



## **The efficacy of case studies for teaching policy in engineering and technology courses**

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## Introduction

The purpose of this paper was to extend the work of Chong, Depew, Ngambeki, and Dark “Teaching social topics in engineering: The case of energy policy and social goals,” that discussed a process to create, integrate, and teach public policy topics in an engineering and technology curriculum<sup>1</sup>. The aim of this paper was to explore a perspective by introducing public policy using a case study approach to undergraduate engineering technology students in the engineering economics course in the College of Technology at Purdue University. The course was an introduction to the time value of money and how it relates to capital investments, equipment replacement, production cost, and various engineering technology alternatives. The substantive contribution of this paper will address the following questions: 1) did the students understand and identify the policy context, 2) how effective was the use of case studies to introduce the students to policy, and 3) areas of improvement to enhance efficacy of the case studies to introduce students to policy?

Engineers are important actors in the sphere of policy. They play key roles in policy through their work or participation in politics. Engineers have the ability to fill the gaps that the policy makers are unwilling to pursue. For instance, policy makers deny science, technology, engineering, and mathematical remedies<sup>2</sup>; policy makers are “unwilling or cognitively unable to cope with uncertainty”<sup>3</sup>; and policy makers “pretend the problems don’t exist”<sup>2</sup>. In the academic environment, Paula Stephen identified a shift that collaboration is on the rise<sup>4</sup>. However, collaboration is not limited to experts within the same discipline, but across various disciplines (or multidisciplinary)<sup>5</sup>, such as an interaction between an engineer and a political scientist. Edward Wilson who is an entomologist of Harvard took a step further and discussed consilience, which is the “convergence of knowledge across once-separate fields”<sup>2</sup>. Another term in expressing consilience is interdisciplinarity, which an individual understands both the engineering and the policy aspects. In light of these examples, public policy is an increasingly important topic in the engineering and technology curriculum as it is recognized by a community of experts, National Research Council of the National Academies (NRCNA), Accreditation Board for Engineering and Technology (ABET), American Association for the Advancement of Science (AAAS), and the National Academy of Engineering (NAE).

## The nature of public policy knowledge

Selection of appropriate instructional strategies is important when teaching any topic including teaching social topics in engineering and technology courses. The selection of instructional strategies depends on the nature of the knowledge that is being conveyed. One way to think about the nature of the knowledge is along a continuum of “well-structured” to “ill-structured.” Examples of knowledge that would be considered well-structured, include a simple algorithmic manipulation or Newton’s law of universal gravitation. In contrast, ill-structured knowledge offers no means to verify the “correctness” of the solution<sup>6,7</sup>. Ill-structured problems require different types of skills than those needed to solve well-structured problems<sup>6</sup>.

Characteristics of well-structured problems are as follows. All elements of the problem are presented<sup>6</sup>. Rules and principles are presented in a predictive way<sup>6</sup>. Solutions are known and the relationship between solution and possible outcomes are probabilistic<sup>6</sup>. Well-structured problems can be frequently “found at the end of textbooks”<sup>6,7</sup>.

Ill-structured problems are more likely to be encountered in real life and professional practice<sup>6</sup>. The solutions for ill-structured problems may require knowledge from many different “content domains with the solution not being predictable”<sup>6</sup>. Some of the attributes of ill-structured problems are as follows. According to Wood (1983) in Jonassen, ill-structured problems possess “elements that are unknown or not known with any degree of confidence”<sup>6</sup>. There are multiple solutions, solution paths, or no solutions at all<sup>8</sup>. Furthermore, there are “multiple criteria for evaluating solutions, so there is uncertainty about which concepts, rules, and principles are necessary for the solution and how they are organized”<sup>6</sup>. According Meacham and Emont (1989) in Jonassen, ill-structured problems “often require learners to make judgments and express personal opinions or beliefs about the problem, so ill-structured problems are uniquely human interpersonal activities”<sup>6</sup>.

Ill-structured problems “tend to be more complex and well-structured problems tend to be simpler, although well-structured problems can be made very complex”<sup>6</sup>. For example, “a video game may be a complex, well-structured problem and deciding what route to travel is a simple, ill-structured problem”<sup>6</sup>. “Ill-structured problems tend to be more situated”<sup>6</sup> and well-structured problems are more abstract<sup>6</sup>. For example, a logic problem that is well-structured is usually abstract in nature. This means that the problem is not enshrouded with other details that need to be stripped away to arrive at the underlying principle. On the other hand, a case analysis problem that is ill-structured is usually situated with context specific information that is only relevant to that particular case. In order for the underlying principles of the case to be discovered, cognitive effort will be needed to uncouple the principles from the contextual situation. However, the reverse can be true. A well-structured story problem “can be quite situated and an ill-structured dilemma could be very abstract”<sup>6</sup>.

The complexity, abstractness, and structuredness of the knowledge are useful in selecting representative sample problems. Jonassen offers a taxonomy of 11 problem types that lie on a continuum from well-structured and abstract to ill-structured and situated:

1. *Logical Problems*
2. *Algorithmic Problems*
3. *Story Problems*
4. *Rule-Using Problems*
5. *Decision making Problems*
6. *Trouble-shooting Problems*
7. *Diagnosis-Solution Problems*
8. *Strategic Performance Problems*
9. *Case Analysis Problems*
10. *Design Problems*
11. *Dilemmas*<sup>6</sup>

Because policy matters are inherently ill-structured, teaching the content using instructional methods that mirror the ill-structuredness is authentic. For this reason, the authors selected the case study method for instruction.

