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INCORPORATING PUBLIC POLICY CREATION AND ANALYSIS ACTIVITIES INTO A MECHANICAL ENGINEERING CURRICULUM

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ABSTRACT

While it is easy to recognize that mechanical engineers can lend their expertise to public policy makers as they create public policy related to science and technology, it is not as clear as to how to introduce mechanical engineering students to public policy activities. The undergraduate curricula in most mechanical engineering programs are considered full, and there are always additional topics that people wish to add. Educators are likely to hesitate before removing material from their programs in order to add material on public policy. Yet, there are techniques that can be used to incorporate aspects of public policy into a standard mechanical engineering curriculum without the removal of much, if any, current content.

In this paper, several techniques for introducing mechanical engineering students to the process of public policy creation will be discussed. While these methods will not make the students experts in policy, they can introduce students to the tools that they need to influence the public policy creation process. These techniques include a comprehensive semester-long project in a technical elective course, a short policy analysis paper for development in a required or elective course, incorporation of public policy considerations in a capstone design project, policy discussions or debates in relevant courses, and a focus on public policy development in extracurricular activities.

In their education, students should not only become technically proficient, but also learn how to track current events and trends, communicate their knowledge effectively, gain knowledge on applying proper engineering ethics, and be aware of the environmental and social context of their work. Through these knowledge areas and skills, students will gain the fundamental working knowledge that they need to influence public policy creation. It may be noted that these are also desirable outcomes for a student's educational program as defined by ABET. Therefore, finding opportunities in a

mechanical engineering program's curriculum to address public policy creation activities also benefits the program by helping it more completely fulfill ABET accreditation requirements.

INTRODUCTION

Engineering students typically receive an education that concentrates on the development of the scientific and design skills of the students. As the primary purpose of most practicing engineers is to apply the education they received to solving technological problems, this is indeed appropriate as the main focus of their education. Yet, engineers work in a society that often makes choices based on reasons other than solely technological merit. As a result, students are not served well if their education does not provide them with a good understanding of the non-technological issues that may impact their careers. Furthermore, their education also often does not provide them with good skills for communicating their expertise to non-engineers. ABET, the Accreditation Board for Engineering and Technology, encourages schools to address these concerns by having them include effective communication, an understanding of the economic, environmental, and societal context of their work, and knowledge of contemporary issues into their curriculum [1]. It has proved challenging to many engineering programs to incorporate these activities into their already full curricula.

In an effort to provide students with a broader perspective on their future careers and to address the above-mentioned curricula issues, two different types of projects were created in the Mechanical Engineering Department at the University of Wisconsin-Milwaukee (UWM). These projects involve connecting the technical knowledge of engineering students to contemporary issues and also advance consideration of

economic, environmental, and societal issues of engineering work. One project is an extensive, semester-long public policy formation project which was incorporated into the *MechEng 435: Powerplant Theory and Design* course. The second project is a shorter project which involves students providing a summary and critical analysis of a proposed policy or piece of relevant legislation. This second project is used in the *MechEng 432: Internal Combustion Engines* course. Both of these courses are senior-level, technical elective courses at UWM. In addition, three other activities designed to educate students on public policy analysis and creation have been developed to lesser degrees; these show promise for future success when applied on a more complete scale.

The MechEng 435 course primarily considers the science and technology behind the generation of electricity in large power plants. Today, energy and the effects of energy usage on the environment has become an important issue for the public. This prompted the author to create a project in which the students develop a policy outlining how the United States should generate electricity in 25 years, and how the country should transition to this proposed plan. As part of the project, the students were asked to perform detailed background research on one form of electricity generation, communicate their research results to the rest of the class, and then create their own individual proposed electricity generation policy for the United States.

The MechEng 432 course concentrates on the basic principles and practical design issues involving Internal Combustion Engines. The course topics also bridge into the realms of energy usage, fuel supply, and air pollution. Such topics are also often seen as the subject of government regulation and to be of public concern. As such, a steady stream of proposals are put forth by government agencies which impact the internal combustion engine industry; in turn, engineers working in that industry may need to work on solutions to problems in the engines so that their company's products are still acceptable under new standards. The model used for the public policy project in this course is not the development of a plan, but rather a critical analysis of proposed plans already in existence. The students are given a topic to consider, do background research on the plan, and then choose to be either in support of or in opposition to the plan. The students must then find material to support their positions, and write a paper presenting their case to the instructor.

