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Effecting Organizational Change at the Macro Level of Professions

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By

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Effecting organizational change at the macro level of professions

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Much has been written in academic and popular publications about organizational change. Topics have ranged from case studies to anecdotal stories of how leaders can change an organization. There is little written on changing the culture and vision of a profession at the macro level.

This dissertation shows that one key to effecting change within a profession is to educate those at the entrant level and thereby effect change with the profession. Over time, these new entrants to the profession will rise to senior positions and be able to effect greater change through the hiring, training, and mentoring processes inherent in the professions and the organizations for which they work. One way to effect change in these entrants is through education in college and professional schools. This study is specifically focused on effecting change in the interdisciplinary field of engineering and public policy. Public policy involves countless infrastructure issues at all levels of government. Engineers are well-versed in dealing with the technical issues of infrastructure but their voice is often lacking at the policy level. Similarly, political scientists are well-versed in policy but are often lacking in a thorough understanding of the technical aspects of the policy.

Through an introductory course in engineering and public policy, undergraduate students from the seemingly disparate fields of engineering and political science were placed in a common classroom and through lectures, writings, presentations, and guided discussions their attitudes on key areas were changed. Areas studied were professional interest, legitimacy, deference, the public policy process, and education outside of a specific field. Through the process of education, changes in each of these areas was possible. Further, the movement was towards making students in each discipline more open to the input, opinions, and attitudes of others, and specifically in shifting engineers toward a more positive view of the public policy process. Being exposed to these topics and to each other's thought processes, changes in professional attitudes were made.

While there is not a specific profession for which any research has been done, the military is used, in places, as an analog to the profession of engineering.

DEDICATION

For my wife Sara, who has been with me from the start through a bachelor's and two master's degrees, and seven Navy Reserve command tours. She is my biggest fan and I appreciate her more than she knows. For my daughter Kathryn, who gave up time with Daddy when I was in class and working late. For my granddaughter Ella, in hopes that she will follow in my footsteps and pursue graduate education. And finally, for my parents, who simply wanted me to get a college degree, never realizing that it would lead to a path of continual education and study for decades to come.

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This would not have been possible with the support of the several Deans and Associate Deans under whom I have served, nor without my staff who protected my time when it needed protecting and encouraged me when I needed it most.

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CHAPTER I

INTRODUCTION

Summary

Through the survey of both engineering and political science students in an introduction to engineering and public policy course, I found that employing a concerted effort of education, attitudes towards other professions can be changed. Students' attitudes toward the other profession (engineering toward political science and vice versa) were surveyed at the beginning of the semester. Throughout the semester, the students were exposed to the thought processes and values of both professions through lectures, reading, class discussion, and outside-of-class- preparation for a simulated Congressional oversight hearing. Students were intentionally placed into groups for the group projects that would require the different majors to collaborate. The same survey administered at the beginning of the semester was administered again at the end of the semester allowing the change in attitudes to be determined.

Purpose of Study

Change in organizations is a much-studied topic with the majority of the emphasis being placed on how organizations manage change. But there is little, if any work done on how to change entire professions. Engineering, along with medicine, law, and the military, and perhaps other professions, are, by their very nature, somewhat risk averse. The cost of failure by trying a new technique, implementing a new model, or even using a new product can result in the loss of human life. For this reason, there is often reluctance in trying new things and the professionals opt for staying with the tried and true methods.

Organizations come in a variety of sizes, large and small, but have some traits in common. They have a designated leader, manager, or boss. There is a well-defined hierarchical structure, most often used for reporting purposes, that communicates ideas, shares a common vision, and philosophy, and provides a process by which members (employees) of the organization are evaluated for proper performance, attitudes and policies are enforced, and the best members or employees are promoted to positions of higher authority.

In contrast to organizations, professions lack a defined head or hierarchical structure. There is no common shared vision short of broad statements such as a “doctor shall do no harm”, an engineer shall “protect the health, welfare, and safety of the public” and a public official shall “serve the public”. Further, these broad statements can only be enforced on organizations that fall under the umbrella of the profession. Entry into the profession is often difficult to regulate, and in those situations in which there are licensing requirements with the profession, the requirements are merely minimum competence to practice standards, they do not evaluate attitudes, philosophy, or vision. However, members generally do have a common underlying education. Engineers earn a bachelor of science degree generally from a program accredited by ABET, Inc. (ABET, 2017a), Medical doctors attend a medical school accredited by Liaison Committee on Medical Education (Association of American Medical Colleges, 2017), and the military officer corps (considered the professionals here) are educated in service academies, through Reserve Officer Training Corps programs at universities and colleges, and various officer accession programs which provide some common training. It is through these common education pathways that new entrants to the professions can have their attitudes and values changed which can then lead to systemic change within the profession.

Changing professional attitudes is important as they relate to public policy for several reasons. The stakes involved in many policy decisions are simply too high to not be well-informed and have broad input. From climate change to transportation, policies developed can cause significant social harm if not developed properly. Engineers often possess special skills and knowledge that can add value to the decision-making process yet they tend to shy away from the policy arena. Political scientists also have an important role in setting policy but may shy away from technical issues or involving engineers because they are uncomfortable with the material and have mental images of engineers being difficult to deal with. If these stereotypes continue, the public will suffer.

Resistance to change in professions is reinforced by the truism that using what has worked in the past will, in most case, ensure it will work in the future. However, there is little opportunity to improve efficiencies, reduce costs, or reduce risks by not trying new ideas, processes and procedures. What is needed is to change the culture of these professions to become more accepting of calculated risks.

Unfortunately, most research has been conducted on changing organizations, not professions. Professions present special issues that are not present in organizations. Organizations have a clearly delineated leadership whereas professions do not. Organizations have the ability to hire and fire people who either do or do not meet the expectations of the organization, but professions have no such controls. Therefore, convincing the leadership of the need for change may be possible in an organization, it is all but impossible to do in a profession.

This study examines some of the differences between organizations and professions, at the macro-level, and offers some insights as to how professions might begin the process of change. While the vision is for change at the macro-level, the initial work is conducted at the micro-level, namely engineering and political science undergraduates. If properly educated, these and other similar students can be the first to spread what Burke refers to as the “virus” and effect greater change (Burke, 2008, p. 6).

Research Question

In the first half of the twentieth century, sociologist Kurt Lewin proposed a model of changing group standards consisting of three steps: 1) unfreezing, 2) moving the group to new standards, and then 3) freezing the new standards (Lewin, 1951, p. 228). His model was developed as result of attempting to get Americans to change their habits during food and material shortages during World War II; specifically, to get homemakers to use evaporated milk rather than regular milk and to use non-traditional meats in cooking (Lewin, 1999, pp. 271, 275). While not specifically focused on a profession, this theory of change was developed to change the habits of a large population, without a clearly defined leadership, and was resistant to change.

The first step of Lewin’s model can be the most difficult to achieve. Allport has indicated that sometimes a “catharsis” is needed in order to remove existing prejudices and open the group to change (Allport, 1945). Further, he states “[t]he important lesson here is that the reconstructing of personal attitudes may take place *after* the course of instruction is completed” (Allport, 1945, p. 8). This seems to indicate that part of the unfreezing process is to get the issue discussed and then the unfreezing may occur sometime after the “cathartic” event.

The cathartic event examined here is an undergraduate course on engineering and public policy which includes lectures, writings, presentations, and significant facilitated discussions between students primarily majoring in engineering and political science. The question considered was, can an interdisciplinary course in engineering and public policy, serve as the "cathartic" unfreezing event amongst a group of undergraduate students that will open the minds of all of the students to allow for a deeper understanding of the contributions to be provided by each discipline?

The penultimate task is to be able to effect change in attitudes at the macro level of professions and this study considered the introductory undergraduate class as the beginning point of that change. Professions possess characteristics that are significantly different from organizations and little work has been conducted on how change can be achieved at that level. This study is the beginning point of that work.

Dependent Variables

The dependent variables considered in this study were the various attitudes of the individual students as measured by a survey. Specific variables considered were attitudes toward other professions, specifically the attitude of engineering students towards political science students and their field of study, and the attitude of political science students towards engineering students and their fields of study. Other variables included attitudes of each profession towards interpersonal skills, knowledge of science and mathematics, involvement in setting public policy, attitudes toward bureaucrats and politicians, value of the various professions to society as a whole, opinions of communication skills, ethics of each profession, and opinions of the adequacy of the American public education system to prepare students to pursue a career in public policy.

The questions above were grouped into five areas for study. The five areas were: professional interest, legitimacy, deference, the public policy process, and education outside of a specific field. These areas were initially analyzed with early data from this study by Green and Emison and found to be of value (Green & Emison, 2006b).

Independent Variables

The independent variables considered were: gender, major, level, and ethnicity. The data were collected to be as inclusive as possible while also recognizing that only limited controls could be placed on course enrollment. Therefore, majors were grouped as either engineering or a related physical/life science, political science or related social/behavioral science, and other. Students selecting other were allowed to specify their major. The maturity of a student was gauged by their classification in college. Students were asked to specify if they were underclassmen (freshmen or sophomore) or upper classmen (junior or senior). The class was restricted to undergraduate students so no graduate students were enrolled. Given the diversity of the student population at the university, ethnicity was self-reported as one of four variables: Caucasian, African-American, Asian-American, or Other. The demographics of the university are list below demonstrating that these categories are representative of the student population.

Table 1.1 Demographics of University Student Population

	Fall 2005		Fall 2015	
	Count	Percent	Count	Percent
Total Enrollment	11,644		17,053	
Female	5,443	46.8	8,287	48.6
Male	6,201	53.2	8,766	51.4
White American/White	8,886	76.3	12,246	71.8
African American	2,376	20.4	3,492	20.5
Asian American/Asian	159	1.4	211	1.2
Other	223	1.9	1,104	6.5

Source: Mississippi State University Office of Institutional Research (2005, 2015). As a result of changes in Federal ethnic identifiers, in 2005 Other included American Indian, Hispanic American, and International; in 2015, Other included American Indian/Alaskan Native, Multiracial, Native Hawaiian/Pacific Islander, Non-Resident Alien, and Race Ethnic Unknown.

CHAPTER II

REVIEW OF THE LITERATURE

Key to Successful Change

As discussed below, there is a clear need for change in both the education of engineers and the practice of engineering. With the wicked, interdisciplinary problems facing society, there is also a growing need for disparate professions especially engineering, public policy, and planning to work more closely together in solving those problems. This requires each develop a better understanding and appreciation of the other. Changing the process of educating students will not be easy, changing the attitudes and opinions of existing professions will be even more difficult yet this is exactly what is being called for by governmental agencies, engineering accrediting bodies, and professional societies. (ASCE, 2017; National Academy of Engineering, 2005; National Science Foundation, 2007; NSPE, 2016)

Little study has been done in the study of changing professions. Most of the work that has been done deals with organizational change, or change at the local, company or institution level. While some of the knowledge gained through these studies cannot be applied directly—who is the management team for the profession of engineering? — some knowledge can be applied.

Differences Between Professions and Organizations

Professions differ from organizations in several ways. While organizations have a defined structure and a hierarchy consisting of well-defined leaders, professions do not. Professions are held together at best by voluntary organizations or accrediting bodies. Palumbo and Styskal (Palumbo & Styskal, 1974) alludes to this in discussing the concept of professionalism. He argues that professions and bureaucracy can be confused due to some similarities but there are distinct differences. Specifically, professions are controlled horizontally through voluntary organizations whereas bureaucracies are controlled vertically. Additionally, professions are controlled internally, by self-control, but bureaucracies are controlled through an authoritative structure.

Strategic Change

Strategic can be a difficult word to define due its many uses, and in some cases, mis-uses (Rumfelt, 2011). The differences in how this term is used is prevalent even within the same profession. Within the military strategic means intercontinental to the Army, nuclear to the Air Force, and "the level at which wars are decided" for the Navy (Barnett, 2009). For my purposes, I think of strategic change as being a pattern of continual change, the "*how* an organization will move forward" (Rumfelt, 2011, pp. 6-7). Mintzberg acknowledges that is one of several definitions in his book *The Rise and Fall of Strategic Planning* (Mintzberg, 1994).

Meeting future challenges

Organizations must plan to meet the challenges they will face in the future if they wish to thrive in the competitive environment that exists today. The challenges and need for change may come from external sources, or when the leadership recognizes a need for change and begins preparing people for the change (Pearlmutter, 1998). Technology is driving many of the changes and it is also causing some of the challenges to be faced in the future. Organizations that wish to continue to be viable and profitable in the future need to be aware of the future and willing to make the changes required.

Change within the engineering field have been recognized by several sources. Akay (2003) notes that "being a technical engineer" is no longer enough. The National Academy of Engineering states that "the practice of engineering needs to change further because of demands for technologies and products that exceed existing knowledge bases and because of the changing professional environment in which engineers need to operate" (National Academy of Engineering, 2005). They further state that engineering education needs to be re-engineered (National Academy of Engineering, 2005, pp. 18-19).

Globalization and Why It Necessitates Change in Professions

Globalization is a primary driving force behind the need to change within the engineering profession. The National Academy of Engineering states "[t]he half-life of cutting-edge technical knowledge today is on the order of a few years, but globalization of the economy is accelerating and the international marketplace for engineering services is dynamic" (National Academy of Engineering, 2005, p. 55). "From the U.S. perspective, globalization is not a choice; it is a reality. To compete in world markets in the "Knowledge Age," we cannot depend on geography, natural resources, cheap labor, or military might. We can only thrive on brainpower, organization, and innovation" (National Academy of Engineering, 2005, p. 162). Acquisitions and mergers of engineering, and other, firms has been stimulated by globalization (Lucena, 2006);

engineers working in these areas will have to cope with the challenges and opportunities brought about by these changes.

Globalization is also requiring engineers to respond to challenges as professionals in an ever-changing environment. Guest notes that "[p]rofessionalism relies increasingly on an ability to respond quickly and effectively, and in a global context, to technological and organizational change, as well as to changing market conditions, client requirements, government policies and national and international regulations" (Guest, 2006, p. 274). Guest further notes the changing loyalties in engineering. "[i]n a networked world, we no longer have long-term loyalty to a single organization but carry out different projects with different groups of people. An individual's first responsibility is to himself/herself and then to the networks of which he/she is a member" (Guest, 2006, p. 274).

Downey and Lucena (2003) note that as a result of two reform movements in the 1980s, there are changes which engineers will need to take advantage of. First, new opportunities will result from a rapidly changing economic scene. This will give engineers opportunities to offer national and international leadership. Second, these changes will create a need for corporations to employ people who are more flexible in addition to the corporations themselves becoming more flexible.

Prepare for New and Emerging Technologies

New and emerging technologies will surely allow for increased speed of change in organizations and some of this has been seen during the recent wars in Iraq and Afghanistan. However, even effecting this change is difficult. Forces resistant to change include not only the resistance that comes from internal sources such as the service bureaucracies, contractors and lobbyists, but also from those who place too much faith in advanced technologies (Boot, 2005).

As technologies are developed, they become integrated into our everyday activities and institutions. We grow to rely on those technologies to conduct routine business and to improve the efficiency with which we serve the public. The National Academy of Engineering points out that as this happens we will see a "convergence between engineering and public policy" (National Academy of Engineering, 2005, p. 11). They go on to state that the practice of engineering needs to change because of the demands for technologies that exceed what we have now and the professional environment in which engineers operate. This can be facilitated by engineering education, but they caution that there appears to be an increasing disconnect between how engineers are educated and how they practice (National Academy of Engineering, 2005, p. 13). To effect this change, the engineering faculty leaders as well as individual faculty will need to be engaged (National Academy of Engineering, 2005, p. 23). The Academy does note that there can be several different tracks in engineering education, and we already see some new tracks such as engineering education; one of the new tracks can include public policy (National Academy of Engineering, 2005, p. 47). This is not only important for public policy but also for engineering education. Lichtenstein (2009) found that a sizable percentage of engineering graduates, 26 percent, said they would "definitely not" or "probably not" pursue a career in engineering upon earning an engineering degree. An additional eight percent said they were "unsure". With such a high percentage, it makes sense to change the way engineering is taught to provide for those students who do not intend to pursue a traditional engineering career.

One could argue that as a result of their education and interest in engineering, engineering students are different from other college students and therefore effecting change within engineering education would need be to be handled differently from other fields. However, in another study, Lichtenstein, McCormick, Sheppard, and Puma found from reviewing the National Study of Student Engagement that there were no significant differences between engineering students and those in other disciplines (Lichtenstein, McCormick, Sheppard, & Puma, 2010, p. 314). It would be interesting to have a similar survey to determine if engineering faculty are significantly different from other faculty and if they are more or less resistant to change.

Increasing Rate of Change

It can hardly be argued that change is not happening, nor that the rate of change is not increasing. This is as a result, in part, of technologies that allow for greater and faster collaboration between individuals and different disciplines. The Internet is a key to this change and with half of the Internet users in the world located in the United States (Bottery, 2006, p. 101), it stands to reason that the United States may be the leader in change. However, Bottery also notes that at a time when flexibility is required, educational institutions, particularly universities, are being forced to be more standardized in order to effectively compete in the global marketplace and further that this inflexibility is increasing within education. All of this means that at a time when change is increasing and workers need to be more flexible, "education systems are being created, and educators conditioned in ways which make them singularly ill-equipped to help their students deal with these challenges" (Bottery, 2006, p. 104).

Resilient Organizations Are Needed

Organizations that are capable of handling change are needed in order to have widespread change across a profession. I have discussed that education is a key aspect of creating these organizations yet those in education may not be open to effecting change. The problem can be looked at from the perspective of changing engineering faculty in hopes of changing engineering education but we must remember that an engineering student also takes courses in other disciplines. Merton, Froyd, Clark, and Richardson have noted that not all faculty are open to change and some, especially in the mathematics department were strong dissenters to proposed changes (Merton, Froyd, Clark, & Richardson, 2004).

High reliability organizations, which arguably have attributes similar to the fields of engineering, law, and medicine, according to O'Neil and Krane "have resilient and overlapping functions that target error reduction" (O'Neil & Krane, 2012, p. 101). This is related to the argument of Graham that having cross-faculty delivery of courses that have been modified and a widely-disseminated impact evaluation looking at the changes made. This is required because "[t]he critical test of sustainability is whether the changes survive a university restructuring and changes to senior management" (Graham, 2012b, p. 599) and programs with those qualities are the most resilient.

Resilient organizations may also not be all that is required either. An organization consists of people and Oreg suggest that change results in stress and an individual's ability to deal with stress, their resilience, may be an indicator of their ability to cope with change (Oreg, 2003, p. 681).

Organizational Change

There are many reasons why organizations must and do change. Structural changes occur as a result of having to meet new budgetary demands, typically when budgets are reduced, but on occasion when budgets are increased. The market also makes demands of organizations that require organizations to change. These changes come with risks but also with rewards. While I look at organizational change it is important to remember that changing a profession is not the same as nor as easy as changing an organization.

