Teaching Engineers How to Make A Difference: Integration of Public Policy Concepts into Engineering Curricula

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Abstract

Engineers, regardless of their areas of specialization, routinely are involved in projects with broad public policy implications. For example, engineers usually play a leading role in the design, permitting, and construction of controversial facilities. In addition, the design and development of any new technology often requires support or involvement from the public as well as the government. In many cases, engineers are poorly prepared to handle political, administrative and legal processes that are vitally important in the implementation of almost any engineering design, construction, or development project. Engineers also miss important opportunities to participate in the development of public policy at the highest levels, including the legislative process and agency rule-making, due to a lack of familiarity and relative comfort with the applicable processes. Consequently, the public and governmental bodies are denied the benefit of the engineer's unique perspective on policy issues. This paper identifies specific areas of public policy often encountered by engineers and discusses policy development processes that would be greatly enriched by increased participation from the engineering community. In addition, the paper identifies ways in which undergraduate and graduate engineering programs can prepare engineers to be more effective practitioners and better serve their clients, their employers, and their profession in the political, legal and administrative environments.

Typical Public Policy Forums

In a democratic society, the development and implementation of public policy can take many forms. Even the term "public policy" is not susceptible to a uniformly accepted definition. In general, the term is most often used to describe the results of actions taken by the government in response to real or perceived public issues and concerns, in a manner that directly or indirectly affects the public.[15] In particular, in the United States, the conversion of a particular issue into policy may occur through various governmental bodies in the legislative, executive, and judicial branches.

Perhaps the type of policy development most familiar to the public is the legislative process, at both the federal and state levels. The public at large becomes involved in this process primarily through the election of legislators. In addition, because state and federal legislation must go through "bicameralism and presentment" (passage by the legislative branch and signing by the President or governor, as appropriate), the public theoretically has another chance to influence legislative policy through elections. However, during the process through which an issue first appears on the legislative agenda, and the subsequent debate, committees, and other legislative decision-making processes, the public has many opportunities to become involved in a more

direct manner. Public policy scholars often state that an issue will only make it to the legislative agenda if a number of factors coalesce.[3,15] Often, these factors include advocacy from the public in the form of media attention, interest group involvement, and testimony from a variety of individuals. Once an issue is placed on the legislative agenda, more opportunities for public involvement present themselves, including lobbying activities and again, testimony. The fact that relatively few citizens take advantage of these opportunities does not make them any less available.

Although legislative action sometimes receives a larger share of media attention, other governmental bodies often play an even more pervasive role in the creation of public policy. Once a policy is enacted into law by a state legislature or the U.S. Congress, administrative agencies normally shoulder the major responsibility for implementing the legislative directives. In fact, the legislative branch, by necessity, often explicitly delegates the development and implementation of the technical details of a statutory program to agencies. These agencies typically are housed within the executive branch of government, but carry out many different functions with a significant impact on policy development, including rule-making, permit issuance, and, in some cases, adjudication of cases.[8] For instance, a government agency such as the Environmental Protection Agency (EPA) administers numerous statutory programs, such as the Clean Water Act and Clean Air Act. In so doing, the EPA routinely engages in the promulgation of regulations (rule-making) that affect millions of individuals, corporations, and other entities. The agency also issues permits for various activities on a daily basis, and also acts as a first level of appeal on many issues. The states have their own environmental agencies, which work with and assist EPA in many of its responsibilities, and also fulfill responsibilities as defined in state legislation.

The public may exert influence on agency actions in a variety of ways. Federal and state laws require agencies to go through a minimal "notice and comment" rule-making procedure prior to finalizing regulations. This process requires the agencies to solicit and consider comments from the public whenever a new regulation or revision is proposed. In addition, most permits and related actions require some type of public notice and/or public hearing before a decision is made. Finally, the directors of state and federal executive agencies are appointed by the governors and President, respectively, and normally serve at the "will and pleasure" of the executive. In this manner, the public has an opportunity to make an impact on agency policy through use of its voting and lobbying power to affect selection of agency leaders.[8, 15] Just as it does with the legislative branch, the public also can exert significant influence on agency action in the form of well-organized, focused attention on a particular issue, which generates media attention and resulting pressure on the agency. This form of public participation often has played a particularly important role in shaping environmental policy through agency action.[5]