Two case studies were used in this study (see Appendix A and Appendix B), which can be found in Dark, Ngambeki, Depew, and Chong Chapter 3 “Social engagement by the engineer” In “Understanding the global energy crisis” by Coyle and Simmons (2014)<sup>9</sup>. The theme of both case studies were energy related. Case Study 1 was about the phasing-out of Germany’s nuclear power plants. Case Study 2 was about the increase of biomaterial cost and its effects upon Eco-Energy Systems LLC.

## **The study method**

### *Participants*

There were 66 undergraduate engineering technology students in the engineering economics course in the College of Technology at Purdue University who participated in the study. Fifty-six were males and 10 were females. The course was primarily juniors and seniors. Thirty-seven students were in school for four or more years. Twenty-six students were in school for three years and three students were in school for less than three years. Forty-eight students who were enrolled in the course were from the department of mechanical engineering technology. The remaining 18 students were from the departments of computer and information technology, electrical engineering technology, industrial technology, and manufacturing engineering technology. Lastly, although 60 of 66 participants responded that they did not take a formal policy course, it can be assumed that they might have a degree of prior understanding of what policy is.

### *Instrument*

An online survey was used to collect qualitative data to determine the participants’ current understanding of basic policy concepts and the efficacy of the case study approach in teaching policy in the engineering economics course.

### *Procedure*

The case studies were introduced as an end of the semester engineering economics course final project 2/3 into the semester. It is important to note that the course did not directly teach concepts about policy and the project was not presented in the means of policy, but based on two goals. First, it enabled the students to apply the range of economic topics they learned throughout the semester. Second, it was to simulate a real-world project experience by working on a team to address various challenges. Participants were randomly placed into teams of four or five, totaling to 15 teams. There were seven teams assigned to Case Study 1 and eight teams assigned to Case Study 2. Each team was given four weeks to analyze their case study and write a report. Both case studies included four guiding questions (see Appendix C and Appendix D).

After the submission of the report, the students were asked by email to individually respond to an online survey that asked the following questions:

1. What is policy?
2. Can you list anything you believe you wrote in your report that was related to policy?
3. Do you feel engineers should learn about policy?
4. What are your thoughts about this group project?
5. Are you interested in learning more about policy?

The survey was designed in a manner where each question was responded sequentially, which did not reveal the next question. The survey restricted the participants from returning back to previous questions, which prohibited the participants from changing their previous responses. The participants were instructed by the survey that each question needed a response. Lastly, due to the restrictions, the participants needed to be mindful on their responses as all responses were final. The submission of the survey was the end of the study.

### **Analysis and results**

The analysis was based on a qualitative study, using open coding, and an inductive reasoning. The inductive reasoning utilized the summative approach, which quantified similar indicators of words, phrases, and sentences to create categories with various frequencies and generate abstractions<sup>10,11</sup>. The first two survey questions focused on the participants understanding and identifying the policy context. If the participants' responses contained multiple major themes, the participants would be placed in multiple themes. For example, a participant may have responded with the themes of *rules and regulations* and *control*; hence, the participant would be included in both themes and quantified.

Survey questions 3, 4 and 5 focused on how effective were the use of case studies to introduce engineering technology students to policy. Survey question 4 also attended to potential efficacy improvements for the case studies. Survey question 3 was a precursor to questions 4 and 5, such that survey question 3 provided an initial perspective to evaluate the effectiveness of the case studies. Survey questions 3, 4, and 5 generated major themes that were organized into categories, since some of the themes had similar characteristics, but authentic in their own respects. Survey questions 3 and 4 displayed the results similar to survey questions 1 and 2, due to the responses containing multiple themes. Survey questions 3 and 5 were designed in a manner where there was a response (either “yes” or “no”) and an explanation of the response. Survey question 5 in contrast to the previous four questions, had specific explanations (i.e., the explanations did not have multiple themes within it), which the participants were placed in a single major theme.

#### *Survey question 1: What is policy?*

There were 61 participants who responded to survey question 1, displaying five major themes as shown in Table 1.

Table 1 *Question 1 Major Themes*

Major Themes	Frequency of Participants
Rules and regulations	54
Actors	26
Control	20
Components of the policy process	18
An authoritative entity that sets forth the rules and regulations	16

*Rules and regulations* was the first major theme, which had the highest frequency of 54 participants who had this theme within their response. This major theme included several types of indicators, such as guidelines, rules, regulations, laws, procedures, standards, protocols, requirements, and so forth. To list a few response examples: a) “The general guidelines that are followed to handle situations”; b) “Policy are the set of rules and regulations that are followed while achieving a particular task...”; c) “Policy is a law that governs certain situations”; d) “A set of standards...”; e) “A protocol that guides decision making...”; and f) “...policy is requirements and guidelines pertaining to a subject, like a class or career”.

The second major theme involved *actors*, with 26 participants including this theme in their response. Actors minimally could be described as an entity or entities, which consist of an individual, government, organization, business, party, or people. To list a few response examples: a) “Policy is the ideology centered around an individual...”; b) “An adopted principle by a government or organization”; c) “A guide for companies, businesses, people...”; and d) “...principle of action adopted or proposed by a government, party, business, or individual”.