Some organizations change by becoming learning organizations which is a model for constant and lasting change. I believe this is perhaps the best model of effecting change within professions. Becoming a learning organization is also one way to effect change and adds lasting value to an organization. However, when effecting change there are many issues which need to be considered including how to precipitate that change and maintain morale within the organization during this difficult period.

Structural Changes

In today's globalized economy it may be necessary to effect structural changes within our institutions. Companies can be seen as analogous to countries in competing in the global market. This competition requires leaders capable of leading these organizations to compete successfully. Fugate and Jefferson argue that our institutions of higher learning over the last several decades have not been effective in producing these graduates and therefore the institutions must change. (Fugate & Jefferson, 2001). Kyvik looks at changes that have been made in the education systems in Western Europe and looks at the binary system common across most of the globe as compared to the hierarchical yet unified system in the United Kingdom (Kyvik, 2004).

Meeting Budgetary Demands

Organizations react most quickly when faced with budgetary demands. While on occasion these demands may be the need to ramp up production and expenditures as a result of a budget increase, the more common situation is one in which demands placed on the organization increase while the budget remains constant or decreases. Shortly after the attacks of 9/11, the US Coast Guard saw a large increase in the need to protect the homeland but the budget was constrained (Wrightson, 2004). Disaster preparedness is also an area in which organizations need to occur as money becomes available for emergencies. While much of the money comes from the federal government, it is spent at the local level and often the local officials are better prepared to spend the funds. Donahue argues that there is a greater role for local and state governments to play in meeting the demands of the public in times of emergencies (Donahue & Joyce, 2001).

Meeting Market Demands

In addition to meeting current and near-term budgetary demands, organizations must also be able to meet the changing demands of the market. In research institutions, those that are able to adapt to interdisciplinary research, i.e. are able to change, are able to gain an edge in the research funding market (Sá, 2008). The ability for an engineer to adapt and be flexible in a changing market is noted by Lucena, as well as the need to change how engineering education is conducted in order to produce such graduates (Lucena, 2006). Even education is subject to market forces as it is forced to be more “future focused” (Goldspink, 2007).

Learning Organization

Becoming a learning organization is one way of effecting organizational change that can be lasting. This involves not only a change in the organization itself but in the members of the organization as well. Although Peter Senge (1994) is the most recognizable name in the area, others are also advocates of learning organizations.

Peter Senge and Organizational Change

The idea of a learning organization was popularized in the 1990s by MIT professor Peter Senge (1994) and has since been adopted by many organizations. Senge's premise is to take a systems approach to an organization and problem solving within that organization. This is best accomplished by encouraging a culture of learning within the organization and of the organization itself. Senge's five disciplines are systems thinking, personal mastery, mental models, building a shared vision, and team learning; and of these he considers systems thinking the most important because the disciplines must "develop as an ensemble" (Senge, 1994, p. 12). Although organizations only learn through its individuals, individual learning is no guarantee of organizational learning. However, organizational learning does not occur without individual learning (Senge, 1998). Having individual learning occur, particularly in education, is important because it is through changes in the thought processes of professors, and not necessarily changes to the structure of education, that real change will occur (Kezar & Rhoads, 2001).

Value of Being a Learning Organization

Simon points out that organization learning is not just the learning done by an individual, but is the sharing and transmission of that information to others in the organization. He argues that within organizations, individuals do not simply learn by themselves but it is rather a social phenomenon (Simon, 1991). Having individuals who are willing to learn is also effective in changing organizations. The argument is that once an individual recognizes and embraces the need for change, that attitude will spread to others and ultimately the entire organization will change (Beer, Eisenstat, & Spector, 1990).

Effecting Change

Change occurs as a result of internal or external forces. If the result comes from external forces, then the organization runs the risk of being behind market demands and being placed in a position of making changes without adequate thought and preparation. When an organization makes changes as a result of internal forces, it indicates that the organization is aware of the environment in which it operates and is prepared to meet new demands. This gives the organization an opportunity to plan for change. However, there is still often a need of some critical event to initiate that change.

Creating a Crisis to Precipitate Needed Change

When a crisis occurs, change happens in response to that crisis. The change may be temporary and last only until the crisis is resolved or it may be a permanent change, especially if the crisis has resulted in a permanent change in the state of affairs of the organization. One of the steps required for successful change, according to Kotter and Heskett (1998) is to create a sense of crisis or need for change. Kotter discusses how to create a sense of urgency within an organization to facilitate change, which is very similar to creating a crisis (Kotter, 2008). In some cases, it may be necessary to artificially create a crisis in order to stimulate change.

Similarly, Lewin refers to creating a sense of crisis to effect change. He states that "to break open the shell of complacency and self-righteousness, it is sometimes necessary to bring about deliberately an emotional stir-up" (Lewin, 1999, p. 282).

Maintaining Morale During Times of Change

Maintaining morale during organizational change is a critical factor. Communicating with those in the organization is one key to maintaining morale but Argyris points out that too much communication can have a negative impact on morale and in some cases morale is higher where communication is lower (Argyris, 1956). Overcoming resistance to change can also harm morale, even if participation in the change is widespread, so leaders must take time to manage the change properly or morale will suffer and resources will be wasted (Fernandez & Rainey, 2006).

Sources and Precipitators of Change

Change is always occurring in any system, whether it is a physical, social, or business system. The second law of thermodynamics states that entropy increases, that is the level of disorder within a system naturally tends to increase unless work is input into the system to compensate. This law has been applied by engineers, poets, philosophers, and economists (Kirwan, 2000). It recognizes that "the entropy of the universe is continually increasing" (Spanner, 1964, p. 79), and the inherent dissymmetry in nature that allows for the fact that "no process is possible in which the sole result is the transfer of energy from a cooler to a hotter body" (Atkins, 1984, p. 25). We recognize this in organizations where left to its own, the organization tends to become more disorganized without the continual input of energy into the organization through leadership, training, education, and the following of established procedures and policies. Add to this natural tendency towards disorder the often-disruptive changes brought on by changes in technology, expectations of workers, and needs to meet demands of customers or the public, the number of factors working to effect change grows quickly, it is clear that any organization will tend to disorganization without active work to preserve the status quo.

Globalization

Over the last several decades, there has perhaps been no greater change in the world than that of globalization. As a result of the Internet and ease of communications, it has become possible to communicate quickly with others, especially with those in other countries. In 1971 the first email message was sent (Center for Computing History, 2017) which reduced the reliance on messages being physically mailed from location to location, to the public introduction of the World Wide Webb in 1991 (Bryant, 2011), communications and commerce have seen tremendous change.

The idea of being so tightly connected across time and space was popularized by Thomas Freidman in his book *The World is Flat* (Friedman, 2005). Freidman discussed many examples of this interconnectedness that he learned from his travels around the world. He noted how products can be developed in one country, be prototyped in another, and how teams around the world can work on one design during each individual country's normal work hours thereby allowing for work on a problem to continue essentially around the clock. His book also made a strong case for the need to become more international in our thinking and account for rapid transmission of knowledge across cultural, geographical, and temporal boundaries.

While Brewer and Sanford (2011) advocate for incremental change, they note that there comes a time when transformational change is needed. This transformational change is required when technology, globalization, competition, and the economy require that change in order for the organization to remain successful.

Tichy (1982) notes that there are several forces affecting organizations and necessitating their change. These changes are caused by pressure in the technical, cultural, and political areas which impact organizations. Within the technical area, he mentions one source of falling productivity in the United States as “intense world competition.”

Impact of the Practice of Engineering

Practicing the profession of engineering has changed dramatically as a result of globalization. The engineering services marketplace has become dynamic and having a strong military, plentiful natural resources, and cheap labor no longer ensure the profession can thrive (National Academy of Engineering, 2005, pp. 55, 162). The European Union is but one example of how globalization has impacted engineering. Airplanes built by Airbus are constructed from various modules that are themselves built in many different nations, then brought together to be assembled into the final product. The very nature of a global economy has now seen Airbus helicopters built in Columbus, Mississippi and parts of Airbus airplanes constructed in Mobile, Alabama (Appelbaum, 2017).

The transmission of knowledge has also affected engineering education. Engineers in the United States not only need to be aware of the standards within in the U.S., they must also be conversant with standards published by the International Standards Organization (ISO). Further, many code requirements that were limited to the U.S. now come from international codes. Products designed and constructed in the U.S.

for international consumption must also meet the standards of the country that will import them. This can be as simple as ensuring fittings and components are metric rather than U.S. standards to having to modify designs to conform with policies of the importing nation.

Within the United States, people from other countries arrive to receive a technical education. In cases where an adequate number of American engineers cannot be found, foreign nationals are often called on to fill those vacancies (National Science Foundation, 2007). This is especially true in the ranks of academia where U.S. citizens with terminal degrees can frequently earn higher salaries in the private sector leaving academic positions open to be filled by engineers from other countries.

A professional engineer has several obligations that must be met, but two prime obligations are the protection of the health, safety, and welfare of the public, and maintaining his or her professional competence. According to Sheppard, Macatangay, Colby, and Shulman, "[g]lobalization of engineering work has added urgency and complexity to each of these goals" (Sheppard, Macatangay, Colby, Sullivan, & Shulman, 2009, p. 9) and additional education is required in order to continue to meet an engineer's professional obligations.

Impact on Education

Globalization has caused the connection between education and public policy to be ever stronger than it was in the past. Public policy has always been key in providing primary and secondary education at the local level but globalization may not always be well understood by the local policy makers who are instrumental in providing this education. To remain competent and competitive, they must understand and adapt to this new connected culture in which their students will work.

Higher education is particularly affected by globalization (Downey, 2005). Colleges and universities are no longer merely places of learning, the bastions of knowledge; they have become key to economic development and development of technologies for the business world. “Recent marketplace shifts make it necessary for higher education institutions to play a more prominent role in the development and commercialization of new technologies. As a result, economic development strategies have been refocused to include investment in higher education to attract businesses by providing better trained workforces and more robust research and development capabilities" (Feiock, Jae Moon, & Park, 2008, p. 28). Feiock et. al. specifically mentions areas that are directly related to engineering and the technical professions, but the business and public policy disciplines are also impacted. While technologies are developed, they must be developed within the laws and policies of the countries in which they will be used. As such, individuals who understand both the public policy and the technical aspects of these new products and technologies are needed to ensure policies are developed and implemented to allow the use of the new technology or, work with the technical professionals to ensure the technologies being developed are done so in accordance with existing policy.

Friedman’s work illustrates that more and more people are now able to participate in society as a result of globalization but this can also raise some issues in terms of education and training. Referring to Freidman, Feiock et. al., states that there is “a need to increase efforts to provide better education in science, technology, engineering, and math in order to ensure that Americans are competent in advanced technologies and are most creative in efforts to improve that technology, whether it is product or process oriented" (Feiock et al., 2008, p. 28).

Changing how engineers are educated is especially important. Engineers, as well other professionals, have their areas of expertise. This expertise is gained through years of education, study, and practice and it should be appreciated but it must also be shared. However, in a global society, it cannot be shared as an absolute. That expertise was obtained from education and work in a specific location under particular cultural norms, and while the scientific principles will apply in any culture, the specific application of that knowledge may or may not, yet that expertise must be shared. Bottery notes that "[p]rofessionals do have their understandings and expertise to share, and they should not be shy in declaring these; but they need to recognize other understandings, others' expertise, in a societal-wide debate on what is needed to improve what exists" (Bottery, 2006, p. 111). Unfortunately, he also notes that just when adaptability and flexibility are needed in education, educators and their institutions are becoming ill-equipped to help their students adapt to these changes (Bottery, 2006, p. 104).

The traditional path for educating, and ultimately licensing, an engineer consisted of several years of education at a university or college, followed by learning the more practical aspects of the profession during the first few years on the job. After completion of typically four years of professional experience, an engineer could then sit for the licensing examination. However, as a result of the rapid change in technology, it became apparent that learning for an engineer could not stop after graduation, even if he or she chose to remain in the same job. Therefore, developing an appreciation of and for lifelong learning became an objective of the ABET criteria in evaluating engineering programs (ABET, 2013).

Guest (2006) discusses not only organizational change within engineering, and specifically the Senge learning organizations in which many engineering professionals work, he also introduced the concept of networks. An individual's network will impact how they learn, where they learn, and why they learn. An individual's loyalty has shifted. "In a networked world, we no longer have long-term loyalty to a single organization but carry out different projects with different groups of people. An individual's first responsibility is to himself/herself and then to the networks of which he/she is a member" (Guest, p. 274).

The importance of understanding public policy by technical professionals is also noted by Guest. "Professionalism relies increasingly on an ability to respond quickly and effectively, and in a global context, to technological and organizational change, as well as to changing market conditions, client requirements, government policies and national and international regulations" (Guest, 2006, p. 274). And although the need for having a better understanding of the public policy process is noted by and mentioned as an ABET objective (criterion c) (ABET, 2013), it is difficult to find subjects within an engineering curriculum in which public policy is specifically addressed.

Engineers solve problems in the realm of society, and therefore must understand the society within which they operate. Xeidakis (1994) cites several capabilities an engineer must possess including technical skill, leadership, an understanding of economics, and good written and oral communication skills. They must also have a human side so that the problems can be solved with an eye toward the future while meeting the human needs of today. He notes that when asked what type of engineer should be produced by universities: one with technical competence; one with an understanding of public policy; or a manager; the most common answer is that the engineer should have all of those skills. But is it possible to produce such an engineer? Universities are slow to adapt to change due to economic reasons, so as Xeidakis states, even though university faculty may agree what type of engineer should be produced, it may not be possible to produce that type of engineer (Xeidakis, 1994).

Impact on Public Policy

Public policy has been impacted by the effects of globalization. Issues range from the granting of visas to foreign nationals to fill vacant positions in the United States to climate change. As the capabilities of technology have grown, new areas of application of that technology have arisen. Chemical engineers no longer simply work in the petrochemical industry but are involved in biotechnology, nanotechnology, and other areas necessitating a need for change in how they are educated (Downey, 2005). Downey also discussed what he calls Problem Definition and Solution (PDS) which, he points out, has application in the engineering and public policy arena. “An engineering and public policy track, he says, “would prepare students for problem definition work beyond the firm, e.g., in government or non-profit sectors” (Downey, 2005, p. 593). The availability of the Internet and the ability to connect almost any device to it, creating the so called “Internet of Things” brings tremendous convenience to the individual citizen but also puts critical infrastructure at risk of cyberattack as demonstrated by recent hacking on baby monitors and security cameras (Madnick, 2017) with potential to compromise transportation systems and the electric power grid. The advent of self-driving cars, or autonomous vehicles, presents many public policy issues that engineers, in concert with others, will have to address. These issues include ethics, infrastructure, regulation, safety, and liability (Kaplan-Leiserson, 2016).

Engineers, by their education, experience, and knowledge, play a pivotal role in the arena of public policy and technology. Through their work, engineers will make decisions, or have an impact on those who do make decisions about requirements for devices and systems that will in turn have an impact on the public (Unger, 1982).

In the realm of the environment, engineers also play a critical role in whether or not they design environmentally responsible products. Additionally, environmental engineers design treatment facilities and develop remediation capabilities. Semerjian, El-Fadel, Zurayk, and Nuwayhid note that environmental engineers and scientists need be more "involved in emerging social and political issues relating to their field as to help structure and articulate rational environmental policy, and properly practice their profession at the interface between policy and technology" (Semerjian, El-Fadel, Zurayk, & Nuwayhid, 2004, p. 180). And while they note the need for greater involvement, they note that graduates in these programs are lacking in education "in life sciences, public policy, ethics, risk assessment, and indicated the need for better communication [skills]" (p. 174).

Problems Have Changed

The very nature of problems themselves have changed over the years and it is necessary for education to change so that these problems can be adequately addressed. Education is expected to be future orientated and complex problems are arising that need complex solutions (Goldspink, 2007). Problems today are multi-faceted and more interdisciplinary in nature than in the past.

Problems are Interdisciplinary and Complex

Problems facing society today increasingly rely on more than one discipline to solve. Within the field of engineering, what was once the domain of a specific discipline of engineering, now requires several disciplines. The National Academy of Engineering notes that there is “a growing need for interdisciplinary and system-based approaches” to problems (National Academy of Engineering, 2005, p. 4)

Developing new products can also result in policy issues. Within the field of biomedical engineering, new instrumentation and implants can extend human life. However, these devices come at a cost and as life spans are increased, the health care cost of individuals is also increased. Hyman (2003) also notes that “it is not unusual for a new design criteria to evolve from changes in the social environment within which engineers operates [sic]. In the last several decades, vastly increased public sensitivity to the impacts of technology has fostered the concept that engineering should consider the societal concerns as part of the design process." Both engineers and other policy makers must be engaged in the process in order to ensure the needed support is present to pay for these improvements.

In a report on issues facing engineering, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) repeatedly refers to the complexity of technical problems facing the world and how they are interrelated with public policy (UNESCO, 2010). They point out that “[t]echnological change is a complex process that must be managed all the way from concept to the market place” (p. 66). And while this is true, UNESCO also states that engineers are ideally suited to public policy because they “are trained to analyse problems and find solutions in a rational, systematic way. The entire engineering mindset is to define a problem, identify alternatives, select the best solution, and then implement it. Engineers are knowledgeable about an array of subjects including business and public health as well as technology" (UNESCO, 2010, pp. 176-177). The issue with this is, they say, within the profession. Changes must happen such that the "engineering profession more globally…dispel[s] the perception that engineers cannot participate in public policy or politics just because they are engineers" (UNESCO, 2010, p. 178). Of course, political scientists are also adept at identifying alternatives and making selections based on many factors as well. This is one of several traits the two professions share.

Problem Solutions are More Collaborative

As the complexity of problems increases, the solution to those problems requires more collaboration among different professions. As Sheppard says, "there is just simply too much to know and to do" (Sheppard et al., 2009, p. 6).

And collaboration is changing from how it was in the past. As reported by the National Academy of Engineering:

> In the past, steady increases in knowledge have spawned new subspecialties within engineering (e.g., microelectronics, photonics, and biomechanics). However, contemporary challenges—from biomedical devices to complex manufacturing designs to large systems of networked devices—increasingly require a systems perspective. This drives a growing need to pursue collaborations with multidisciplinary teams of technical experts. Important attributes for these teams include excellence in communication (with technical and public audiences), an ability to communicate using technology, and an understanding of the complexities associated with a global market and social context. Flexibility,

receptiveness to change, and mutual respect are essential as well (National Academy of Engineering, 2005, p. 10).

Of importance to this study is the social context expertise required of engineers.

Current Education System is not Adequate for Interdisciplinary Problems

The educational system, at least in the United States, is by and large no longer focused on producing liberally educated graduates. The focus has become one of narrow specialized education with the intent of producing graduates who are employable and has lost its focus on producing graduates with the skills needed to attack truly interdisciplinary problems. One purpose of the course developed as part of this study was to reintroduce concepts of interdisciplinary problem-solving using real-world examples.

