AC 2008-2129: IMPROVING ETHICS STUDIES THROUGH A SPIRAL CURRICULUM: PILOTING AN ETHICS DISCUSSION AT THE SENIOR LEVEL

Kumar Mallikarjunan, Virginia Polytechnic Institute and State University

Dr. Kumar Mallikarjunan is an associate professor in Biological Systems Engineering at Virginia Tech. He is interested in understanding and implementing a spiral theme based engineering curriculum for the Biological Systems Engineering program, engineering ethics, and promotion of undergraduate research.

Christan Whysong, Virginia Polytechnic Institute and State University

Ms. Christan Whysong, a graduate student of Biological Systems Engineering at Virginia Tech, has been actively engaged in learning about curriculum development in addition to pursuing her engineering research related to noninvasive testing and biomedical applications.

Jenny Lo, Virginia Polytechnic Institute and State University

Dr. Jenny Lo, assistant professor of Engineering Education at Virginia Tech, is interested in understanding and improving engineering curriculum at the freshman level, engineering ethics, and promotion of undergraduate research.

Improving Ethics Studies through a Spiral Themed Curriculum: Piloting an Ethics Discussion at the Senior Level

Abstract

The Biological Systems Engineering (BSE) and Engineering Education departments at Virginia Tech have identified the need to enhance undergraduate student exposure to engineering ethics. It was decided the best method for improving ethics training is to have students continuously revisit engineering ethics material at increasing levels of complexity through a four-year spiral themed curriculum. This is one goal of Virginia Tech's Department Level Reform (DLR) project, funded by the National Science Foundation (NSF). Previous work has consisted of compiling a library of related ethics case studies, particularly related to Bioprocess Engineering, along with different methods for implementing these case studies. An ethics exercise was implemented at the BSE sophomore level during the fall 2006 semester. This work has been presented at the 2006[1] and 2007[2] ASEE Annual Conference and Expositions. As the project moves into its final phases, these departments have continued to expand their library of ethics case studies and piloted an exercise to be used during the fourth phase of the spiral.

BSE students focusing in Bioprocess Engineering are required to take a Food Process Engineering course taught during the fall semester of their senior year. Some appropriate ethics case studies for this course include the conflicting views of the food industry and consumers. Companies often add controversial ingredients, such as trans-fat and diacetyl, to their products to make them tastier and typically target youth who often influence family purchases. If successful in attracting a younger consumer to a product, a company will usually have a customer for life.

Students were asked to complete a pre-survey, designed to gauge their understanding of the above ethical issue. Students then read the provided resources and individually completed an informal written assignment, of which the goal was to have students form their own opinions about the topic. When students returned to class, they shared their views with the class during a discussion. Students were then asked to complete the pre-survey questions as a post-survey to gauge their learning experience from this exercise. This activity increased student exposure to the American Society of Agricultural and Biological Engineers (ASABE) Code of Ethics for Engineers and also increased awareness of ethical issues related to food companies adding questionable ingredients for the purpose of creating lifelong consumers for their products.

Background and Spiral Approach

At an institution, 1200+ engineering students enter a general engineering program and participate in a common first semester course offered by the Department of Engineering Education (EngE). Each year approximately 30 of these students elect to enter into the Department of Biological Systems Engineering (BSE) with about half focusing in the Bioprocess Engineering area of the department. A collaborative effort between some faculty of EngE and BSE, funded by the department-level reform (DLR) program of the National Science Foundation (NSF), is currently underway. The goal of the DLR program for these two departments is to reformulate curricula within the EngE and BSE programs by utilizing a theme-based spiral curriculum approach. Jerome Bruner, the twentieth-century psychologist, proposed the notion of a spiral curriculum in

which basic ideas are visited repeatedly in an increasingly complex manner.[3] Figure 1 provides a visual description of the spiral curriculum being implemented by the EngE and BSE faculty. Active learning in the form of hands-on activities is one of the strategies being used to teach the main theme of sustainability, with supporting themes of design, systems, and ethics.

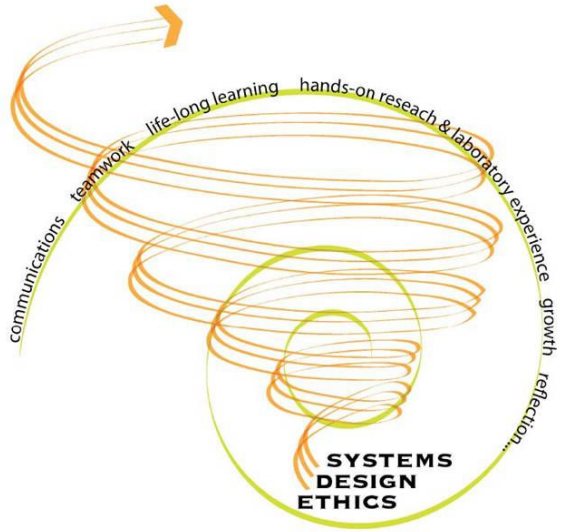

Figure 1. Schematic of a spiral theme based curriculum.

