Applying Action Research to Develop Curriculum for Engineering Ethics Based on Moral Practice

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Abstract

Engineering ethics is a new subject in engineering college. Some engineering professors do not believe they are qualified to teach the course. In addition, the general idea thinks ethics is not a subject can be taught. This project applied the methodology of action research to enhance the teaching influence. Five steps were applied to the course of engineering ethics and society to evaluate the effect of moral implementation. Based on the lecture of ethical theory and case studies, students explored how the development of science and technology impacts the society. Then, the students proposed a 21-day ethical practice to evaluate their ethical process. The procedure was recorded by students, a cooperative teacher, and lecturer's teaching notes.

Key words: engineering ethics, action research, Lawrence Kohlberg's stages of moral development

Introduction

Engineering ethics is a new subject in engineering college. Some engineering professors do not believe they are qualified to teach the course, while others believe it is difficult for engineering students taught outside of their department to relate the discussions to the engineering issues in the real world [1]. Therefore, this project applied the methodology of action research to improve the teaching effect.

Action research is a process in which teachers investigate teaching and learning, so as to improve their own and their students' learning [2]. There are five steps in the process of action research [3].

1. Identification of problem area
2. Collection and organization of data
3. Interpretation of data
4. Action based on data
5. Reflection

The project based on these five steps is introduced below.

1. Identification of problem area

Engineering Ethics is part of professional ethics. These kind of ethic courses were not so popular until 2001, when three Harvard graduated students caused the Enron Scandal. The public asked why well-educated people make unethical choices [4]. However, after professional ethics are highly popular in higher education, another serious financial crisis happened in 2007–2008. The public were not satisfied with ethical program in the college and asked "Does an 'A' in Ethics Have Any Value?" [2] These are not two special cases about moral behavior does not fit to educational level. People usually expect that well-educated person behaves morally, since this is a major purpose of education. Nevertheless, some serious social or international crimes or problems, like Enron Scandal and Financial crisis of 2007-2008, caused by those people with professionalism. And this situation is worldwide in all specialties and makes it's harder and harder to trust a specialist.

Based on this situation, this project tries to solve the problem: how to enhance moral level in the course of engineering ethics?

2. Collection and organization of data

There are three kinds of data collected for this research.

As an action researcher for the course of Engineering ethics, we came back to survey the curriculum of the subject. Based on American Society for Engineering Education [5], there are three Learning objectives in the Engineering Ethics course: 1. Students should recognize ethical issues; 2. Students should exercise ethical thinking; 3. Students should apply ethical judgment. Obviously, they are mostly related to moral mind. In other words, the curriculum does not practice on the ethical behavior. Nevertheless, the general public expect the professional ethics course could lead the future experts behave morally.

The target course for this project is engineering ethics and society in the Department of Mechanical Engineering in Southern University of Science and Technology. The instructor has taught this course since 2013. As a result, the second data is from previous students' feedback. After all the course activities and the grades are finalized, the students were required to answer some questions. Table 1 is an anonymous questionnaire results taken in the end of each semester. The record was taken for the course "Engineering ethics and society" from 2013 to 2016. One to three of this course were lectured each semester by the author. Class code is used to identify the three different classes. The questionnaire has two parts. While the second part is free response, the first part is five 5-scale questions, including:

(1) Use interesting questions or examples to inspire students to learn.

(2) Informs the class of the goal(s) or objective(s) for lesson.

(3) The teacher would offer constructive response toward students' reflection.

(4) Offers praise, rewards to students in class for their good performance.

(5) Is obviously enthusiastic and earnest about lesson topics while teaching in class.

The original one is in Chinese and translates into English

above. The average of the five question's score is put on the third column, questionnaire grade. The next one, final grade average, is the average of all students' final grades. It was 100 scale before the final semester of 2014 academic year and changed into 4-point scale afterwards in the school system. The fail rate is the number of the students who do not pass divided the total number of the students who register the class, which is the number in the next column. The final column is the number of the students who took this questionnaire.