In addition to these projects which constitute significant portions of the grade, the author has experimented with the students engaging in informed discussions of policy issues, and has been involved with student organizations whose activities involve public policy issues. Some ideas on consideration of public policy issues with capstone design projects have also been developed.

In this paper, a description of the students taking these courses will be provided. In addition, a thorough description of the activities, observations on common problems and features

of the projects, and a discussion of the positive impacts of the projects will be given.

STUDENT AND COURSE BACKGROUND

The Mechanical Engineering (ME) Department at UWM attracts a wide range of students. Some students are traditional, full-time students, others are part-time students, and some are students returning to college after working for several years. The average time it takes for full-time students in the ME department to graduate is approximately 5 years. While some of the students have excellent abilities and would succeed at most schools, many of the students arrive at UWM with deficiencies in their math, science, or communication skills. The students in the MechEng 432 and 435 courses are primarily senior-level students, and have worked over the years to remove most of their deficiencies. But in many cases, the students may still lack some of the analysis skills that would be common among students at many institutions.

The courses in which these projects were conducted, MechEng 432 and 435, are senior-level technical electives in the Mechanical Engineering Department. Depending on how the technical electives fit into their schedules, students usually take their technical electives during the last two years of their undergraduate education. These classes meet twice a week, in 75-minute lectures. Each course is offered every 3 semesters, and many students will take both courses before graduating. Over the last ten years, the MechEng 432 course has seen class enrollment fluctuate between 22 and 37 students, with an average enrollment of 28, while the MechEng 435 course has had its enrollment fluctuate between 7 and 25 students, with an average enrollment of 17.

For several offerings of the MechEng 435 class, the instructor assigned one short term paper asking the students to briefly research one electricity-generating technique and summarize the technology and the benefits and detriments to the technique. The students were also assigned a large project of designing the thermodynamic cycle for a combined cycle power plant. As many of the students take a different technical elective with a similar cycle design project, the instructor decided to replace the two projects in MechEng 435 with a new public policy development project; this provided students with a different educational experience that would give them a different perspective on their future careers. In the Fall 2006 semester, when this new public policy project was implemented, 24 students completed the course. The project was repeated in three subsequent course offerings, with 20-25 students participating in the project with each offering.

Based upon the success of the project in MechEng 435, consideration was given as to how to extend this project concept to other courses. As part of the MechEng 432 course, students complete a comprehensive design project that is proposed by the student according to their particular interests as related to engines. As this project gives students considerable flexibility and is popular with the students, it was decided to not replace it with a project of the same scope of the one used in

MechEng 435. Instead, a much shorter project involving just the analysis of a proposed governmental policy was introduced into MechEng 432. The project was first assigned in Fall 2007, with 34 students in the course, and was repeated in the Spring 2009 semester with 27 students enrolled in the course. In the Fall 2010 semester, 26 students performed the project.

DESCRIPTION OF POLICY CREATION PROJECT

The public policy creation project used in MechEng 435 is thoroughly described elsewhere [2], and will be summarized here. The project began with the instructor introducing some of the elements of public policy formation. These elements, at least for an energy-related policy, include an assessment of the science and technology, a consideration of economic impacts, an assessment of the impact of the policies on the environment, as well as the political realities (through public perception) of the policy and its development. In these lectures, the students were introduced to the elements of the creation of a public policy. In addition, throughout the semester, the instructor discussed how different topics covered in lecture might impact public policy development.

Depending on the number of students in the course, up to 9 different categories of electricity-generation techniques are presented for consideration by the students. These include solar energy, wind power, coal-fired power plants, gas-fired power plants, nuclear fission, and hydroelectric facilities. The students were then asked, in a randomly-selected order, to choose one of the techniques for their detailed consideration. Depending on the number of techniques open for consideration, and the number of students in the course, a limited number of students may select a technique. It is desirable to have at least 2 students studying a technology in depth, and there is typically a limit of 4 students placed on each technique. The selection of the techniques was performed three weeks into the semester.