As part of this project, a library of ethics case studies, particularly related to Bioprocess Engineering, was developed and has begun to be incorporated into the curriculum. This library and methods for implementing these case studies, was created as part of an undergraduate research project during summer 2005.

In addition the two departments incorporated an ethics exercise, revolving around one of these case studies (genetically modified products) in a designated sophomore course offered in the BSE Department. The details from these works were presented during the 2006[1] and 2007[2] ASEE Annual Conference and Expositions.

Freshman year: ethics instruction

One of the main objectives of the freshman introductory engineering course, taught by EngE is that students should be able to demonstrate an understanding of professional ethics and be able to apply it to real-life situations upon the successful completion of the course. During this course students watch the National Institute for Engineering Ethics' Incident at Morales video which introduces ethics concepts such as making tradeoffs, public health, and differences in international laws. Students are required to read a chapter discussing basic moral theories and a few classic engineering case studies from a basic engineering text such as Holtzapple and Reece's Concepts in Engineering[4]. Additionally, students reflect on ethics by participating in a group exercise, which has included group skits and presentations in past semesters. Students are put in groups and asked to present or act out a given ethical situation. The class then participates in a discussion about what they have just observed. This introduction to professional ethics becomes the foundation for ethical training received in the upperclassman years.

BSE sophomore year: ethics instruction

BSE sophomores are required to take an Introduction to BSE course which includes an oil extraction laboratory. The lab exercise focuses on reintroducing the systems concept to students through process flow, yield, and waste reduction aspects. A BSE faculty member introduces the lab material in which students grind raw cottonseed, extract the oil, and refine the raw oil. The procedure exposes students to vegetable oil production, yield calculations, and waste product disposal.

Upon completion of the laboratory, students are required to perform a formal write up, consisting of introduction, materials and methods, and results and discussion sections. In addition, during the fall 2006 semester an ethics aspect was incorporated into this lab. Students were provided with a brief written introduction to genetically modified, or transgenic, products and asked to complete an informal written assignment which had them consider differences that might occur in the production of cottonseed oil if transgenic cottonseed were used as the raw material.

Once the assignment was collected, a BSE graduate student led an informal class discussion regarding the potential ethical concerns of genetically modified products. Throughout the discussion, students were asked to place themselves in different perspectives (consumers, farmers, oil extraction companies, etc.) to analyze the situation. The goal of the discussion was to allow students to observe the different views of their classmates.

BSE senior year: case studies

Pilot case studies focused on controversial food ingredients because they address key ethical issues, including food safety, health concerns, and conflicting views of the government, the food industry, and consumers. Trans-fats and diacetyl were the two examples provided. More information concerning these case studies are given below.

Food companies often partially hydrogenate vegetable oils, allowing for more saturation and higher melting points. This makes the oils more spreadable, more likely to inhibit spoilage, and more applicable for baked, fried, snack, and processed foods. Recent studies have shown trans-fats have a negative effect on blood lipid levels, increasing bad cholesterol levels and decreasing good cholesterol levels. This has lead to an epidemic of coronary heart disease in the Western World, specifically the United States[5]. In 1999 the U.S. Food and Drug Administration (FDA) recommended avoiding consumption of trans-fats. Additionally as of January 1, 2006, manufacturers are required to list the tans-fat content separate from the total fat content found on the standard Nutrition Facts label on food products[5].

Trans-fats continue to receive a bad reputation in the media as some groups have begun banning the tasty ingredient. One of these groups includes the Indiana State Fair whose vendors sell deep-fried Oreos®, Twinkies, corn dogs, funnel cakes, and french fries. Instead fair vendors are now required to use trans-fat-free cooking oil, which has been found to produce treats as yummy as those made in the regular oil. Additionally some fast food chains, including Kentucky Fried Chicken™, Girl Scout® cookies, and New York City have either banned or cut back on trans-fats[6].

Diacetyl, also known as butanedione, occurs as a natural byproduct of fermentation and is typically found in dairy products such as butter, cheese, and milk. It provides the buttery odor and flavor of many foods, especially microwave popcorn. It has recently come under scrutiny because some microwave popcorn manufacturer workers have begun developing a rare lung condition known as bronchiolitis obliterans, more commonly deemed popcorn lung.