Semester	Class code	Grade	Final grade average	Fail rate	Number of students	Number of respondents
2013 -1	class A	4.3783	72.14	3.45%	58	54
2013 -2	class N	4.3434	68.09	5.45%	55	52
2014-1	class CB	4.1593	68.47	20.00%	55	52
2014 -2	class N	4.3808	72.90	9.62%	53	53
2015 -1	class CB	4.3492	2.08	15.87%	65	64
2015 -2	class N	4.3882	1.93	23.64%	55	51
2016-1	class A	3.8367	2.33	10.00%	60	60
2016 -1	classCA	4.0828	38	42.62%	62	58
2016 -1	class CB	3.5074	1.79	29.31%	59	55
Average	-	4.16	1.90***	0.18	58.00	55.44
Standard deviation	-	0.31	0.35***	0.13	3.91	4.36

Table 1 Course* questionnaire results in the end of semester

* The record was taken for the course "Engineering ethics and society" from 2013 to 2016.
  **The full score is 5.
  *** Only the values after the first semester of 2015 academic year are counted.

According to table 1, there are always more than 50 students taken the course. The questionnaire Grades various from 3.50 to 4.38 with average and standard deviation of 4.16 and 0.31, respectively. Final grade averages are between 1.38 and 2.08 after the first semester of 2015 academic year while the minimum grade to pass the course is 1.7. The average and standard deviation are 1.9 and 0.35, respectively. Fail rates between these semesters are from 3.45 to 42.62%. It varies a lot with the average and standard deviation are 18% and 0.13, respectively.

The second part of the questionnaire are free response from the students. These are totally 8 opinions collected from 2013 to 2016. The response data are not abundant, because it is not compulsory. However, these are from those who have strong opinions.

Basically, the feedbacks can be divided into three categories: positive, neutral and negative feedbacks. There are three positive, one neutral, and five negative feedbacks.

The positive feedbacks are referring to the effective course discussion, thanks to the lecturer's intention and the potential to learn more things during the limit class time.

The neutral one thinks this course is tough.

The five negative feedbacks have three main ideals. Two of them thinks the course is useless. One thinks it's time consuming. Two feedbacks complain the attitude of the instructor is too strong.

The third data is a quick survey during the class time. Because the second data from the students think this course is useless and time consuming, a survey was taken in the beginning of the semester: do you know what morality/ethics is? The table below is some typical statistic results.

Table 2 the statistic results of the survey A* in the class time

class	Positive	Negative	Student number
1	41	14	55
2	45	7	52
3	20	11	31

*the survey question is: do you know what morality/ethics is?

It is clear that majority believe they know what morality and ethics are.

3. Interpretation of data into the course design

According to the first data, the learning objectives from American Society for Engineering Education only consider moral judgement. However, referring to the question defined in the beginning of this paper, it does not fulfill the demands of the public. Ordinary people expect the experts with high education training can benefit the society by moral behavior. However, the smart and innovative people are better at rationalizing doing what they want to do. Obviously, these people are capable of moral judgement to decide if they behave morally. However, their problem is a lack of the ability to behave morally.

According to the second data from the previous students, the average Questionnaire Grade is 4.16 out of 5, while the average fail rate is 18%, in such a huge class number, more than 50 students.

The previous statistic data about this course also shows that the deviation is quite high in Questionnaire Grade and fail rate among classes; however, the student numbers kept high.

The free response from the previous classes also shows different opinions. In addition, they probably cannot represent the overall situation of most students owing to limited response number. However, it still presents some extreme opinions. Majority does not response in this part, because it's more time consuming. Only those who are more emotional would write down something. This part reveals some severe viewpoints. For example, they think the course is useless and take lots of time. Part of the reasons is that they are most senior with many serious and time-consuming course at the same semester. Therefore, they prefer lower loading on other subjects.

Furthermore, the data of the negative feedback also say that students think the instructor is fierce and subjective. It's hard to judge if the feedbacks are fair to the instructors. But it shows there is some effort can make to enhance the results.