Interdisciplinary problem solving requires understanding problems from many different points of view and those points of view are arguably best obtained from a liberal education. However, the reduction in hours required for an undergraduate degree has forced disciplines to eliminate or reduce the courses deemed less important, i.e. those that produce a well-rounded graduate. In engineering, this has resulted in eliminating courses in the social and behavioral sciences, humanities, and fine arts. In the non-technical majors, courses in science and mathematics have been reduced. Instead of producing graduates who know more about more, colleges and universities are producing graduates who know less about less; and are doing so at a time when those very graduates need a more in depth understanding of an even broader range of subjects. And although this is recognized by some professional organizations, such as the National Society of Professional Engineers in its policy statement number 1752 (2010) and by ABET in their criterion (c) (ABET, 2013), it remains difficult to include this material in an already full curriculum.

For some majors this problem is solved by requiring graduate degrees, but in the case of engineering, there is and has been tremendous resistance to requiring an advanced degree for entry into the profession (Grose, 2012). While it can be argued that there are many reasons for this opposition, Ressler (2012) argues it is due to some organizations taking the view of what is better for industry rather than what it best for the profession. This knowledge cannot be expected to be gained while on the job, because the majority of the people in the profession who would instill this knowledge lack the knowledge themselves. This one reason why room in the curricula must be found to at least expose students to the content of these broader subjects.

Cooperation Needed Across Disciplines

With the profession of engineering, it is widely recognized that various engineering disciplines must work together. UNSECO notes of chemical engineers, for example "The work of today's chemical engineers involves strong multidisciplinary collaboration with physicists, chemists, biologists, mathematicians, instrumentation specialists and business people" (UNESCO, 2010, p. 129). However, it is not merely an electrical engineer recognizing they need the expertise of a mechanical engineer to solve a problem, it is all engineers needing to recognize that their solutions will have societal impact and non-technical disciplines are required. Further, those who make public policy—political scientists, lawyers, businessmen, and others—must also recognize that technology has limitations in the problems it can solve, and the misapplication of technology to problems can have detrimental effects on society.

Although engineers have used their technical skills to better society, they have typically taken a limited role in shaping public policy. They have instead allowed public policy to be shaped by others while they remained relatively quiet. The issue with this is that then leaves others with perhaps less expertise to make public policy decisions without input from those who know the most about the issue. "Engineers become second and third stage implementers rather than first stage implementers" resulting in "a cost, either in too many dollars being spent on a solution or a solution that cannot deliver on the expectation when public policy is designed without adequate recognition for the technical requirements necessary for success" (UNESCO, 2010, p. 176). Modern technology has also placed us in a situation where "the consequences of wrong choices or errors in execution can be massive in terms of damage to the environment and the loss of life, liberty, and property" (Unger, 1982, p. 5) which makes it imperative that engineers engage in the public policy process.

Downey ask the question of whether an engineering graduate must be just one thing? He discusses how the current education of education needs to change to focus on how problems are defined and somewhat less on how they are solved. With changes in pedagogy, engineers can be educated to be better prepared to work beyond the traditional engineering firm and in areas of government and non-profit organizations, by preparing students to work with those who define problems from a different perspective (Downey, 2005).

Problems are Multi-Faceted

The problems faced by engineers today are multi-faceted and require an even greater understanding of non-technical issues. After the terrorist attacks of 9/11, the face of engineering changed. Engineers can no longer simply look at the good their works can produce but they must also consider how those works can be used for malevolent purposes. Akay points out that it is no longer enough for an engineer to simply produce technology with a focus on the technical aspects, a modern engineer must "also reach beyond pure technology to consider the causes of vulnerabilities as well as relevant social, economic and cultural issues." "Engineers also have a responsibility to consider the causes of and conditions that give rise to vulnerabilities and malevolence" (Akay, 2003, p. 147). To fully embrace this responsibility, engineers must have a better understanding of the non-technical issues impacting their profession. Interestingly, a model does exist to do this. ABET placed a renewed focus on communication skills and engineering programs responded by more closely integrating other academic areas on campus and from industry to develop improved communication courses (Williams, 2001).

In a study of students participating in the Washington Internships in Science and Engineering (WISE), Hyman discusses that the most valuable aspect of the program to many students is a new outlook on politics. The program removes many pre-conceived concepts of politics and the idea that the political process would be better if it were only "more 'analytical' and less 'political'". In place of those preconceived ideas, students obtain a much more realistic and necessarily more sophisticated view of politics and how engineers need to learn to more effectively participate in that political process (Hyman, 1988).

Wicked Problems

The very nature of problems being faced by society in general and engineers and political scientists in particular is changing. Increasingly, problems become less closed form and more interdisciplinary, interrelated, and often without a clear solution. Engineers and scientists learn from Newton's Third Law of Motion that for every action, there is an equal and opposite reaction. This concept governs their thinking about not only technical problems, but also societal problems as well. However, in society there is no equivalent of Newton's laws. In fact, in solving societal problems, we can say that for every action, there is a limitless number of possible reactions and, furthermore, these reactions may never be fully known. Many of these reactions may also be political and relate more to policy than to technical issues.

Rittel and Webber refer to these types of problems as, and coined the phrase, "wicked problems". They discuss wicked problem in the context of planning and including some aspects of engineering in their discussion such as determining the location of a freeway (Rittel & Webber, 1973). But I think they draw too fine a line and several times point out that engineering and science problems can be solved but planning problems are more difficult. There is some merit to their argument but it seems to further divide the two professions and lead to the idea that each can be practiced in isolation of the other. Engineers are becoming more involved in the siting of freeways and need to be better able to deal with wicked problems. Similarly, those involved in planning need to better understand the engineering solution to problems and recognize that even when a freeway is designed, it was designed with certain assumptions in mind. If the planners or policy makers make changes, the assumptions made in the design may no longer be valid.

Overview of Organizational Change

Organizations change through learning over time (Allison & Zelikow, 1999, p. 144). Oftentimes, as suggested by Kotter (2008), this change occurs as the result of some crisis, artificially created or organic in origin, such as a budgetary crisis (Van Loon, 2001). According to Simon, "[a]ll human learning takes place inside individual human heads; an organization learns in only three ways: (a) by the learning of its members, (b) by ingesting new members who have knowledge the organization didn't previously have, (c) by introducing new knowledge into its files and computing systems" (Simon, 1997, pp. 228-229).

Behavioral Changes

Changing an organization involves changing the behavior of the people within that organization. Sometimes a key element of changing this behavior is to change the behavior, or even the people themselves, who the leaders of the organization (Giberson et al., 2009). While this can be done, admittedly with difficulty and repercussions, in an organization, it is more difficult to do within a profession.

Structural Changes

Organizations also change as the result of modifications to their structure. Some of these modifications occur over time through an evolutionary process (Stańczyk-Hugiet, 2014), others occur through some other means such as a merger. Change in structure have an immediate impact on the organization whereas behavioral changes may take longer to have an impact (Aplin, 1978).

Kurt Lewin and Change Theory

Although there are many models of organization change, most relate in some way to the three-stage process of change proposed by Kurt Lewin (1951). Lewin, a social psychologist, investigated how to implement lasting change among various groups. He was interested in a wide range of organizational change ranging from modifying attitudes towards minorities to changing shopping and eating habits of families and purchase of War Bonds during World War II (Lewin, 1951). Lewin proposed that in order to effect change you must first unfreeze an organization, a process through which the organization realizes that it needs to change. The second stage then is to actually implement the change. The third, and final, stage is to freeze the organization at the new level after the change. This stage is critical in order to prevent the organization from falling back into old habits and practices (Lewin, 1999, p. 282).

The three-step model of change proposed by Kurt Lewin is well-known and widely accepted in the field of organization theory, even though some argue it is outdated and dismiss it as no longer applicable (Burnes, 2004). The primary objection to Lewin's theory is his third and final stage, refreezing. This stage of his theory is often criticized on the basis that change is constant and change should not be thought of as being frozen at some point.

Other models have been proposed but many of these can also be re-couched in terms of Lewin's three step model. Graham, for example, discusses an eight-step model (Graham, 2012a) but this can be rearticulated into Lewin's three step process by labeling her first three steps as unfreezing, the next three as moving, and the final two as refreezing. Weick argues that Lewin's model applies in case of constant inertia but proposes a slightly different sequence in cases where change is continuous, a more sensible process would be freeze, rebalance, and unfreeze (Weick & Quinn, 1999).

Lewin notes that if left alone, individuals will not necessarily form themselves into democratic groups but will more likely form themselves into groups through chaos. Additionally, “[t]he democratic follower has to learn to play a role which implies, among other points, a fair share of responsibility toward the group and a sensitivity to other people’s feelings” (Lewin, 1944a, p. 289). To account for this in the introduction to engineering and public policy class, I ensured there was adequate interaction amongst the varied class members through several group assignments that required interaction amongst the group members. Rather than allow the groups to self-select, I assigned students to specific groups to encourage, ever require, interaction.

Unfreeze

Recognizing the need for change is the first step in effecting change. In order to do this Lewin argues that internal resistance to change must first be overcome and this is done by applying a force to effect the change (Lewin, 1951). In making this change Lewin argues that is important to not simply consider the desired goal of the change but look at all of the options and possibilities (Kippenberger, 1998). Overcoming this resistance to change, the unfreezing of the current state, is the primary focus of my research—how can we lower the resistance to change and allow an organization—a profession—to move to a new state.

Human nature is to resist change and this resistance is one of the first steps that must be overcome. In Kotter’s eight stages of change Lewin’s unfreezing can be thought of a combination of Kotter’s stages 1, 2, and 3 with some overlap of stage 4 with moving the organization along the path of change (Graham, 2012a; Kotter, 1996). These stages are developing a sense of urgency which is a critical stage discussed at greater length in *A Sense of Urgency* (Kotter, 2008), developing a powerful guiding coalition, creating a vision, and communicating that vision (Graham, 2012a). Graham states that there is growing evidence that this 8-stage model of Kotter's is the basis for more recent changes in engineering education (Graham, 2012a, p. 9). Due to the timeframe involved in effecting institutional culture changes in a profession, this study will, of necessity, focus primarily on the first stage of the process, unfreezing, by changing attitudes of engineering and political science students.

Moving

Moving to a new state is arguably the easiest of the three steps in that once the resistance to change has been overcome all that needs to be done next is to implement the change. While there are still challenges to make the needed change, moving to the new state should be the easiest. This of course will require effective leadership and a willingness to accept some risk. In case of significant change, it is also important to have good lines of communication and to create opportunities for short-term wins.

Once the organization has been unfrozen, it is time to move the organization to its new state. This combines steps 4, 5, and 6 of Kotter's ten stages of organizational change. These steps include communicating the vision, empowering others to act on the articulated vision, and planning for and creating short-term wins (Graham, 2012a; Kotter, 1996). These short-term wins can be celebrated and break up the path to organization change into smaller trips.

What is the Goal?

To be successful, any change within an organization must be done with a clear goal in sight. The case under consideration here is the changing of the mindset of the engineering profession to play a greater role in the development of public policy, especially when technical issues are involved, and to encourage political scientists to seek the involvement of engineers setting policy, especially technical policy. This involves not only changing the attitudes within the profession but also within the system that educates the engineers. Unfortunately, there is “a dearth of information on how to achieve successful, widespread change to the engineering curriculum” (Graham, 2012b, p. 12). An additional reason to change the goals of engineering education is that 26 percent of those who complete an engineering degree either probably will not or definitely will not pursue a career in engineering (Lichtenstein et al., 2009). These are students who clearly have demonstrated their ability to grasp technical concepts and complete a rigorous degree program, if the educational program could be made more receptive to the idea of public policy then these graduates would be prime candidates for jobs or additional education in the public policy area.

Downey and Lucena note that another reason for change within engineering education is so that more flexible engineers can be produced. In an age of globalization and the changes within organizations required to remain competitive, engineers must be flexible (Downey & Lucena, 2003). Engineers, Downey states, “set out on pathways that turn them into many different things”, he asks the question “must a degreed engineer be just one thing?” (Downey, 2005, p. 593).

Refreeze

The third and final stage in Lewin's change theory is to refreeze. Refreezing change is a critical step in this process. If not done properly it will be easy for the individuals in an organization to slip back into their old ways of doing things and thereby undoing the change that was just made.

As initially conceived, once the new state has been achieved, the organization would be frozen again in order to preserve the new state. However, in an ever-changing environment it may not be in the best interest of an organization to become static again. If an organization becomes a learning organization, then the change can be refrozen at a state that will allow for continued change (Argyris, 1993, p. 244). Weick and Quinn (1999) argue in situations where there is inertia in the system and there is a state of continuous change, the three-step process would be better thought of as freeze, transition, and unfreeze. Any new stage achieved will likely only be temporary so it is best to think of the new stage as one of flexibility, one in which the members are continuously learning and changing.

Lewin's model of organizational change is often criticized as being outdated and no longer valid. While it worked well until the 1970s, the increase in oil prices in the 1970s meant that organizations needed to be able to change quickly and be in a state of continuous change (Burnes, 2005). I disagree with this assessment and think that Lewin's model is still applicable so long as a more open definition of his terminology is accepted and used.

Senge and Refreezing

Senge (1994) popularized the concept of systems thinking, his fifth discipline, and the development of learning organizations. Learning organizations are focused continuous improvement and consists of four core values: personal mastery, mental models, shared vision, and team learning. Senge believes that an effective learning organization must achieve a shift of mind, *metanoia*. The introduction to engineering and public policy course was designed, in part, to achieve this *metanoia*. It also stresses to students the importance of life-long learning (personal mastery) and looking at the world and problems from the perspective of others (mental models).

Role of Attitudes in Organizational Change

Change does not happen in a vacuum and the attitudes of individuals as well as the values of the organization must be considered and accounted for. In some cases, it may be necessary to change these attitudes and values.

Individual Attitudes

"All human learning takes place inside individual human heads" (Simon, 1997, p. 228) therefore individuals clearly play a key role in change within an organization. Military sociologist Morris Janowitz, according to Greenwald, finds that resistance to change within the military resides in the middle officer ranks rather than at the top or bottom ranks. This is due to the fact that at the lower ranks the inclination is to adapt as needed to meet the realities of combat. At the higher levels, there tends to be less resistance due to the fact that those who tend to innovate are also those who are most competitive for promotion (Greenwald, 2000, p. 16). This is the basis for working with those at the entrant level of the profession.

Corporate Values

Not only are the values of individuals important in organizational change, the values of corporation, the culture within the organization are also important (Zilwa, 2007). Exploring and understanding these values during the change process can be helpful in achieving the change. Individual journaling is one way of exploring these values although most people are not accustomed to keeping journals which limits the success of this particular strategy (Hill, 2005).

Although the values of the organization are separate from the values of the individuals, they are related. Individuals will make choices of where they work based on their individual values, including even which professions they choose to pursue, and the leadership of the organization is reflected in the values they use to promote individuals to leaderships positions (Andersen, 2010). This can be used to the organization's advantage in effecting change by directly relating the values of the organization to the those of the individual and linking the change in the organization to the desires of the individuals to have an impact on society.

Similarity Between the Military and Engineering

In looking at change within professions, I contend that not all professions operate from the same perspective—some professions welcome and even seek change, others tend to resist change. I believe this is, in large part, due to the risks and rewards of change. While any professional should be willing to accept greater risks for greater rewards, some must be tempered by the greater costs of failure. A business professional, for example, may risk a great sum of money in a new venture and be well rewarded should the venture experience great earnings. Should the venture fail then all that is lost is money. As long the professional has enough money to survive, losing some money causes little if any harm.

Other professions operate within a different paradigm; a paradigm in which the cost of failure could vastly exceed the benefit of success. These professions then tend to behave with great conservatism, resist trying new and unproven technology, and, when they do make changes, they make them incrementally. The military “takes a custodial approach toward their institutions and conservative outlook to change” (Greenwald, 2000, p. 14) which is a similar view taken within the engineering profession. Both professions involve technology and technological change; both professions have impact that extend to society as a whole; and defeat or failure in either also has consequences that reach beyond the boundaries of those involved in making the decisions (Greenwald, 2000; Petroski, 1985). Failure in a battle can result in the death of many, and error in an engineering design can also result in the death of many people. Defeat in battle has consequences that extend to the politics of a state; failure of an engineering design can have consequences that extend to the larger economy.

Additionally, both engineering and the military are among the oldest of professions. As a result, they have a significant history, vast knowledge base, and are very mature. These factors contribute to the culture of the profession that make it difficult to effect change.

Resistance to Change

Organizational change would be easy were it not for resistance. Resistance is the natural tendency to prefer the status quo, to continue doing that which has always been done. To effect change within an organization or a profession, this resistance must either be overcome or avoided. Lewin was the first to coin the phrase “resistance to change” but the meaning he had in mind was the resistance of the fields returning to a point of equilibrium, rather than a psychological characteristic of an individual (Dent & Goldberg, 1999, p. 25).

Overcoming resistance would be easy were it not for the fact that organizations are composed of people and people are inherently resistant to change (O'Toole, 1995; Oreg, 2003, p. 683). Burke groups this resistance to change into three broad areas: Blind Resistance, Political Resistance, and Ideological Resistance. The concern is that “change usually involves a shift away from a known situation, with all its familiarity, comfort, and advantages” to something that is unknown and uncertain (Burke, 2008, pp. 92-93). But this resistance is not necessarily a resistance to change itself but rather concern over losing something of value (Burke, 2008, p. 91).

Working with and educating those who are presenting the resistance can overcome it. Resistance to change is often thought to be a factor of an individual however, resistance to change is not inherently in the individual but rather arises from circumstances in which change takes place (Coch & French, 1948). Studies conducted by Coch and French demonstrated that resistance to change can be overcome, at least in industries consisting of piece work. Coch and French, through interviews, found “common pattern of feelings and attitudes which are distinctly different from those of successful non-transfers [those not transferred to a new department or new piece of machinery]. In addition to resentment against the management for transferring them, the employees typically show feelings of frustration, loss of hope of ever regaining their former level of production and status in the factory, feelings of failure, and a very low level of aspiration” (Coch & French, 1948, p. 516).

Burnes notes that Coch and French found that "[t]he way to change the forces in the field to achieve a desired outcome is not to attempt to impose change, but to encourage participative decision-making" (Burnes, 2015). Kotter and Schlesinger (1979) note that the four most common reasons individuals resist change are: a desire not to lose something of value, a misunderstanding of the change and its implications, a belief that the change does not make sense for the organization, and a low tolerance for change." This resistance, they say, can be overcome with effective communication within the organization regarding the changes and the need for change.