Although the judiciary often is not associated with policy development, courts can have a powerful influence on the manner in which policies are implemented. Through its statutory interpretation powers, and also the ability to develop judicial policies in the context of civil cases, the court system is an important part of public policy development. For instance, the interpretation of a relatively technical statutory or regulatory term often depends on the approach utilized by a particular judge. More conservative judges tend to rely only on the express

language of a particular provision to interpret its meaning, while less conservative judges will look to such things as overall legislative intent and the policies behind a statute to make a decision.[3] The difference in these two approaches makes a very significant difference in the outcome of cases.

The Engineer's Role

In all the processes described above, engineers can and do play important, albeit sometimes over-looked, roles. With respect to each of three branches of government, examples abound where engineers have influenced the outcome of policy-making processes. As noted by one writer, "…it is the engineers who draw up the politicians' shopping lists by furnishing specific solutions to particular problems." The writer goes on to describe how engineers utilized political expediency to promote their plan to put a man on the moon, which required the President's support and legislative funding.[4] This high-profile example of the engineer's political influence, when properly exerted, is but one of many, less publicized examples. By acting as advocates for solutions to existing problems, through agenda-setting activities such as legislative testimony or more behind-the-scenes efforts, engineers have helped move issues forward that may otherwise have fallen subject to other legislative and agency priorities.

One of the most important aspects of public policy development is prioritizing or agenda setting. This is something that by necessity occurs in all policy-making forums, including the legislative process and agency rule-making. The term "agenda setting" has been defined as "the politics of getting problems to government."[9] Due to finite public resources, this first step in policy development is critical – examples abound of issues that made it to the top of the priority list only because of enhanced attention from the public or interest groups. A far greater number of issues remain unaddressed and unresolved in the public policy arena due a lack of appropriate advocacy and attention. This is especially true for complex technical issues, which often do not make it onto the public policy agenda unless aggressively advanced by an interest or professional group with not only technical knowledge, but also the communication skills and political awareness required to make the issue appealing to policy makers.[10] Charles Jones identifies three patterns of agenda setting in the public policy process. The first type involves a relatively passive government that reacts to the expression of public interest. Under the second model, government defines a process and actively encourages participation from public and private interests in prioritization of issues. The third pattern plays out when institutions "systematically review societal events for their effects and set an agenda of government actions."[9] Engineers and other technical professionals have an important role to play in all three of these patterns, as representatives of the public, government, and the regulated community.

Specifically with respect to policy development at the agency level, engineers are involved in the process on a daily basis, and in many different ways. While many industries and clients of engineering consulting firms have access to attorneys and other professionals who assist them with the policy and legal aspects of permitting, rule-making, and all associated negotiations and relationships with agency personnel, the engineer often is the "first on the scene" with respect to any particular issue. The engineer employed by a corporation or consulting firm usually has a working relationship with his or her counterparts at the relevant administrative agencies. In addition, many policy issues arise during the early planning, feasibility, and design processes

associated with any technical or engineering project, and it is the engineer who normally is serving in a management role at these points. Engineers also play a big part in this process as leaders and employees of administrative agencies.

As an example of the engineer's importance in early policy development, I use a set of facts from a recent "real-world" situation involving the interaction of engineers, agency personnel, and lawyers. In this particular situation, an engineer had planned, designed, and supervised the construction of a wastewater treatment facility for an industrial client. Immediately after start-up, the plant commenced routine violations of its discharge limitation for a certain pollutant. The relevant state environmental agency instituted enforcement proceedings, at which point the industrial client hired an attorney. As it turned out, the pollutant at issue was not regulated, at either the state or federal level, with specific numeric discharge limitations or water quality criteria, but was a pollutant for which the agency had adopted an informal policy for regulating at a level above and beyond formally adopted levels. The consulting engineer later argued that the application of this criterion was not appropriate in this particular situation, but there was scant evidence in the permit file or the engineer's records of any type of negotiation or discussion between the consulting engineering and agency engineer. Since agency "policies" do not have the force and effect of law, the consulting engineer, who was the client's sole point of contact and direction with respect to permitting of the new facility, had lost the valuable opportunity to influence clearly negotiable permit parameters and, more importantly, to use his technical expertise to convince the agency that the entire policy should be revisited. The engineer had simply accepted the result produced by the agency, without considering the bigger policy picture regarding the agency's approach or appreciating his potential importance in policy development on this issue. In this case, the engineer would have been negotiating from a point of strength – with respect to other pollutant parameters, the plant was designed (and operated accordingly) to produce much lower than regulated levels of pollutants. As it was, lawyers ended up arguing the case "after the fact", which is always more expensive and less effective than proactively addressing the issue, and which put the engineer into a situation that was both embarrassing and fraught with potential professional liability.