There were 20 participants who included the third major theme based on some sort of *control* in their response. This major theme was comprised of three types of indicators, such as to govern, allowable actions, and obey (or followed). The following responses illustrate this theme: a) “A governing set of rules or laws that control a premises”; b) “Policy is a law that governs certain situations”; c) “A set of rules and/or guidelines for a particular matter that outlines what is allowed and what is not allowed...”; d) “The thing that people abide by and obey”; and e) “Policy is similar to a rule that the general public must follow without exceptions”.

The fourth major theme, 18 participants stated *various components of the policy process* in their response. The types of indicators were adoption, proposal, alternatives, development, agreement, and decisions. Responses as the following: a) “A policy is a set of rules or standards adopted by a person, government, company, or other entity...”; b) Policy is a principle of action proposed by a government”; c) “...method of action selected from among alternatives...”; d) “Policy is the development of laws and regulations...”; e) “An agreement...”; and f) “Policy is a way an entity makes decisions”.

The last major theme was based on *an authoritative entity that sets forth the rules and regulations*, which 16 participants included this theme in their response. Response examples include: a) “Policy is a term used to describe the rules and regulations set forth by the higher powers in a particular subject”; b) “It can be a procedure or protocol that has been set, or implement by individual organization”; c) “Policies are guidelines or rules constructed by the

government, work, or someone who is higher up”; d) “Policy are standards or procedures set by a government”; and e) “A protocol or system made by government”.

*Survey question 2: Can you list anything you believe you wrote in your report that was related to policy?*

There were 51 participants who responded to survey question 2, displaying five major themes as shown in Table 2.

Table 2 *Question 2 Major Themes*

Major Themes	Frequency of Participants
General policies	21
Economics	15
Rules and regulations	13
Actors	11
Concerns	11

The first major theme was the identification of *general policies*, which had the highest frequency of 21 participants who had this theme within their response. This theme included broad indicators based on the term “policy”, such as carbon emissions policy, renewable energy policy, environmental policy, France and Germany nuclear policy, and economic policy. The response examples were: a) “Government policies regarding carbon emissions”; b) “...the Germans plan to have a renewable energy policy...”; c) “Environmental policy was important in our report”; d) “I personally wrote about the policies of France and Germany in regards to nuclear power”; and e) “Economic policy”.

The second major theme was *economics*, which was an expected theme, since this was an economic project. There were 15 participants who included this theme in their response. The economics theme had many types of indicators. To name a few, production, cost, investment, pricing, and reverse auction (reverse auction was provided in survey question 4 in the second case study as a policy mechanism). Examples of responses: a) “...we wrote about the economic impacts of ethanol production”; b) “...deconstruction of the plant would be costly”; c) “The money invested could be a part of policy, because there is policy on how much money can be spent”; d) “Electricity pricing”; and e) “I wrote about reverse auction, which could be a policy”.

Similar to survey question 1, *rules and regulations* was considered a major theme. There were 13 participants who included this theme in their response. This theme included indicators, such as standards, laws, guidelines, rule, and regulations. The participants responses were: a) “Environmental standards...”; b) “...the thing I believe is related to policy is the environmental acts that has been established...”; c) “EPA environmental guidelines...”; d) “The ethanol plants have a set amount of biofuels they have to create each year due to a certain rule”; and e) “EPA regulations with regard to hazardous material and water usage/treatment”.

*Actors* was the fourth major theme. There were 11 participants who included this theme in their response. The indicators that were included in this major theme were government, agency, company, and businesses. The participants’ responses: a) “Germany’s government proposed a

policy to phase out nuclear energy”; b) “...environmental policies that have been set forth by the EPA”; c) “I discussed how many companies who were once huge coal and nuclear companies may be adjusting their policies and goals...”; and d) “The way it would financially effect the business”.

The last major theme was *concerns*, which 11 participants included this theme in their response. There were two types of *concerns*. First, were general *concerns*, such as safety, dealing with hazardous and volatile material, deconstruction of the plant, and offset the energy void. Responses were the following: a) “...I spoke about how policies regarding safety is changing regarding nuclear power in Germany and Japan...”; b) “EPA regulations with regard to hazardous material...”; c) “...the deconstruction of the plant would be costly matter, especially when dealing with ethanol, which is somewhat of a hazardous and volatile material”; and d) “The entire report since it was about European energy policy and ways to offset the void left by the policy”. The second *concern* was specific to the environment. Examples of responses: a) “Ethanol production plants in the state of Indianan are not permitted to draw primary source water from wetlands...”; b) “Policies on water usage within a protected environment are part of our report”; c) “...policies about plants that harm the environment”; and d) “...environmental acts that has been established as an effort to preserve the quality of the environment”.

*Survey question 3: Do you feel engineers should learn about policy?*

Sixty – four participants responded to survey question 3 and provided an explanation that engineers should learn about policy, because of six major themes that were organized within three categories, **need**, **impact**, and **inherit** as shown in Table 3.