The military is an organization in which there is deep historical experience and a conservative outlook toward change. This results in an inability to evaluate new ideas and technologies due in large part because of the significant cost involved in being defeated (Greenwald, 2000, p. 7). The status quo is protected out of fear that new technology may replace people with equipment or computers. It is those who have a vested interest in protecting the status quo who are resistant to modernization efforts (p. 14). Within engineering education, faculty are particularly resistance to change in part out of concern of "perceived pressure from accreditors" (Basken, 2009).

Resistance to change occurs only in certain sectors of the workforce. Those who are new to a profession or an organization, especially those who are young, will have little resistance to change. In fact, they may be quite open to it. Their opinions of and attitudes towards the organization have not developed and they have little, if any, experience on which to base their judgment. There is no status quo for them to maintain. At most, they bring with them the opinions developed and learned from professors in college.

Jansen (2000) has noted there is a call to dispense with the term and concept of *resistance to change*. Lewin is credited with the introduction of the concept of resistance to change but he was referring to it as a systems concept, not an inherent trait within individuals, although the psychology of individuals is a component of the system (Dent & Goldberg, 1999). Kotter (2007) similarly notes that what is seen as resistance to change may actually be structural impediments within the organization rather than resistance within individuals.

Resistance to change varies from individual to individual. While some openly embrace change, others go to great lengths to resist change. Oreg (2003) found that individuals who are less tolerant of risks and try to avoid ambiguity show higher levels of resistance to change than others. Unfortunately, avoiding ambiguity and being risk averse are traits commonly associated the professions under consideration here, especially engineering.

How Change is Brought About

Organizations have a worldview that consists of their high-level abstract beliefs. These beliefs give meaning to the organization's values and mission that also involves the beliefs of the members of the organization. The attitudes, perceptions, and behaviors of members within an organization guide and direct the organization. Once the worldview of the organization is changed, the other elements will also change (Levy & Merry, 1986, p. 10).

Levy and Merry also discuss first- and second-order change. First order change is the change that occurs naturally as an organization matures. These changes do not involve change to the core of the organization and are essentially incremental. Second order changes are the more radical changes that occur in organizations; these are transformational changes and involve “multi-dimensional, multi-level, qualitative, discontinuous, radical organizational change involving a paradigmatic shift” (Levy & Merry, 1986, p. 5). A first order change in the military would be the adoption of a new technology such as the telegraph over written messages delivered by horse. In engineering, it would be the adoption of a new, less expensive type of concrete. Second order changes however would have far greater impacts on the professions. The adoption of counterinsurgency by the military in Afghanistan had significant impact on how the military organized itself. The development of microprocessors has permitted engineers to develop much more complicated devices that require multi-disciplinary design and related changes in how engineers are organized.

Strategic change begins by redefining the purpose and mission of an organization and then effecting change within the subsystems of the organization. There are three approaches that can be considered to bring about strategic change (Levy & Merry, 1986, p. 25). If leaders see themselves as the end state, then they can simply state the new strategy and “lead” the organization to the new end state. There is very little given as to how this “leading” is to be done (p. 25).

Redefining the organizational purpose and then changing the paradigm in the technical, political, and cultural subsystems in the organization can also effect the change. The technical subsystem revolves around how work gets done. It includes the Weberian bureaucracy, systems used within the organization, the job descriptions, and the technical systems used. This subsystem might well operate according to Taylor’s theory of scientific management. The political subsystem involves exchange theories, reward allocation, how problems are solved and how conflicts arise and are resolved. The cultural subsystem is the one that involves human psychology human relations, and organizational development (Levy & Merry, 1986, p. 26).

Change can also occur by creating a climate and environment in which the need for change can be seen and accomplished. This is done by working at the lower levels of the organization by:

1) Presenting the problems facing the organization to those at lower levels.
2) Having managers hold meetings that allow for members to express their concerns and offer potential solutions.
3) Have top management make a symbolic decision that demonstrates their commitment to change.
4) Create a new standard that allows individuals to determine where change needs to be made.
5) Develop structures that will allow the organization to transition to the next level.

Lewin would call this stage the defreeze stage (Levy & Merry, 1986, p. 27). This defreeze stage is the stage at which the need for change is demonstrated and the organization is placed in a position to move forward.

Changing Education

Just as Lewin had to educate the public about other food choices during World War II (1999), engineers must also be educated about the need for change. As a surrogate for engineering design I have elected to use a change in attitudes toward engineering and public policy. Through a course developed and taught, Introduction to Engineering and Public Policy, my co-instructor and I effected changes in attitudes of both engineering students toward public policy and political scientists, and of political science students towards the involvement of engineers in the public policy setting process and the profession of engineering. Being able to effect these changes is a good indicator that other changes could be achieved through education of the next generation of professionals.

The literature offers little on the process of effecting widespread change in the undergraduate engineering curriculum (Graham, 2012a). With such little information available on changing the engineering curriculum, it stands to reason that there is even less available discussion where public policy was overtly injected into engineering curricula but, there are some cases. One course used cases developed by students who participated in the Washington Internships for Students of Engineering (WISE). In this class, the WISE students were asked to “include enough technical content so that they [the cases] would be suitable for use in traditional technical courses while simultaneously exposing students to at least one of…five public policy dimensions.” These dimensions were:

1. Government as the employer.
2. Government as the regulator.
3. Government as the customer.
4. Government as the designer.
5. Government as the technology driver.

The class also tested student attitudes towards engineering and public policy issues and found that 66% of the students developed and improved perception of engineers in the public policy process and 93% believed engineers should be more active in the public policy process. Prior to the class, when asked about how much they had thought about the connection between engineering and public policy, 25% had given it a great deal of thought, 50% had thought about it somewhat, and the remaining 25% had given it very little thought (Hyman, Brown, & Lagerberg, 1990).

In addition to noting a world-wide call for cultural change in the education of professional engineers, Walkington (2002) provides a framework for changing the curriculum in engineering education. She notes that “change is a journey, not a blueprint. It is non-linear and loaded with uncertainty” (2002, p. 134). She also states that there are four stages to implementing curricular change. The first stage is establishment/orientation (background and setting of the change), followed by refining the nature of the change, then design and development of the curriculum, and finally implementation and evaluation (2002).

The process described above was followed in the development of the Introduction to Engineering and Public Policy course which is the subject of this study, even though we were merely designing a single course rather than an entire curriculum. Stage 1, was the discussion between the course developers generated an article noting the lack of public policy in engineering courses (Creighton, 2004). Through trial runs of the course, adjustments were made in content taught and requirements expected of the students. The course was adjusted and evaluations were done each semester. In addition to the typical, university-required student evaluation of teaching, each semester concluded with an open discussion with the students about what they liked and did not like, what they wanted added to or removed from the course, and what their thoughts were on the value of the course. Over the semesters, the course evolved and changed as a result of this input and lessons learned (Green & Emison, 2006b).

The course developed in this study is an elective course for engineering students and does not provide credit towards their degree program however, political science students can substitute this course for their required public policy course. Given there is no “degree credit” for this course for engineers, the question can be asked why it should even be taught. The reasons given above, effecting change in the profession, was the primary reason the course was developed, but it also can have other implications. Lichtenstein et. al. (2009) found in their study that just because a student earns an engineering degree, they may not enter the engineering profession. But perhaps more importantly to me was their finding that students’ “career thoughts were swayed by a single experience such as internship, faculty/staff interaction, mentoring” (Lichtenstein et al., 2009, p. 232). Therefore, a secondary effect of this course may be the mentoring and interaction with the students that results in career changes.

Factors Affecting Change and Their Background

Change is typically assumed to be the dependent variable and the organization is the independent variable which seemingly implies that the organization makes a conscious decision to effect change within itself. The organization then merely has to effectively manage that change to achieve its desired results. Factors within the environment will evolve over time, they will change, and if these factors are important to an organization then the organization must adapt. Should the change be dramatic and the organization not change, then it will likely die. Should the organization recognize, even anticipate, these changes and adapt accordingly, then it will not only survive, it may well thrive.

At times, it is acceptable for individual organizations to change but at other times it seems more prudent to change entire professions. Professions differ from organizations in several ways that make them more difficult to change but the result of changing a profession is that many organizations can be changed as a result. Organizations tend to be relatively small and narrowly focused on specific services or products. Professions are generally larger and have a broader focus. Organizations tend to have a common figurehead such a chief executive officer or president whereas professions will tend to either have no figurehead or have several, as in the case of multiple engineering societies that regulate the profession of engineering. Regardless, the one major difference between an organization and a profession is the lack of a central figure that can direct and effect change.

The structure of the organizations may also change as in the case of professional societies accepting members from other countries and opening new chapters in those countries. Recognizing the need to be more competitive globally, a corporation may branch into other markets and may geographically disperse its workforce to improve market accessibility or improve resiliency from a man-made or natural disaster.

Finally, the processes residing within a profession may change. The advent of inexpensive computing power changed the way certain engineering calculations were performed. In many cases, estimates or approximations were replaced with complex mathematical models that provided great accuracy in the final result. In the recent wars in Iraq and Afghanistan, I would argue that theory of counterinsurgency has changed the processes by which the United States military fights wars.

Regulators are challenged with developing rules and enforcing regulations that may or may not be appropriate in a global economy. In the past, regulators could assume that steel used in a structure came from the same country in which the structure was being constructed and therefore met any national standards. No longer is this the case. The steel used may well have come from country different from the one in which the structure is being built and it may or may not meet required codes and standards. In the end inspection costs can rise or confidence in the inspection can lessen. These changes should be understood in developing public policy.

While changing the processes within an organization is certainly possible, to have lasting change then the values of the people within the organization must be changed (Tichy, 1983, p. 264). Resistance to change by people is one of the major reasons for the failure of organizations to change, yet most current models of change have little to say about change within people (Davis & Songer, 2009, p. 1324). Human nature is, for the most part, a constant and therefore very difficult to change. Thucydides' *History of the Peloponnesian War* (Strassler, 1996) is studied at the Naval War College, in part, to stress this constancy of behavior to those who will plan and direct national security strategy. Yet to achieve lasting, structural changes it is human nature, or at least innate attitudes, that must be changed.

Changing the attitudes of people, changing human nature is, I believe, the most important factor in achieving lasting change in organizations and professions. It is therefore the main focus of this dissertation. Changing attitudes is not easy but the benefits of doing so are valuable to organizations, professions, and society as a whole.

To change professional attitudes, I believe that the attitudes of key individuals must be changed and these key individuals will then be able to change others. To change attitudes, individuals must first develop an appreciation and understanding of other professions, especially those they will work with closely. This may require that long-held paradigms of their own profession be discarded and new paradigms embraced. It will certainly require an examination and newfound appreciation of the values deemed important by other professions. The end result will be greater interdisciplinary cooperation on addressing global societal needs.

Professions have developed processes by which members are indoctrinated to the culture and practices of the profession. In the military, the process may be accomplished through boot camp or officer candidate schools. In engineering the process is accomplished through the entirety of the college education as students are taught how to solve problems and how to “think like engineers”. Political scientists are similarly educated in college to look at problems from a particular point of view through their study of various forms of government, elections, history, and international relations, among others. Sometimes the process is subtle such that engineers tend to attach more importance to physical data than to societal factors, and other times is more blatant as when engineers are taught that their primary ethical duty is to protect the health, safety, and welfare of the public. There is a fine line here however, a person entering an organization brings values with them and those values should be, somewhat, accounted for, while at the same time the individual is expected to adopt some of the organization’s values (Cook & Yanow, 1993, p. 387). Changing these values may be necessary in order to effect change in the organization and profession but it will involve challenging these long-held values. Further, the process may involve changing not just values, but rather entire paradigms. For the purposes of this dissertation, it may require that the engineering profession truly recognize the need for a better, more in depth understanding of public policy. It may require that political scientists interested in working in the engineering and public policy arena recognize that they may need more technical education in addition to their standard political science education requirements.

One key to changing these values, I believe, is increasing the level of respect for different professions. Stereotypes are useful for dealing with topics at a conceptual level but they tend to be counter-productive at the individual or group level. By having students and professionals work more closely together they may develop a better understanding of what each other does and where they fit in the larger picture. They can begin to realize that although their colleagues may think differently, they are thinking and their points of view have merit. This should then result in a greater appreciation of and respect for other professions. Once new levels of respect have been achieved it will be easier for different professions to work together in solving common problems. This will result in greater interdisciplinary cooperation.

The vast majority of literature on change deals with organizations, namely corporations. These may be small offices or multi-national firms but they all tend to have a central figurehead—a chief executive officer, president, or board of directors—that is capable of setting policy and directing change. What is lacking is information on how to effect change in organizations that lack this central figurehead—organizational entities that are large and decentralized, in other words, those that mimic professions. The military is one such organization in which there is a central figurehead yet the organization is so large and diverse that it is difficult to make fundamental changes. This begs the question of does organizational theories developed for and applied to organizations also apply to the larger quasi-organizations known as professions?

Organizations typically studied are business organizations that have a profit motive. The changes they make tend to be made only after a careful risk analysis has been done and the benefits of making the change offer an increase in profit or continued survivability as an organization. Should the risks be miscalculated the losses are monetary in nature and may not even impact the survivability of the organization. While engineers are certainly concerned about profits, their ultimate goal is the protection of the public. Public policy, while cognizant of fiscal restraints, is not always focused on profit or a positive rate of return. In fact, many aspects of public policy are difficult to monetize.

But how do we effect organizational change in professions? Professions are not organizations in the typical sense, and they certainly do not have a central figurehead to lead change. Yet they do have to deal with environmental changes, many of which are not of their own choosing. These professions tend to have common goals, just as organizations, they share common values, but their underlying organizations are also competitors for members, customers, clients, and other resources.

Professions such as engineering, law, medicine, and even the military may be thought of as semi-structured organizations but with some important differences from other professions. These differences include the costs involved in taking excessive risks, the possibility of failure and its resulting high cost, and the reluctances to change from long established and proven patterns of behavior and practice. The profession of engineering, for example, can change by having the multitude of engineering firms undergo change individually or change can be imposed from the profession level. The profession tends to be risk averse because the failure of an engineering design may result in the loss of life. There are many unknowns in an engineering design that are accounted for by the use of factors of safety and reliance on past practices. Changes in factors of safety or changes resulting in making past practices not applicable involve taking risks that may result in loss of life.

In the 1990s, the accrediting process of engineering programs changed from that of counting credit hours in specific subjects, to one based on outcomes. ABET, Inc. the engineering accrediting body, developed 11 criteria, commonly referred to as a-k, by which outcomes for program specific programs should be developed and measured. Of interest to me are criteria c) and h). Criterion c states that students should have "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" and criterion h states that students should have "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" (ABET, 2013). These criteria were the genesis of the development of the introduction to engineering and public policy course used in this study and are specifically the changes in the profession I measure in this study.

The need for professions to change is readily apparent in today's global economy. Thomas Friedman popularized this change in his book *The World is Flat* where he described what he called "flatteners" and including concepts and technologies such as work flow software, open-sourcing, and offshoring (Friedman, 2005). Technology is changing at a rapid pace that in turn is impacting how work is performed. As a result of enhanced communications capabilities, the effects of distance in conducting business have been essentially eliminated allowing organizations to participate in business on a global scale. Associated with this is the need to understand the new environment including ethical challenges, business practices, as well as laws and regulations. This is one reason why it is imperative for engineers to comprehend the public policy process and for political scientists and others involved in public policy to understand the technical aspects of policies.

I argue that the engineering profession has been significantly impacted by globalization and has changed to address the challenges. The change has, however, been resisted by some, embraced by others, and reluctantly dealt with by many. Resistance to change is not unexpected in engineering and it can be argued that resisting change is expected in conservative, risk-averse professions such as engineering. When dealing with the design of structures and equipment that impact the health, safety, and welfare of the public, resisting changes to long-established policies and procedures is perhaps in the best interest of all concerned. However, resisting change within the education system, will continue to produce engineering graduates who are similar to those produced in the past, technical experts, while ignoring the call to have engineers who are prepared to develop products and systems with an understanding of how they will work in function in society, the issues that are called to be specifically addressed by ABET criteria c and h.

By better understanding how change in professions occur, we will be better able to effect structural change within specific professions and the organizations of which they are comprised. In turn, by changing organizations, the behaviors, structure, and processes within those organizations will also be changed yielding a profession and organizations that are more responsive to global changes.

If professions can, in fact, be changed, then there are several secondary benefits that could arise. By changing the profession as a whole then the individual organizations that comprise the profession could be changed simultaneously. By forcing this change from the level of the profession, much of the risk of organizational change would be reduced or eliminated. The behavior of multiple organizations and individuals would be affected, new structures would develop, and processes would be modified or created. Done properly the result of changing a profession would be improved responsiveness, understanding, and output of many organizations.

CHAPTER III

THEORY

Goal of Research

The research goal of this dissertation is to examine if an interdisciplinary, introductory course on engineering and public policy can be developed and used to effect changes in the professional attitudes of engineering and political science students. This study looked at the first stage, unfreezing, in Lewin's three-stage process of effecting change at the macro level of professions.

Lewin states that "Experiments have shown, however, in a precise manner that what is usually called the character and the abilities of the individual, his ideals, his goals, his motivation and values, his perception and his productivity, his friendliness and objectivity, his tendencies to domination and submission, that all these properties can be changed to a large extent by changing the social atmosphere or the group belonging of this individual. This holds for the follower as well as for the leader" (Lewin, 1944b, p. 394). The interdisciplinary nature of the introduction to engineering and public policy course changed the group of the individual, and the content of the course changed values and perceptions of the students.

Theory Applies at the Formal Education and/or Entrant Level

The reason to focus on education of those at the entrant level of the profession is the idea that they possess minimum inertia, have less mass to unfreeze, and they are more malleable and open to change thereby making it easier to shape their attitudes. Janowitz (1974, p. 119) found in the military that those at the bottom of the rank structure and those at the top of the rank structure were more receptive to and likely to change. Those in the middle were the ones more likely to become defensive and resist change. This is one of the reasons to focus the changing of a profession on the students and new entrants—they are most likely to change, the senior level members are not in need of change, and the mid-level members are too resistant to change. Additionally, resistance comes from those with an interest in protecting the status quo (Greenwald, 2000) and the new entrants have no status quo to protect.

Several decades ago, Henry Petroski described how change within engineering has historically occurred in his book *To Engineer is Human: The Role of Failure in Successful Design* (Petroski, 1985). His thesis was that once a successful method of design was developed, tried, and proven, changes to that method were made gradually. As those gradual changes proved successful, engineers would become more confident in the techniques and would continue to make more changes until such time that a catastrophic failure occurred. Following failure, the state of the art would revert to more robust design techniques and the process would begin once again.

The incremental change outlined by Petroski (2013) served the profession well in a time when there was no need to effect rapid change. However, the economy and business environment of more recent times has applied a forcing function on the engineering profession to develop designs faster, complete projects more quickly, and minimize costs in design, construction, and maintenance. Given the high costs of unsuccessful designs and construction practices, there is often resistance to change.

