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LITERATURE REVIEW OF THE KNOWLEDGE AND SKILLS THAT ENABLE ENGINEERS TO PARTICIPATE IN PUBLIC POLICY

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ABSTRACT

The role of engineers in public policy can be seen as a twofold endeavor: (1) to help create public policy related to the utilization of technology to solve public problems, as well as monitor and assure compliance with such policies; and (2) to use engineering knowledge to assist in the construction of policy directives to help solve social problems. The engineering education community agrees that it is noteworthy that students increase their understanding of different public policy issues. One example is related with its creation and evaluation. Different courses have been created to reach this purpose. However, there are curricular questions in which explicit or suggested answers are needed to promote the dialogue around them and build consensus. Two of those questions are related with the knowledge and skills that engineering students must obtain in order to be able to participate in the creation and evaluation of Public Policy issues. The results of a literature review are presented here among with the evidences that support it. Some topics related with the knowledge that engineering students should develop to succeed in public policy are the history of engineers in public policy, how public policy affect the technical field, from where the public policy emerges, the policy making process, and the knowledge of how to write of a public policy. In the same way, different skills will be presented as emerged from the literature review. Some of them are: being able to identify and use the correct discourse depending of the audience, the ability to make decisions after assessing different possible solutions based on different attributes, the understanding of ethical situations, and appreciation of complexities and problems with open-ended questions.

1. INTRODUCTION

In 2004, the National Academy of Engineering (NAE) published a document titled "The Engineer of 2020: Visions of engineering in the New Century"(National Academy of Engineering, 2004). One of the claims made by the authors of this report was that engineers must "get more involvement in the setting of public policy and participation in the civic arena" because "technology …[has become]… increasingly ingrained into every facet of our lives"(National Academy of Engineering, 2004). Although programs in engineering and public policy started more than twenty years ago in well-known Universities like Carnegie Melon

(1976) and Maryland University (1981) (American Association for the Advancement of Science, 2011), and the need for engineers that know about public policy was manifested by entities like IEEE (Casazza, 1992); there is no agreement yet, in the academic community, as to what and how to teach and engage engineers with public policy. The main goal of this literature review is to identify the basic concepts (knowledge) and the necessary skills that will enable engineers to participate effectively in public policy. The main sources were articles detailing how public policy is taught in schools of engineering through specific courses or over the whole curriculum.

2. BASIC CONCEPTS THAT ENGINEERS SHOULD KNOW ABOUT PUBLIC POLICY

The following concepts related with public policy emerged repeatedly from the literature related with teaching public policy to engineers: the definition of public policy, the role of engineers in public policy from a historical point of view, the interaction between engineering and public policy, the source from which public policy emerges, and the policy making process and the need for engineers to know how to write public policy. Because of the nature of the problem, the type of literature review done for the project was thematic. In this review, the major ideas of different authors who have written about general curricular design, curricular design in public policy for STEM programs, and authors who have published their course curriculums in public policy whose students are categorized under the umbrella of STEM, were investigated.

2.1 Definition of Public Policy.

In order to effectively engage in public policy, engineers must understand what public policy is. Tull & Jones (2006) established that public policy is the "funding, procurement, and/or regulation that the government provides". Myers (2008), includes in the definition "decisions", "commitments" and "actions". In addition, it includes not only the government but also the interpretation of the government's positions of authority interpreted by "various stakeholders" (2008, p. 13) . Myers also adds that a public policy "affect[s] the daily lives of the government citizens"(2008, p. 13), "our lives including, but not limited to, federal, state and local governments. Public universities, its utilities, and NGOs may also be included." (Devon & Haight, 2006, p. 2).

2.2 History and role of engineers in Public Policy

It is also helpful for engineering students to be aware of the history of engineers in public policy so they can understand how the current role of engineers in public policy has developed. Going back in history, the first engineering school was the United States Military Academy and at the beginning of the 19th century, before the Civil war, this institution "became the nation's major source of civil engineers and of engineering educators" (Smithsonian, n.d.). However, it was only until 1849 in which the Renserlaer School was transformed in the first instituiton that provided professional training for engineers in America: The Renserlaer Polytechnic Institute (Noble, 1979). In spite of this, the schools of engineering were limited (only six) and it was only until the the Morril act, 1862, when the number of schools of engineering was increased to seventy (Noble, 1979). According to Grose (2009), one of the reasons that explained why engineers American engineers are not as involved in public policy as in some other nations, is

because there was an inherent association between local business and early land-grant colleges. This association made American engineers "always tightly aligned with industry" (2009, p. 48) and because of that, engineers "haven't been encouraged to become public servants" (2009, p. 48). This is not the case in many other nations for example in France, in which engineering schools were devoted to supplying the government demands for engineers (Chatzis, 2009): engineers have "historically constituted the French state" (Jesiek & Shen, n.d., p. 2). Likewise, in China, "many engineers have held powerful positions in the upper ranks of … [its]… ruling communist party" (Jesiek & Shen, n.d., p. 2).