I cite this particular example not to imply that engineers are somehow inferior to other professionals – clearly, that is not the case. The situation described merely illustrates that engineers under-value their own potential impact and influence on policy decisions, and can fail to insert themselves into policy debates at the appropriate time due to a lack of education on and comfort with relevant policy processes. In this case, the process was permit issuance, but other agency processes are just as important.

As noted above, administrative agencies fulfill a large part of their missions through the promulgation of regulations, which have the force and effect of law in the sense that they are enforceable against the regulated community and others in the form of fines, penalties, and sometimes criminal sanctions. Prior to issuing a proposed regulation, agencies investigate, analyze, and prioritize specific issues on the regulatory agenda. After publishing a proposed regulation, agencies then go through a proscribed process that requires them to glean additional information through public comment and debate.[8] Engineers regularly are involved in all aspects of this process, although perhaps not as often as they could be. Engineers working for specific

agencies, of course, are involved in the agency research and agenda-setting process, as are engineers employed by the regulated and academic communities, either directly or as consultants. As noted above, problems which make it onto the policy-agenda often are those for which solutions have already been identified by engineers.[4] Engineers also can be extremely effective in the comment process, whether they are representing clients or simply themselves. In this type of forum, participation and advice from the engineering community has a much bigger impact than many engineers perceive. From the perspective of agency leaders and employees, the attorneys and association members who regularly appear at meetings to represent various interests can provide information useful to the decision-making process. However, especially when subject matter is technical in nature, it is often engineers who provide the most powerful and convincing arguments for one regulatory proposal or another. Ironically, though, it is engineers who make the most infrequent appearances at public meetings, unless required to do so by their employers.

One aspect of policy-making that tends to plague administrative agencies involved in the attempted resolution of technical topics is scientific uncertainty. In many cases, agencies are faced with either a complete lack of credible scientific evidence or, alternatively, with equally credible scientific evidence and arguments that point toward vastly different policy decisions. In such cases, agencies may choose not to act all, until the scientific community reaches better consensus or, more commonly, may choose to yield to public and political pressure to make a decision in the face of scientific uncertainty. In these situations, decisions routinely are made on a "pure policy" basis and as a direct function of people, events, and timing.[5] Engineers often are perceived as "honest brokers" during this type of policy debate, even though scientific and engineering judgment often is affected by social and political factors, especially in the face of several scientifically plausible options.[15] However, engineers arguably are in a better position than most to resolve conflicts and uncertainties and move the policy agenda forward.

Engineers also provide an important service in the judicial arena. While most engineers are aware that members of their profession are hired as experts or otherwise called to testify in court cases, even the engineers who engage in this activity tend to underplay their potential importance. This may be due to the perception that lay juries lack interest in the "technical details" of cases, which, admittedly, has some basis in fact. However, especially in cases tried before a judge or administrative hearing boards, the trier of fact often places great importance on testimony from engineers. For example, in a recent federal court case involving the emotionally volatile issue of mountaintop removal mining, it was the testimony of an engineer, on behalf of the plaintiff environmental groups, that seemed to change the course and outcome of the case. In such situations, the most effective testimony is elicited from those engineers who are aware of the broader political and policy implications, and who feel at least some level of comfort with the process.