However, engineering also factors in economics in its projects so there is the realization that change is required.

Kurt Lewin's theory of change (1951), discussed above, states that in order to effect change, the status quo must first be unfrozen; a case must be made for change and the organization must be prepared to make change. The next step is to actually effect the change within the organization through whatever methods are needed. Finally, once change has been made within the organization, it must be frozen and become institutionalized. A traditional view of this theory is that it must be repeated each time change is needed. However, the change made within an organization can be the idea that change is constant and the organization should always be changing. This, in effect, creating what Peter Senge would call a learning organization.

Arguably the most difficult part of this process is unfreezing the organization due the natural resistance to change inherent in organizations as a result of its inertia. I propose that there are key subsets of people in the organization who are in positions to effect change and turn the organization into a learning organization. I see organizations, especially those of the military, medicine, law, and engineering, as consisting of three groups: the senior leaders, the sages; the middle level, those who have completed initial training, have years of experience, and are striving to become leaders in the profession, and finally; the younger entry level members who have recently graduated from college and are learning the ways of their profession. By changing attitudes in the new entrants into the profession, I hypothesized that the profession can be changed through two of the three methods which result in organizational change: learning of new members, and ingestion of new members with new knowledge (Simon, 1997). In this case studied here, those new members not only gained new knowledge—that of the public policy process—

gained from the introductory course, but they gained a new attitude towards engineering and public policy as a result of the learning and interaction they had in the course. The introductory course then gave students both new knowledge and new attitudes.

The entrant level is the appropriate level to focus on with change efforts. The middle level of an organization is resistant and difficult to work with due to their indoctrination and habits formed (Greenwald, 2000). While the senior leaders have much to risk in making changes but they also have much to gain; they also have external pressures on them to innovate and were likely selected in part because of their ability to embrace change and innovation (Janowitz & Little, 1974). Finally, there are the entry-level members of the profession who have not been indoctrinated, are relatively recent graduates and open to learning, and are perhaps not quite as concerned about immediate advancement.

By educating the younger members of a profession, perhaps even before they enter the profession, minds can be shaped to be more open and accepting of change. They can then move through the ranks and become leaders who are open to change. Admittedly, they will need work for organizations where such attitudes are accepted and they will likely be most successful in organizations where the leaders are open to change.

Encourage Participation in the Public Policy Process

Another issue within the profession of engineering is the lack of participation in the development and implementation of public policy. The laws of nature limit what can and cannot be done within engineering, and those laws are inviolate. In addition, engineering is also regulated by many codes and standards which are set by governmental bodies. There are according to Hyman (2003) seven generic public policy activities which impact the practice of engineering:

1. Regulations and Standards
2. Technology innovation policy
3. Research and development
4. Procurement
5. Incentives and subsidies
6. Analysis and dissemination of technical information
7. Regulating the practice of engineering.

While the inviolate laws of nature cannot be changed, the regulations and standards that impose significant limitations on engineering design and the economics of those designs, can be changed if only engineers were more involved in the public policy process. Engineers however, often “have a jaundiced view of the public policy process” (Grose, 2009) and are reluctant “to become involved in the public policy process” (Galloway, 2007). "There is concern that the perpetuation of the old paradigm by engineering schools will all but assure minor roles for engineers in the future – in accordance with the old adage, engineers are always on tap, rarely on top. Engineers are there to solve problems defined by others, along with imposed constraints on the solution, but not to set the agenda for problems to be solved" (Splitt, 2003, p. 8). Through the introduction to engineering and public policy course, engineering students were able to see how public policy impacts their careers and why they need to be more active participants in the process. Likewise, political science students gained a better understanding of how engineers work and became better at formulating problems and developing constraints which bind engineers’ solutions.

Lewin's Theory of Organizational Change

The model which I used for changing the profession of engineering at the macro-level is that of Lewin. As discussed above, Lewin stated that change occurs in three steps: unfreezing, moving, and refreezing. While monitoring this change over a profession cannot be accomplished in a short time frame, Lewin's three steps can be applied to the students in the introduction to engineering and public policy class.

Step 1: Unfreeze

The first step in Lewin's model of organizational change is to unfreeze the current state. This can indeed be difficult in that it requires an organization recognize the need to change, open itself to change, and then carry through with the planned change. Through discussion and case studies in the introduction to engineering and public policy course, both engineering and political science students were exposed to several public policy issues that are facing the nation and the need for solution is stressed. Through discussions, there were also cases in which bad policy has been made because of a lack of full understanding of the technical issues and failure of engineers to be involved in the policy-making process.

Overcome Resistance to Change

Recognizing the need for change is the critical first step in effecting change within an organization. However, there is almost always resistance to change. Overcoming the desire to do things differently than they have been done in the past requires overcoming the inertia to remain at the status quo. John Kotter says that this is the most difficult step in changing an organization. Failure to establish a great enough sense of urgency to effect change is the leading cause of transformation failures (Kotter, 2007). In organizations where change is successfully achieved, there have been one or two key leaders who initiated the change and began their transformation efforts shortly after arriving in their positions. They also created the sense of urgency needed to effect the change (Kotter & Heskett, 1998).

Kotter believes that having a sense of urgency is critical to implementing lasting change in an organization but the urgency has to be real and not a false sense of urgency. Finding and effectively communicating this sense of urgency is one of the important tasks of the leader(s) of an organization. It must be done carefully so as to avoid being detrimental to morale and eliminating the desire to succeed. He also notes that avoiding a crisis is generally seen as the mark of good leadership but sometimes a crisis is necessary for change (Kotter, 2008). While fabricating a crisis can be risky, it may be necessary to focus the attention of the organization on the need for change and adaptation to new circumstances. A famous example of strategy is from the story of *The Mutiny on the Bounty* when, after leading the mutiny, Fletcher Christian lands on Pitcairn Island with the remaining crew and orders the *HMS Bounty* burned to the waterline. By burning the ship he removed any possibility of the crew getting off the island and forced them to focus on what was needed to survive on the island (Nordhoff & Hall, 1932). The *Mutiny on the Bounty* was used in the introduction to engineering and public policy as a case study on interest groups and how leadership decisions set policy.

Vision is Required

To effect change, a well-defined vision of the future state must be developed and communicated. This is the job of the leader and arguably, one of the defining characteristics of a leader. Whereas managers do things right, leaders are those who do the right things (Manasse, 1985). Leaders who are successful at transformation “provide the organization with visions of a desired future state” (Levy & Merry, 1986, p. 171) and this will typically involve creating that vision.

Given a profession has no identifiable management structure, the profession cannot expect an individual to provide this leadership. In actuality, the profession itself must give this vision and that is what has been occurring over the last several years. The call for increased education at the engineering/public policy boundary and more and better engagement of engineers with the public policy process has been made by ABET, Inc. in their accreditation criteria, the National Academy of Engineering in their varied reports, the National Society of Professional Engineers, and the American Society of Civil Engineers (ABET, 2016; American Society of Civil Engineers, 2007, 2008, 2015; National Academy of Engineering, 2004, 2005, 2007; National Science Foundation, 2007; National Society of Professional Engineers, 2010; NSPE, 2016). Publications from the National Academy of Engineering were used in the introduction to engineering public policy course to both provide the vision that change is needed as well as to present some specific topics that are critical to society today.

Need for Change Must Be Communicated

Not only is developing a vision required, once it is developed it must be articulated to and throughout the organization in order to effect change (Bass & Avolio, 1993). Kotter lists under-communicating the need for change as his error number four for why efforts at transformation fail (Kotter, 2007). In looking at how change occurs in public institutions, Moynihan and Landuyt point out that it is not merely the communication of the vision in words but also in actions. They found in a study of Texas state employees, that the employees looked to the leadership for their actions, "specifically, how leaders spend their time, attention and resources" to determine if the desire to change is real (Moynihan & Landuyt, 2009, p. 1102). Pearlmutter states that according to Kanter, truly transformational leaders "communicate conviction and commitment and are persistent in their efforts, sharing their beliefs in the viability of change" (Pearlmutter, 1998). This is further illustrated by Yukl and even amplified that this communication must be consistent, for the process can take several years. He states that "[t]o be successful, leaders must build broad support for a proposed change, then guide the processes required to implement the change, which often takes several years of concerted effort." (Yukl & Lepsinger, 2006). Clearly, one semester is not adequate time to change a profession but it was enough time to change individuals who will enter the profession. This study focused on examining if those changes could be made in the individuals who will then make changes in the profession.

Step 2: Move

Moving is the easiest of Lewin's three steps but that does not mean it is necessarily easy. In this study, the process of moving from one state to the new state was accomplished through education and practice. Once students were made aware of the need to change attitudes, the introduction to engineering and public policy course discusses how to move from one state to another.

The students were first educated about the public policy process. Lectures and discussion focused on defining the policy process and how to conduct policy analysis. Bardach's (2005) eight-fold path was taught, in part, to demonstrate that policy setting is a logical process in hopes that it would appeal particularly to the engineering students.

Additionally, the public policy institutions were discussed. The legislature was covered along with how interest groups work with the legislature. The role of the courts was also discussed with a focus on how they can limit policies through interpretation of laws, and how the chief executive and bureaucracy play vital roles in developing and enforcing rules and regulations to carry out laws.

Step 3: Refreeze

In the ever-changing environment of today, a profession and its members should be willing to accept continual change. This is especially true in public policy involving technology. As technology evolves, public policy must change as well. This will require the mind set of Senge's *metanoia* as discussed above. Having students achieve this state of *metanoia* will aid the change of organizations. "Organizations learn only through individuals who learn. Individual learning does not guarantee organizational learning. But without it no organizational learning occurs" (Senge, 1998, p. 411). As individuals pursue their individual quest for personal mastery, the organization—the profession—will become a learning organizations (p. 412).

In the introduction to engineering and public policy class, students were aided in achieving *metanoia* through exposure to pertinent case studies such as hazardous waste disposal and climate change. Through legislative oversight hearing simulations, they were challenged to improve their critical thinking skills, communication skills, and their understanding of other professions. The cases assigned for the hearings also emphasized the boundary of public policy and technology and how they worked together. It was especially through these legislative hearing simulations that students were intimately exposed to the thought processes of the different professions so that they could develop an appreciation for the specific talents and skills each specialty brought to the case.

Attenuators and Modifiers of the Theory

With any theory comes limitations. The theory here similarly has some attenuating factors that necessitate a modification of the standard theories of organizational change. The limitations are the result of professions being non-hierarchical and lacking a formal structure.

Lack of a Leader

The importance of a leader is noted throughout organizational change theories. Leaders are expected to present a case for change (Brewer & Sanford, 2011; Goehrig, 2008), be an effective communicator of the change (Bass & Avolio, 1993; Beer et al., 1990; Huggett, 1999; Kotter, 2007; Kotter & Heskett, 1998; Levy & Merry, 1986; Lira, 2004; Manasse, 1985; Shelton, 2001), and maintain morale during the changes (Fernandez & Rainey, 2006). At best, a profession has surrogate leaders, namely organizations that have influence over the profession through governmental policy or education accreditation. Arguably, these leading organizations would be those that are making calls for changes in engineering education, ABET, the National Society of Professional Engineers, the American Society of Civil Engineers (ASCE), the National Academy of Engineering, the National Science Foundation, and NCEES, the organization that develops and administers national engineering licensure examinations (NCEES, 2017). A major issue with NSPE and NCEES are that they affect only licensed professional engineers. According to Parker (2004), in 1999 only 33 percent of engineers who hold at least a bachelor of science degree are licensed, and the distribution of licensure across the disciplines is far uniform ranging from approximately 70% for civil engineers to 15% or less for biological engineers. However, ABET impacts all accredited engineering programs in the United States and organizations such as NCEES, NSPE, ASCE, and other prominent professional societies are ABET member societies and have input to the accreditation criteria and process (ABET, 2017b).

Size of Professions

The size of professions is also significantly different from typical organizations. The National Society of Professional Engineers (2017) estimates that there are approximately 2 million engineers working in the United States. The United States military, as of May 2017 had a total of some 2.1 million service members with about 1.3 million serving on active duty and over 800,000 serving in the reserve component (Defense Manpower Data Center, 2017). Most United States businesses are much smaller than these professions. Walmart, the largest employer in the United States had 2.2 million total employees in 2013 with 1.3 million working in the US and the remainder working outside of the US. The tenth largest employer in the US in 2013 was General Electric with 305,000 employees (Hess, 2013).

CHAPTER IV

METHODS

The goal of this dissertation is to examine if an interdisciplinary course in engineering and public policy can unfreeze preconceived ideas of engineers and their involvement in public policy held by both the engineers themselves and the political science students they will work with. Unfreezing these ideas in the engineering students can thereby create a macro level change in the profession of engineering where the culture of engineering becomes one in which the need and responsibility to be engaged in the public policy process is recognized and perhaps embraced. Changing the preconceived ideas of engineers held by political science students can also make them more willing to seek input from engineers and be more willing to have them involved in the public policy process. By focusing on engineering students, change will occur through the ingestion of new members into the profession who are operating under a new paradigm and, as they progress to leadership positions over their careers, they will encourage similar thinking in their subordinates (Moynihan & Landuyt, 2009; Simon, 1991). With the profession of engineering taken as analogous to the profession of the military, entrant level members along with the senior members are the most open to change and innovation and have no status quo to maintain, which makes them more willing to accept risks and change (Greenwald, 2000; Janowitz & Little, 1974).

These changes were measured through a survey instrument that was developed and then administered at the beginning and end of the Introduction to Engineering and

Public Policy course. The survey was administered each time the course was offered therefore the available data constitutes the entire population so there are no issues with sampling. By comparing the percentages of those who disagree or strongly disagree with the statements presented in the survey at the beginning of the course and at the conclusion of the course, changes in professional attitudes and other factors can be determined. These results can also be broken into specific groups of engineering students and political science students, upper classmen and lower classmen, and can also be studied based on ethnic groups and gender. The survey was also administered to classes in political science and engineering that do not discuss public policy nor have political science and engineering students working together on assignments as a control.

Hypotheses

Effecting changing within an entire profession is difficult and will take considerable time if it is to occur through the introduction of new attitudes at the entrant level. However, the literature is ripe with data and studies indicating that change within organizations can be accomplished by the introduction of new ideas and mindsets at the entrant level. With an organization serving as the surrogate for a profession, then it stands to reason that macro level change in professions can be achieved through a similar method. Therefore, several hypotheses can be tested through this study and are detailed below.

Table 4.1 Hypotheses

H_1	Stereotypes of engineers and political scientists will be more positive at the conclusion of the Introduction to Engineering and Public Policy course than at the beginning.
H_2	The perception of the legitimacy of each other's professions will be viewed more positively at the conclusion of the Introduction to Engineering and Public Policy course than at the beginning.
H_3	The professions of engineering and political science will be viewed more positively by the other profession at the conclusion of the Introduction to Engineering and Public Policy course than at the beginning.
H_4	At the conclusion of the Introduction to Engineering and Public Policy course, students will have a perceived improvement in their understanding of the public policy process than they had at the beginning.
H_5	At the conclusion of the Introduction to Engineering and Public Policy course, students will have an increased recognition of the need for a broad education outside of their technical disciplines than they had at the beginning.

Research Methodology

The hypotheses above were tested using an introductory course in engineering and public policy developed at Mississippi State University as a case study. Specifically, the results obtained from administering a professional attitudes survey at the beginning and the end of the course were analyzed for changes over time by computing the difference between the sum of the percentages for disagree or strongly disagree at the beginning of the course to the those at the end of the course. The survey instrument is attached as Appendix A. This course was designed to be offered and taught at the undergraduate level with the only pre-requisite being completion of a second semester freshman English Composition course. The course was designed to be open to all students but the focus was on attracting and teaching engineering and political science students.

Case Study: Engineering and Public Policy Class

According to Lewin's three-step model of change, the first step is to unfreeze the current status in preparation for moving to a new state. To determine if the current state has been unfrozen, its state must first be established. The test environment for this project was within a course developed at Mississippi State University by Gerald A. Emison and Robert A. Green entitled Introduction to Engineering and Public Policy (Green & Emison, 2006a, 2006b). This course was cross-listed as both an engineering and a political science course and could be used to partially satisfy degree requirements for political science students but is more often than not an elective which does not apply towards a degree for engineering students. This cross-listing was done to appeal to each discipline's demographics while also demonstrating that it was open to all students. While it was directed to these specific majors, it was open to any student at the university.

The purpose of the course was to have both engineering and political science students work and learn together with the goal of having engineers come to an appreciation of the importance of public policy and their need to be participants in policy decisions, and to develop an appreciation of the technical skills and thought process of engineers amongst those in political science. As a result of the course, both groups of students enrolled in the course now see themselves as a team in setting technical public policy.

The course was broken into four major topic areas: activities of policy analysis, institutions in public policy, role of values and ethics in public policy, and a look at some specific policy topics. An overview of course content is given in Table 4.2 below as an example of a typical offering of the course. The specific policy topics covered would vary some from semester to semester depending on the availability of subject expert guest lecturers.

Table 4.2 Course Schedule and Topics

Number of Class Periods	Topic
1	Course Introduction
3	The Activities of Policy Process Defining Policy Analysis Policy Analysis Frameworks Future of Engineering
9	Institutions in Public Policy Legislatures Bureaucracy Courts Interest Groups Chief Executive
3	Role of Values in Ethics in Public Policy Ethical Frameworks Cases and Applications
8	Specific Policy Topics (First lecture academic framework and overview, second lecture was presentation by experienced professional) Biomedical and Biotechnology Nuclear Power Environment Homeland Security/Defense
4	Legislative Oversight Hearings Simulation
2	End of Course Course Review Wrap-Up Student Feedback Final Exam

Research Design

Using a survey, students enrolled in the Introduction to Engineering and Public Policy course were asked to complete a pre-course survey during the first or second day of class. The survey was anonymous in that it asked for no personally identifiable information but did ask for some demographic data. The same survey was given to the students during the last day or two of class with each survey being marked as post-course. As a control, the same survey was also administered to a political science course and several engineering classes. These classes were selected as controls because they were required courses either in the majors or for a certificate, thereby eliminating self-selection bias.

Survey Instrument

A survey instrument was developed that asked for each student's demographic information to determine if there are differences resulting from those factors and is presented in Appendix A. Specifically, students were asked for their gender, ethnicity, major (engineering or related physical/life science, political science or related social/behavioral science, or other), and their level in school (upperclassman or lowerclassman). Although this information could have been collected with greater granularity i.e., what was their specific major and what was their specific classification, asked in the manner used allowed for collection of important data while maintaining anonymity.

Then the students were presented with a list of thirty-five questions or statements and asked for their level of disagreement or agreement on a five-point Likert scale (Strongly Disagree to Strongly Agree). The instrument was approved the Mississippi State University Institutional Review Board and students were encouraged, but not required, to complete it.

