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Integration of Public Policy into Civil Engineering Undergraduate Curricula: Review of Civil Engineering Body of Knowledge and Course Application

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Abstract

The field of civil and environmental engineering directly ties with serving the needs of the public through infrastructure development and improvements in sustainable environments. Integrating this reciprocal connection between public policy and civil engineering into undergraduate civil engineering education is critical for the preparation of the next generation of engineers. This project, first, reviews the guidance of public policy in civil engineering programs, such as ASCE's Civil Engineering Body of Knowledge. Then, a pedagogical application is presented that focuses on the integration of public policy concepts, methods, assessment tools and techniques in a required, upper level course in civil and environmental engineering at Bucknell University. Iterations of this course integration have been taught for over a decade, and experiences on how to engage students around this timely topic is included. Specific course materials including discussion strategies are presented, as well as methods to maintain up-to-date connections with critical ever-changing topics such as climate change. Also, case studies related to ASCE Policy Statements are shared, and summative assessments that tie directly to ABET criteria are presented, in order to showcase ways that public policy can be taught at the undergraduate level at institutions throughout the United States. Within the lesson material, both a combination of regulation and market-based instruments are presented using civil and environmental engineering examples to spur interest in field and practical applications. Lastly, opportunities within the engineering and public policy arena, in terms of graduate programs and career pathways, are introduced to spark future career interests. As more undergraduate engineers are exposed to the topic of public policy, they can begin their careers with a more well-rounded and holistic understanding of how they can lead and potentially improve the field of civil engineering in serving the public, economy, and the environment.

Keywords: public policy, civil engineering, undergraduate, curricula, CEBOK, pedagogy

Introduction

Public policy continues to be interconnected with the field of civil engineering as it plays a role in how infrastructure is developed. In the twenty-first century, civil engineers are faced with multidisciplinary challenges that require skills beyond the traditional technical knowledge. American Society of Civil Engineers' [1] *Vision for Civil Engineers in 2025* establishes the need for civil engineers to serve as "master builders, stewards of the environment, innovators, managers of risk, and leaders of public policy". Therefore, the emphasis on cultivating and educating the "next generation" of civil engineers to take on these roles is important.

This emphasis has been evident in a number of engineering education guidance programs such as ABET [2], National Academy of Engineers [3] and ASCE's [4] Civil Engineering Body of Knowledge (CEBOK). Although civil engineering and public policy curricula are more prevalent at the upper level graduate programs, effort to integrate public policy at the undergraduate level provides value in cultivating well-rounded civil engineers that understand multidisciplinary constraints [5, 6, 7].

This project focuses on the development and implementation of public policy concepts, methods, assessment tools and techniques into a fourth year, required, civil and environmental engineering course at Bucknell University. Pedagogical material and processes are presented with integration of the ASCE Policy Statements and other relevant public policy case studies. A description of summative assessments that tie to ABET criteria is provided. Also, a discussion of how to spark future career interests through presenting public policy career pathways and continued professional development opportunities in graduate programs is included. Although there are a few programs that have been developed that focus solely on civil engineering and public policy [6], this paper serves to provide an example of how traditional civil engineering programs throughout the country can begin to more directly integrate public policy into curricula.

Public Policy in Engineering Education

Civil engineers continue to shape the world through the planning, design, and construction of infrastructure systems. Through these developments, the role of public policy plays a significant part in guiding the opportunities and challenges associated with building and changing the existing landscape. Laws and regulations are set in order to ensure compliance of policies during all phases of development [8].

In contrast, civil engineering also has an ability to influence public policy and the possibilities for how policy is addressed [9]. In the United States, primarily lawyers, public administrators, and social scientists set public policies [10]. However, advancements in the field through technological innovation can open the door to new possibilities in terms of how the public uses infrastructure and finding ways to reduce impacts on the environment.

Civil engineering-related policies touch on all aspects of society, economy, and the environment. Some examples of policy areas that guide infrastructure development include climate change, public health, safety, disaster mitigation, licensure, public engagement, and land conservation. ASCE [11] has developed Policy Statements targeting the "major technical, professional, and educational issues of interest to the civil engineering community and the nation."

Review of CEBOK and Related Engineering Program Guidance

As 21st century complex problems continue to emerge, an awareness of the need for improvements in public policy education to civil engineering undergraduates has been identified [8]. Civil engineering and engineering education guidance programs are incorporating this need through integrating public policy goals into civil engineering undergraduate outcomes.