The National Society of Professional Engineers (NSPE) has recognized the importance of engineers in the development of public policy. In the introduction to its "Legislative and Regulatory Agenda," NSPE notes that the engineering profession's responsibility to protect the public is dependent on its "participation in the democratic process" and its ability to "offer significant contributions to the development of public policy."[13] In addition, the NSPE has

implemented many programs, such as the Federal Issues and Engineer Ambassador programs and its Political Action Committee, to encourage increased involvement of engineers in public policy development. The society has even compiled a list of agencies that indicates the level of importance, for each agency, of having a professional engineer in a key leadership position. These programs and initiatives should come as no surprise, given the fact that the NSPE Code of Ethics requires engineers to "seek opportunities to participate in civic affairs…and work for the advancement of the safety, health and well-being of their community," and also to "endeavor to extend public knowledge and appreciation of engineering and its achievements."[12]

The Employer's Perspective

Recently, Marshall University solicited suggestions from regional engineering employers regarding the need for the coverage of particular topics in both undergraduate and graduate engineering curricula. In 1999, a focus group was convened, consisting of approximately twenty managers from industry, consulting firms, and government agencies who regularly employ and work with engineers. In a facilitated session, the participants provided input on revising and updating a graduate engineering curriculum designed primarily for working professionals. Although the group stressed the importance of keeping their engineers up-to-date with rigorous technical courses that reflect the newest technology, an overwhelming majority of the managers kept returning, again and again, to the importance of other professional skills such as communications, leadership, and the ability to both identify and work within the confines of political and social institutions. While not phrasing their answers explicitly in terms of "public policy," when pressed for examples, the engineering managers often referred to situations involving the public policy process, including the navigation of public hearings, working with agency and other government officials, and similar examples.

In the year following the focus group meeting, an independent consultant performed a study for West Virginia's higher education agency on the need for graduate engineering programs in the region surrounding the state's capitol city. The consultant surveyed 253 regional engineering employers – including industry, consulting firms, and government – and also performed more intensive, in-person interviews with 27 of the surveyed employers. The results of this study were consistent with the results of the focus group meeting. At the graduate level, the employers in the study repeatedly emphasized the need for continuing education opportunities related to project management skills, including the ability to function effectively in business, legal, and professional environments. In addition, the employers stressed the importance of undergraduate programs capable of producing well-rounded graduates who have some familiarity with the practicalities of engineering practice prior to their employment.[11]

Finally, our institution once again convened a focus group of engineering community leaders in 2001 to discuss the directions of undergraduate engineering programs of the future. The group was quite uniform in the belief that undergraduate engineering programs should be broader than those they themselves had experienced. In particular, many of the participants stressed the need for undergraduate engineering students to be educated not only in mathematics, science and engineering principles, but also in the liberal arts and subjects relating to the social and political environment in which engineers must function. Most of the employers expressed their desire for new engineers to have a working knowledge of various political and legal issues, including

agency regulations and permitting, as well as a broader appreciation for the legal implications and consequences of their actions. Several participants noted that, although today's graduating engineers will change career directions many times as technology advances, the one constant will be their collective ability to handle the political, legal, social, and business pressures associated with engineering projects.

These localized perceptions are quite representative of the national engineering community at large. No better example of this exists than the very active involvement of the engineering industry in the development of the revised engineering program evaluation criteria in 2000 by the Accreditation Board for Engineering and Technology (ABET). These new criteria reflected various industry concerns, including the desire to make explicit that engineering programs must go beyond the traditional technical curriculum and required minimum hours of liberal arts courses to impart to their graduates "the broad education necessary to understand the impact of engineering solutions in a global and societal context" and an awareness of the "economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political aspects" of engineering practice.[1]

Policy as Part of an Engineering Curriculum

Many seem to agree that engineers can be vital components in the public policy process, no matter what form the policy development process may take. Engineers have a unique and very practical perspective on the world, and their analytical and problem-solving skills can be used not only for the solution of quantitative design problems, but in the resolution of policy debates that involve non-quantitative social and political issues. This aspect of the engineer's reasoning ability is one that is persistently over-looked by the public, political leaders, and engineers themselves.[6,7]

This all presents an opportunity for educational institutions to provide engineers a more solid foundation for participating in policy-making processes at all levels. The goals of such an educational endeavor should be two-fold: first, engineers must understand and feel comfortable with the various mechanisms associated with public policy development and, second, engineers must consciously recognize their own importance and role in policy-making.