2.3 The role of policy in technological development

Another topic that engineering students must learn is how public policy affects their technical field. One way to gain that knowledge is by studying the legislation about topics related to different engineering disciplines (Isaacs, Barry, & Bosso, 2006).

The necessity for engineers to know about regulations could be inferred from Isaac et al's argument that: "[regulations] promote the advancement of research and development, promote more timely commercialization of products, protect the public from possible negative effects of these technologies and their use, and, in the process, be responsive to public concerns regarding technology" (2006, p. 5).

Cassaza (1992), in the same way, claimed that engineering students should understand the role of regulation as a "substitute of market forces" (1992, p. 8) and that engineers could also be involved in the "process of establishing tariffs" (1992, p. 8) in the market. As a consequence, one could argue that if students know about regulations, they would discover how those regulations affect their discipline. Once they are able to identify those regulations, they can identify opportunities for developing products within those regulations that, "protect the public from possible negative effects of … technologies" (Isaacs et al., 2006, p. 5). The regulations, or the laws, are also the warrants that validate the claims that an engineer could state when creating solutions (Ross & Karis, 1991).

2.4 The source from which Public Policy emerges

Students must also be aware of who shapes the public policy. In order to participate in policymaking, students need to understand the various stakeholders in the policy process. Casazza claims that there is a "bias" against engineers at "Federal hearings in Washington" (1992, p. 6) because of "their poor understanding of the working of the workings of government" (1992, p. 6). Green and Emison (2006), in the same way, proposed the following roles from government as crucial to be understood in "setting public policy": "Legislatures (Legislative staff), lobbyist, bureaucracy, courts, interest groups and chief executives" (2006, p. 6). Myers and Stuart (2010) also argue that students should learn how a law is enacted and how various actors affect that process. Myers argues that groups and individuals exercise "influence in the forms of money, prestige, information, media attention, leadership, and political management skills to sway senior legislators to its agenda" (2008, p. 16).

2.5 The policy making process

One additional concept that engineers should address is the policy-making process. According to Hira & Bailey (2008) not understanding the policy making process makes individuals "see policymaking as an irrational process driven solely by ignorance and political influence" (Grose, 2009, p. 1). This discourages individuals from getting involved in the policymaking process. Understanding how to use relationships and influence to affect policy is also important for engineers trying to influence policy related to engineering.

3. SKILLS TO BE ABLE TO PARTICIPATE IN PUBLIC POLICY

3.1 Communication

Communication is a critical skill that engineers must develop in order to succeed in public policy. One of the claims Cassaza (1992) made was that "engineers must develop significant communication skills" as one of the ways to decrease a "bias" (1992, p. 6) that, according to him, existed against engineers in the United States government. Likewise, Dunn (2006), Tull and Jones (2006) proposed courses in public policy for engineers in which the learning outcomes were related explicitly to the development of communication skills. Dunn (2006) argued that author's students should "communicate project results effectively" (2006, p. 2). Tull and Jones (2006), similarly, argued that students should develop "verbal, written, graphical ... skills with special emphasis on the verbal communication of technical information" (2006, p. 2). In other courses, like the initiatives presented by Devon and Haight (2006), by Harter and Libros (2010), by Yeigh and Yeigh (1999) or by Myers and Stuart (2010), communication is not explicit as a learning outcome, but to succeed in the courses, students were asked to do assignments in which they had to use effectively their written and verbal skills.