ASCE's [12] first Civil Engineering Body of Knowledge (CEBOK1), identified "business and public administration" as one of the fifteen outcomes that should be incorporated into curricula as a prerequisite for licensure [13]. ASCE's [14] second Civil Engineering Body of Knowledge (CEBOK2) further emphasized the role of public policy by adding two additional outcomes (humanities and social sciences) to the existing math and science outcomes under a "foundational category" [15]. Also, two separate outcomes for "public policy" and "business and public administration" were created under a "professional" category. The third category "technical" also has some policy-related outcomes including "risk and uncertainty" and "contemporary issues and historical perspectives".

Since then, the third edition of ASCE's [4] CEBOK3 reorganizes the outcomes into four categories (foundational, technical, professional, and engineering fundamentals). Although the outcomes of "public policy", "business and public administration", and "contemporary and historical perspectives" were removed as separate outcomes in CEBOK3, they are now integrated in the "professional responsibilities outcome". Also, a new outcome, "engineering economics" was added in order to address the business-related topics in CEBOK2 [13]. Table 1 summarizes this comparison of all three versions of CEBOK in order to show the changes in the outcomes over time, specifically in relation to public policy and policy-related outcomes.

As mentioned, CEBOK3 now emphasizes public policy within the "professional responsibilities" outcome. CEBOK3 states "professional responsibilities" include the following topics: safety, legal issues, licensure, credentialing, innovation, knowledge and appreciate of history and heritage of the profession, cultural perspectives, public policy, and global perspectives [4]. CEBOK3 stresses the importance of public safety as the primary responsibility of civil engineers. Therefore, civil engineers must be "aware of the wide variety of legal and regulatory responsibilities that pertain to the practice" [4]. These responsibilities include understanding and applying standards, codes, regulations, contracts, and guidelines at all jurisdictional levels (federal, state, and local). This is a critical component of civil engineering and public policy education.

The National Academy of Engineers [3] has developed the Grand Challenges as a way to engage students in the complex problems of the twenty-first century. These problems address societal, technical, economical, and environmental issues through four "cross-cutting" themes: sustainability, health, security, and the joy of living. All four of these themes influence, as well as are influenced by, the field of civil engineering. Engineering programs throughout the country have adopted the Grand Challenges program to infuse public policy-related topics into real world problem solving [16].

ABET [2] also provides guidance on student outcomes as part of an ABET-accredited engineering program. There are seven outcomes, with two that directly address connection to "global, economic, environmental and societal contexts" [2]. Outcome 2 focuses on the "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, and environmental, and economic factors" [2]. Outcome 4 is the "ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts" [2]. Although public policy isn't directly stated in the outcomes, the need to incorporate multi-disciplinary issues and the cause and effect of engineering decisions and solutions on other systems is evident.

Although there is consensus that humanities and social sciences topics such as public policy are important, there is a wide range of approaches used to introduce and incorporate them into curricula ([15, 17]. Due to constraints within the undergraduate engineering education curriculum, very few public policy and engineering programs exist at the undergraduate level [6]. Most institutions begin to bridge these concepts together more directly at the graduate level through engineering and public policy master's and doctorate level programs.

Therefore, this research focuses on the implementation of public policy in a required upper level undergraduate civil and environmental engineering course (CEEG 492- Civil Engineering Planning and Design I) at Bucknell University as examples of pedagogical techniques that can be used to build on public policy issues taught in the first three years of the student's undergraduate career. This application has been taught for over a decade (since 2011), and therefore, although methods and case studies are continuously updated, a general insight into the process and applications used in the fourth-year are presented.