The bulk of the project then consisted of the students performing detailed research on their chosen technology, and preparing two reports. From their research, the students were to provide a summary of the following points:

- (1) a technical engineering description of the technology, including an assessment of the current state and usage of the technology;
- (2) a discussion of the environmental impacts of the technology;
- (3) a discussion of the economics of the technology, considering the capital and operating costs as well as any likely future potential incentives or taxes;
- (4) a discussion of the public perception and acceptance of the technology; and

- (5) a prediction of the state of the technology, along with its relative cost and environmental impact approximately 25 years into the future.

Therefore, the students were not only required to perform background research to get an understanding of the fundamentals behind their technology, they were to also gain an understanding of how their technology fits into a societal and global context. Based on this information, the students were to prepare two reports. The first report, called the "Technique Evaluation," was to be a 10-page report thoroughly discussing the 5 points described above, and any additional relevant information that they uncovered. The second report, called the "Technique Summary," was to be a 1-2 page summary of the Technique Evaluation.

There were different purposes and target audiences for the two reports. The Technique Evaluation was meant for the instructor of the class, and needed to demonstrate the depth of understanding that they achieved with their research. The details behind the technology were to be discussed in greater depth, as were the environmental, economic, and public perception factors. Also, future research directions expected for the technology were often included in these reports. The purpose of the Technique Summary was to put the Evaluation into a brief synopsis. The target audience for the Summary was to be considered the general public, but in practice was their classmates. For the Technique Summary, the students were not to expect a great deal of background knowledge from their audience, nor an ability to quickly learn about the technology in depth. Their summary was to contain only a one-paragraph description of the technology, written in a way that an intelligent, but uninformed, individual could understand the fundamentals behind the technique. They were then to concentrate their summary on the environmental, economic, and public perception information that they gathered, as that would be of most use to those developing public policies: the students in the class. They were also asked to provide "hard" information for the other students, rather than presenting vague general ideas. For example, the students were asked to find actual costs of a given technology, rather than stating "the technology is 'expensive.'" Both the Technique Evaluation and the Technique Summary were due two months after the selection of the technology.

For the Technique Evaluations, the instructor did provide the students with an opportunity to turn in their evaluations for his review up to two weeks before the due date. Such a review of drafts has been found to be valuable [3,4]. In his review, the instructor would see if the students were missing any necessary information, and if they had obvious errors in their writing or report format. Typically about a quarter of the students take advantage of this opportunity, and all improve their reports as a result of the review. In addition, some general problems (primarily in the formats of the reports) were noted by the instructor, and these were relayed to the rest of the class to aid them as well. However, most students who did not turn in a

report for early review did not appear to benefit as much from these comments as those who did submit a report for review.

The instructor then prepared a hard copy of each Technique Summary for each student in the class, and these packets were distributed at the following class. The students then had the last two weeks of the semester to read these summaries, and prepare a 2-3 page proposed Electricity-Generating Policy for the United States to follow for the next 25 years. These policies were to include what the student proposed for the distribution of electricity generation 25 years into the future, how the United States should transition to this distribution, and where to spend research money to develop improved technologies. As there was no single correct answer, the students were asked to justify their decisions by considering the environmental, economic, and public perception factors described in the student Technique Summaries. If information was not available in the student Technique Summaries provided to the class, the students were not expected to have found this information independently. This was done to teach the students about the need for sufficient quality information when creating a public policy, and would help them learn what would be good for them to include in such Summaries in the future.

From the above description, it should be apparent that this type of project can be very time-consuming, and will necessarily be the focal point of the students' work outside of class through an entire semester. As such, it will not be appropriate for all classes. Shorter projects can be created which tap into some of the ideas behind this type of project.

A short survey was given to the students to assess their impressions of the project. The details of this survey can be found elsewhere [2]. Briefly, the students appeared to most benefit from their improved understanding of the implications of different electricity generating techniques, and also an improved understanding of the environmental implications of the techniques. In addition, 12 of the 21 survey respondents indicated that the project made them more likely to try to be involved with public policy decisions in the future. While this is not an overwhelming percentage of the students, it is promising as few of the students would have been particularly familiar with public policy from their engineering studies.