Table 3 *Question 3 Major Themes*

Category	Major Themes	Frequency of Participants
Need	A need to learn, understand, and know the rules and regulations	19
	A need to obey, follow, and comply with the rules, regulations, and general policies	16
Impact	Impact product development, implementation, and outcomes	19
	Impact engineers	17
Inherit	Inherit by the institution	12
	Inherit everywhere	4

**Need** comprised the first two major themes, a need to *learn, understand, and know the rules and regulations* with a frequency of 19 participants who included this theme in their explanation; and a need to *obey, follow, and comply with the rules, regulations, and general policies* with a frequency of 16 participants who included this theme in their explanation. The theme to *learn, understand, and know the rules and regulations* consisted of many types of indicators. To name a few, rules, standards, guidelines, and requirements. Examples of participants’ explanations: a) “To know which rules...”; b) “Engineers should know the general policies of the products and standards of manufacturers”; c) “Engineers have to follow certain guidelines”; and d) “...understand why those requirements are necessary”. Besides *learning, understanding, and*



*knowing the rules and regulations*, engineers are controlled by the rules, regulations, and policies. In essence, it is the need to *obey, follow, and comply with the rules, regulations, and general policies*. Examples of explanations: a) "...needs to comply with standards and policies..."; b) "...it is very important to obey and follow policy..."; c) "Engineers have to follow certain guidelines while doing their duties"; and d) "Engineers will be following policies the rest of their lives...".

The second category was **impact**, due to policy affecting the third major theme of *product development, implementation, and outcomes*; and instrumentally affecting the fourth major theme of *engineers themselves*. The theme *product development, implementation, and outcomes* had a frequency of 19 participants who included this theme in their explanation. Some of the indicators included product design, development, implementation, and outcomes. The explanation examples were: a) "It affects the type of product they will produce and the materials that will be used to produce that product"; b) "...policies affect the things that they design and create"; c) "Any design or engineering implementation should take policies into account"; and d) "A good engineer (or an engineer who knows about policy) can build something without causing destruction or harm toward someone or something". Extending (d) explanation, 17 participants included the theme *engineers*, explaining that engineers get impacted by policy. To list several indicators, policy impact their decisions, becoming well rounded, ability to complete tasks, better understanding of the world, and so forth. Examples of the participants' explanations: a) "It will help them to make better decisions"; b) "They should because it will make them more well-rounded people..."; c) "...help guide them to how to complete tasks"; and d) "...so they know what is going on in the world...".

Although there was a **need** and an **impact** of policy, 12 participants responded that an engineer will **inherit** policy in one of two ways. One way is artificially, which the fifth major theme was through an *institution*. This major theme was an authoritative entity that adopts and/or set forth policies. There were several indicators from the theme of *institution*, such as policies within companies, policies of other entities (i.e., manufacturers), government enforced policies on businesses, and aspects of an engineer's job. Participants' explanation examples: a) "Whichever business they become apart of, they will adopt that particular businesses policy"; b) "...standards of manufacturers"; c) "Engineers are hired by companies who have policies they enforce. That business has policies given to it by the government"; and d) "...policies apply to many aspects of an engineer's job in the real world". Along the lines of this "real world," 4 participants' explained that policy was *everywhere* as the last major theme and engineers inherit policy naturally. Examples of the participants' explanations: a) "...applied to everyone regardless their career"; b) "Everything has a policy"; c) "...policies exists..."; and d) "Policy is important to understand because it is seen in various areas of everyday life".

*Survey question 4: What are your thoughts about this group project?*

The overall thoughts about the group project were generally positive. There were 36 participants who reacted to the group project positively (i.e., only provided positive feedback). There were 22 participants who reacted to the group project negatively (i.e., only provided negative feedback). There were seven participants who provided both positive responses and negative responses. Lastly, there was one participant whose response did not relate to this question.

## Positive feedback

The participants who provided positive feedback displayed five major themes organized in three categories, **practicality**, **benefits**, and **positive project attributes** as shown in Table 4.A.

Table 4.A *Question 4.A Major Themes*

Category	Major Themes	Frequency of Participants
Practicality	Realism	18
Benefits	Academic	25
	Career	5
Positive project attributes	Favored	9
	Quality aspects	8

**Practicality** contained the first major theme, *realism*, which had a frequency of 18 participants who included this theme in their response. Indicators included simulation of the real world, teamwork, saw a bigger picture (e.g., decisions could impact an entire population), and enabled the participants to apply their knowledge. Examples of the participants' responses: a) "Overall, this project was setup well and helped expose us situations in the real world..."; b) "...learned to collaborate with other members and bounce ideas off and understand other people's perspectives"; c) "I thought it was a good opportunity to see, as engineers, how much of an impact decisions you make can have on an entire population"; and d) "...we got to really apply our knowledge we learned throughout the year within something practical". From the indicators, simulation of the real world was the main indicator. Meaning, 10 of 17 participants discussed this indicator in their response.

**Benefits** was the second category containing major themes of *academic benefits* and *career benefits*. There were 25 participants who included the major theme of *academic benefits* in their response. Indicators included, improved knowledge, helpful for future course work, developed policy analytical skills, and enabled students to go outside their borders. Response examples were: a) "The project was helpful in gaining knowledge about something that I didn't know very much about"; b) "...this project would definitely help me in other class in which there would be something related to case the case studies"; c) "This group project has definitely helped me develop a lot of analytical abilities of analyzing policy"; and d) "It was also beneficial in that it made us take at the world outside our own borders". From the indicators, improve knowledge was the main indicator, which had 12 of 25 participants that discussed this indicator in their response. In addition to academic benefits, five participants included the major theme of *career benefits* within their response. An example of a participant's response: "I personally think that this project is really useful because it gives an early exposure to real world situation because we are dealing with real world problems. This really helps towards future career...".