Table 1- Comparison of Outcomes in ASCE's CEBOK1, CEBOK2 and CEBOK3

<table>
<tr><th>ASCE CEBOK1 [12]</th><th colspan="2">ASCE (2008) CEBOK2 [14]</th><th colspan="2">ASCE (2019) CEBOK3 [4]</th></tr>
<tr><td>Technical Core</td><td rowspan="4">Foundational</td><td>Mathematics</td><td rowspan="4">Foundational</td><td>Mathematics</td></tr>
<tr><td>Experiment</td><td>Natural Sciences</td><td>Natural Sciences</td></tr>
<tr><td>Design</td><td>Humanities</td><td>Humanities</td></tr>
<tr><td>Multi-disciplinary</td><td>Social Sciences</td><td>Social Sciences</td></tr>
<tr><td>Engineering Problems</td><td rowspan="11">Technical</td><td>Materials Science</td><td rowspan="7">Technical</td><td>Project Management</td></tr>
<tr><td>Professional/Ethical</td><td>Mechanics</td><td>Engineering Economics</td></tr>
<tr><td>Communication</td><td>Experiments</td><td>Risk & Uncertainty</td></tr>
<tr><td>Life-long Learning</td><td>Problem Recognition and Solving</td><td>Breadth in Civil Engineering</td></tr>
<tr><td>Contemporary issues</td><td>Design</td><td>Design</td></tr>
<tr><td>Engineering Tools</td><td>Sustainability</td><td>Technical Depth</td></tr>
<tr><td>Specialized Area</td><td>Contemporary Issues & Historical Perspectives</td><td>Sustainability</td></tr>
<tr><td>Project Management, Construction & Asset Management</td><td>Risk and Uncertainty</td><td rowspan="4">Engineering Fundamentals</td><td>Materials Science</td></tr>
<tr><td>Business & Public Administration</td><td>Project Management</td><td>Engineering Mechanics</td></tr>
<tr><td>Leadership</td><td>Breadth in a Civil Engineering Area</td><td>Experiment Methods and Data Analysis</td></tr>
<tr><td rowspan="10"></td><td>Technical Specialization</td><td>Critical Thinking & Problem Solving</td></tr>
<tr><td rowspan="9">Professional</td><td>Communication</td><td rowspan="6">Professional</td><td>Communication</td></tr>
<tr><td>Public Policy</td><td>Teamwork and Leadership</td></tr>
<tr><td>Business and Public Administration</td><td>Lifelong Learning</td></tr>
<tr><td>Globalization</td><td>Professional Attitudes</td></tr>
<tr><td>Leadership</td><td>Professional Responsibilities</td></tr>
<tr><td>Teamwork</td><td>Ethical Responsibilities</td></tr>
<tr><td>Attitudes</td><td colspan="2" rowspan="3"></td></tr>
<tr><td>Lifelong Learning</td></tr>
<tr><td>Professional and Ethical Responsibility</td></tr>
</table>

Pedagogical Method

Prior to entering into the fourth year at Bucknell University, civil and environmental engineering students (two separate majors in the Department of Civil and Environmental Engineering) have been exposed to public policy issues, themes, and opportunities in a number of courses in their first, second, and third years. Real world course projects, day-to-day news stories, and cross-disciplinary problem solving is used to expose students to public policy from the introductory-level courses (introduction to engineering) to sub-discipline specific courses (such as geotechnical, water, structures, transportation, and environmental). It is important that students are exposed to policy concepts early on so they have an awareness of issues as they learn technical knowledge, similar to professional-related issues such as leadership, teamwork, communication, etc. [18]. Once students have entered their fourth-year, they have the technical knowledge and are ready to apply public policy issues to real design challenges.

By incorporating public policy issues (and related professional issues) in all four years of the undergraduate experience, students can have a deeper understanding and awareness of the impact engineering has on society, environment, and the economy [17]. This study highlights specific strategies used at the fourth-year (once students have already been exposed to real world examples in a number of subdiscipline-specific courses) to further formalize the connection between public policy and civil and environmental engineering design.

The required upper level course for all civil engineering and environmental engineering majors (CEEG 492- Civil Engineering Planning and Design I) highlighted in this study begins with revisiting core topics that are embedded in the public policy discussion such as leadership, ethics, and sustainability. All three of these concepts have been taught and assessed in previous courses, however, they are revisited again, at a time when technical knowledge has been fully established (in the fourth year) and students are ready to apply the concepts in the field post-graduation. Figure 1 displays a flow chart of the core topics used in preparation for the public policy application.

Leadership is addressed as the first concept in order to spark student interest in having an ability to "make change" and influence the world through engineering design and development. This connects to public policy as traditional policy-makers tend to be lawyers, public administrators, and social scientists [10], therefore, empowering civil engineers with the leadership skills needed to develop and propose policy is critical. For the leadership section, some highlights of what is covered include discussing the paper "What is Engineering Leadership? A Proposed Definition" [19], specifically how to define engineering leadership and how to compare it with engineering management. Also, ten qualities of an effective leader are discussed and students complete a self-evaluation of their own leadership qualities based on "The Art of Leadership" [20]. Individually, students rate each of the ten leadership qualities (vision, ability, enthusiasm, stability, concern for others, self-confidence, persistence, vitality, charisma, and integrity) on a scale of one to ten (low to high) based on their success in that particular area. Then, they provide a self-reflection summary on their scoring results and how they plan to improve on three specific areas. Students also watch a portion of the ASCE [21] video on "Recognizing the Importance of Leadership during Covid-19 and Beyond" to make connections of how practicing engineers use leadership skills to address current real-world public health issues.

