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A MODULAR APPROACH TO INCORPORATING PUBLIC POLICY INTO ENGINEERING COURSES

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We propose an approach to designing instructional modules that integrate public policy considerations into traditional engineering courses. The proposed modules begin with technical problems that are typically encountered in specific engineering courses. Hence, instructors can incorporate the modules without requiring a major change in either their teaching style or syllabus. The technical components of the modules serve as natural gateways to explore the policy context. Further, the policy context components are compartmentalized so that instructors can choose which components to utilize and how much time to devote to them. In addition, the modules contain notes that serve as a learning experience for instructors unfamiliar with the policy context and facilitate customization by instructors. A detailed description of one such module is provided in this paper as an example. Brief descriptions of several other modules are provided as well as the opportunities for the policy context of a given module to be paired with other technical problems in multiple engineering courses.

Literature Review

The ABET definition of engineering design includes policy and regulations among possible design constraints. Among the student outcomes required by ABET are: “an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors” and “an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and social contexts” [1]. Clearly, the appropriate incorporation into engineering curricular of public policy issues can help to satisfy these ABET requirements.

Ngambeki, et.al. reviewed eight different approaches to incorporating public policy into engineering curricular, ranging from a singular seminar to entire courses to multi-year degree programs [2]. Some of these varied approaches have been extensively described [3] - [6]. The approach described in this paper focuses on incorporating policy considerations into typical engineering courses.

In the early 1980s, each student participating in the Washington Internships for Students of Engineering (WISE) program developed an engineering/public policy case study intended for use in existing engineering courses [7]. After a short learning curve and some revisions, seven of these cases were, after peer review, accepted into the ASEE Case Library (see ECL 256, 258, 259, 260, 261, 262, and 276) [8]. While the WISE cases provided useful insight into engineering decision-making and addressed the larger public policy context in which these decisions were imbedded, the technical material in the WISE cases was not targeted to specific courses. Nevertheless, eleven draft WISE cases were class tested by 250 upper level students in 16 different existing courses in civil, chemical, mechanical, and agricultural engineering at eight different schools [9]. One of the results of the student survey was a very strong student interest in including public policy issues along with the technical material. Other efforts include using public policy oriented case studies in an engineering economics course [10].

One reason that case studies have not been widely adopted in typical engineering courses is that cases usually start with a story narrative that requires a sharp departure from the flow of the lecture/discussion/problem solving mode prevalent in typical engineering courses.

Six of the classes included in the tests described in [9] were design courses. Focusing on design education, Hyman provided many examples of opportunities to incorporate public policy considerations into engineering design courses, using a variety of formats and techniques in addition to case studies [11]. An even more focused look at design education examined public policy issues as key ingredients of capstone design courses [12].

One of the approaches examined by Ngambeki, et.al. were modules which "…usually take place over 1-3 course periods" [2]. This is the approach described in this paper, but with much greater flexibility for the class time devoted to the modules.

Module Design

It is necessary that the modules be attractive to, and contain valuable learning experiences for, students. However, a good module must appeal to faculty as well since faculty will choose whether to use these modules in their courses. This is particularly important since the modules contain public policy material that is not normally covered in traditional engineering courses.

Several groups of faculty members are the target audience for these modules. Initial adopters are likely engineering faculty who already understand the engineering/public policy connection and would use the example module described later in this paper in a course that they regularly teach. Other initial adopting faculty might use the example module and the information in this paper as templates for developing similar modules for other courses. These two groups of faculty might then transfer such modules to colleagues who may not have an a-priori understanding of the policy context but are willing, even eager, to include the material as a way to satisfy ABET requirements.

Careful attention must be given to module design so that faculty will perceive the modules as valuable additions to their individual courses. We believe that we can maximize the chances that engineering faculty will use these modules if the modules:

(a) pose technical problems on topics that are normally included in typical undergraduate engineering courses;
(b) contain complete solutions to the technical problems;
(c) include a logical, natural, and seamless connection between the technical material and the related public policy context;
(d) give instructors great flexibility in how and to what extent the public policy material is made available to the students;
(e) include many notes to the instructor with suggestions for how to use different components of the module; and

(f) facilitate customization by instructors via use of segmentation and formatting techniques.

In addition, we recognize that since many engineering instructors may not be familiar with all public policy components of every module, the policy components should be self-contained and designed to serve as learning experiences for instructors as well as students.

We now turn to a detailed description of one such module plus brief descriptions of several other possible modules.

Example Module

The primary purpose of this example module is to illustrate how: the technical and public policy parts can be related to each other; the public policy part can be segmented; and instructor's notes can be incorporated.