The third positive category was **positive project attributes** that contained two major themes, those who *favored* the project and *quality aspects* of the project. There were nine participants who included the major theme of *favored* in their response. The indicators were a general liking of the project, good end of the year project, would like more of these kinds of projects, and should keep this project because it was valuable. The participants' responses were: a) "I felt it was good"; b) "I think the group project was a good way to wrap up this semester..."; c) "...I

would have preferred to have several case studies throughout the semester...”; and d) “...definitely something you guys should keep”. There were two main indicators, which were good end of the year project and would like more of these kinds of projects. Both indicators each had 3 of 9 participants who included these in their response. The last major theme was *quality aspects*, which had eight participants who included this theme in their response. The indicators were relevance, not specific and restraining, topic interest, and flexibility. Responses as the following: a) “...interesting topic that is relevant to modern day economics”; b) “College is often so specific and restrained to raw coursework that we seldom get to step back and look at a specific application going on right now in the world”; c) “I found this project to be very interesting, being that I’ve been fascinated by the nuclear industry and this gave me another opportunity to learn more about it.”; and d) “I thought that the case study was particularly good for my major because it was about a technical topic and also policy”. The main indicator was topic interest, which had 4 of 8 participants that discussed this indicator in their response. The indicator of relevance followed with 3 of 8 participants.

### Negative feedback

The participants who provided negative feedback also emerged five major themes organized in three categories, **lack of relevance**, **not beneficial**, and **negative project attributes** as shown in Table 4.B.

Table 4.B *Question 4.B Major Themes*

Category	Major Themes	Frequency of Participants
Lack of relevance	Relevance	10
Not beneficial	Career	4
	Academic	3
Negative project attributes	Poor quality aspects	9
	Disfavored	6

The category **lack of relevance** comprised the first major theme of *relevance*, which had a frequency of 10 participants who included this theme in their response. Indicators included no class relevance, not relevant locally, and not relevant to me. The participants’ response examples: a) “I did not see how the case study related to the class at all”; b) “...it’s not relevant locally. Choose something local if you do a case study”; and c) “...could be more related to us at this point in time”. From the three indicators, no class relevance was the main indicator, consisting of 6 of 8 participants who discussed this indicator in their response.

The second category, **not beneficial**, included the second and third major themes of *career* and *academic*. There were four participants who included the major theme of *career* in their response. An example of a participant’s response: “I can’t say that I think it will directly help me in my career...”. Along with no *career* benefits, three participants’ included the major theme of *academic* in their response. The indicators were, did not improve knowledge and not beneficial to my major. Examples of the participants’ responses: a) “...I cannot say that I learned anything...” and b) “I didn’t feel as though it enriched my knowledge base in regards to my major...”. Between the two indicators, did not improve my knowledge was the main indicator.

**Negative project attributes** was the third category, which included the last two themes of *poor quality aspects* and those who *disfavored*. The fifth major theme of *poor quality aspects* had a frequency of nine participants who included this theme in their response. There were three indicators, was not helpful and not useful, should be placed earlier in the course, and no interest in the topic. Examples of the participants' responses: a) "...it's not really useful or relevant information that you take away from it"; b) "I think it would have been more helpful if it had been integrated into the class more, where we developed the project throughout the semester, instead of just something added on once we finished the other parts of the course"; and c) "I found no interest in the topic...". The main indicators were the following, not helpful and not useful had 5 of 12 participants who discussed this indicator in their response. Followed by the indicator, should be placed in the beginning of the course, which had 3 of 12 participants. Lastly, no interest in the topic had 2 of 12 participants. The last major theme was *disfavored*, which had six participants who included this theme in their response. This major theme had four indicators, which were did not enjoy the project, rather have an exam, time consuming, and would not want more of these projects. Response examples: a) "I didn't enjoy it"; b) "I would prefer the final exam over the case study"; c) "This was a bit helpful, but time consuming"; and d) "No, I would not like more of these types of projects". From the indicators, would not want more of these projects were the main indicator, which had 4 of 6 participants that discussed this indicator in their response.

*Survey question 5: Are you interested in learning more about policy?*

A total of 24 participants responded that they were not interested in learning more about policy and 39 participants responded that they were interested. Although three participants provided a response, they were not included in the total, because their explanations of their response were not relevant to the question. Part one will discuss the themes from the 24 participants who were not interested. Part two will discuss the themes from the 39 participants who were interested.

Part one: Participants who were not interested

There were 24 participants who responded that they were not interested in learning more about policy, displaying five major themes organized in three categories, those who were **absolutely not interested**, those who **may or may not be interested**, and those who had **some interest** as shown in Table 5.A.

Table 5.A *Question 5.A Major Themes*

Category	Major Themes	Frequency of Participants
Absolutely not interested	Generalization of no interest	8
	Boundary oriented	2
May or may not be interested	Pressure of time	5
Some interest	Learn on the job	9
	Enough understanding	3

The category **absolutely not interested** had two major themes, *generalization of no interest* and *boundary oriented*. There were eight participants who included *generalization of no interest* theme in their explanation. To list a few explanation examples: a) "I'm just not interested in it";

b) “It just does not sound interesting at all”; and c) “I really don’t like policy or politics so I wouldn’t be interested”. Similar to the *generalization of no interest* theme, the major theme *boundary oriented*, which had two participants who included this theme in their explanation, resisted the interdisciplinary perspective. An explanation example: “I’m too much of a technological based person. I like working with my hands and applying practical knowledge to my career”.