For the ethics section, since all fourth-year students have already been exposed to engineering ethics in previous courses, the discussion focuses on real world "day-to-day" engineering dilemmas that may be faced. First, the ASCE Code of Ethics [22] is presented and discussion of any updates to the code are provided. Then, "Suggested Tests to Evaluate Action" are provided to give students methods for coping with and examining how to face dilemmas [23]. Many times, students have already been exposed to these dilemmas through their own personal experiences in internships and wish to seek insight and resolution. Opportunities to share stories and ask questions are provided through an assignment where they write a "story" (real world or hypothetical) on an ethical dilemma that incorporates multiple ASCE [22] Code of Ethics canons. Students showcase their knowledge of the code which incorporates many elements of public service and safety.

For the sustainability section, core concepts related to the triple bottom line (environment, economy, and society) are revisited as students have learned and utilized these concepts in previous courses in their undergraduate career. At this level, more emphasis is placed on applying sustainability through the development of sustainability metrics and use of rating systems. ASCE's [24] Future World Vision is presented as possible pathways for students to explore as they consider post-graduate careers. This discussion usually sparks a lot of interest based on the opportunity for innovation and technological advancement of the field of civil engineering. Also, opportunities within ASCE, such as the "Committee on Sustainability" are presented as ways to get involved within professional societies and make an impact [25]. Over multiple lessons, the students are taught how to use the "SMART" (specific, measurable, achievable, relevant, and timebound) method [26] for developing sustainability metrics. Also, civil engineering-specific rating systems are showcased as possible options for implementation in senior design and/or possible credentialing opportunities. Many rating systems are shared, but there are three that are discussed in depth: Envision [27], LEED [28], and Living Building Challenge [29]. Students work in teams (senior design project teams) to select one relevant rating system specific to their project and as a result many teams find rating systems that address many infrastructure types including water, wastewater, bridge construction, transportation, etc. The students write up a summary explaining their rating system selection and how it will be used to guide their senior design experience. Also, they identify and explain which relevant metrics (credits) will be incorporated into their design. This exercise allows them to explore the potential impacts of their design on economic, environmental, and societal systems.