Eric Peoples, a worker in a popcorn factory, was one of the first highly publicized cases of popcorn lung. Peoples, aged 32, used to mix flavors for microwave popcorn and claimed his lung condition, of which the only cure is a double lung transplant, was a result of his exposure to diacetyl due to fumes from the oils. He and his wife were awarded 20 million dollars for his injuries from the two makers of the butter oils: International Flavors and Fragrances Inc. and its subsidiary Bush Boake Allen Inc. It was claimed they new the chemicals were poisonous but did not provide adequate warning[7] to the people working with them.

BSE senior year: course implementation

BSE students focusing in Bioprocess Engineering are required to enroll in a Food Process Engineering course taught during the fall semester of their senior year. While students already discuss some contemporary issues during this course, an ethics exercise was piloted in fall 2007. To assist the researchers in knowing whether the exercise will be beneficial for future courses, a pre- and post- survey was developed. Before any material was presented to the class, students took approximately 10 minutes to complete the pre-survey, which consisted of the eight following questions. For questions 1.1 through 1.3, students were to place a mark by all choices applying for them. For questions 1.4 through 1.8, students were to circle the best response where:

1 is strongly disagree
2 is disagree
3 is no opinion
4 is agree
5 is strongly agree

1.1. I have used ASABE's Code of Ethics.
_____ True
_____ False

1.2. I believe _____ is/are responsible for the healthfulness of food products consumed.
_____ Food Companies
_____ Consumers
_____ Government
_____ Other: _____

1.3. When I shop for food products, I look most for:
_____ Taste
_____ Quality
_____ Cost
_____ Other: _____

1.4. I think food companies intentionally add ingredients for the sole purpose of hooking consumers/creating life-long consumers.

1 2 3 4 5

1.5. I believe trans-fats are bad for me.

1 2 3 4 5

1.6. I believe diacetyl (the buttery flavor in microwave popcorn) is bad for me.

1 2 3 4 5

1.7. I believe the government has the right to ban certain food products and/or ingredients.

1 2 3 4 5

1.8. I believe my moral beliefs help me make decisions to professional ethical situations.

1 2 3 4 5

Upon collection of the pre-survey, students were given a brief written introduction along with five current news articles related to the use of trans-fats and diacetyl in food products and the American Society of Agricultural and Biological Engineers (ASABE) Code of Ethics for Engineers. They were asked to read the provided materials and perform any research they deemed necessary to complete an informal written assignment having them consider controversial food ingredients. Students were given the assignment one class period (Wednesday) and it was due the following class period (Friday), for a total of 48 hours for assignment completion. The assignment included the following questions:

1. Is it acceptable for companies to add potentially harmful ingredients to their food products for the sole purpose of creating returning customers by increasing product tastiness?

2. Who should be responsible for the health and safety of food consumers? For example, should the food industry be responsible for creating healthy products or should the consumer hold the ultimate power and be able to decide what he or she consumes?

3. In the articles provided it is suggested workers producing microwave popcorn are becoming sick due to exposure to a specific ingredient. Should the workers have a say in what goes into a food product they are producing?

4. How do you feel about companies targeting specific groups with their products? For example, children have a lot of power in determining what their families purchase. Should companies target children, or any specific group of people with their products?

5. If a company produces a product considered healthy but is found not to be tasty. Is it alright for the company to add an ingredient found to be safe in order to obtain more consumers? What if adding this ingredient makes the product more expensive?

Upon collection of the assignment, a graduate student from BSE led an informal class discussion regarding the potential ethical concerns of food product ingredients. The role of the graduate student was to provide discussion prompts and answer any questions students had. Throughout the discussion students placed themselves in different perspectives (consumers, manufacturers,

manufacturer workers, etc.). The class discussed whether companies should use potentially harmful ingredients, specifically trans-fat and diacetyl, in their products and who should make the decision to include these ingredients in the products, or who is responsible for the health and safety of consumers. The class also discussed the trustworthiness of food manufacturers and the government agencies who are supposed to regulate them. The goal of the discussion, lasting approximately 20 minutes, was to allow students to observe the varying views of their classmates.