DESCRIPTION OF POLICY ANALYSIS PAPER

For the project used in MechEng 432, a shorter policy analysis paper was assigned. This project is designed to be completed over 3-4 weeks in the first part of the semester; this allows the students to devote more time in the second half of the semester to the comprehensive traditional design project which is also part of the course. In this project, the students are given a current public policy issues from the engine or fuels community. They then are to perform additional research to learn more about the proposed policy or regulation. The student will then choose a position (in favor, against, or propose a compromise) on the policy and write a 3-4 page paper describing the basic policy or regulation, explaining their position, and supporting their position with information from at

least 3 reputable sources. As these are not clear-cut issues as to which view should be taken, there is plenty of information readily available to the student to support their position. The students are directed to write their analysis papers towards an audience with a minimal understanding of the technology behind the issue.

This project was first used in the Fall 2007 semester, and was repeated in a similar format for the Spring 2009 semester. Each time, the students were given a choice of three topics. The topics included the following (the semester when the topic is included in parentheses):

1. Increased use of ethanol in the transportation fuel. (F07/S09)
2. Increase the corporate average fuel efficiency (CAFE) standards for passenger vehicles and light trucks. (F07)
3. Regulate a reduction in the pollutant emissions from lawn and garden equipment. (F07)
5. Require stricter emissions standards for Diesel engines, centered on programs such as the EPA's National Clean Diesel Campaign. (S09)
6. Promotion of the use of electric or plug-in hybrid vehicles through anything ranging from providing tax incentives for their purchase to mandating their use. (S09)

As can be seen, two of the topics were changed while one remained essentially the same between the two course offerings. This reflected both changes in the emphasis of policy makers as well as the broad range of topics that are the focus of public policy that impact the internal combustion engine industry.

For the Fall 2010 semester, it was decided to focus the whole class on one topic: "Should the United States government provide financial incentives / support for the development and implementation of alternative personal transportation power sources technologies to replace the internal combustion engine?" This focus was done in order to stimulate a discussion among the whole class after their papers had been completed. While the discussion was not graded, it did provide students with an additional opportunity to hone skills necessary in the public policy creation process: the ability to succinctly verbally state their points, and present them in a manner that others can understand.

While there may not be such a broad range of topics in every field of interest in mechanical engineering, or at least there may not be such a range of potentially controversial topics, most engineering disciplines which involve the public well being should have several topics of current relevance for consideration by the students.

To allow for successful completion of the project, the main tasks left to the instructor are to compile the basic information on the proposed policies to get the students started on the project, providing the students with a review of critical thinking and analysis techniques, and then grading the project.

OBSERVATIONS ON PUBLIC POLICY PROJECTS

A detailed discussion of some of the commonalities found in the Public Policy Creation Projects used in MechEng 435 can be found elsewhere [2]. But some of the observations on how the students performed in general on the projects in both MechEng 432 and MechEng 435 are as follows.

1. Students were generally able to find sufficient information to conduct either their analysis of the policy or to assemble the background for the creation of a policy. However, most students could benefit by having a refresher session on research skills from someone who specializes in such work, such as a librarian. It has been found that students who do not regularly conduct such research (as is common for many engineering students) may struggle with finding quality information [5].

2. Students, even as senior undergraduates in engineering, do not necessarily understand how to judge just the significance of an effect. For example, in the power generation project, many students gave equal significance to the impact on global warming from CO₂ emissions from coal-fired power plants as to methane emissions from decaying plant life in areas flooded for hydroelectric power.

3. Most of the students did find hard information from authoritative sources, rather than relying on soft information with regards to environmental impacts, economic considerations, or public perception.

4. The students' writing styles were often poor or inappropriate. The format of their reports was often not good (such as not providing much of an introduction), and the language used was often folksy rather than professional. When students were given feedback on their writing, it improved considerably. For example, in the public policy creation project in MechEng 435, the students could submit a draft of their Technique Evaluations for feedback, and those students produced much better final versions. In addition, the students often took the feedback they received on their writing from the Technique Evaluations and improved their writing on the final policy paper. This suggests that the students have been taught better writing skills, but that the skills are not yet ingrained and must be emphasized repeatedly.