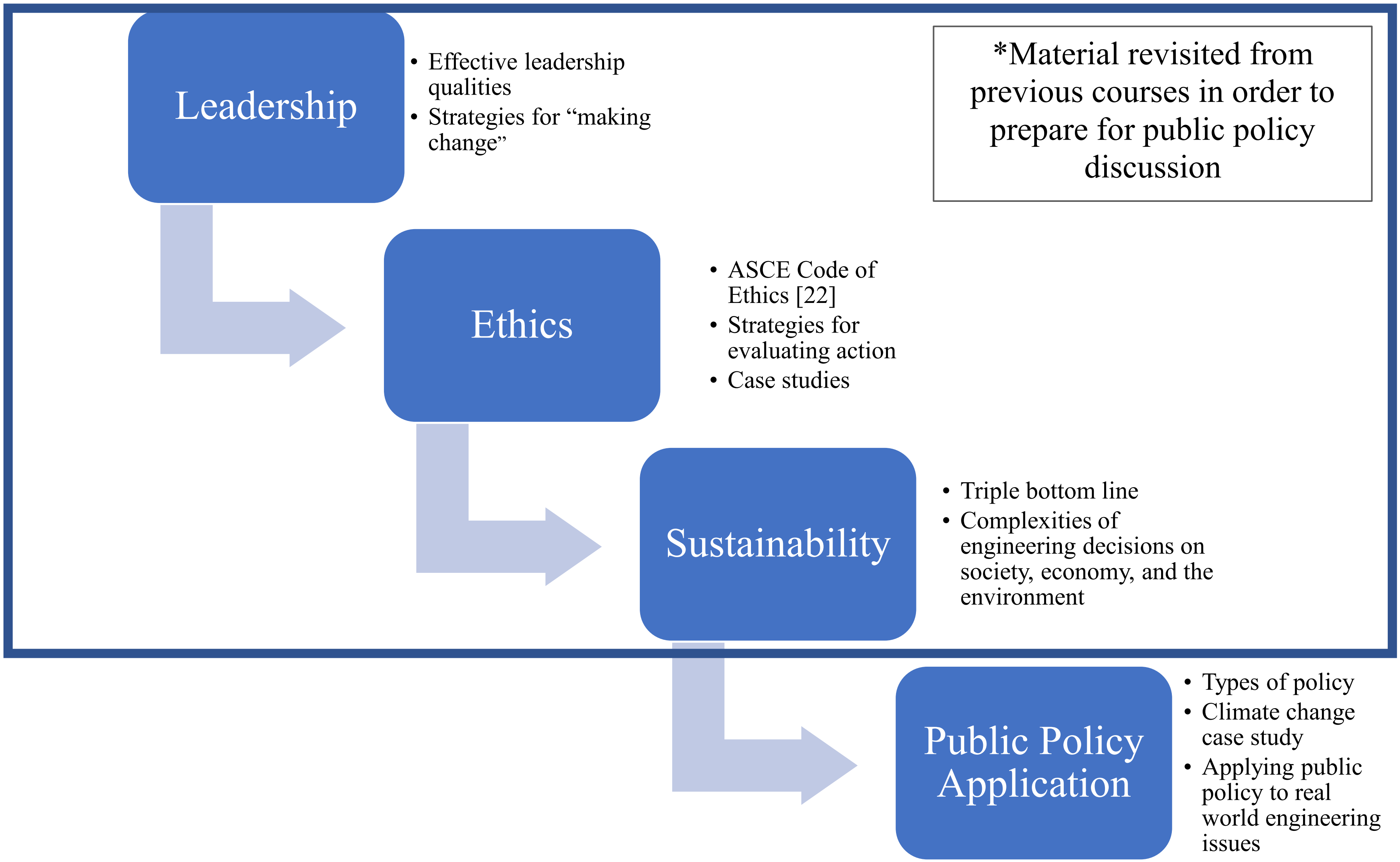

Figure 1- Overview of Concepts Revisited to Prepare for Public Policy Discussion

Public Policy Course Application

After the topics of leadership, sustainability, and ethics are revisited in the course, public policy material is presented. Although, at this point, many public policy topics and concepts have already been discussed (in this course and previous courses in the student's undergraduate career). The public policy portion of the course includes five primary components (Figure 2) over multiple lessons: fundamentals, group activity, case study, assessment, and future applications.

Over the process of implementing these five components, the following five learning objectives are covered, as shown in Figure 2:

1. Discuss the interconnection between the fields of public policy and civil and environmental engineering.
2. Identify types of public policy, including market instruments, and provide examples for each in relation to the field of civil and environmental engineering.
3. Analyze relevant civil and environmental engineering policy topics such as urban planning, water conservation, solar energy, material recycling, public transit, etc.
4. Apply the ASCE Policy Statements to a real world civil and environmental engineering problem.
5. Apply public policy solutions to future course work (feasibility study, senior design) in preparation for post-graduate experiences.