Analysis of the Data

With the exception of demographic data, each question on the survey required a response on a five-point Likert scale. These responses were converted to numerical values which allowed averages to be computed for each question. Changes over time were measured by comparing the difference in percentage who were in disagreement with a particular statement at the beginning of the course to the percentage at the end of the course. Performing the same analysis on the control group will allow the differences in means to be compared between the experimental population and the control population. The control courses were selected specifically because they do not focus on public policy and do not attempt to change attitudes towards professions through lectures, assignments, or teamwork so any differences in the two groups can be attributed to the introduction to engineering and public policy course.

The literature suggests that leaders in professions are typically less resistant to change than others in the organization. This, so the argument goes, is due to their ability and desire to innovate and their lack of adoption of cultural norms (Janowitz & Little, 1974). There is little data available on changing attitudes of engineering students but one study discussed above by Hyman (1990) indicated positive changes can be made through the use of public policy case studies in an engineering course. Jacobsen and Lindqvist (2009) found that by having disciplines work closely together in a training program the training could shape and change professional attitudes in the health care industry. Lewin (1944b) also noted that experiments indicate “the character and the abilities of the individual, his ideals, his goals, his motivation and values, his perception and his productivity, his friendliness and objectivity, his tendencies to domination and submission, that all these properties can be changed to a large extent by changing the social atmosphere or the group belonging of this individual." The introduction to engineering and public policy course changes, at least temporarily, the students group and social atmosphere.

Survey Data Analysis

Several semesters of data were collected from the Introduction to Engineering and Public Policy course from the Fall of 2009 to the Fall of 2015. The survey data not only asks questions about attitudes toward engineering and technology and political science and public policy, it includes some demographic information such as a student's broad discipline of study (engineering or political science) and their gender.

The survey questions were grouped into five general areas: 1) professional interest; 2) legitimacy of engineering and political science as professions; 3) deference, or the belief that each profession is important and has value; 4) understanding of the public policy process; and, 5) the need for education outside of the student's specific field. Combining responses from selected questions in these general areas, indices were created and analyzed.

Comparison to Control Group

One semester, Fall 2009, data was collected from other courses to form a control group. This data was collected from some engineering and political science courses. The survey instrument was the same for the control group as it was for the experimental group.

Method of Analysis

Raw survey data was collected and coded for analysis. Nominal data consists of gender, major, classification, and ethnicity. Gender of Male was coded with a value of 1 and Female with a value of 2. Those majoring in engineering or a related physical/life science were coded as 1, political science of related social/behavioral science were coded as 2. Upperclassmen (juniors and seniors) were similarly coded as 1 while a value of 2 was assigned to lowerclassmen (freshmen and sophomores). Ethnicity codes assigned were: Caucasian, 1; African-American, 2; Asian-American, 3; and Other, 3. These variables constitute the independent variables of the study. Missing data were coded with a value of 9 and were excluded from analysis.

Responses to the professional attitude questions asked in the survey were assigned ordinal values. A response of "strongly disagree" was coded a 1, "disagree" as 2, "neither agree nor disagree" as 3, "agree" as 4, and "strongly agree" as 5. These values allow for the calculation of average responses and comparison of pre- and post-course survey data. These dependent variables were then averaged over the population.

These data were analyzed combining the percentages that disagree or strongly disagree at the beginning of the course and at the end of the course. The difference in these percentages allowed me to determine if the course had an impact on changing attitudes and I was able to test the hypotheses. Using the demographic data collected, the responses were broken into subgroups for more detailed analysis. This allowed me to determine if the changes were similar or not for engineers and political science students.

The information gained from responses to each survey statement was useful in itself but I believe a better view of the changes in attitudes is obtained by aggregating responses from several of the statements together for analysis rather simply looking at changes in responses to specific statements. These aggregated variables are listed below in Table 4.3.

Table 4.3 Aggregated Variables

Attitudinal Variable (Index)	Survey Questions Aggregated for Analysis
Professional Interest	1, 2, 3, 4
Legitimacy of Professions	5, 6, 16, 17
Deference, Belief Profession has Value	7, 8
Understanding of Public Policy	9, 10, 14, 18
Need for Education Outside of Student's Specific Field	23, 24

The methodology for testing each hypothesis is detailed below.

Hypothesis Testing Methodology

For each hypothesis, there were one or more statements on the survey that were analyzed to test the hypothesis. The statements analyzed for each hypothesis are identified in the results. In most cases, the percentage of those who disagreed or strongly disagreed with the statement were summed at the beginning of the course and again at the end of the course. The difference in percentages between the beginning and the end of the course were used to test the null hypothesis. In a few cases where the difference between the pre-course and post-course results were small, I also looked at changes in those who agreed or strongly agreed with the statement. Each of the survey statements used for testing the hypotheses were evaluated from either the perspective of those students who self-identified as engineering or a related discipline, or in political science or a related field, depending on the wording of the statement.

Issues and Concerns

Participants in the Introduction to Engineering and Public Policy course have an interest in the subject matter and therefore the data can suffer from a self-selection bias raising concern as to the applicability to the analysis to a larger population. This can present a special problem for the engineering majors. Whereas the political science majors are required to take a public policy class to meet their degree requirements, and this class is one of two that satisfies that requirement, there is no such requirement for engineering students. Engineering students who enroll in the course receive no credit towards their degree by taking this class, with the exception of a few who might take the class in partial fulfillment of the requirements for a Leadership Studies Minor.

Students enrolling in this course were also perhaps already aware of concerns over engineering and public policy issues and were therefore more open to change. Those who were not interested in the class, perhaps saw no value in the course, or were simply entirely unaware of the issues discussed in the class, may be the ones who were least receptive to change. Regardless, I investigated the changes in attitudes of students over the duration of the semester so by validating that the attitudes of the self-selected students could be changed, I argue that it stands to reason that the attitudes of other students could also be changed if they took the class.

Possible Skewing of Results

In situations where an individual performs a self-assessment, results can be skewed as a result of the individual being overconfident. Tsai et. al. (2008) note that overconfidence can increase when subjects are presented with more information, even though judgement does not increase. According to Griffin et. al. (1990), even when predicting one's own behavior, overconfidence can be a concern if "one fails to anticipate correctly what the details of the 'situation' in question will actually be like and how the situation will be subjectively experienced" (1990, p. 1129). They further note that "social perceivers characteristically leap to unwarranted dispositional inferences, that they fail to use the seeming extremity, inappropriateness, perversity, or even the simple distinctiveness of the actor's behavior as a cue that they (the observers) have somehow misconstrued the situation" (1990, p. 1130). While these threats to validity are of concern, they are controlled for here in that I am looking at *changes* in responses rather than *absolute values*. In other words, I am not concerned with how well someone thinks they understand the public policy process or how ethical they think a profession is as I am in how their opinion of their understanding changes as a result of the class.

CHAPTER V

RESULTS AND DISCUSSION

Experimental and Control Groups

Data were collected from those students enrolled in the Introduction to Engineering and Public Policy class each time it was offered from the Fall 2009 term to the Fall 2015 term. Control data were collected in Fall 2009. A comparison of the demographics of the control and experimental classes is given in table 5.1 below.

Table 5.1 Comparison of Experimental and Control Groups

Variable		Experimental	Control
Gender	Male (%)	64.2	80.4
	Female (%)	35.8	19.6
	n	193	352
Major	Engineering or Related (%)	38.0	78.1
	Political Science or Related (%)	57.3	16.0
	Other (%)	4.7	6.0
	n	192	351
Classification	Upper (%)	52.1	91.8
	Lower (%)	47.9	8.2
	n	194	352
Ethnicity	Caucasian (%)	76.8	79.8
	African-American (%)	19.1	14.5
	Asian (%)	0.5	3.7
	Other (%)	3.6	2.0
	n	194	351

Sources: Experimental data from GE 2713 Intro to Engineering and Public Policy. Control data from GE 3011 Engineering Entrepreneurship, CHE 4134 Process Design, PS 2703 Intro to Public Policy, ME 4333 Energy Systems Design, and IE 4513 Engineering Administration.
Note: Percentages for each demographic group total 100% down each column.

There are some interesting differences in the control and the experimental groups. The experimental group has a much larger percentage of females than does the control group. This is, I believe, in part due to the self-selection of females to pursue public policy and also due to a large number of engineering students, a traditionally male dominated field, in the control group. The ethnic composition of the two groups is remarkably similar. However, the control group has proportionally more engineering and far more upper classmen than the experimental group. This is due to the fact that I had greater and easier access to engineering courses to administer the survey and the fact that by far, most engineering courses are upperclassmen courses due to their prerequisites. Given these differences, I decided that that it would be best in this study to exclude the control group from further analysis and consider the collection of additional data as possible future work. Therefore, all upcoming tables provide data only from the experimental group.

Hypothesis H_1: Investigation of Stereotypes

My first hypothesis is that stereotypes of engineers and political scientists held by their peers in the other field will be more positive at the conclusion of the Introduction to Engineering and Public Policy course than at the beginning. This was tested by evaluating the results from the first, second, third, and fourth survey statements. The full survey is given in Appendix A.

Analysis of first survey statement

The first survey statement reads "Engineers only care about the technical aspects of public policy decisions." Of primary importance here are the changes in responses to the question from those majoring in political science or related fields. The results of those are summarized below in table 5.2.

Table 5.2 Political Scientists' Attitudes Towards Engineers

Engineers only care about the technical aspects of public policy decisions.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	3.4	5.9
Disagree (%)	24.1	62.7
Neither Agree nor Disagree (%)	29.3	11.8
Agree (%)	41.4	19.6
Strongly Agree (%)	1.7	0
n	58	51

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=109)=18.394, p<0.001.

There is a dramatic shift in the percentage of students who either disagreed or strongly disagreed with this statement from the beginning of the course to the end. Initially, 27.5% of the students disagreed or strongly disagreed this statement and 43.1% either agreed or strongly agreed with the statement. After going through the class and working with engineering students, 68.6% of the political science students were in disagreement with the statement leaving only 19.6% who agreed with the statement. Political science students clearly developed a more positive attitude towards engineering students over the duration of the course. For these and all following results, variables were recoded by aggregating strongly disagree and disagree together, and aggregating strongly agree and agree together. Measures of statistical inference were then computed and are provided based on recoded variables. However, there is value is showing the changes within the aggregated variables, i.e. from Agee to Strongly Agree, so they complete results are reported in the body of the tables that follow.

Political Scientists and Technical Concern

The second statement of the survey is a measurement of the attitude of engineers towards political scientists. This statement reads "Political scientists do not care about the technical aspects of public policy decisions." Table 5.3 shows how the responses of engineering students changed over the duration of the course.

Table 5.3 Engineers' Attitudes Towards Political Scientists

Political scientists do not care about the technical aspects of public policy decisions.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	5.4	5.6
Disagree (%)	27.0	61.1
Neither Agree nor Disagree (%)	21.6	13.9
Agree (%)	43.2	19.4
Strongly Agree (%)	2.7	0.0
n	37	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregate results are statistically significant with χ^2 (2, N=73)=8.847, p=0.012.

Just as with the political science students, engineering students saw the same dramatic change in attitudes. At the beginning of the class, 32.4% of the engineering students disagreed or strongly disagreed with the statement that political scientists do not care about the technical aspects of policy decisions. By the end of the course, this number has risen more than 34 points to 66.7% of engineering students disagreeing with the statement.

Given the magnitude of the shift in attitudes of both engineering and political science students, my first hypothesis is supported. It therefore seems clear that a course offered at the university level can effect real, measureable changes in the attitudes of one profession to another.

Engineers' Interpersonal Skills

A commonly held belief is that engineers do not possess adequate interpersonal skills to interact with society, much less be effective in the public policy arena. This is the subject of the third statement in this study. Students were asked if they agreed or not with the statement "Engineers have inadequate interpersonal skills to work well with people." I looked at this from the perspective of the political science students and those results are given below in Table 5.4.

Table 5.4 Political Science Students' Perception of the Adequacy of Engineers' Interpersonal Skills

Engineers have inadequate interpersonal skills to work well with people.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	5.1	11.8
Disagree (%)	42.4	58.8
Neither Agree nor Disagree (%)	23.7	19.6
Agree (%)	28.8	9.8
Strongly Agree (%)	0	0
n	59	51

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=110)=7.671, p=0.022.

Again, we see an improvement over the duration of the course in the attitude of political scientists toward engineers' interpersonal skills. At the beginning of the class, 47.5% of the political science students were in disagreement with the statement. At the end of course, that percentage had grown to 70.6%, an improvement of 23.1%. Although not tabulated here, it is worth noting that the engineering students' perception of their own interpersonal skills improved during the course. At the beginning of the class, 64.8% of the engineering students disagreed or strongly disagreed with this statement but 77.8%

were in disagreement at the end of the class. This 13.0% improvement is almost as large as the change in the opinions of the political science students.

Political Scientists' Mathematical and Science Ability

Perhaps one of the greatest differences between the education of engineers and political scientists is the amount of math and science courses taken by each major. Engineers tend to stereotype political scientists as not having a strong math and science background and therefore perhaps not being capable of making technical policy decisions. This attitude is covered in the fourth statement considered in this study, namely, "Political scientists have inadequate skills and knowledge of math and science to make technical decisions." The responses of engineering students to this statement are tabulated in Table 5.5 below.

Table 5.5 Engineers' Perceptions of Political Scientists' Math and Science Knowledge

Political scientists have inadequate skills and knowledge of math and science to make technical decisions.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	2.7	2.8
Disagree (%)	27.0	47.2
Neither Agree nor Disagree (%)	18.9	11.1
Agree (%)	43.2	33.3
Strongly Agree (%)	8.1	5.6
n	37	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically insignificant with χ^2 (2, N=73)=3.252, p=0.197.

Just as with the previous statements, there is an improvement in engineers' perceptions over the duration of the course toward the ability of political scientists to make technical policy decisions. At the beginning of the course, 29.7% of the engineering students disagreed or strongly disagreed with the statement, whereas 50% disagreed or strongly disagreed with it by the end of the course, a shift of 20.3%. Or, looking at it from the positive perspective, when the class began, 51.3% of the engineering students agreed or strongly agreed with the statement but that number dropped 12.4% over the term of the course to 38.9%. While there was a change in attitudes, the results are not statistically significant for this one statement.

Validation of Hypothesis 1

An analysis of the results from survey statements one, two, and three, allow me to reject the null hypothesis and validate my hypothesis. I do note that the results from statement four are statistically insignificant but I believe the direction supports this hypothesis. When asked about engineers only being concerned about technical aspects of public policy, the political science students gained a more favorable attitude toward engineers as evidenced by the shift of those who disagreed or strongly disagreed with this statement from 27.5% to 68.6% over the course. Similar results were found when engineers were presented with the statement that political scientists do not care about technical aspects of public policy. The percentage who disagreed or strongly disagreed with this statement shifted from 32.4% to 66.7% over the duration of the course.

The third and fourth statements of the survey are directed at specific skills of each profession to work in the area of public policy. Political science students were asked if they agreed with the statement that engineers lacked the interpersonal skills needed to work with people. Over the duration of the course, the number of political science students who disagreed or strongly disagreed with this statement rose from 47.5% to

70.6% over the duration of the course demonstrating the course did serve to indicate their attitude on interpersonal skills of engineers could be positively impacted. Engineering students were asked about their belief that political science students lacked adequate math and science skills to participate in technical public policy discussions. During the course, the engineering students came to realize that the political science students did have the skills needed to engage in public policy. Over the duration of the course, the percentage of engineering students who disagreed or strongly disagreed with this statement increased from 29.7% to 50.0% indicating a more positive attitude about the math and science knowledge of political science students although the findings were not statistically significant. A recent paper by Nuzzo highlighted recent concerns over the use of *p*-values alone for hypothesis testing. She states "[t]he irony is that when UK statistician Roald Fisher introduced the P value in the 1920s, he did not mean it to be a definitive test. He intended it simply as an informal way to judge whether evidence was significant in the old-fashioned sense: worthy of a second look" (Nuzzo, 2014, p. 150). Given the results of three of the four hypotheses, I think this falls into the "worthy of a second look" rather than outright rejection category.

Hypothesis H_2: Legitimacy of the Professions

Hypothesis 2 states that the perception of the legitimacy of each other's professions will be viewed more positively at the conclusion of the Introduction to Engineering and Public Policy course than at the beginning. Legitimacy here is defined as the belief that each of the professions has justification to be engaged in the public policy process. Legitimacy is measured by statements 5, 6, 16, and 17 in the survey (see Appendix A).

Right to be involved in public policy

The first statement analyzed below concerns whether engineers should be involved in the public policy process. The second statement is related to the first with a slight difference. Clearly political scientists are and should be involved in the public policy process so the second statement focused on their involvement in *technical* policies.

Engineers' Involvement in Public Policy

One of the goals of this study was to encourage the participation of more engineers in the public policy process. The stereotypical perception is that engineers should not be involved in public policy. Arguably, even some engineers hold this belief as well. This issue is directly addressed with survey question five, "Engineers should not be involved in public policy." The results from this statement viewed from the perspective of political science students are summarized in Table 5.6.

Table 5.6 Political Scientists' Perception of the Legitimacy of Engineers in Public Policy

Engineers should not be involved in public policy.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	23.7	47.1
Disagree (%)	52.5	43.1
Neither Agree nor Disagree (%)	16.9	3.9
Agree (%)	6.8	0.0
Strongly Agree (%)	0.0	5.9
n	59	51

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=110)=4.931, p=0.085.

When the course began, 76.2% of the political science students disagreed or strongly disagreed that engineers should not be involved in the public policy process.

This increased by 14.0% to 90.2% by the end of the course. This indicates that the course proved effective in shifting attitudes of political science students towards believing engineers did have a role to play in public policy. The anomaly here is the 5.9% who strongly agreed that engineers should not be involved in public policy, but this represents the belief of only three students and may be due to a bad experience in a group assignment where an engineering student did not perform as they had hoped, or some similar situation. These results were statistically significant at the $p<0.1$ level and should be treated with caution.

Political Scientists' Involvement in Technical Policy

Next, the shift in attitudes of engineering students toward the involvement of political scientists in technical public policy matters was measured by asking for responses to the statement "political scientists should not have input on technical policies." Changes in the attitudes of engineering students are shown in Table 5.7 below.

Table 5.7 Engineers' Perception of the Legitimacy of Political Scientists in Technical Policy

Political scientists should not have input on technical policies.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	21.6	30.6
Disagree (%)	56.8	61.1
Neither Agree nor Disagree (%)	13.5	2.8
Agree (%)	5.4	2.8
Strongly Agree (%)	2.7	2.8
n	37	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically insignificant with χ^2 (2, N=73)=3.112, p=0.211.

When the survey was administered at the beginning of the course, 78.4% of the engineering students disagreed or strongly disagreed with this statement. By the end of the course, that number had risen to 91.7%, a 13.3% change, once again demonstrating the ability of a college-level course to change professional attitudes towards students from a different field in a positive direction. These results were not found to be statistically significant.