Both undergraduate and graduate engineering programs can play a role in meeting these objectives. At the undergraduate level, most traditional students may have some exposure to public policy development concepts due to courses and out-of-class experiences at the K-12 level, but most lack a working knowledge of the process. Therefore, information on policy development forums, such as the legislative branch, administrative agencies, and the courts, must be made available in some form. While much of the basic information may be covered in courses taken as part of a liberal arts core or related mechanism, engineering students must put the information into their own context in order to internalize it for future use. In other words, engineering students need a solid base in public policy development that can be provided by liberal arts courses, but then need follow-up that integrates the material into the engineering curriculum so as to make the point that these political and legal realities are very much a part of engineering practice.

One approach to the above is a special engineering course, which often carries a name such as "Engineering Practice", "Engineering Projects" or "Engineering Seminar." In this type of format, engineering students are presented with real-world problems and case studies, and thereby forced to deal with the policy instruments discussed above. These courses are valuable, and serve the purpose of introducing students to inter-disciplinary thought and team-work within the context of engineering problems. More difficult, but also more effective, is the incorporation of these topics within "traditional" engineering courses.

In reality, many opportunities exist to insert relevant public policy issues into existing undergraduate engineering courses. Although this is less true for the traditional freshman and sophomore courses, junior and senior level design courses cover topics rife with public policy implications. For example, the development and implementation of power systems, in actual practice, often stirs public policy debate and always raises various federal, state, and local regulatory issues. Meaningful discussion of these issues in the context of a class dealing with technical design methods and criteria reinforces to the student that these policy issues are inexorably inter-twined with the design process. Similarly, highway design projects often become entangled in very complex environmental issues and other political and social controversy. Teaching engineering students how to function more effectively in this environment, as part of highway design courses, also lets them know that these issues cannot be ignored and are part of every design project – in other words, determining the proper path from A to B may be based on everything *but* the most efficient, economical design. The same is true, of course, of environmental engineering design courses – the list goes on and on. However, as always, the devil in is the details. How can this material be covered in a class that is already "over-booked" with respect to material coverage, and by instructors who may not themselves feel comfortable with the material?

While some engineering professors may be familiar and comfortable with the public policy process and associated issues, many are not. This presents a problem because, as with most things, real-life examples and anecdotes play a crucial role in making the subject come alive for engineering students. The problem can be solved in various ways – team-teaching, wise use of adjuncts and guest lecturers, and creation of additional opportunities for faculty to become involved in the public policy process through consulting and other activities. With respect to the issue of introducing even more material within the confines of a semester, the only answer is prioritization. Many engineers, such as those that took part in our focus group meetings, agree that it is not the detailed coverage of numerous topics that stayed with them and helped them with their engineering careers, but the way in which they learned to learn. So perhaps there is more room than we all suppose to cover topics of broader importance to engineering practice – ABET certainly seems to think so.

At the graduate level, the same approach can be used, with a little more focus. Of course, most engineering graduate students are not going to be taking liberal arts courses as an introduction to public policy development, but presumably they have either been exposed to the material at the undergraduate level or through actual engineering practice. Within the graduate curriculum, there is an opportunity to insert more specific courses geared toward policy issues, such as "Engineering Law" and more focused courses, depending on the student's major, such as "E-

Law and Policy" for computer engineers, or "Environmental Regulations and Policy" for environmental engineers. However, once again, it is important to take advantage of resources outside the traditional university setting to put the material into context.

Conclusion

In order to understand why their involvement in so important in the development of public policies, engineers must be made aware of the legal and other immediate implications if they do not become involved. In addition, they must also understand that professionalism demands their involvement. Most professional engineers know that the first and foremost responsibility of engineers is to protect the public safety and welfare at large. After all, this is the factor that sets engineers apart from other professions. However, many engineers do not recognize that they cannot wholly satisfy that responsibility unless they become active participants in the development of public policies. By utilizing their unique set of skills, talents, and educational experiences, engineers can affect the outcome of policy decisions in a major way. It is the responsibility of their educators to help them realize their importance in this big picture.

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