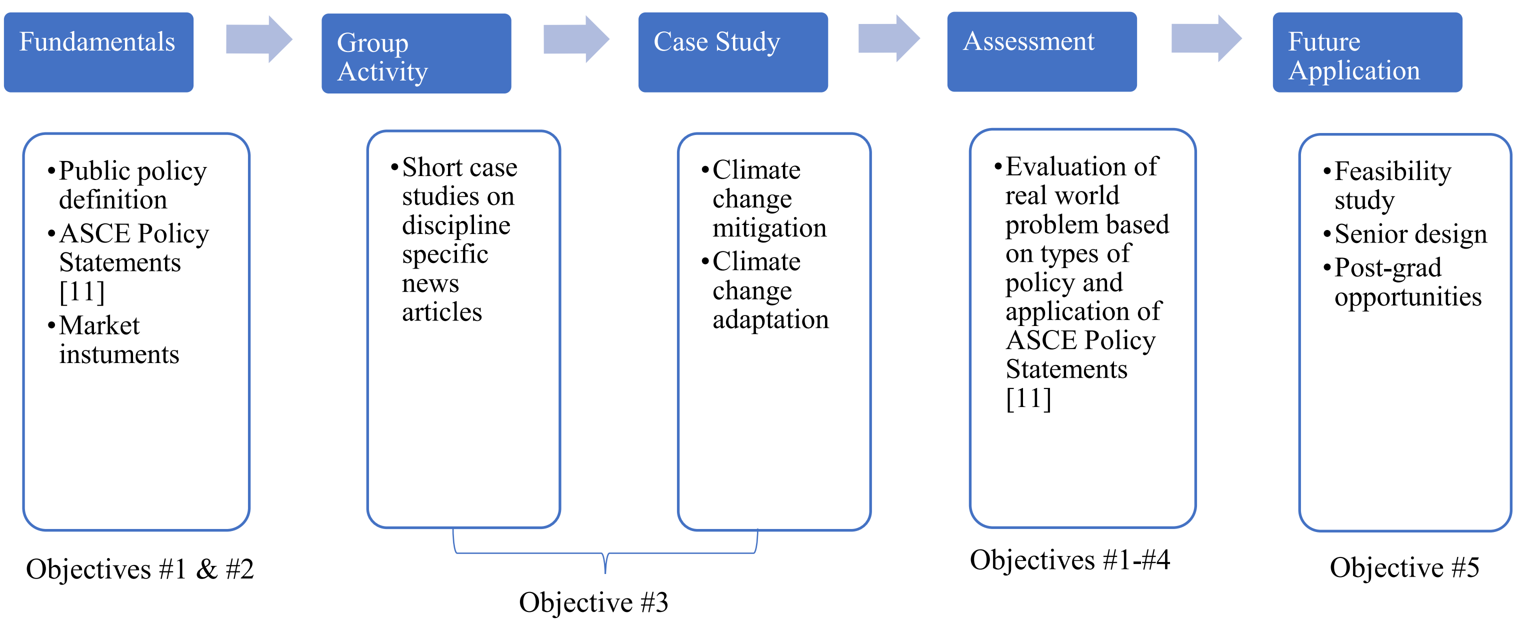

Figure 2- Public Policy Pedagogical Components in CEEG 492

Students are provided these objectives in each class as part of a "summary sheet" which is a document that provides an outline of the topic, lesson objectives, activities, and any problem statements needed for the class that day. This teaching strategy is based on the ASCE [30] ExCEEd Teaching Workshop (instructor completed in 2011 and received the ExCEEd Teaching Award in 2015) which focuses on improving engineering education through discussing effective teaching strategies. Also, discussion strategies from this workshop are implemented in order to engage students in two-way dialogue and provide a more interactive experience, rather than a traditional lecture style.

Fundamentals (Objectives #1 & #2)

The first portion of the public policy course material is focused on making sure all students are familiar with core concepts (learning objectives #1 and #2). Although students have learned about public policy issues in previous courses, revisiting the terminology as well as the fundamental reason this concept applies to civil and environmental engineering is discussed. Few students have the opportunity to take a public policy-specific course due to the rigor of the engineering curricula, so it is important to make sure all students are provided the same knowledge prior to asking for students to achieve higher categories in Bloom's taxonomy (remember, understand, apply, analyze, evaluate, and create) [31].

A warm up exercise is used to see how much prior knowledge students already have entering the class. The students answer two questions, "What is public policy" and "What is the relationship between public policy and civil and environmental engineering?" Then, as a class, their ideas are shared to launch a deeper discussion on the interconnection (cause and effect relationship of public policy and civil and environmental engineering). The opportunities to influence policy decisions is discussed, as well as the role policy plays in shaping the field of engineering (constraints, laws, regulations, codes, etc.).

The next discussion is focused on major twenty-first century topics that connect policy and engineering. Students identify topics such as public health, safety, climate change, land development, disaster mitigation, for example. Since the spring of 2020, class time has also been devoted to discussing the role of the COVID-19 pandemic on the field, specifically short and long-term changes that may continue as a way to promote public health and safety through design. Lastly, ASCE's Policy Statement website [11] is shown in order to present the multitude of topics and interconnections between civil engineering and policy. Some example policy statements are highlighted and discussed more in depth.

Once a general understanding of the interconnections is achieved, then specific forms of public policy are presented such as laws restricting behavior, laws establishing a maximum or minimum threshold, and market instruments. The purpose of each type of policy is discussed, as well as examples for each are provided:

- Laws restricting behavior- zoning and land use regulations, seat belt/driving rules, construction safety
- Laws establishing a maximum or minimum- speed limit, truck weights on bridges, building capacity, greenhouse gas limits

- Market Instruments- fuel taxes, transit subsidies, emission fines, toll road fees, energy star labeling, and renewable energy credits

Examples of market instruments are highlighted through showing videos and websites that depict applications of these instruments in civil and environmental engineering.

The discussion portion concludes with explaining the role of privatization and how some forms of governmental activities and assets are transferred to the private sector. The pros and cons of this process are shared and students present examples of how this is applied in the field. The opportunities of private public partnerships are also showcased through examples of real-world case study projects.