Finally, one of the public feelings about ethics is that the course is talking some common sense. The materials are boring that everyone knows the moral rules. That's the reason why the authors took the quick survey in the third part of the data. And the results do prove that the students believe that they have known what moral is and what the materials will be covered. And that is easy. Therefore, they do not think it's necessary to

pay much attention to the course. Moreover, the purpose of the engineer training is to solve a problem. It usually means to get a right answer. When a question does not have a right answer, it is not familiar to the engineering students. Based on the feedback from the students (table 1), they don't understand why they have to learn something without correct answers. Besides, it's not just for the students. The engineering professors are not used to deal with a question without a correct answer either.

4. Action based on data

These are the three main findings about this course from the data sequentially:

1. Behave morally, instead of ethical knowledge only.
2. The curriculum design is useless and time-consuming.
3. Ethics is common sense.

Based on the data interpretation, our team proposed three approaches accordingly. First, the major course design will lead to moral practice. Second, case studies were introduced into the class. Because it is one of the most recommended methods for moral lectures[1]. Finally, the beginning of the course will lead student to realize that they don't really know what ethics are. A re-construction to the moral principles was processed.

The project was applied to a two-credit course, engineering ethics and society, in semester 105-2, between 2017 February and July. This course is for junior in the department of mechanical engineering in Southern Taiwan University of Science and Technology. There are total 57 registered students, with 50 male and 7 female students. Eight of them are senior who took the course the second time, while the rest are junior.

The curriculum design in 18 weeks is divided into three parts in the following.

A.   Re-construct the moral concept

After the course introduction in week one, a new moral and ethical concept is constructed in following three weeks. The previous students thought ethics is common sense why bother to spend time to study it. Therefore, the curriculum design was to break the moral framework and the myth of ethics.

Week 2: introduce many moral dilemmas to challenge students what ethics is. The goal is to make student realize that they do not know ethics.

After they figure ethics is not what they thought, week 2 and 3 offers two principles to rebuild the concepts.

Week 3: Based on Lawrence Kohlberg's stages of moral development, allow students discover their moral level and know it does have a standard to follow for moral issues.

Week 4: Introduce the most common ethical principles: Utilitarianism and Deontologie. Another approach discusses the standard about what the right thing to do.

B.   Apply case study of engineering ethics

According to the second item in the previous section: The curriculum design is useless and time-consuming, an effective teaching method should be applied.

"These high-profile cases may be useful for attracting the attention of engineering students, but the typical ethical dilemmas encountered by most engineers are more mundane. Therefore, case studies of more common-place events are also used in classrooms."[1] Written by Joseph Herkert, associate professor of multidisciplinary studies and director the Benjamin Franklin Scholars Program at North Carolina State University.

This statement demonstrates case study is effective for the study of engineering ethics. Therefore, the principles and cases of engineering ethics were introduced between week 5 and 9. The moral principles are from the ethics manual of Chinese Civil and Hydraulic Engineering Society. The cases are mixed with typical and mundane examples. The previous one includes the Ford Pinto, 2014 Kaohsiung gas explosions and so on. And other famous engineering ethical cases were discussed also. These are familiar to the students and easily arouse their interests. One homework was assigned to prepare for the discussion. Two speakers demonstrated how to communicate with passions. They enhanced the presentation skills applied into the case study, as well as the final project.

C.   Discover the moral limit by moral practice on STS case

After the midterm, the course focused on the item how to fulfill the demand of the public: the ethical course should enhance the moral level of the learners. The issue of STS (Science, Technology and Society) were introduced firstly to arouse their attention the contribution and damage of engineers. Then, instead of lecturing ethical story and knowledge, the curriculum required the student to practice a moral behavior based on the STS studies. The students in a team have to figure a group activity to improve the society. In addition, one homework was assigned to build a life-long habit within 21 days. They would set up a goal and practice a moral behavior consistently.

Based on their homework, this is the most struggle moment. It was easy to speak morally; however, it is difficult when we have to sacrifice for the public. For example, some teams decided not to use disposable plastic bags, chopsticks. They all found small behavior change in everyday life could cause unpleasant difficulty. This ethical dilemma usually reaches their boundary and it is a struggle to make decision morally. Two training workshops for oral presentation were applied and then a poster was orally presented in public and compete with other teams.

5. Reflection

These are the collected data to evaluate course effects.