The example module is introduced by posing the following question: What force must a person in a wheelchair exert to propel himself or herself up a wheelchair ramp? This can be part of a class discussion or homework assignment in a sophomore statics class, hence satisfying characteristic (a) in the preceding section. In the module, the analytical solution to this problem in terms of the ramp angle immediately follows the presentation of the problem, thereby displaying characteristic (b). The seamless segue into the public policy aspect of this module [characteristic (c)] comes from the fact that the maximum permissible slope of wheelchair ramps is specified by federal regulations pursuant to the Americans with Disabilities Act (ADA).

The public policy part of this module makes up 12 of the 17 pages of this module. Most instructors are unlikely to incorporate that entire public policy material into their courses. For this reason, the public policy aspect of the module is divided into the following six discrete components with the instructor free to choose which of these components to utilize, and how and to what extent to use them:

1. <u>Design Standards</u>: Provides the ADA design standard specifying the maximum ramp angle;
2. <u>Legislative Language</u>: Examines the language of the ADA and its requirements for issuing regulations implementing the law;
3. <u>Regulatory Process</u>: Describes the thorough and open process for proposing, seeking comments, and finalizing the ADA regulations;
4. <u>Key Institutions</u>: Focuses on the structure and role of the Department of Justice and the Architectural and Transportation Barriers Compliance Board (ATBCB);
5. <u>A Hero</u>: Tells the story of Justin Dart who is frequently referred to as the Martin Luther King, Jr. of the disability rights community; and
6. <u>History</u>: Traces several decades of federal government actions regarding disability rights that culminated in passage of ADA in 1991.

For example, the briefest exploration might involve the instructor using the <u>Design Standards</u> component to describe the ADA regulation that specifies the maximum ramp angle so that the statics problem can be solved. Such an approach might only take a few minutes of class time.

A deeper dive into the policy context of this component can occur by the instructor providing the students with access to the 240 page ADA document entitled Accessibility Guidelines for Buildings and Facilities. This provides students with the opportunity to explore other ADA accessibility regulations since the ramp angle standard is just one of many regulations included in the document. These explorations can occur as part of a class discussion (has anyone in the class benefitted from this or other ADA regulations or know someone who has?), supplementary readings, homework assignment, etc.

An even more in-depth learning experience can occur if the instructor chooses to ask the students to do an on-line search for the ramp angle design standard. The instructor can provide the students with the suggested search strategy included in this module component, or allow the students to devise their own search strategy.

The four options discussed above for determining the ramp angle is an example how this module component incorporates the desired characteristic (d). Some instructors might choose to conclude use of this module once the ramp angle has been determined. Others might decide to select material from other policy components of the module to facilitate additional reading, class discussion, and/or homework assignments.

The <u>Legislative Language</u> component can demonstrate the complexity of the ADA law and the generality of the language together with the mandate for the executive branch agencies to develop detailed rules within a specified time. This component provides the opportunity for the students to learn that the language of ADA, as well as all other laws, are codified in the United States Code (USC). Student awareness of the USC can help them identify whether and how their future engineering decisions on issues such as safety and environment are constrained by federal laws.

The <u>Regulatory Process</u> component familiarizes students with the Federal Register, the daily government journal that publishes all announcements of regulatory and other administrative activities of federal agencies, including proposed regulations, announcements of public hearings on the proposals, opportunities to provide comment, analysis of feedback on proposals, and issuance of final regulations. Students will also have the opportunity to learn that the adopted regulations are codified in the Code of Federal Regulations (CFR). Engineering students familiarity with the Federal Register and CFR will help them access federal rules affecting their engineering work.

In the <u>Key Institutions</u> component, the students will have the opportunity to search to see whether any engineers are members of the Architectural and Transportation Barriers Compliance Board (ATBCB). There is also the opportunity for students to ponder why the Department of Justice is involved, rather than having the standards issued directly by the ATBCB.

The <u>Hero</u> and <u>History</u> components provide the students with narratives describing the decades-long political struggle leading up to passage of ADA and emphasize the dedication and resourcefulness needed to develop and enact major federal legislation.

To demonstrate how this module satisfies the desired characteristic (e), notes to the instructor are strategically placed throughout the module in italic font and separated from material intended for distribution to students. The example module is a Microsoft WORD document and instructors can edit or use the software's "hidden text" capability to control which portions of the module are accessible to their students, thereby satisfying the desired module characteristic (f).
The complete example module is available on-line for use, modification, and as a model for other modules [13].

Variations of the Example Module

Slight variations in the technical problem, such as replacing the wheelchair by a baby stroller or a scooter, can be matched with the same policy components. The ADA design standard for wheelchair ramps also specifies the maximum rise of ramps in addition to the ramp angle. Thus the public policy aspect of this module can also be paired with the following technical problem from a dynamics course: How much restraining force must a wheelchair user apply when going down a ramp to limit his/her ramp exit velocity to x mph? Clearly, several other related dynamics problems could be paired with these policy components.