5. Many of the students come into the projects with a lack of knowledge of contemporary issues. (As an example, one student was greatly surprised that the public has a general negative opinion of nuclear fission.) Of course, the purpose of these projects is to help their education with regards to

contemporary issues, and the societal impact on engineering. But one must keep in mind that some of the students entering these projects may have nearly no knowledge of such things with regards to these engineering topics. This observation can also be carried over into the classroom lectures, as the teachers in class should probably not assume that students have a wealth of background knowledge on contemporary issues.

Some consideration should be given to the size of the classes for which these projects are appropriate. The main criterion to determine this for the short policy analysis paper is how much work the instructor is willing to put into the grading of the projects. The only real limit on this is how much time the instructor is willing to spend on grading. If exceptionally large classes are to be used for such papers, one may want to consider offering several choices of topics in order to provide more variety.

However, as set up, there is a realistic limit on the number of students working on a comprehensive project like the policy creation project. As the students are expected to learn about the various techniques from the Technique Summaries written by their fellow students, and then assimilate that information to create their own proposed policy, one must consider limiting the number of reports that are to be read by each student. Along these lines, the maximum number of students in a class for this form of the project is approximately 25. This type of project could be used in larger classes, but the instructor would need to streamline the number of Technique Summaries to be read by each student. This could be done by dividing the class into smaller groups, with the project self-contained in each group. It could also be done by requiring all the students working on detailed reports on the same technique to work together to produce a single Technique Summary for that technology. The latter would promote working as a group, with the associated educational benefits.

It should also be noted that while these projects were used in senior-level courses, fundamentally there is nothing that would require these types of projects to be used in only such courses. These types of projects should also work well at different levels in the curriculum. When assigning this type of project, the expectations on the students need to be made according to their level of education. This type of project can even be of use in the freshman year, as it can give engineering students a different perspective of engineering at the start of their education. That enhanced perspective may then carry over through the rest of their studies.

ADDITIONAL STRATEGIES TO INTRODUCE PUBLIC POLICY

While the two strategies described in detail above have been well-tested and have been found to be well-received by the students, additional strategies have been used to a lesser extent. These methods can be used as alternative means to expose Mechanical Engineering students to either the public policy

formation process itself or to issues that spur the creation of public policies and result from public policies.

One strategy, partially introduced in MechEng 432 but not formally evaluated, is to have the students participate in informed discussions or debates on a technical topic of interest that is the topic on some public policy. In the Fall 2010 semester, only one topic was assigned in the policy analysis paper. This limitation on the choice of topics was done in order to stimulate a discussion of the issue, and that all students would feel informed enough about the issue to participate in the discussion. In addition to this direct connection to the public policy assignment, later in the semester the instructor allocates lecture time in MechEng 432 for a discussion on pollutant emissions. In this discussion, students are asked to contribute their thoughts related to the issue of balancing emissions reductions from engines versus economic considerations. The students are not pre-warned about this discussion, however, and they are expected to be able to contribute their thoughts on-the-spot.

This method of informed discussions or debates should help to prepare the students to be able to present their technologically-informed opinions in a manner that can convey their thoughts to others in a time-constrained environment. In other words, it should enhance their oral communication skills, and should give them practice in explaining science or technology to those who may not have the background information that they possess. Unfortunately, because these exercises were not formally graded, it was difficult to motivate the students to wish to contribute to the discussions. A few students will typically say a few things, but most students do not seem to want to participate. This may be a result of the nature of the students as they may not have great confidence in their speaking abilities or level of expertise.

To improve the likelihood of promoting a stimulating discussion, it would be beneficial to incorporate a formal grading of student participation in the process. It may also be beneficial to assign particular roles to individuals, and have them fill those roles. For example, this could take the form of a committee hearing, and different students could be chosen to be members of the committee, each with their own particular opinions for which they are seeking support. You could have other students play the roles of witnesses, who are called to present testimony on each side of the issue under debate. In such a way, each student is given a specific role to prepare for, and can focus their efforts to make those contributions, rather than having everyone prepare for a general discussion of an issue.