1. Course questionnaire results in the end of semester
2. Students' homework
3. Photos of the class activities
4. Lecturer's teaching notes
5. Feedbacks from the cooperative teacher

A.   Course questionnaire results in the end of semester

According to Course questionnaire results in the final semester of 2006, the questionnaire grade is 4.13 while the average and standard deviation in the previous semesters was 4.16 and 0.31, respectively. The grade is tiny lower than the average. Secondly, the final grade average is 1.67 while the minimum grade to pass the course is 1.7. The average and standard deviation of the final grades were 1.9 and 0.35, respectively. Next, the fail rate is 28.07% with the average and standard deviation previously were 18% and 0.13, respectively.

Overall, the final grades are worse than the previous semesters.

B. Students' homework

Students noticed that engineers benefit the society; however, our works also results in some risks or drawbacks to the general public owing to the case study. 21-day ethical practice report was a written assignment to propose a plan that they can do to reduce the harm caused by techniques. The report had to address why, what, how, when and where they implement the team project. Here is some reflection according to their written report of 21day ethical practice.

1.   Although the topic is old, we still serious to achieve it. And we believe that what we do more or less will change the environment.

2.   When I started implementing this project, It's really not used without plastic bags. If you forget to bring a green bag, you can only hold it by hand. Sometimes I really feel very troublesome; however, after 3-5 days, gradually getting used to it, I found that I only need to be diligent. Put the bags into the backpack before going to bed every day. This plan can continue smoothly, even after 21 days, you can still carry on. This will make a contribution to the Earth.

C. Photos of the class activities + lecturer's class note

Based on the observation of the photos in the class time and the notes from the instructor. Some commends are like the following. Usually, one key person in a team lead the progress going well. It is important to have a good leader in a team's activity. It's also true when two teams are discussing, for example an moral practice on STS case.

Most teams engaged to the class activities like the photos shown; however, some would hide and wait. This part probably would require further students' feedback in the future work.

D. Feedbacks from the cooperative teacher

The cooperative teacher was responsible for the training workshops for oral presentation in week 6, 7, 11 and 13. She pointed that the original 18-week curriculum was interrupted by the activities. Even though the workshops are helpful to enhance the civic communication skills for the ethical course, too many objectives to reach simultaneous would exhaust the learners. This command coincides with the students' free response in the end of the course.

Overall, compare with the previous semesters in the end of the semesters, the questionnaire results of this course are within the normal range; however, the failing rate is higher and the final grade average is lower than the previous classes.

Case study/discussion is an important method for students to understand the dilemma and critical points in the real life. Lectures should be well prepared including the pros and cons of the cases. Especially, how to create the way to make students speak out the points, not the instructors talking alone. In addition, create a safe and friendly environment to encourage all opinions. Do not define right or wrong answers based on our own moral opinions. The status of a lectures is there to support all students instead of being a strong opinion leader. Guide the students to see all the possibilities in a neutral position.

The student homework demonstrate that they are quite engaged into the class activities. Even though, the 21-day implementation had proven more troublesome than they expected, they began to get used to it and tried to persuade their friends and families to do so too. Moreover, they felt good that they can contribute to the Earth.

On the other hand, good students would find benefits after the implementation; however, others would feel exhausted and complained in the questionnaire. They would say something like the course is useless and took too much time, like the free response from the previous semester.

Conclusions and suggestions

This project applied 21-day ethical implementation report to enhance the process of moral practice; however, it is not obvious to see how the students change their moral level during the process. An interview by a third people would observe deeply and closely in the key step of the course.

Finally, since the cooperative teacher and some students report that learners seemed exhausted by the intense activities. In addition, they are juniors with heavy loading on other subjects. Is it fair to ask all students to contribute so much to learn? It's fine for the outstanding students who like to think and practice; nevertheless, some slow learners in engineering department are not used to philosophical thinking. Engineers are trained to simplify a question and pay less attention to life issue. The goal of engineering is to accomplish a work, not much to think globally and eternally; however, what the course asks is not just what they are used to do, is it a good idea to have all students to pass the course with one standard? Or is the standard to pass 21 days' practice too high? Is there an evaluation to push the student to discover what they are and what they should be? And keep the decision open to the students to choose whether they are going to improve. These are questions researchers can work on continuously.

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