Another feature of this particular module derives from the fact that the ADA and its ensuing regulations are very comprehensive. The same federal regulatory document that specifies permissible ramp angles also specifies the coefficient of sliding friction on wheelchair ramps. Hence, most of the public policy part of this module could also be incorporated into a module that starts with this technical problem: Determine the force needed to slide a heavy box up a wheelchair ramp.

There also are opportunities for problems in several other technical courses. For example, the ADA requirements for elevator door openings and closings could serve as a basis for modules in courses in dynamics and automatic controls. In addition, ADA mandates for bus lifts can serve as the foundation for modules targeted to courses in machine design, mechanisms, and hydraulics. Technical problems normally covered in several electrical and computer engineering courses can also serve as entry points for modules that deal with ADA requirements for telephone and alarm systems. Thus, with only relatively minor changes, the public policy components of this example module can be married to a variety of technical problems associated with many different engineering courses.

Katrina Module

As another example of a possible module, consider the technical problem of determining the hydrostatic pressure at the base of a vertical wall. This problem is typically included in either a sophomore-level statics course or a junior-level fluid mechanics course. This problem can be the entry point into a public policy module that deals with the failure of the New Orleans floodwalls and levees during Hurricane Katrina. A myriad of public policy issues can be included in such a module. One possible focus for the public policy components of this module is the role of the Corps of Engineers, specifically their design guidelines for flood walls, their budget requests compared to funding levels approved by Congress, their role in post-Katrina clean-up, etc. And because the Corps' mission is much broader than flood control, and includes designing, building and operating canals and hydroelectric facilities, the policy context of such a module could be matched with a variety of technical problems taught in other courses.

Another entry point for the same module could be the problem of determining the stress at the bottom of a vertical wall subject to hydrostatic pressure. This problem is typical of a class of problems normally covered in a sophomore/junior course in strength of materials.

Other Opportunities for Policy Context Modules

The ADA and Katrina modules described above deal with the past: ADA with existing legislation and regulations; Katrina with the prelude and aftermath of a recent catastrophic event.

There are a myriad of other federal government policies that can be matched with technical material covered in typical engineering courses. Some possibilities include safety standards (seat belts, airbags, etc.) for automobiles; the Clean Air Act; Water Pollution Control Act; regulation of the airwaves by the Federal Communications Commission; energy efficiency standards for household appliances; certification of new airplane designs by the Federal Aviation Administration; licensing of energy facilities by the Federal Energy Regulatory Commission; etc. State and local government policies such as building codes; design of roads and bridges, noise ordinances provide further opportunities for module development.

There are also many opportunities to develop modules that are future oriented, dealing with ongoing and contemporary unresolved issues such as those that occur in the environmental, energy, national security, biomedical, and computer privacy arenas.

Technical Courses and Policy Issues

The above discussion demonstrates that: a given engineering course can include multiple topics that are suitable for public policy modules; a given technical problem can be included in more than one engineering course; a given technical problem can be the entryway for more than one policy issue; and that a given policy issue can be reached via more than one technical problem. These types of relationships are illustrated in Figure 1.

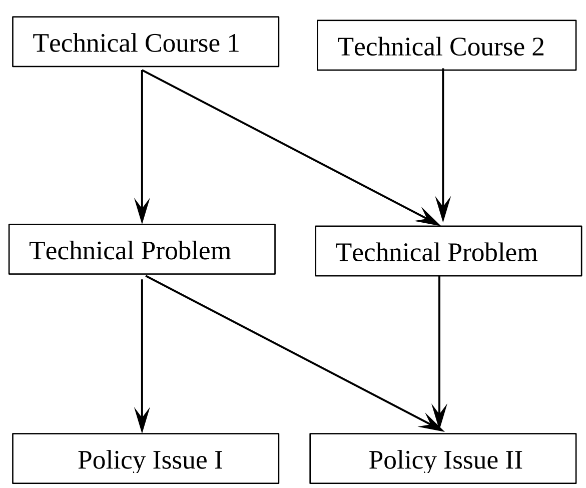

Figure 1. Relations between technical courses, technical problems, and policy issues in modules

Summary

The modules developed under the approach proposed in this paper are targeted to specific engineering courses and begin with complete statements and solutions for technical problems that are typically encountered in those courses. These technical components of the modules will serve as natural gateways to exploration of the public policy context. Hence, instructors will not need a major change to either their teaching style or syllabus to accommodate the modules. Further, the public policy components will be compartmentalized so that instructors can choose which components to utilize, how to utilize them, and how much time to devote to them. In addition, the modules will not require that engineering faculty have expertise, or even familiarity, with the public policy component. Each module will be self-contained with extensive use of notes to the instructor. These features – targeting specific technical courses, smooth transition from technical problems to policy context, compartmentalizing public policy components, and helpful notes to instructors, should make these modules appeal to many engineering faculty.

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