Perception of Too Many Political Scientists Involved in Public Policy

Another stereotype is that too many political scientists (politicians) are involved in setting public policy. This attitude was measured directly by the statement "the problem with setting public policy is that there are too many political scientists involved." The change in the attitude of engineers toward this state is tabulated in Table 5.8 below.

Table 5.8 Engineers' Perception of Too Many Political Scientists Being Involved in Public Policy

The problem with setting public policy is that there are too many political scientists involved.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	2.8	2.8
Disagree (%)	30.6	36.1
Neither Agree nor Disagree (%)	52.8	33.3
Agree (%)	11.1	22.2
Strongly Agree (%)	2.8	5.6
n	36	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically insignificant with χ^2 (2, N=72)=3.401, p=0.183.

The analysis of this statement is more complicated than the others and is also not statistically significant. Although 33.4% of the engineers either disagreed or strongly disagreed with this statement at the beginning of the course and the percentage had increased 5.5% to 38.9% by the end of the course, that is not sufficient evidence to validate the hypothesis. A contradiction of validation is that at the beginning of the course, 13.9% of the engineering students agreed or strongly agreed with the statement and by the end of the course, that percentage had risen to 27.8%. This seemingly negates the results indicated by the percentage in disagreement.

With this statement, it seems that the rather large percentage, 52.8%, who were neutral prior to the start of the class had formed an opinion by the end of the course resulting in only 33.3% remaining neutral. It is not possible to determine the cause of this ambiguity from the data here but it seems plausible that the course informed the engineering students more about public policy allowing them to develop an opinion. One explanation is that through the course, the engineers realized they needed to be more involved in public policy, then this increase could be seen as saying that too few engineers are involved in public policy. This question also did not differentiate between public policy and technical public policy which could be the subject of future research.

Perception that Engineers Should Have Only Technical Input

Looking at the same concern from the perspective of political scientists, the survey asked students how well they agreed with the statement that "engineers should be involved in public policy but only on technical issues." Looking at this statement from the perspective of the political science students shows how much they changed their viewpoint about engineers being involved in public policy as policy experts, rather than merely technical experts. Table 5.9 shows the results of the survey on this statement.

Table 5.9 Political Scientists' Perceptions of Engineers Being Involved in Policy Only on Technical Issues

Engineers should be involved in public policy but only on technical issues.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	3.4	10.0
Disagree (%)	30.5	32.0
Neither Agree nor Disagree (%)	30.5	28.0
Agree (%)	33.9	26.0
Strongly Agree (%)	1.7	4.0
n	59	50

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically insignificant with χ^2 (2, N=109)=0.787, p=0.675.

The results here are less ambiguous in terms of the change in percentage who disagreed with the statement, but are still statistically insignificant, than for the corollary discussed above. At the beginning of the course, fully 34.9% of the political science students disagreed or strongly disagreed with this statement. By the end of the course, that percentage had risen to 42.0%, a 7.1% increase in those who were in disagreement with the statement, indicating the attitude of political science students had been moved in a positive direction. Further, the percentage who agreed or strongly agreed with the statement decreased by 5.6% over the duration of the course from 35.6% at the beginning to 30.0% at the end, further indicating the positive change in attitude of political science students toward engineers.

Validation of Hypothesis 2 Unclear

After analyzing the responses to survey statements 5, 6, 16, and 17, I found an overall shift toward more positive attitudes of the others' profession but with the exception of statement 5 (Table 5.6), the results were statistically insignificant, and statement 5 must be used with caution. The evidence here suggest that the null hypothesis cannot be rejected but I think this also qualifies as needing further research, perhaps involving more observations. The political science students showed an increase in their belief that engineers should be involved in public policy. Over the duration of the course, the percentage that disagreed or strongly disagreed with the statement that engineers should not be involved in public policy shifted from 76.2% to 90.2%. Engineers, when presented with the statement that political scientists should not have input on technical policies shifted from 78.4% who disagreed or strongly disagreed in the beginning to 91.7% by the end of the course. When given the statement that the problem with setting public policy is that there are too many political scientists involved, the percentage of engineering students who disagreed or strongly disagreed with this statement changed from 33.4% at the beginning of the class to 38.9% by the end, indicating that too many political scientists was not a problem in setting public policy. Similarly, when told the engineers should be involved in public policy but only on technical issues, the political scientists changed from 34.9% disagreeing or strongly disagreeing with the statement at the onset of the course to 42.0% at the end of the course.

Hypothesis H_3: Deference to Each Other's Profession

My third hypothesis states that "the professions of engineering and political science will be viewed more positively by the other profession at the conclusion of the Introduction to Engineering and Public Policy course than at the beginning." If the stereotypes are accepted as true, then I would expect to see some changes in the deference to the others' profession but the results obtained were ambiguous and inconclusive. Deferring to a profession is a measure of how much you value that profession. If engineers believe political scientists have value as a profession, then I expect to see them defer to them in matters falling in their areas of expertise. Similarly, if political scientists value the profession of engineering, then I expect to see them defer to engineers on technical issues. As students became more familiar with the others' profession over the course, their level of deference to that profession was expected to increase but the results were not clear.

Deference, or the belief a profession has value to setting public policy is measured by statements seven and eight in the survey included as Appendix A.

Deference of Political Scientists to Engineers in Technical Matters

Looking first at statement seven, which reads "Political scientists should defer to the judgement of engineers on technical matters", I measured the change in the attitudes of political science students which is an indicator of their deference to the profession of engineering. These results are shown in Table 5.10.

Table 5.10 Political Scientists' Attitude on Deference of Political Scientists to Engineers on Technical Matters

Political Scientists should defer to the judgement of engineers on technical matters.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	3.4	9.8
Disagree (%)	15.3	15.7
Neither Agree nor Disagree (%)	23.7	15.7
Agree (%)	55.9	43.1
Strongly Agree (%)	1.7	15.7
n	59	51

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically insignificant with χ^2 (2, N=110)=1.479, p=0.477.

The results from this statement were inconclusive in terms of the change in percentage who disagreed with the statement and were also not statistically significant. Looking at the percentage of political science students who disagreed or strongly disagreed with the statement, I found that 18.7% of the political science students were in disagreement at the beginning of the course but 25.5% were at the end of the course; a change of 6.8% which would seem to indicate that political scientists came to not appreciate the value of engineers in making technical decisions. However, looking at those who agreed or strongly agreed with the statement, there was almost no change with 57.6% being in agreement when the pre-course survey was given and 58.8% when the post-course survey was given. However, on a positive note, those who strongly agreed with the statement showed an increase from 1.7% to 15.7% which indicates that more political science students thought they should defer to engineers.

In this group of political science students, the largest percentages were contained in the neither agree nor disagree (neutral) or agree categories. Students who enrolled in the Introduction to Engineering Public Policy course self-selected and likely already had fairly positive attitudes toward the other profession. There was also little technical content covered in the course which may have played a role. Although the policy cases discussed were technical in nature, there was no rigorous analysis that would have truly demonstrated the technical skills of either profession.

Deference of Engineering Students to Political Scientists in Non-Technical Matters

The next statement measured the opinion of deference towards political scientists. The statement read "engineers should defer to the judgement of political scientists on non-technical matters." Looking at this from the perspective of engineering students yields the results given in Table 5.11.

Table 5.11 Engineers' Attitudes on Deferring to Political Scientists on Non-Technical Matters.

Engineers should defer to the judgement of political scientists on non-technical matters.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	5.4	5.6
Disagree (%)	21.6	25.0
Neither Agree nor Disagree (%)	27.0	19.4
Agree (%)	40.5	41.7
Strongly Agree (%)	5.4	8.3
n	37	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically insignificant with χ^2 (2, N=73)=0.592, p=0.744.

Unfortunately, the results, tabulated in Table 5.11, are also somewhat inconclusive and statistically insignificant. The pre-course survey indicated that 27.0% of the engineering students disagreed or strongly disagreed that they should defer to political scientists in non-technical matters but by the end of the course, 30.6% were in disagreement. This shift of 3.6% seemingly indicates that engineers did not gain an understanding of the political science profession to the point that they would defer to political scientists on non-technical matters. However, looking at the percentage who agreed or strongly agreed with the statement I saw a change from 45.9% at the beginning of the course to 50.0% at the end of the course. This indicates that students gained a better appreciation of the political science profession however, this 4.1% change is the result of one student. For the pre-course survey, there were 15 engineering students who agreed with the statement and two who strongly agreed; at the end of the course, the number of students were 15 and 2 respectively.

The reason for these inconclusive results are due in part to the small number of engineering students in the population, such that one or two can make a large change in the percentages and, as above with the technical issues, the course did not cover policy development so the engineering students would not have experienced first-hand the skillset that political scientists can bring in developing public policy. It is also possible that these factors affected the chi-squared values. For future work, these statements could be further refined and divided into several questions that would perhaps get closer to deference question. A larger sample would also likely yield different results.

Validation of Hypothesis 3 Unclear

Based on these results, both the magnitude of the change in percentage who disagreed over the duration of the course and the *p*-values of the various statements, the null hypothesis cannot be rejected. Evidence exists that either confirms the null hypothesis or makes the results inconclusive. This is due, in part, to the fact that there were relatively few engineering students in the population which means that a change in one or two students can have a large impact on the percentages reported. But perhaps most importantly is that while the course did involve technical policy issues, it did not include the development of technical policy or the technical comparison of alternative policies. There is value in developing technical policies and analyzing alternative policies, but it was beyond the scope of this class and is an aspect of a possible advanced engineering and public policy course.

Hypothesis H_4: Understanding of Public Policy

My fourth hypothesis is that at the conclusion of the Introduction to Engineering and Public Policy course, students will have a perceived improvement in their understanding of the public policy process than they had at the beginning. With the ultimate goal being to get more engineers involved in public policy, changing attitudes of engineers and political scientists towards the others' profession is only one step. This is one part of the solution but attitudes towards public policy, especially the attitude of engineers toward public policy, must also be changed. One way to change these attitudes was to provide the students with an understanding of public policy.

Attitude Toward Bureaucrats

The ninth statement from the survey (Appendix A), reads "Bureaucrats are a hindrance to implementing good public policy." This statement was developed from the stereotype that bureaucrats are slow, dull, inefficient, and only interested in protecting their jobs. Several lectures in the Introduction to Engineering and Public Policy course are dedicated to the topic of bureaucrats, including discussion of common bureaucrats most people do not think of as bureaucrats (public school teachers, policemen, firemen, etc.). This stereotype is common so it is looked at from both the perspective of engineering students and from political science students.

Change in Engineers' Perception of Bureaucrats

Table 5.12 shows the results of the pre- and post-course survey of engineering students responses to the statement about bureaucrats.

Table 5.12 Engineers' Perceptions of Bureaucrats

Bureaucrats are a hindrance to implementing good public policy.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	2.7	5.6
Disagree (%)	13.5	47.2
Neither Agree nor Disagree (%)	51.4	36.1
Agree (%)	24.3	8.3
Strongly Agree (%)	8.1	2.8
n	37	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=73)=11.874, p=0.003.

As shown above, there is a large shift towards a more positive view of bureaucrats by engineering students. When the course began, 16.2% either disagreed or strongly disagreed with this statement, in other words, they did not believe bureaucrats were a hindrance to public policy. By the end of course, another an addition 36.6% of the engineering students shared this opinion giving a total of 52.8% who were in disagreement.

Change in Political Scientists' Perception of Bureaucrats

Stereotypes of bureaucrats are held by many people so I was not just interested in the change in attitude of engineering students, but also of political science students. Table 5.13 shows the shift in attitudes from the beginning of the class to the end of the class for political science students. Interestingly, the changes parallel those of engineering students.

Table 5.13 Political Scientists' Perceptions of Bureaucrats

Bureaucrats are a hindrance to implementing good public policy.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	0.0	13.7
Disagree (%)	16.9	33.3
Neither Agree nor Disagree (%)	47.5	33.3
Agree (%)	27.1	17.6
Strongly Agree (%)	8.5	2.0
n	59	51

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=110)=11.838, p=0.003.

When the class began, 16.9% of the political science students disagreed or strongly disagreed with the statement, yet by the end of the class that percentage had risen to 47.0%, a 30.1% improvement. These numbers are very similar to those seen for engineering students, indicating that the course under study was effective in shifting the attitude of students toward bureaucrats to a positive one, specifically that they were not a hindrance to setting public policy.

Need for Bureaucrats

Both engineering and political science students were asked whether they agreed with the statement that "bureaucrats are a necessary part of the public policy process." This was the tenth statement in the survey (Appendix A) and is another way of determining the attitude of students towards bureaucrats.

Engineers' Perceptions of the Need for Bureaucrats

I first looked at the shift in attitudes of engineering students toward the need for bureaucrats and show the results in Table 5.14.

Table 5.14 Engineering Students' Opinion on the Need for Bureaucrats in the Public Policy Process

Bureaucrats are a necessary part of the public policy process.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	2.7	0.0
Disagree (%)	5.4	0.0
Neither Agree nor Disagree (%)	40.5	27.8
Agree (%)	43.2	52.8
Strongly Agree (%)	8.1	19.4
n	37	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=73)=5.076, p=0.079.

With this statement, there is little disagreement at the beginning of the course and none at the end however, there is a large change in the percentage of those of who were neutral, 40.5% to 27.8%, so I looked at the percentage of engineering students who either agreed and strongly agreed with the statement. The pre-course survey showed that 51.3% of the engineering students agreed or strongly agreed that bureaucrats were a necessary part of the public policy process and that percentage increased to 72.2% by the post-course survey, a 20.9% shift towards a more positive attitude. The results from this statement are statistically significant at the $p<0.1$ level and need to be treated carefully.

Political Scientists' Perceptions of the Need for Bureaucrats

Similar results to those above for engineering students are found for political science students as shown below in Table 5.15.

Table 5.15 Political Science Students' Opinion on the Need for Bureaucrats in the Public Policy Process

Bureaucrats are a necessary part of the public policy process.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	3.4	0.0
Disagree (%)	11.9	2.0
Neither Agree nor Disagree (%)	28.8	17.6
Agree (%)	54.2	68.6
Strongly Agree (%)	1.7	11.8
n	59	51

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=110)=9.193, p=0.010.

The pre-course survey revealed that 55.9% of the political science students agreed or strongly agreed that bureaucrats were a necessary part of the political policy process. By the end of the course, that percentage was 80.4%, a 24.5% shift toward a more positive attitude of bureaucrats.

Understanding of the Public Policy Process

A sizeable portion of the Introduction to Engineering and Public Policy course is devoted to explaining the process of setting public policy. Recognizing that most students lack a full understanding of the public policy process, the course was developed to help explain the process. For engineering students in particular, the course demonstrated that there is a rational process for setting policy and it is done with thoughtful analysis. Statement 14 of the survey in Appendix A measures this directly by asking students their level of agreement with the statement "I have a good understanding of the public policy process."

Engineering Students' Understanding of the Public Policy Process

I looked first at the change in self-assessed understanding of the public policy process and how it changes throughout the course for engineering students. Results are shown in Table 5.16.

Table 5.16 Change in Engineering Students' Self-Assessed Understanding of the Public Policy Process

I have a good understanding of the public policy process.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	2.8	2.8
Disagree (%)	38.9	0.0
Neither Agree nor Disagree (%)	38.9	5.6
Agree (%)	19.4	66.7
Strongly Agree (%)	0.0	25.0
n	36	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=72)=38.150, p<0.001.

At the beginning of the course, 19.4% of the engineering students indicated they agreed or strongly agreed with the statement that they had a good understanding of the public policy process. By the end of the course, that percentage had increased by 72.3% to 91.7%.

Political Science Students' Understanding of the Public Policy Process

This aspect of the course, increasing the understanding of the public policy process had similar effects on all students, given most have had little, if any, exposure to how public policy is made. In spite of this lack of education prior to the course, it would seem that political science students would believe they have a better understanding of the process than do the engineering students. And this is indeed what was found. Table 5.17

details the responses of political science students to the statement "I have a good understanding of the public policy process."

Table 5.17 Change in Political Science Students' Self-Assessed Understanding of the Public Policy Process

I have a good understanding of the public policy process.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	3.4	2.0
Disagree (%)	22.0	2.0
Neither Agree nor Disagree (%)	28.8	0.0
Agree (%)	37.3	68.0
Strongly Agree (%)	8.5	28.0
n	59	50

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=109)=32.298, p<0.001.

The changes in political science students parallels that of the engineering students. At the beginning of the Introduction to Engineering and Public Policy course, 45.8% of the political science students agreed or strongly agreed that they had a good understanding of the public process. This compares to 19.4% of the engineering students at the same time. So, more political science students did believe they had a better understanding of the process than did engineering students when the course began. At the end of the course, fully 96.0% of the political science students agreed or strongly agreed that they had a good understanding of the public policy process. This percentage is comparable to the 91.7% for engineering students.

The data clearly indicate that students can be educated about the public process. Understanding the process is one step towards changing attitudes about public policy and being able to get more engineers involved in the process.

Need for Cooperation Between the Professions

Another part of getting more engineers involved in public policy is changing the attitude of both the engineering and political science professions that greater cooperation is needed. This attitude was measured by the eighteenth statement on the survey contained in Appendix A. This statement reads “Political scientists and engineers should work more closely with each other on public policy issues.” It too warranted examination from the perspective of both types of students.

Engineering Students’ Attitude Changes Towards Greater Collaboration

Table 5.18 tabulates the results of asking engineering students their level of agreement on whether political scientists and engineers should work more closely with each other on public policy issues.

Table 5.18 Change in Attitude of Engineering Students on Greater Collaboration with Political Scientists on Public Policy Issues.

Political scientists and engineers should work more closely with each other on public policy issues.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	0.0	0.0
Disagree (%)	0.0	0.0
Neither Agree nor Disagree (%)	5.6	8.3
Agree (%)	41.7	25.0
Strongly Agree (%)	52.8	66.7
n	36	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically insignificant with χ^2 (2, N=72)=0.215, p=0.643.

Surprisingly, the percentage of engineering students who agreed or strongly agreed with this statement decreased over the duration of the course yet again, the findings for this statement are not statistically significant. At the beginning of the course, 94.5% of the engineering students either agreed or strongly agreed that engineers and political scientists should work more closely with each other on public policy issues. However, by the end of the course, that percentage had dropped to 91.7%. While the decrease in percentage was neither expected nor desired, it was still positive in the sense that over 90% of the engineering students believed engineers and political scientists should work more closely together. Also, none of the engineering students disagreed nor strongly disagreed with the statement at the beginning or the end of the course. Furthermore, this percentage change is the result of one student. At the beginning of the course, there were 34 students who agreed or strongly agreed (15 and 19 respectively) with the statement, and by the end of the course there were 33 students who agreed or strongly agreed with the statement (9 and 24 respectively). Countering the loss of one student from the agree or strongly agree group, nine were added to the strongly agree camp.