Group Activity (Objective #3)

Case study projects are further utilized through a group activity exercise completed in class. Students are presented four to five different civil and environmental engineering public policy topics, depending on the size of the class. Typical topics include urban planning, disaster mitigation, water conservation, public transit, green building, and solar energy. They are asked to select a topic that is relevant to their career interests, and then they are grouped into teams of three or four focused on one of the topics. A current news article (published within the last six months of the class) is provided for each topic, and students work in teams to read the article and then complete the following case study questions:

1. What is the main public policy issue being addressed?
2. What market instruments are discussed and how are they implemented?
3. What are the benefits and challenges faced with the current methods used?
4. What suggestions or recommendations would you provide to address the problem? What additional policy methods/market instruments could be used, if any?

Each team presents a brief synopsis of their article and then shares their findings for the questions. While each team presents, the students complete a tabular worksheet that has rows for each topic and columns for describing the civil engineering/public policy topic, and then examples of policy methods discussed by each team. By the end of the entire activity, students have been exposed to multiple real-world case study problems across various civil and environmental engineering subdisciplines (learning objective #3).

Case Study on Climate Change (Objective #3)

In order to give students a more in-depth discussion on one application, climate change is selected as a continual theme that has emerged throughout courses in the first, second, third, and now fourth-year classes at Bucknell University. Climate change is presented as a critical complex problem that needs to be considered in civil engineering planning, design and construction projects. The actions that civil and environmental engineers can take in each sub-discipline to reduce carbon emissions (mitigation) as well as prepare and protect infrastructure systems from potential impacts (adaptation) is discussed [32]. Video clips, news articles, case studies, and design strategies, are used to build on the students' existing knowledge and connect concepts of climate science to the field of civil engineering. A partner exercise is used to allow students to develop planning, design, or construction related techniques that show both mitigation and adaptation efforts. Students are asked to list at least three examples of mitigation and adaptation methods for their subdiscipline interest area (water, environmental, transportation, geotechnical, and structures) and then they share their findings with the class. By the end, students become familiar with climate change mitigation and adaptation strategies applicable to five sub-disciplinary areas of civil and environmental engineering.

Assessment (Objectives #1- #4)

In order to formally assess student knowledge, a writing prompt is assigned and is used for direct assessment for ABET student outcome #4 "ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts" [2], with an emphasis on societal contexts. The writing prompt assignment requires students to select a policy topic from the list of ASCE Policy Statements [11] that they are passionate about. Then, they are asked to learn more about the topic by finding a current news article (or two) that reflects this topic, and then they complete the following questions below in a one-page response:

1. Public Policy Issue- What is the main public policy issue being addressed in the news article and how does it relate to civil and environmental engineering? Be sure to emphasize the "social" context of the issue and the role of engineers to protect health, safety, and welfare of the public.
2. Public Policy Statements-Identify all of the ASCE Public Policy Statement(s) that correspond to the issue and discuss the policies that correspond to the issues in the news article.
3. Market Instruments-What public policy market instruments are discussed in the news article? If there are none, identify which could be used to address the issue (you may have to look beyond the article to know what is already existing in reference to that topic). For each market instrument, discuss the benefits and challenges of those approaches.
4. Additional Recommendations-What suggestions or recommendations would you provide to address the problem (beyond monetary market instruments)? How do these recommendations work in support of (or in conjunction) with market-based instruments?

The responses provided by students indicate their level of achievement of the student learning objectives #1 through #4, and provide valuable, and many times creative, approaches to addressing policy issues in civil and environmental engineering. Feedback is provided in order to further student learning and typically includes additional relevant policy statement applications and/or additional examples of types of market instruments that could be applied. Although ABET outcome #4 is directly assessed in connection to this assignment, it should be noted that ABET outcome #2 is further addressed in a subsequent assessment activity in the following semester of senior design.

Future Application (Objective #5)

The public policy component of this course is taught early on, around the time senior design projects and teams are formed. Therefore, the opportunity to incorporate the ideas and design strategies into senior design project planning, and eventually, the design process is possible. Future applications, such as senior design, are discussed with the students.

Another application is the discussion of policy, regulations, and codes associated with a class feasibility study project. Since senior design projects vary in focus and scope, a general feasibility study project is used to teach all students about the civil engineering planning process. Steps such as identifying codes and constraints with site development, exploring environmental impacts, identifying methods for public engagement (such as charrette workshops), as well as determining socio-economic challenges associated with project development, are presented.