Another method to incorporate public policy into a Mechanical Engineering curriculum is to require considerations related to public policy in capstone design projects. While these projects naturally involve substantial technical components, opportunities exist for incorporation of issues related to public policy. For example, formal adherence to existing engineering standards can be a required component of the projects. Or, consideration of local laws may be expected.

A gathering of the opinions of the local community to be affected by a design may be required as a prelude to the creation of a design. The types of requirements that may be added to a capstone design project will vary based on the nature of the specific project, but opportunities exist for many projects to be cognizant of standards and laws that have been put in place as part of public policy creation efforts. In other projects, students may be expected to develop a plan on how to get their design accepted by a local governmental body or the local community. While such requirements will not provide the students with a great deal of experience in developing public policy, it will increase their awareness of both the non-engineering issues that influence the creation of public policy and the impacts of public policy on their designs. Many capstone design projects already include some of these requirements, such as adherence to engineering standards, but emphasis on how these factors were developed can help students better recognize how their jobs are impacted by non-engineering factors.

It can be noted that the four methods already discussed for incorporating public policy into a Mechanical Engineering curriculum all are included as part of formal courses. As with the first two methods, the second two methods can be easily modified for lower level courses, and may be of particular interest in some freshmen-level courses. All of these strategies can be adopted without dramatically altering a standard Mechanical Engineering curriculum, and can be introduced and implemented with only an hour or two from the lecture content during the semester. Larger projects may result in a more technically-oriented design project being replaced, but the educational benefits of such a change may prove to be well worth it, depending on the number of large technical-design projects the students complete during their studies.

A fifth method for incorporating public policy into the education of Mechanical Engineering students is one that resides outside of the formal curriculum. This technique is to encourage active participation by students in student organizations that focus the attention of students on engineering activities that involve the public directly. For example, student chapters of the organization Engineers Without Borders have become very popular among students. [6,7] These groups are usually working on engineering projects for residents of poor nations, and the students must learn about the formal standards that apply in those nations, as well as how to work with local residents to see how those local communities have established policies that will apply to projects [8]. While such activities may not directly impact public policy creation in the United States, the students do gain experience with how public policy (official and unofficial) affects their designs, and they obtain the improved communication skills necessary for informing others of their technical solutions to problems. Furthermore, the students in such organizations can be inspired to try to influence US government policies with respect to foreign aid.

Other types of student organizations can also help informally to prepare to work in the realm of public policy. For

example, at UWM there is an engineering student organization devoted to alternative energy. The students in this organization learn about different alternative energy technologies, and also work to design systems for use on campus. These students need to learn how to work inside a bureaucracy to get their designs accepted and implemented on the campus. While they may not be creating public policy, they are receiving valuable lessons for working inside an organization that has been informed by public policy. Even students working on projects for design competitions for ASME or SAE learn that they must have their designs conform to regulations, and that there are often sound policy reasons (such as safety) for these regulations. So, while student organizations may not provide students with a formal public policy component, these activities do support a greater appreciation for the role of public policy in engineering and the development of skills important for helping to create public policy.

BENEFITS OF THE PUBLIC POLICY PROJECTS

From an engineering education viewpoint, there are a number of benefits that are achieved with these projects. First, students are given a project experience that goes beyond the typical design or laboratory projects. Decisions in their future will be made for reasons other than only technological merit. These types of projects give students the opportunity to learn more about economic, environmental, and public perception factors that may impact their careers in the future, and improves their knowledge of contemporary issues.

Second, students get additional experience to improve their written communication skills. In both types of projects, the students get experience writing for a non-technical audience, and in the more comprehensive policy creation project, the students also practice their writing directed towards a technologically-knowledgeable audience.

Third, students are exposed to a different way in which they can use their engineering education in their future careers. The students see that they can use their skills to potentially influence or create public policy.

Fourth, the students learn more about the current technology involved in either the different electricity-generation techniques or the internal combustion engines. Writing about the topic tends to cause students to learn the material more thoroughly than they achieve by sitting in lecture or reading a book [9].

