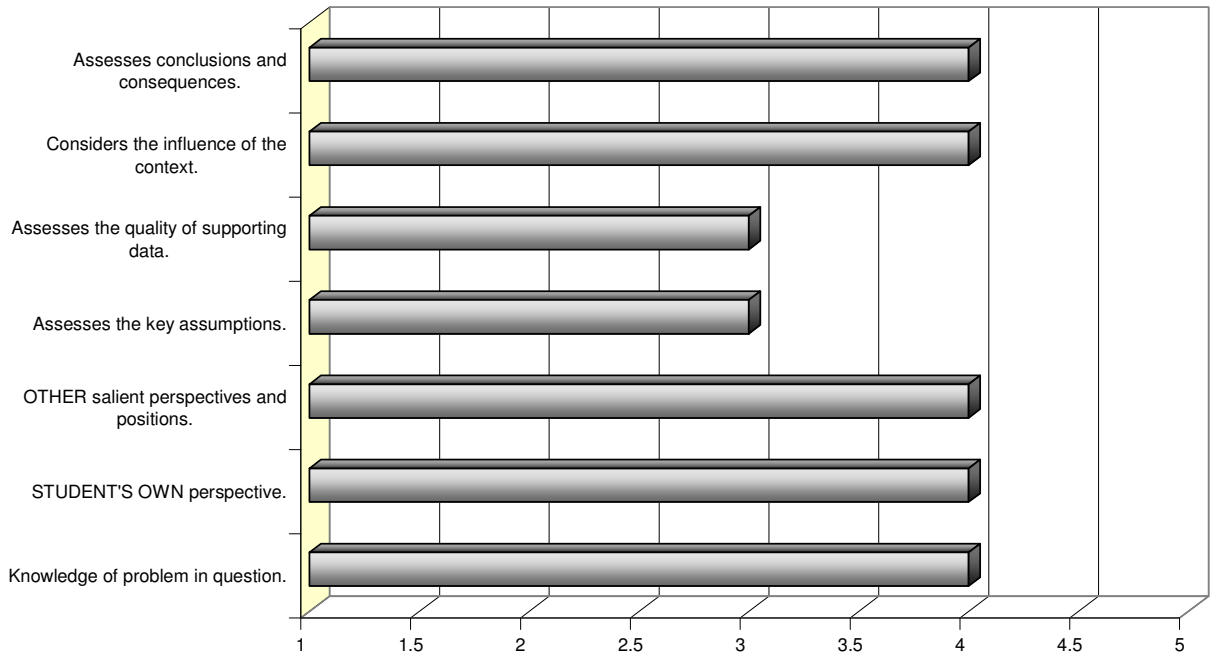
WASHINGTON STATE UNIVERSITY

PULLMAN, WA. 99164.

LIKERT SCALE WEIGHT DISTRIBUTION :

		5 STR. AGREE	4 AGREE	3 UNDECIDED	2 DISAGREE	1 S. DISAGREE
1	Knowledge of **problem in question.**	√				
2	STUDENT'S OWN **perspective.**	√				
3	OTHER salient **perspectives and positions**.	√				
4	Assesses the key **assumptions**.			√		
5	Assesses the quality of **supporting data.**			√		
6	Considers the influence of the **context.**		√			
7	Assesses **conclusions and consequences**.	√				

APPENDIX D : Assessment using Likert Scale (Rubrics Courtesy of W.S.U., Pullman)



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