Some of the assignments that students were asked to do were "oral presentations of … [project] … results" (2006, p. 8), a written report with a critical analysis (Devon & Haight, 2006) and tasks focus on the development of skills while working independently out of class (T. Myers & Stuart, 2010). Other strategies proposed were the writing of "position papers" (Harter & Libros, 2010) or the engagement of students in public policy debates (Yeigh, 1999). However, one strong concern about engineers' communication skills is not their ability to communicate technical knowledge but their ability to communicate that knowledge in a way that could be understood by people from other technical disciplines or even more challenging, by non-technical people. Teaching engineering students merely to learn universal expected procedures …[that are appropriate only in their own field],… will provide them with inadequate preparation for the multidisciplinary arena of public policy (Ross & Karis, 1991, p. 241). Cassaza reinforced this idea: [Engineers]… "must understand that there are different audiences for which different techniques must be used" (1992, p. 7). Likewise, Dunn Dunn (2006) made their students present their project to the external public, the Chicago Department of the Environment and to the Environmental Protection Agency (EPA), a very different audience to engineers.

Finally, a further skill related with communication, is the ability to express opinions, relay facts, and articulate arguments clearly and concisely in writing. This skill is "substantially different [from] writing laboratory or design project reports" (T. Myers & Stuart, 2010, p. 4). This

knowledge can be taught in different ways such as writing a letter to public officials (2008, p. 79) or how to write a public policy for "targeted audiences'" (2010, p. 4). The work from Ross and Karis (1991), supports this claim: The importance of communicating effectively in sites ... labeled as "non-congruent sites of discourse," that is, sites in which they will need to interact and communicate with members of discourse communities whose file-dependent rules and procedures are different from their own.

3.2 Contrast and Compare multiple attributes to make decisions

Engineers, in order to be ready for public policy, must develop the ability to weigh different attributes in order to contrast and compare them before making a decision. Tull and Jones (2006) justifiy this skill with the definition of public policy since it is "the art of the government in terms of selecting alternative courses of action" (2006, p. 4). Myers (2008) also shows that this skill is needed because public policy can be shaped by "competing groups, seeking shares of government resources" (2008, p. 14). According to Myers, in the process of public policy, a public policy maker will be lobbied by members of competing groups in order to promote the inclusion in the agenda of issues that benefit the group they represent. Tull and Jones (2006, p. 4) also support this skill while explaining the role that engineers can play as public policy analysts. According to them, the policy analysts "formulate, implement, and evaluate public policy … [using] … cost-benefit analysis, and risk analysis to analyze public policy alternatives" (2006, p. 4). Likewise, Cassaza (1992) supports the notion that engineers must be able to evaluate different alternatives. When communicating those alternatives to the public policy decision makers, they need to be able to explain "what alternatives were considered, why were these chosen, what assumptions were made, and what the uncertainties were" (Casazza, 1992, p. 7). In the same way, students who were taught by Grose (2009), had to complete a project in which "the key … was … [the] … process called multi-attribute decision making, which requires weighing several actors [in which the possible outcomes were ranked]" (2009, p. 48). Rusell et al (2006), reinforces this idea by stating that well-grounded decisions required the understanding of different issues like "technological capabilities, limitations, costs, and collateral impacts" (2006, p. 2). Myers and Stuart (2010) added economics, risk and environmental issues to the attributes that can be contemplated in decision making.

3.3. Interdisciplinary work

The final skill that is going to be presented as a result of this literature review is related to the ability to appreciate and work with people from other disciplines. This skill is relevant not only for public policy but for preparing engineering students to interact in all environments in which they might find themselves working as professionals (Russell et al., 2006). The way in which every profession communicates and works is different. It is critical that engineering students acknowledge that the values and manner of interaction of each profession with technology and society are different (Green & Emison, 2006, p. 6).

If engineers do not take a more active role in the setting of public policy, they will be left to work within the policies set by others who may lack adequate technical skills and they will be remiss in their duties as citizens to foster good policy. If the policy setters do not develop a

greater appreciation of the technological issues involved they will develop and implement policies that are less than optimal (Green & Emison, 2006, p. 2).

4. CONCLUSION

An increase in engineering students' knowledge of public policy and the active participation of engineers in public policy has been repeatedly recognized by leaders in both the engineering and political spheres as relevant. However, there is little empirical evidence regarding how engineering students should be exposed to public policy. This study defines some of the major skills and knowledge that engineering students need to have in order to participate effectively in public policy based on a thorough review of the literature. Knowledge of the role of policy in technological development, basic knowledge in the way the government work, the source from which policy emerges and both abilities to communicate beyond disciplinary boundaries and to contrast and compare technical, societal and environmental attributes to make decisions , are the most mentioned skills and knowledge that students should have according to the literature review.

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