In addition to course applications, future opportunities, such as public policy graduate programs, are showcased. Specialty engineering and public policy programs like University of Delaware [33], Carnegie Mellon [34], and University of California Berkeley [35] are shown, as well as professional organizations and professional development opportunities related to the cross-cutting themes, are presented. Many times, students will follow up with questions regarding how to engage and apply to these programs. Also, potential career pathways (both private and public) that merge both fields together (such as an urban planner, environmental policy analyst, energy manager, and disaster planner) are discussed [36]. Differences in working at various levels of government (federal, state, or local) versus the private sector are shared. Also, current roles of alumnae that have pursued these types of positions are provided to show examples of possible pathways after graduating from Bucknell University. In general, exposing students to these unique civil and environmental engineering experiences opens their minds to non-traditional careers and research related opportunities within the field.

Reflection and Future Work

Through review of engineering education guidance, there is an emphasis on infusing policy topics into the development and implementation of public policy material into civil and environmental engineering. Programs such as ABET, ASCE's CEBOK3, and other program guidance, state the importance of a well-rounded engineering that understands and can solve multi-disciplinary real-world problems. Although, these programs do not directly list "public policy" as a student outcome, understanding societal contexts and professional issues are stated as being critical to the knowledge and growth of civil and environmental engineers. Opportunities to directly embed public policy into the outcome definitions is something that can be promoted in future versions of engineering guidance.

Although many institutions face the challenge of identifying which topics to include and which to exclude, public policy can be easily connected to many real world, current day issues, as presented in the course application at Bucknell University. This course application at the fourth year builds on knowledge gained during the previous three years in the civil and environmental engineering program. The importance of the policy integration at all years of the undergraduate curriculum is also noted as it is not something added in at the end to just meet accreditation requirements, but rather comprehensively incorporated into various sub-disciplinary courses [18]. By doing this in the fourth year, basic topics can be revisited, and then a deeper understanding and application to case studies, feasibility study projects, as well as senior design, can be expected.

In order to further this study, development of a four-year process for public policy integration at the undergraduate level can be proposed. Since very few universities have a unique "public policy and engineering" undergraduate program [6], having a detailed flow chart would be useful to identify core courses and typical opportunities for multi-year application, prior to the fourth-year application.

This study serves as the foundation to providing universities with ideas specifically for the fourth year and ways to begin the integration into a course (or courses). In addition, the following recommendations and next steps are provided with regard to both engineering program guidance and program integration:

- Public policy in student outcome guidance- Engineering education guidance programs can more explicitly target the concept of "public policy" as a part of required learning outcomes.
- Public policy in the undergraduate curriculum- An effort to formalize the amount of public policy knowledge gained in the undergraduate level, versus leaving it for the graduate level, could be clearer across institutions throughout the country.
- Undergraduate program guidance- Program guidance on how to integrate public policy at all four undergraduate levels is needed (from introductory courses to upper level required design courses).
- Inventory of public policy pedagogy- Undergraduate civil and environmental engineering programs can be inventoried and assessed based on their existing public policy methods, in order to have knowledge of existing efforts.
- Public policy material in design level courses- Example public policy pedagogy applications, such as this study, can be shared and adopted at similar civil and environmental engineering programs.
- Public policy pedagogical improvements- As the course application at Bucknell University has evolved since 2011, the methods and case studies have continuously been improved to reflect current day issues. This yearly improvement cycle will continue, and it is suggested that other public policy course application follow a similar iteration upon each course delivery.

Conclusion

Public policy is an ever-changing discipline that directly connects and influences the field of civil and environmental engineering. As twenty-first century challenges continue to emerge, having cross-disciplinary engineers that can be creative, understand societal contexts, and apply professional skills, along with using technical knowledge, is important. After a review of engineering education guidance programs such as ABET, ASCE's CEBOK3, NAE's Grand Challenges, it is evident that professional and societal topics, such as public policy, should be infused in the undergraduate curriculum. More direct emphasis on the topic of "public policy" as a student outcome could be included, however, many programs struggle with finding time and space in existing curricula to incorporate these concepts.

This study includes the development and implementation of public policy topics into the CEEG 492- Civil Engineering Planning and Design I course at Bucknell University since 2011. This application serves as an example of how institutions can begin to directly cover public policy in a required upper level course (or courses). Future work includes exploring recommendations for a multi-year course integration across all four years of a traditional civil and environmental engineering curricula. This course application includes revisiting key terminology and applies case study methods to allow all students to have a comprehensive knowledge of public policy, regardless of prior experiences. As more institutions incorporate these methods and a more formalized support of public policy application is embedded in engineering guidance, the next generation of civil and environmental engineers can continue to influence and promote policy that solves multi-disciplinary complex engineering problems.

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