Since the Departments of Engineering Education and Biological Systems Engineering are only beginning to implement ethics training using the spiral themed curriculum, it is essential to develop an assessment plan for future evaluation. As mentioned above the tool utilized for this exercise was a pre- and post- survey. At the end of the class discussion, students were asked to complete a post-survey which consisted of the same eight questions given in the pre-survey along with an additional seven questions allowing the students to evaluate the exercise. The survey, lasting approximately 10 minutes, consisted of the following questions. For questions 2.1 through 2.3, students were to place a mark by all choices that applied to them. For questions 2.13 through 2. 15, students provided short answer responses. For questions 2.4 through 2.12, students were to circle the best response where:

1 is strongly disagree
2 is disagree
3 is no opinion
4 is agree
5 is strongly agree

2.1. I have used ASABE's Code of Ethics.

_____ True
_____ False

2.2. I believe _____ is/are responsible for the healthfulness of food products consumed.

_____ Food Companies
_____ Consumers
_____ Government
_____ Other: _____

2.3. When I shop for food products, I look most for:

_____ Taste
_____ Quality
_____ Cost
_____ Other: _____

2.4. I think food companies intentionally add ingredients for the sole purpose of hooking consumers/creating life-long consumers.

1 2 3 4 5

2.5. I believe trans-fats are bad for me.

1 2 3 4 5

2.6. I believe diacetyl (the buttery flavor in microwave popcorn) is bad for me.

1 2 3 4 5

2.7. I believe the government has the right to ban certain food products and/or ingredients.

1 2 3 4 5

2.8. I believe my moral beliefs help me make decisions to professional ethical situations.

1 2 3 4 5

2.9. I feel the issue of food companies versus consumers is an ethical concern.

1 2 3 4 5

2.10. I feel the class discussion format was beneficial

1 2 3 4 5

2.11. I would like to see more discussions used in my courses.

1 2 3 4 5

2.12. The topic of food companies versus consumers interests me.

1 2 3 4 5

2.13. What could be done to improve this exercise?

2.14. What did you enjoy about this exercise?

2.15. What are some other ethical topics related to Bioprocessing Engineering that you would like to learn about?

BSE senior year: assessment

Students were given two days to complete an informal written assignment having them consider controversial ingredients in food products. Students were to write short answers to five questions designed to help them formulate opinions toward the topic. Students were able to use the material provided in the handouts about case studies related to the use of trans-fats and diacetyl in food products or could perform external research for the assignment, although it was not required. Of the 17 students enrolled in the class, only six students submitted assignments. Of these six, none of the students performed external research, however all of the students appeared to think critically about each response, with one student specifically mentioning one of the provided articles. Five students wrote paragraphs for each question explaining their opinion toward the given situation while one student simply wrote responses consisting of only a few words.

One goal of the written assignment was to have students look into an ethical situation and use their responses to form their own opinions toward the use of controversial food ingredients in food products. Once assignments were collected, a BSE graduate student led an informal class discussion concerning this topic. This discussion allowed students to share their opinions with their classmates. To begin the discussion, the students discussed their opinions toward the use of

trans-fats and diacetyl in food products. Throughout the discussion, students utilized different perspectives, including that of consumers, adults, children, food companies, food company workers, and government, to analyze the ethical case study. Key ideas students discussed included adults having the power to choose what their children eat, labels being used on food products so consumers can decided what they purchase, workers being informed of potentially dangerous situations and how to avoid them, and companies being able to target whatever audience it wants. The class discovered their opinions toward the situation varied depending on which perspective students placed themselves into. For example, a consumer may not want a particular ingredient in a product because he or she thinks it is unhealthy, however the manufacturer may want the same ingredient in the product because it is tasty and draws more consumers, which results in more profit. As with any exercise, some students were more involved while others were less involved, however the discussion was an important learning tool. Through the discussion, students had the opportunity to learn about a new topic they may not have previously considered. It was also imperative to see other people may not share their same opinions so they will be better prepared for later in their careers.

Prior to receiving any information regarding the topic and after the students submitted the written assignment and participated in a class discussion, students completed eight questions pertaining to their previous ethics experience and the topic. Considering the 17 students enrolled in the course and correcting for students who did not submit responses for either the pre- or post-surveys, 12 responses were tabulated and recorded.

An important part of ethics instruction is for students to know there are places they can turn to if they need help. One of these tools is a code of ethics, provided by different organizations. Since the main organization BSE associates with is the American Society of Agricultural and Biological Engineers (ASABE), students were provided with a copy of the ASABE Code of Ethics of Engineers. Figure 2 shows an increase in the number of students indicating they have utilized the ASABE code of ethics before and after this exercise, and a t-test analysis also indicated a significant difference in student responses (P = 0.0388).