The second category was **may or may not be interested** that contained the third major theme of *pressure of time*. *Pressure of time* consisted of five seniors who were either in their fourth or fifth year in school. Examples of explanations includes: a) “My senior year so not really motivated”; b) “Well I am graduating in a couple weeks, so the only policies I want to learn about are relevant ones to me and my career”; and c) “I am ready to be done”.

The last category was based on **some interest**, which discussed the participants who had previously made an attempt to learn policy and those who will be open in learning policy in the future. The category **some interest** contained two major themes, *learn on the job* and *enough understanding*. Nine participants explained that they will *learn on the job*. Examples of explanations includes: a) “I will learn about them later when I start working”; b) “Because I think policy is something that a person learns from experience it can’t be taught”; and c) “Because I have many other things to learn more and I think policy can be learned indirectly in my works in the future”. The last major theme, *enough understanding* about policy had three participants who included this theme in their explanation. Illustrating a couple examples of the participants’ explanations: a) “I feel I have enough an understanding about it at this point” and b) “I have already learned a basic understanding of policy and fail to see how further knowledge would benefit me in my future”.

Part two: Participants who were interested

Contrasting part one, part two will discuss the 39 participants’ explanations to their response on why they were interested in learning more about policy. The participants displayed seven major themes organized in three categories, **importance**, **self-improvement**, and **instrumental effect** as shown in Table 5.B.

Table 5.B *Question 5.B Major Themes*

Categories	Major Themes	Frequency of Participants
Importance	Important	9
	Global impact	4
	Need to experience	3
Self-improvement	Improve knowledge	8
	Improve decision making	2
Instrumental effect	Career investment	13
	Social contribution	3

The first and most general category was **importance**, expressed through three major themes, *global impact*; *need to experience*; and the catch-all, plainly *important*. The first major theme,

there were nine participants who felt policy was *important* and included this theme in their explanations. To list a few explanations to illustrate this major theme: a) “Policy is an important part of our government and the world economy”; b) “Because it is something that was not covered in my previous courses and I feel is important”; and c) “I feel it is important as citizens to know what goes on around you. By learning about policy you are able to learn what will or could happen in your future”. The second major theme was *global impact*, which had four participants who included this theme in their explanation. Examples included: a) “Policy influences our everyday lives. Policy is something that I think the American people need to know more about and understand more”; b) “I believe it is something that every citizen, be it an American or global citizen in general should have a fundamental understanding of policy...”; and c) “I am interested because the world is governed by policy and our ways of life are guided by them”. The last major theme of this category, policy was a *necessity to experience*, which had three participants who included this theme in their explanations as illustrated: a) “I feel it is necessary to be expose to policies” and b) “I feel as though policies will obviously be used heavily in my future and it would be helpful to have more experience”.

Transitioning from the broad conceptions of the importance of policy, the second category was specific to **self-improvement**, such as the fourth major theme of *improving knowledge* and the fifth major theme of *improving decision making*. There were eight participants who had the major theme of *improving knowledge* in their explanation. To illustrate several examples: a) “Just to have some basic knowledge”; b) “I’d be interested to dig a little deeper because this sort of knowledge not only helps you professionally, but also personally”; and c) “I think it’s interesting to learn how and why policies are set the way they are”. Along with *improving knowledge*, two participants included the major theme of *improving decision making* in their explanation. For example, “I personally think that as an engineer, we should learn more about policy, because it provides good skill in decision making”.

The third category of **instrumental effect** further explains on what these participants will be able to do with the knowledge of policy, such as a *career investment* as the sixth major theme and *social contribution* as the seventh major theme. The major theme *career investment* had 13 participants who included this theme in their explanation. Examples includes: a) “Learning about policy would be beneficial for my future career”; b) “It is a good knowledge to have when working for a business since every company has their own policy that they follow”; and c) “when we graduate we will have to deal with policies where ever we end up working”. The last major theme, *social contribution*, three participants’ explained how they will use their *career investment*. The participants’ explanations: “I like to know how to accommodate for all needs and be able to design without causing problems” and “I want to be involved on how this country is run, and that is through policy”.

## Discussion

*Revisiting: Did the students understand and identify the policy context?*

The students did understand and identify the policy context. In survey question 1, the participants were asked to describe policy. As a result, there were several major themes that were provided, which may indicate a prior understanding. *Rules and regulations* was the dominant theme. It was

also observed in survey question 1 that 5 of 6 participants who had taken a policy course in the past, included *rules and regulations* in their description, which may indicate an institutional influence. In a third observation, the participants' descriptions of policy spilled over into the second survey question. For instance, two of the major themes found in survey question 1, *rules and regulations* and *actors* were also major themes in survey question 2. It was observed that 37 of 51 total participants may have derived a policy framework from survey question 1 or it may be that they applied their prior understanding to assist in responding to survey questions 2 and 3. Table 6 demonstrates several examples of this observation.