Fifth, with some modifications to its implementation, these projects can give students more experience conducting information research. The students can also practice interpreting and assessing information.

RELATIONSHIP TO ABET ACCREDITATION

An additional benefit to the formal course-related public policy introduction techniques is that they can help Mechanical Engineering programs meet several of the student outcomes expected by ABET. Currently, as part of ABET Criterion 3, Student Outcomes, 11 different outcomes must be demonstrated

by programs [1]. These represent abilities that a program's students are expected to have by the time they graduate. Outcomes (f), (g), (h), and (j) are all outcomes which can be supported through the use of the methods described here for incorporating public policy into the curriculum. These are also outcomes that often are challenging for engineering programs to sufficiently demonstrate to ABET. Outcome (f) involves professional and ethical responsibility, (g) involves communicating effectively, (h) concentrates on understanding the impacts of engineering solutions in a global and societal context, and (j) requires an understanding of contemporary issues.

These outcomes all involve activities that are often given less emphasis than the hard technical knowledge imparted in an engineering curriculum. As less quantitative skills, it is often more difficult to demonstrate that these outcomes have been achieved. However, the course-related methods for public policy introduction discussed here all bring these outcomes up to a position of prominence and provide an avenue for which they can be assessed. In particular, the detailed project involving the creation of a public policy and the less-extensive policy analysis paper directly connect to these outcomes and would greatly ease the burden of demonstrating achievement of the outcomes if they are incorporated into a required course or into several elective courses.

Specifically, by working on these projects, students are demonstrating that they need to be held to high professional and ethical standards because they are taking society as a whole into consideration as they apply their engineering knowledge to public policy. The projects all focus on communicating effectively, with much emphasis given to communicating to people with a non-technical background. The projects automatically focus the attention of the students onto global and societal problems, and often include economic and environmental considerations as well. And provided the public policy questions assigned are relevant today, the projects will require the students to understand contemporary issues. One can also argue that by encouraging students to apply their engineering skills and knowledge to the creation and implementation of public policy throughout their careers, Student Outcome (i), which involves recognizing the need for life-long learning, is also supported.

SUMMARY AND CONCLUSIONS

In this paper, two different types of projects that can be used in traditional engineering courses to promote the understanding of the creation and analysis of public policy are described in detail, and three other methods are also discussed. The activities involving the analysis of a public policy, the creation of public policy, and the informed discussions involve having the students study issues related to public policies affecting the discipline that they are studying in a particular class. One project is the simple analysis of a proposed policy, with the end-product being a short paper from the students. This type of project works well in a course where only a

moderate amount of time can be expected of the students. A second type of project is a comprehensive analysis of a technology and the creation of a public policy impacting how society will function with that technology in the future. This type of project requires a significant amount of time, and is best used in a course where it becomes a main focal point of the course. The third type of project involves background research and preparation, and enhances the oral presentation skills of the students, but should not require an exceptional time commitment from the students.

In addition, it is suggested that capstone design projects can place a greater emphasis on the use of the results of public policy into their criteria for evaluation. Finally, examples of the impacts that participation in the activities of engineering student organizations on the level of appreciation for public policy held by the students are provided.

When included in a traditional engineering course, students gain a much deeper understanding of how engineering can affect society at large by concentrating on not just the technology normally studied in engineering courses, but also on the economic, environmental, and societal impacts of the technology. In the process, the students acquire some of the skills expected of them by ABET. This is done without sacrificing the engineering rigor expected from such courses. This broadens the students' educations, helps engineering programs meet ABET expectations, and provides the students with more knowledge of how engineering fits into the rest of the world.

When using these types of projects, the instructor should keep in mind that this is not the type of work that most engineering students are used to performing. Adequate time must be spent in class explaining public policy analysis and creation, and resources to help the students find and evaluate appropriate information must be provided. Furthermore, it is best to pay more attention to the writing skills of the students. The writing of the students improved with feedback, and students must be reminded about good report writing techniques. If these things are done, the projects should produce a well-rounded engineering graduate who will be able to apply their skills to public policy analysis and creation in the future.

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