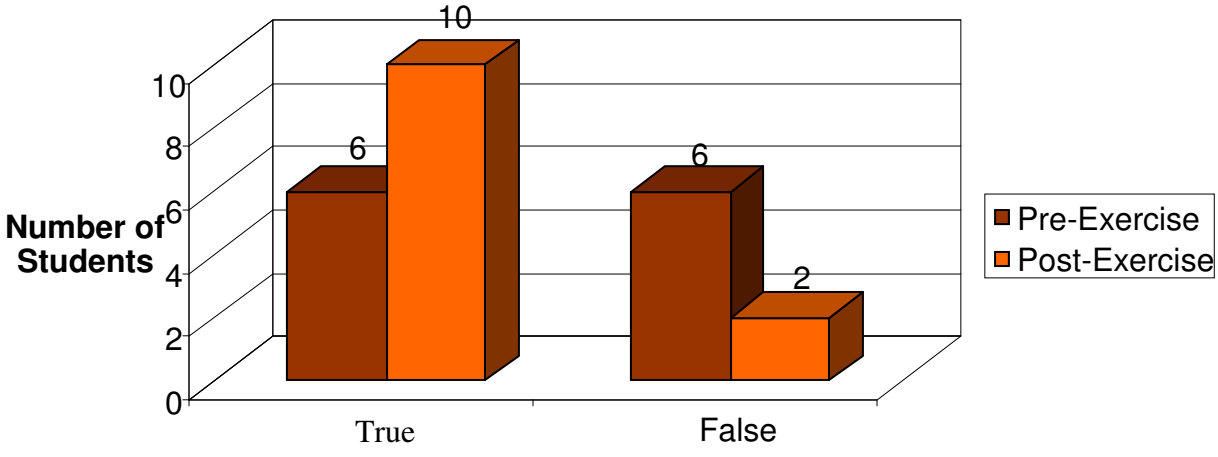

Figure 2. Number of students indicating they have used the ASABE Code of Ethics of Engineers.

Question 1.2 on the pre-survey and 2.2 on the post survey asked students to indicate who they believe should be responsible for the healthfulness of food products available to consumers. Students were not required to select only one option, but instead were directed to indicate all options they felt were appropriate. As can be seen in Figure 3, there were a few differences in students' selections after the exercise than before, however a t-test analysis, results shown in Table 1, indicated no significant differences between responses ($P > 0.1$).

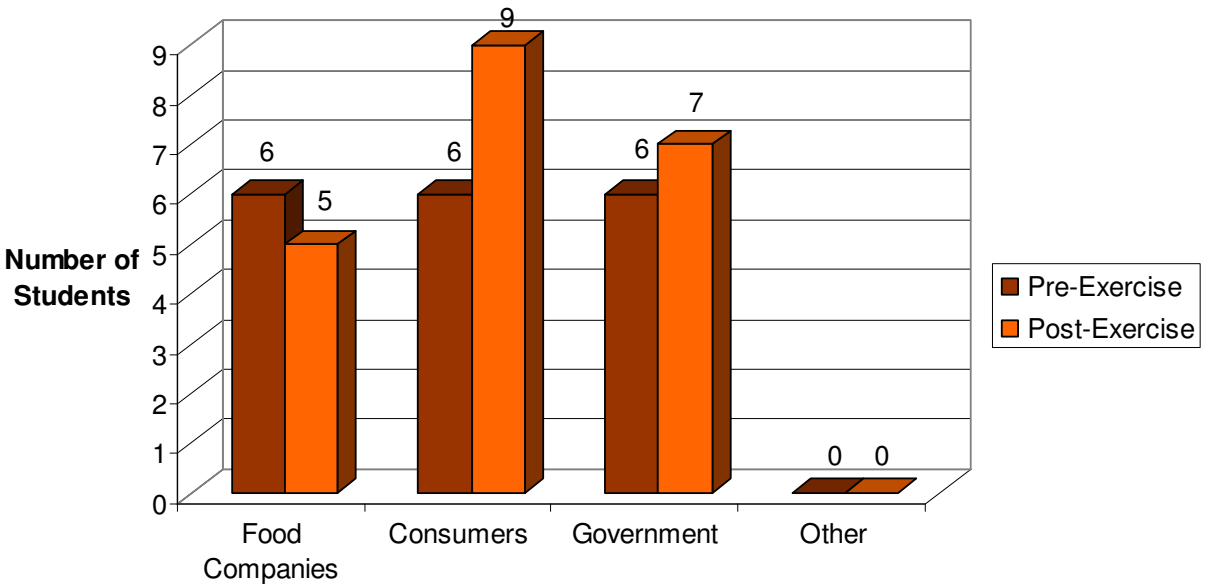

Figure 3. Number of students indicating who they believe should be responsible for consumer safety.