Table 6 *Observation of the Spillover*

Participant	Question 1 response	Question 2 response	Explanation
P04	"The thing that people abide by and obey."	"The environmental policy/The policy set by the company."	The "thing" that people abide by and obey is the environmental policy or the policy set by the company.
P06	"Policy is a law that governs certain situations."	"Environmental concerns are related to policies set by the government to protect the environment."	Environmental concern is the certain situation. Policies set by the government to protect the environment, which policies would be considered as the laws that govern the situation.
P11	"Policy is a term used to describe the rules and regulations set forth by the higher powers in a particular subject."	"In our report, we talked about environmental issues, which relates to the environmental policies that have been set forth by the EPA."	Environmental policies associates to the rules and regulations set forth by the higher powers, such as the EPA.
P18	"Policy is a principle of action proposed by a government."	"Germany's government proposed a policy to phase out nuclear energy."	The principle of action is the policy to phase out nuclear energy proposed by the government.
P24	"Policy is a set of rules or regulations that are followed for a certain function."	"Germany has a policy of shutting down their nuclear power plants."	Germany has a policy, which is the set of rules and regulations that are followed for a certain function, which is the shutting down their nuclear power plants.

Several questions surfaced from the observations that may need further investigation. First, why did the participants choose their particular descriptions to explain what is policy, which was used on survey questions 2 and 3? Second, why did the participants focus their responses around *rules and regulations* and to some degree the other themes? Third, what was their source origin of prior understanding? Lastly, could there be an institutional influence that could be further studied through Elinor Ostrom's Institutional Analysis and Development Framework<sup>12</sup>?

*Revisiting: The efficacy of case studies to introduce students to policy?*

There were several observations that can be drawn from the results to respond to this question. First, survey question 3 was used as a precursor question to understand the participants' position on policy as a future engineer. Sixty – four participants responded that engineers should learn about policy, because of the following major themes: a) to learn, understand, and know the rules and regulations; b) obey, follow, and comply with the rules and regulations; c) policy will be used for product development, implementation, and outcomes; d) the engineers themselves, and e) the participants are experiencing policy in everyday life and/or will be exposed to policy during their career.

The second observation, in survey question 4, the case studies were effective to the extent that there were a greater amount of participants who felt positive than negative. A potential rationale of the positive responses may be due to the case studies complementing the students' responses to survey question 3 or what their career may entail. For instance, the positive participants felt that the project simulated the real world, the project was relevant in exploring their interests, had academic benefits (this could lead to career benefits), and most importantly, direct career benefits.

The third observation, in survey question 5, there were moderately more participants who would be interested in learning more about policy than those who would not be interested. It could be attributed to the exposure of the case studies. Although 64 participants responded that engineers should learn about policy, 10 participants were absolutely not interested, which may indicate the case studies had no effect upon their perspective. In regards to the 39 participants who responded that they were interested in learning more about policy, the case studies might had an impact on the participants' understanding and view of policy. There were three categories that may be considered as indicators, the importance of policy, self-improvement, and an instrumental effect.

*Revisiting: Improving the efficacy of case studies to introduce students to policy?*

The responses from survey question 4 could also shed light on how public policy could be added to the engineering technology curriculum. For instance, instead of assigning case studies that assumed a utilitarian acceptance, may want to focus on customization. The case studies may be customized to focus on the following: a) what students deemed relevant, b) topic of interest, and c) academic and career orientation. Another indicator that may be a factor would be placing the project earlier in the semester or the beginning of the semester.

### **Conclusion and future work**

Public policy is an increasingly important topic in the engineering technology curriculum. This paper expanded the work of Chong et al.<sup>1</sup> through a study that provided a perspective and an approach by utilizing two public policy case studies that were used as an end-of-year final project. Although the course did not directly introduce policy concepts and the case studies were not presented as policy case studies, the participants did understand and identify the policy context, ranging between rules and regulations, to particular actors, general policies, economics, and so forth. The second part of the study was to understand the efficacy of the policy case



studies. Based on the participants' responses, they provided a perspective that the case studies were deemed effective. The case studies might have complemented the students' responses that engineers should learn about policy or what their career may entail. In addition, the case studies may have had an effect in shaping the participants' understanding and view to facilitate the participants' interest in learning more about policy. Lastly, there were suggestions for potential case study improvements. These improvements encircled customization through student relevancy, academic and career orientation, and topic interest. Another potential improvement was to place the project earlier in the semester or at the start of the semester. The channels for future works will be to further investigate: 1) prior policy understanding, 2) the case studies impact in shaping and enhancing policy understanding, and 3) the case studies impact in changing students' views and attitudes.

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## Appendix A. Case Study 1

### CASE STUDY 1

Energy is a global necessity. However, societies are struggling to find answers to address the wicked problems of energy sustainability, environmental/climate concerns, and health. A potential alternative would be the increased usage of nuclear power, because it provides significant benefits, such as clean emissions, cost effectiveness (i.e., there is not a high demand to develop newer technologies or purchase additional technologies to reduce the carbon footprint), the base-load is reliable and predictable, and it does not have to refuel often. Although nuclear power plants present benefits, Chancellor Merkel of Germany announced a plan to phase out (i.e., shut down) their nuclear power plants by the year 2022.

To understand the reasoning for phasing out nuclear power plants, it is essential to understand the history that led up to the decision. Germany's first nuclear plant went online in 1957, which represented the political and economic movements of the time (Flegel, n.d.). In 1960, Germany introduced the Atomic Energy Act with the primary aim of encouraging nuclear energy. However, not every actor was on board with the nuclear program. An anti-nuclear interest group that was made up of environmentalists and peace activists believed there should be policy changes regarding military usage of nuclear and nuclear waste disposal. The oil crisis in the 1970s promoted the idea that energy diversity and therefore nuclear energy was good for the state, but the 1986 Chernobyl incident revitalized the anti-nuclear movement and discouraged public support for nuclear power plants (Isenson, 2009). However, it was not until 2002 that Chancellor Schroder with the support of the Social Democratic Party and the Green Party, passed the first nuclear phase out deal to end all nuclear energy production by 2021 (Mauldin, 2011). The phase-out deal modified the Atomic Energy Act of 1959 by including a section that no new licensing would be distributed, which prohibited the building and operation of new nuclear power plants and other nuclear facilities (Vorwerk, 2002). According to BBC Online Network (1998), Schroeder provided three reasons for the phase-out: a) there was a growing concern to handle nuclear waste, b) nuclear was a social problem, and c) nuclear had no economic purpose.