Table 1. Results from a t-test analysis for Question 2 on the pre- and post-exercise surveys.

Student Selection	t	P	Significance
Food Companies	-1.00	0.3388	Not Significant
Consumers	1.39	0.1911	Not Significant
Government	0.56	0.5863	Not Significant
Other	-	-	-

Question 1.3 on the pre-survey and 2.3 on the post survey asked students to indicate what they look most for when shopping for food products. Students were not required to select only one option, but instead were directed to indicate all they felt were appropriate. As Figure 4 shows, there were a few differences in students' selections after the ethics exercise than before, however a t-test analysis, results shown in Table 2, indicated no significant difference ($P > 0.1$). Students selecting "Other" for either survey indicated other qualities they look for are a product's nutrition and uniqueness.

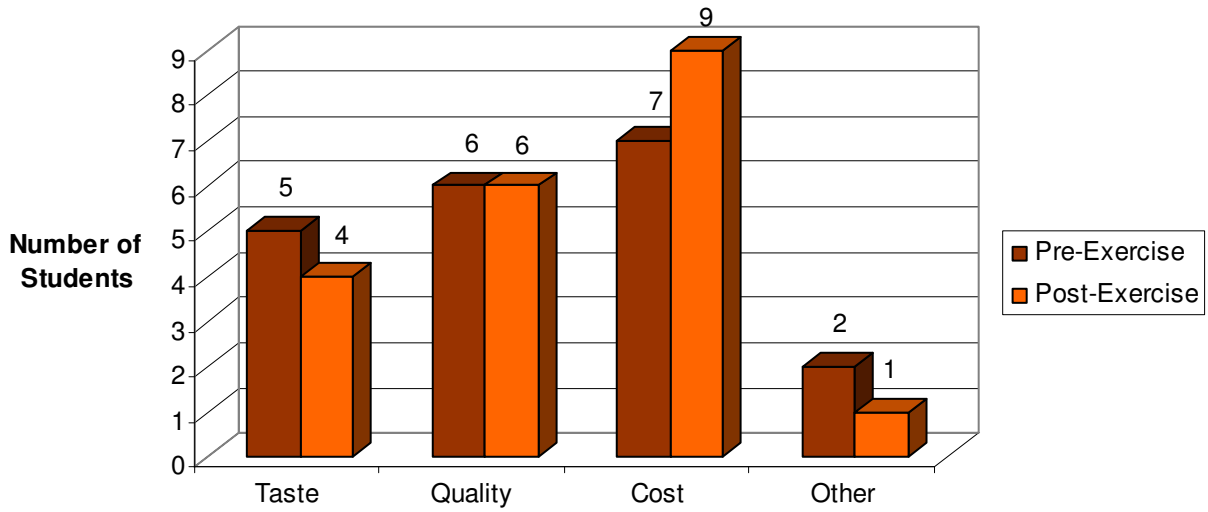

Figure 4. Number of students indicating the quality they look for when buying food products.

Table 2. Results from a t-test analysis for Question 3 on the pre- and post-exercise surveys.

Student Selection	t	P	Significance
Taste	-1.00	0.3388	Not Significant
Quality	0.00	1.0000	Not Significant
Cost	1.48	0.1661	Not Significant
Other	1.58	0.1747	Not Significant

For questions 1.4 through 1.8 on the pre-survey and 2.4 through 2.8 on the post-survey, students selected the best answer where 1 was strongly disagree, 2 was disagree, 3 was no opinion, 4 was agree, and 5 was strongly agree. On average the 12 responding students had no opinion (3.7 ± 1.1) before the exercise but agreed (4.3 ± 0.5) after the exercise that food companies intentionally add ingredients for the sole purpose of hooking consumers and creating life-long consumers (Questions 1.4 and 2.4). A t-test analysis for Question 4 indicated no significant changes in students' responses before and after the exercise ($P = 0.0674$). On average students agreed both before (3.9 ± 0.8) and after (4.3 ± 0.6) that trans-fats are bad for them (Questions 1.5 and 2.5). A t-test analysis for Question 5 indicated no significant changes in students' responses before and after the exercise ($P = 0.2199$). The class' opinion toward diacetyl's effects on health changed significantly ($P = 0.0246$), with the average having no opinion (3.3 ± 1.2) before the exercise but agreeing (4.0 ± 0.9) after the exercise that diacetyl is bad for them (questions 1.6 and 2.6). No significant change was observed in the class' opinion toward the role of the government regulating food products and ingredients (mean = 3.9) (Questions 1.7 and 2.7). On average students agreed both before (4.8 ± 0.5) and after (4.6 ± 0.5) the exercise that their moral beliefs help them make decisions to professional ethical situations, and no significant changes were found between pre- and post-surveys ($P = 0.3388$). Figure 5 shows the cumulative class totals for questions 4 through 8 on the pre- and post-surveys. Since the maximum number an individual student could select was five, the maximum number of points possible in Figure 5 is 60. Table 3 presents a summary of the results from t-test analyses performed for Questions 4 through 8.

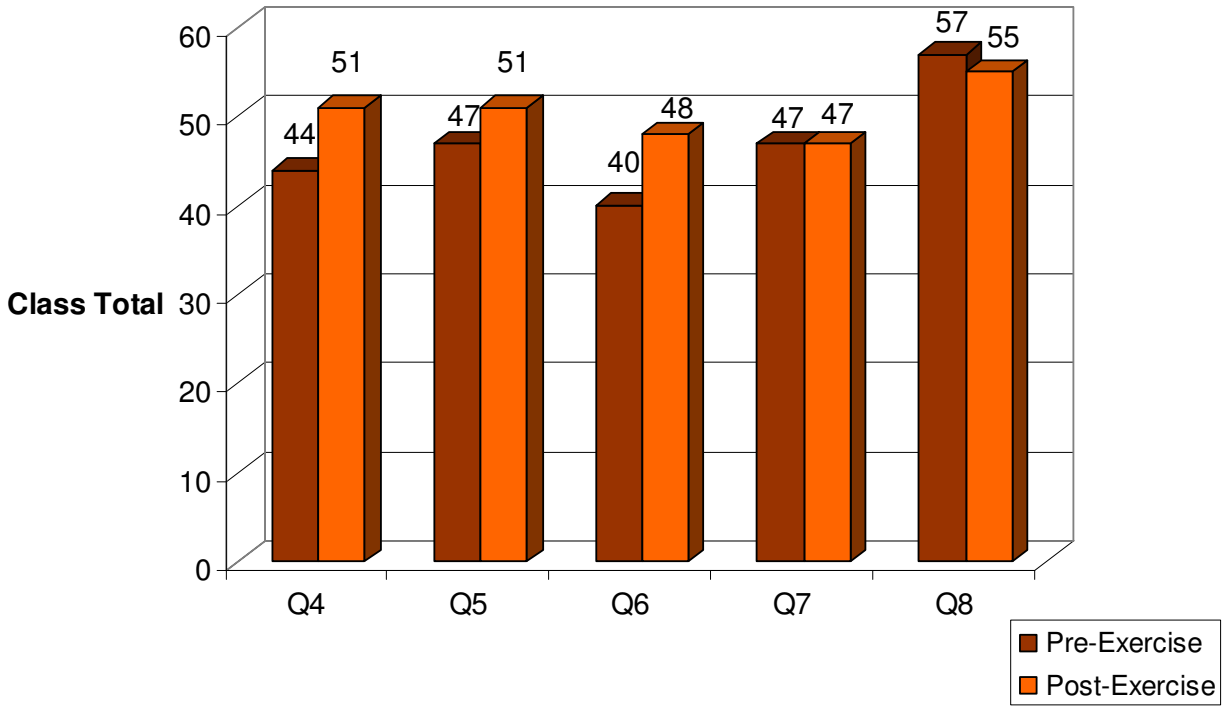

Figure 5. Cumulative class total selection for questions 4 through 8 on the pre- and post- surveys.

Table 3. Summary of results for t-test analyses of Questions 4 through 8 on the pre- and post-exercise surveys.

	t	P	Significance
Question 4	2.03	0.6740	Not Significant
Question 5	1.30	0.2199	Not Significant
Question 6	2.06	0.0246	Not Significant
Question 7	0.00	1.0000	Not Significant
Question 8	-1.00	0.3388	Not Significant

To evaluate how students felt about this ethics exercise, seven additional questions were created. Responses to the first four questions were tabulated and recorded. As Table 4 shows, on average students agreed (3.9 $\pm$ 0.8) the issue of food companies versus consumers is an ethical concern (Question 2.9). On average students agreed (3.9 $\pm$ 0.9) the class discussion format was beneficial (Question 2.10). On average students agreed (3.8 $\pm$ 0.8) they would like to see more discussions used in their courses (Question 2.11). On average the class had no opinion (3.5 $\pm$ 1.0) as to whether the topic of food companies versus consumers interested them (Question 2.12). Question 2.13 was an open-ended question asking students to list what could be done to improve the exercise. Some responses included:

- Use a presentation as part of the discussion
- Provide more time to complete the written assignment
- Provide more news articles which are not so similar

Question 2.14 asked students to list what they enjoyed about the exercise. Some responses included:

- Learning about a new topic
- The discussion (six students)
- Interactive environment
- Hearing others' opinions

Question 2.15 asked students to list other ethical topics related to Bioprocess Engineering they would like to learn about. Some responses included:

- Pharmaceutical companies and products (three students)
- Milk pasteurization
- Caffeine labeling
- Genetic engineering of foods
- Industrial production of enzymes, organisms, etc.
- Who feels the impact of unethical decisions

Table 4. Results of questions analyzing how students felt about the exercise.