Chancellor Merkel, the Christian Democratic Union, Christian Social Union, and the Free Democratic Party, in 2010, did not agree with Chancellor Schroder and his supporting parties phase out deal, because of Germany's commitment towards the European Union 2020 energy strategy which requires 20% renewable energy, energy supply, and steadiness of energy prices (Moore, 2012; Spiegel Online International, 2010). Merkel developed a new strategy that gave all nuclear plants that were constructed before 1980 an eight year license extension and those plants after 1980 a 14 year license extension (Moore, 2012; World Nuclear Association, 2013). In 2011, 23 percent of Germany's electricity was generated through nuclear power (Dempsey & Ewing, 2011). On March 11, 2011, an earthquake and tsunami struck Japan resulting in a meltdown at the Fukushima Nuclear Plant. Days after the event, Merkel formed the Ethics Commission on Safe Energy Supply that evaluated Germany's 17 nuclear power plants. Months later, in light of Japan's nuclear disaster and public opposition, the Ethics Commission on Safe Energy Supply took a deontological position and recommended Merkel to shut down eight of the 17 nuclear plants and to return to Schroder's phase out deal to protect the country from future threats from nuclear disasters (Dempsey & Ewing, 2011; Moore, 2012; Nuclear Energy Institute, 2012).

*Figure A Case Study 1: Germany's Nuclear Power Plants*<sup>9</sup>



## Appendix B. Case Study 2

### CASE STUDY 2

Eco-Energy Systems owns an ethanol plant in the heart of the Midwest. The plant has a production capability for producing 20 million gallons of ethanol per year and employs 30 production workers. Most of the ethanol plants in the United States can produce 60 million gallons or more each year. In 2012, ethanol production dropped for the first time in 16 years. This was primarily due to the reduced demand for gasoline since 2008. Most gasoline in the United States is blended with ethanol. The current production ceiling requires approximately 13 billion gallons of ethanol to be blended at 10% (E10) under a government mandate. Also, future projections by the Department of Energy show an increase in demand to 15 billion gallons by 2015, which is the target date established by the RFS (Renewable Fuel Standards). However, the cost of biomaterials has increased substantially undercutting profits by 30%. You have been assigned to lead a team of managers, engineers and scientists from Eco-Energy Systems to conduct a review of the facility and make recommendations to the President and CEO on the future of the operation. You are expected to be sensitive to environmental and societal concerns in developing your final report.

There are some environmental and economic issues to be considered in any decisions on the future of the ethanol plant.

1. Ethanol production requires using large volumes of water. When in full production, the plant pumps approximately 6 million gallons of water a day from a wetland, which helps some local residents in low lying areas by keeping the water table low and basements dry. However, environmental groups are threatening legal action because they view tampering with the water levels as detrimental to local wildlife and the natural ecosystem. If these lawsuits are successful, the company would have to pay millions of dollars for remediation, leading to the closure of the plant.
2. If the plant is closed, approximately 90 jobs will be lost from the community with a population of 1200. So, the economic impact of closing the production facility is quite significant to a small community.
3. Any decision to dismantle the operation will require an environmental impact study which will be expensive and time consuming. There could also be issues associated with hazardous materials.
4. Based on projections of increased demand for ethanol, the President Eco-Energy is willing to consider expanding the facility to increase production capacity to 100-150 million gallons per year. The expansion could also include focusing production on second generation biofuels utilizing cellulosic feedstocks such as corn stover or other energy crops such as miscanthus, switchgrass, and tree plantations. However, these projections of demand are uncertain.

*Figure B Case Study 2: Eco-Energy Systems LLC.*<sup>9</sup>

### **Appendix C. Case Study 1 Guiding Questions**

1. *What are the economic implications of phasing out Germany's nuclear program? Who will be impacted by this decision and to what extent?*
2. *What are the economic differences that made Germany consider the tragic events in Japan as a reason to phase out their nuclear program while France did not?*
3. *Germany is a leader in the renewable energy sector and plays a huge role in the European Union 2020 energy strategy. What are some economic alternatives that could replace and improve the 23 percent energy lost that will be created by the phase -out deal without increasing the carbon footprint and cost?*
4. *Evaluate the economics of nuclear energy in Germany. Using Germany's evaluation, compare it to Japan and the United States economics regarding nuclear energy.<sup>9</sup>*

### **Appendix D. Case Study 2 Guiding Questions**

1. *How do you reconcile the competing interests of being a profitable business serving the interests of shareholders and being socially responsible to the community and future generations?*
2. *What are some of the potential financial consequences of closing the facility? What recommendations would you offer to the President?*
3. *What are two alternatives you would recommend to upper management? What are the consequences? Which alternative would you recommend?*
4. *Would utilizing "reverse auction" as one possible policy mechanism to make the production of biofuels more economic viable a good alternative?<sup>9</sup>*