Question		Average (Out of 5)	Standard Deviation
2.9	I feel the issue of food companies versus consumers is an ethical concern.	3.9	0.8
2.10	I feel the class discussion format was beneficial.	3.9	0.5
2.11	I would like to see more discussions used in my courses.	3.8	0.9
2.12	The topic of food companies versus consumers interests me.	3.5	1.0

Lessons Learned

To enhance ethics training during the undergraduate career, engineering ethics should be taught throughout the engineering curriculum. As the DLR project progresses into its next phases, BSE seniors enrolled in the Food Process Engineering course took part in a pilot ethics exercise. This exercise was in addition to contemporary issues already discussed in the course and consisted of pre- and post-surveys, a written assignment, and an in-class discussion. The following are some of the lessons learned through the pilot exercise.

This exercise was given to the class right before fall break, coming one and a half weeks before the end of the semester. Additionally, students were responsible for submitting a take-home test the same the week the material was presented. It is believed students would benefit more from

this exercise, if better care is taken next time it is offered to schedule a better time for it, preferably closer to the beginning of the semester and not near a test. Additionally, students indicated they felt like the two days given did not provide enough time for them to complete the written portion of the exercise. When a similar ethics exercise was implemented in a sophomore class, students were given one week to complete the assignment, and no comment was received as to not having enough time. The next time the senior exercise is used, students should be given one week to complete the written assignment.

Since students are used to sitting through more formal lectures, and this exercise was meant to be informal, a few students suggested bringing a formal presentation to class on the day of the discussion. While an informal format is believed to provide for an environment conducive to students expressing their opinions, it is recommended a few power point slides be put together to help guide the discussion. Slides may consist of a few bullets students can observe during the discussion.

As part of the post-survey students completed additional questions evaluating this exercise. These questions lead to the conclusion students believe the class discussion format was beneficial and would like to see more class discussions used in other courses. Other discussion formats may include small group class discussions and small group online discussions[1].

After reviewing the data it was found changes in students' responses for Question 1 (exposure to ASABE code of ethics) and Question 6 (use of diacetyl) on the pre- and post-surveys were statistically significant (at α=0.05). It was also found changes in students' responses for Question 4 (food companies adding ingredients) on the pre- and post-surveys were statistically significant (at α=0.10). To optimize student exposure to engineering ethics it is important to show statistically significant changes for the majority of the questions posed to the students before an exercise when compared to after the exercise. Additionally it has been suggested the questions asked during this pilot study may have been biased and did not relate enough to professional ethics. Therefore, it is recommended this exercise be officially implemented into the curriculum beginning fall 2008, incorporating the following altered questions aiming to create more of an ethical dilemma for the students:

1. I believe food companies have the right to intentionally add ingredients to their products for the sole purpose of creating a life-long consumer base for their product.

2. I believe trans-fats have no impact on my health.

3. I would support the use of diacetyl, which has recently been suggested as the cause of lung disease in popcorn factory workers, for use as a food ingredient (e.g. buttery flavor in popcorn).

4. I believe the government should ban certain food products and/or ingredients which may not be considered safe.

5. I believe my moral beliefs will interfere when I make decisions regarding professional ethical situations.

Future work

As the Departments of Engineering Education and Biological Systems Engineering are in the middle of implementing the described ethics training through a spiral-themed curriculum, it is essential to orchestrate an assessment plan for future evaluation. This exercise proved the use of a pre-assignment questionnaire and post-assignment questionnaire are vital as an assessment tool for this exercise and future exercise implementation in other courses.

As the DLR project moves into its later phases, EngE and BSE will continue incorporating the library of ethics case studies into designated courses in BSE. In addition the ethics exercise described in this paper will be improved considering student responses and officially incorporated into the fall 2008 course. This continued implementation will provide the opportunity to look at a longitudinal study, tracking a single group through the BSE program. Finally, student responses to surveys will be utilized in the development of additional case studies which will be added to the library.

Acknowledgements

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