The statement did not distinguish between technical public policy and public policy in general but the students may have unintentionally read that into the statement. The results shown in Table 5.11 indicate that some engineers believe they should defer to political science students on non-technical policy issues which may have played a role here. Future research could include presenting students with this question in terms of technical and non-technical policy issues to see if there is any difference in attitudes as a function of type of policy.

Political Science Students' Attitude Changes Towards Greater Collaboration

Political Science students were also presented with the statement "Political scientists and engineers should work more closely with each other on public policy issues" and asked their level of agreement with the statement at the beginning and end of the course. Results for political science students were in general positive and are shown in Table 5.19.

Table 5.19 Change in Attitude of Political Science Students on Greater Collaboration with Engineers on Public Policy Issues.

Political scientists and engineers should work more closely with each other on public policy issues.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	0.0	2.0
Disagree (%)	0.0	2.0
Neither Agree nor Disagree (%)	16.9	8.0
Agree (%)	57.6	30.0
Strongly Agree (%)	25.4	58.0
n	59	50

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically insignificant with χ^2 (2, N=109)=4.125, p=0.127.

When the Introduction to Engineering and Public Policy course began, 83.0% of the political science students either agreed or strongly agreed with this statement. By the end of the course, the attitude of political science students had shifted 5.0% in the positive direction to 88.0%. Although there was positive shift in attitude, there was 4.0% who disagreed or strongly disagreed with the statement at the end of the course compared to 0.0% at the beginning. This 4% consisted of two individual students and the change in their attitudes in the negative direction may well be related to the lack of specificity as to whether this cooperation was on non-technical or technical issues. The findings of this statement were found to not be statistically significant.

Validation of Hypothesis 4

Considering the totality of the data from the 9th, 10th, and 14th, and 18th statements from the survey (Appendix A), the null hypothesis is rejected giving credibility to the hypothesis that at the conclusion of the Introduction to Engineering and Public Policy course, students will have a perceived improvement in their understanding of the public policy process than they had at the beginning. The results from statements 9, 10, and 14 were found to be statistically significant while only statement 18 was found to be statistically insignificant. This is clearly indicated when students were asked directly about their understanding of the public policy process through statement 14 (Tables 5.16 and 5.17). The statements dealing with the role of bureaucrats in public policy (Tables 5.12, 5.13, 5.14, and 5.15) supported the hypothesis. The idea that engineers and political scientists should work more closely with each other on public policy issues as measured by statement 18 (Tables 5.18 and 5.19) was the sole anomaly and was statistically insignificant. This statement was one which the students overwhelmingly agreed with at the beginning of the course and decreased slightly for engineering students and increased slightly for political science students. Given the large percentage who were in overall agreement at the beginning of the class and the fact that the changes were the result of a few students, this statement is certainly worthy of additional research. A larger sample size could yield different results as could measuring on a 7-point Likert scale rather than a 5-point scale.

Hypothesis H_5: Need for Broad Education

Those involved in public policy benefit from having a broad education and especially an understanding of the subject matter under consideration. A common stereotype of both engineers and political scientists is that they are rather narrowly educated in their specific disciplines. While this argument can be made for both professions, it applies more so to engineering. When it comes to setting public policy, especially technical policy, each profession would benefit from a greater understanding of the others' profession.

My fifth hypothesis is that at the conclusion of the Introduction to Engineering and Public Policy course, students will have an increased recognition of the need for a broad education outside of their technical disciplines than they had at the beginning. Testing of this hypothesis was done through statements 23 and 24 in the survey in Appendix A.

Engineers Need More Political Science Courses

The first test of this hypothesis deals with the idea that engineers should take more political science or related courses than they presently do. The expectation was that engineering students would recognize the need for their taking additional political science courses in order to gain a better understanding of the field.

Engineering Students' Attitudes Toward Their Need to Take More Political Science

Statement 23 of the survey in Appendix A reads "engineers should take more political science (or related) courses." Table 5.20 below details the results of the engineering students on this statement.

Table 5.20 Change in Attitude of Engineering Students Regarding the Need for Them to Take More Political Science or Related Courses.

Engineers should take more political science (or related) courses.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	2.8	0.0
Disagree (%)	8.3	2.8
Neither Agree nor Disagree (%)	19.4	5.6
Agree (%)	55.6	52.8
Strongly Agree (%)	13.9	38.9
n	36	36

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=72)=5.681, p=0.058

At the beginning of the Introduction to Engineering and Public Policy course 69.5% of the engineering students agreed or strongly agreed that they should take more political science or related courses. This is not all that surprising given that the engineering students enrolled in the course did so out of their interest in the area and not because it was a requirement or even gaining them credit towards their degrees. By the end of the course, the percentage had increased to 91.7% with a grand total of only two students who neither agreed nor disagreed and one student who disagreed. Clearly, even though these students were predisposed to the idea that they needed more knowledge in the area of political science, the course further reinforced that idea. However, these results are significant only at the $p<0.1$ level and must be used cautiously.

Political Science Students Need More Engineering Courses

The second test of hypothesis H_5 examined the attitude of students about the idea that political science students need more technical courses. This was measured by statement 24—political scientists should take more engineering, science, and math courses—and considered from the perspective that as a result of the course, political science students would recognize the need to take additional courses in engineering-related disciplines.

Political Science Students' Attitude Toward Their Need to Take More Technical Courses

Next, I looked at the results of the survey from the perspective of political science students, and saw further evidence that the course had an impact on the change of attitudes. Table 5.21 summarizes the change in attitudes of political science students toward their need to take more engineering, math, and science courses.

Table 5.21 Change in Attitude of Political Science Students Toward Their Need to Take More Technical Courses

Political scientists should take more engineering, science, and math courses.	Pre-Course Results	Post-Course Results
Strongly Disagree (%)	11.9	2.0
Disagree (%)	11.9	18.0
Neither Agree nor Disagree (%)	35.6	16.0
Agree (%)	30.5	48.0
Strongly Agree (%)	10.2	16.0
n	59	50

Source: Engineering and Public Policy Professional Attitude Survey, GE 2713 Introduction to Engineering and Public Policy, Fall 2009-Fall 2015.
Aggregated results are statistically significant with χ^2 (2, N=109)=6.941, p=0.031.

The Introduction to Engineering and Public Policy course resulted in a 23.3% change in the attitude of political science students, indicating that through the course they gained an appreciation of their need to have more technical courses. When the course began, 40.7% of the students either agreed or strongly agreed with the statement that political scientists should take more engineering, math, and science courses. By the end of the course, that percentage had increased to 64.0%.

One issue that could bear further investigation is the difference in attitudes of engineers and political scientists toward their own need for further education in the other's discipline. Comparing the results of those who disagreed or strongly disagreed with the statement in Tables 5.20 and 5.21 I saw a large difference between engineering and political science students. At the end of the course, 2.8% of the engineering students disagreed that they needed more political science or related courses, whereas 20.0% of the political science students disagreed or strongly disagreed that they needed more engineering, science, or math courses. It would be interesting for further research to look into this difference and differentiate between those political science students who truly do not believe they need more technical courses and those who simply do not want to take more technical courses.

Validation of Hypothesis H_5

The results of the survey showed a marked increase in the change of attitude of both engineering and political science students toward the need for additional college coursework in the other's discipline thereby allowing for a rejection of the null hypothesis. Although one of the two measures is only statistically significant at the $p<0.1$ level, combined with the other statement a case can be made for overall significance. The Introduction to Engineering and Public Policy did show the ability to change students' attitudes on the need for a broader education including study outside of their major areas in order to be effective public policy makers.

CHAPTER VI

CONCLUSION

The overarching objective of this dissertation was to examine if organizational change at the macro level of professions could eventually be effected according to Lewin's three-stage process of change theory. The first step of Lewin's theory is to overcome resistance and unfreeze the current situation such that change could happen. As an investigation that this unfreezing could be achieved by intentional intervention, I used an Introduction to Engineering and Public Policy course to demonstrate that attitudes of entrants into a profession could be changed. Ultimately, according to theory, these entrants will effect change throughout the profession over time as they interact with their peer professionals.

Specifically, the research goal of this dissertation was to examine if an interdisciplinary, introductory course on engineering and public policy could be developed and used to effect changes in the professional attitudes of engineering and political science students. This was accomplished by the validation of three of the five hypotheses tested, although admittedly some of these hypotheses have chi-squared values indicating they results must be interpreted cautiously. The two hypotheses which were not validated may well still be valid hypotheses but the statements presented to the students did not adequately discriminate the factors that needed to be measured.

The results from these hypotheses also indicate the difficulty of conducting research of this type. The group of students analyzed constituted the entire population of those who were enrolled in the course but they are a sample of the greater populations of engineering and political science students. Students self-selected to enroll in the course which could well have influenced their opinions but there is no way to force students to take the course so there will always be some bias in the results. The question then is one of whether these results can be applied to the greater population? I believe they can be applied, with caution, and the results do indicate that further research is warranted.

The use of *p*-values are useful in interpreting data however the American Statistical Association (ASA) has issued some recent guidance in the use of the values. I have therefore interpreted my findings with these findings in mind. Specifically, the ASA notes that "*p*-values do not measure the probability that the studied hypothesis is true, or the probability that the data were produced by random chance alone" and they further note that "scientific conclusions and business decisions or policy decisions should not be based only whether a *p*-value passes a specific threshold" (Wasserstein & Lazar, 2016, p. 131). Additionally, the ASA states that "[s]maller *p*-values do not necessarily imply the presence of larger or more important effects, and larger *p*-values do not imply a lack of importance or even lack of effect" (2016, p. 132). Essentially the ASA is stating that the *p*-value is a useful tool but not the only tool for making inferences about data. They note that "[p]roper inference requires full reporting and transparency" (2016, p. 131) which why I have fully reported the findings here.

I have also been mindful of the caution given by Vidgen and Yasseri in the use of *p*-values for hull hypothesis significance testing (NHST). They warn that the use of terminology of significant or nonsignificant is often encouraged by NHST but that "[t]his dichotomizes the *p*-value on an arbitrary basis, and converts a probability into a certainty. This is unhelpful when the purpose of using statistics, as is typically the case in academic studies, is to weigh up evidence incrementally rather than make an immediate decision" (Vidgen & Yasseri, 2016, p. 2). Consequently, the analysis and interpretation of the results must be a combination of directionality of change as well as statistical significance and therefore I have reported *p*-values and used them as one tool in interpreting the results.

The five hypotheses investigated are stated above in Table 4.1. The analysis of the data collected from a survey administered to both engineering and political science students demonstrated that an introductory college course can indeed change attitudes within future professionals.

Hypothesis Tests Results

The data from the experimental group was examined by combining the results of those who disagreed and strongly disagreed with a statement into a disagree value, and combine those who agreed or strongly agreed into an agree value. Those who neither agreed nor disagreed were left as a neutral group. The differences in percentages of the groups of students, engineering and political science, were then compared by measuring how much the percentages changed from the beginning of the course to the end of the course.

Stereotypes

By interacting with each other throughout this course, students' perceived stereotypes of the others' profession were changed. Political science students came to understand that engineers do care more about policy than simply its technical aspects, and engineers came to see that political scientists cared about the technical aspects of policy. In addition, political science students found that engineering students possessed interpersonal skills and could interact with non-engineers while the engineering students recognized that political science students had some technical skills needed in policy formulation.

Legitimacy of Professions

Each discipline also recognized the value and legitimacy of the other profession. Engineers learned that political scientists had value they could add to technical policy decisions and political science students saw that engineers could and should be involved in public policy. Additionally, political science students changed their opinions over the course coming to believe even more that engineers should be involved in public policy in general, and not merely on technical policy issues. Further, the perception held by engineering students that too many political scientists were involved in technical policy decisions was changed for the better. Accepting that each profession has expertise to offer and a legitimate role to play in public policy is a major step towards getting more engineers involved in public policy and having them accepted by the political science students who are already involved.

Deference to Each Other's Profession

This is the only hypothesis tested which was not validated. Results were ambiguous from the perspective of both engineering and political science. Here, by deference I mean that the engineering profession would recognize the specific strengths of political scientists and defer to their opinions on matters within their realm of expertise. It would also mean that political scientists would see value in skills the engineers have, namely technical skills, and would defer to them on those matters. However, the data did not bear this out over the duration of the course. But even those results were not completely conclusive for in both cases, there was a noticeable increase in the percentage who strongly agreed with the statement over the duration of the course. So, while the majority did not see a change in the positive direction, for some students there was a noticeable shift towards a more positive attitude. As discussed in the results, this may well be due to the fact that the course did not strenuously exercise the skills of either set of either discipline in actually drafting policy.

Understanding of Public Policy

Another positive outcome of the study was the finding that students did come to have a better understanding of public policy from several aspects. They learned the role bureaucrats play in implementing public policy through the course and came to understand that bureaucrats were not a hindrance to public policy but were, in fact, a necessary part. Even the political science students developed a positive opinion of bureaucrats over the duration of the course.

Both political science and engineering students developed a better understanding of how public policy is set based on their pre- and post-cost self-assessment. And while both groups of students already had a positive attitude about the need for both professions to work well together, this sentiment grew stronger over the duration of the course.

Need for a Broad Education

The Introduction to Engineering and Public Policy course also had a positive impact on the students' understanding of the need for a broader education. Again, while both engineering and political science students enrolled in the course started with the belief that they needed a broader education, perhaps one reason they self-selected to take the course, their belief grew stronger over the duration of the course as evidenced by an increase in the percentage who agreed or strongly agreed with the statement.

Future Work

This study has demonstrated that attitudes can be changed by education through a college-level course. Lewin's first stage of organizational change can be achieved by direct intervention with education. What remains to be seen is if these students, entering their respective professions, will be able to infect others with their attitudes and ultimately change the profession of engineering such that more engineers will engage in public policy.

And while I make the claim that students attitudes have been changed, I do so with caution. Nuzzo notes a study conducted in 2010 which found that political moderates saw the world in shades of gray, whereas political extremists saw the world in terms of extremes. The findings were determined to be very significant based on a *p*-value of 0.01 but when they tried to reproduce the results with additional data, the new *p*-value was found to be 0.59 (Nuzzo, 2014, p. 150). I do believe the findings here are significant, even if not always statistically significant, and warrant additional study and research. A larger data set could very well change the statistical significance of these findings—those that are significant could become non-significant and those not significant could become significant. But the changes observed, with the exception of Hypothesis 3 are clear with this sample. Whether the findings can be definitively applied to the larger population of engineering and political science students can only be truly determined with additional data and further research.

There are several ways these findings could be studied further. These students, had they been personally identified, could be tracked throughout their careers in a longitudinal study to see how much change they impart. A study of upper- and mid-level executives could also be done to determine how many of them had their attitudes unfrozen as an entrant into the field and the impact it had on their rise to their current levels. The statements in this survey could also be rewritten in some cases, have additional statements added, and expand the Likert scale from 5 to 7 to further define the level of agreement or disagreement. Regardless of the long-term impact, the Introduction to Engineering and Public Policy class had an impact on the students studied here and supports the observation that such a course can foreshadow unfreezing of attitudes in a professional engineering climate.

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APPENDIX A

ENGINEERING AND PUBLIC POLICY PROFESSIONAL ATTITUDE SURVEY

Engineering and Public Policy
Professional Attitude Survey

Semester __________ ○ Pre-Survey ○ Post-Survey

The purpose of this research project is to measure changes in your attitudes toward other professions as a result of taking the Engineering and Public Policy class through the administration of this survey. This survey will be administered at the beginning, and again at the end, of the semester, which will allow us to measure any changes in attitudes. Results from these surveys will be used in publications, reports, proposals, and presentations. By participating in this survey you will help us gain a better understanding of what your attitudes are and how this course changes those attitudes. We can then better design courses that will allow engineering and political science students to gain a better appreciation of each other's professions.

There are no known risks associated with this survey and your participation is voluntary. You may choose to not answer any or all of the questions below. If you choose to not participate, simply return your form when the others are returned. You do not need to tell us you chose to not participate. By completing this survey, you are consenting to your participation in this research project. At the conclusion of the semester, this information will be analyzed to determine any changes in attitudes. It should take approximately 5 to 10 minutes to complete this survey.

We make no attempt to link attitudes to you as an individual. The data we ask are only to allow us to draw broad conclusions. We do not want you to sign your name to this survey and we are not asking for any information that will allow us to identify you as an individual. We will not analyze the data until the course is completed and final grades have been submitted.

If you have questions or concerns about this survey or this research project you may contact Robert Green at green@bagley.msstate.edu.

Demographic Data

My gender is: ○ Male ○ Female

My major is: ○ Engineering or a related physical/life science

○ Political Science or related Social/Behavioral science

○ Other (please specify) ____________________________

I am an: ○ Upperclassman (junior or senior)

○ Lowerclassman (freshman or sophomore)

I am:
- ○ Caucasian
- ○ African-American
- ○ Asian-American
- ○ Other

Attitudes toward professions

Please indicate how much you agree or disagree with the following statements. Please answer with the understanding that when the term "engineer" is used, it includes engineering, physical and life sciences, mathematics, and other technical fields. When the term "political science" is used, it refers to political science, social and behavioral sciences, liberal arts, and other non-technical fields.

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Engineers only care about the technical aspects of public policy decisions.	○	○	○	○	○
2. Political scientists do not care about the technical aspects of public policy decisions.	○	○	○	○	○
3. Engineers have inadequate interpersonal skills to work well with people.	○	○	○	○	○
4. Political scientists have inadequate skills and knowledge of math and science to make technical decisions.	○	○	○	○	○
5. Engineers should not be involved in public policy.	○	○	○	○	○
6. Political scientists should not have input on technical policies.	○	○	○	○	○
7. Political scientists should defer to the judgment of engineers on technical matters.	○	○	○	○	○

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
8. Engineers should defer to the judgment of political scientists on non-technical matters.	○	○	○	○	○
9. Bureaucrats are a hindrance to implementing good public policy.	○	○	○	○	○
10. Bureaucrats are a necessary part of the public policy process.	○	○	○	○	○
11. Politicians are more concerned about getting re-elected than about helping others.	○	○	○	○	○
12. Politicians make decisions based on what people want rather than what people need.	○	○	○	○	○
13. Engineers make decisions based on what people need rather than what people want.	○	○	○	○	○
14. I have a good understanding of the public policy process.	○	○	○	○	○
15. Those involved in the public policy process are important to the betterment of society.	○	○	○	○	○
16. The problem with setting public policy is that there are too many Political Scientists involved.	○	○	○	○	○
17. Engineers should be involved in public policy but only on technical issues.	○	○	○	○	○
18. Political scientists and engineers should work more closely with each other on public policy issues.	○	○	○	○	○
19. I have a good understanding of the Engineering profession.	○	○	○	○	○

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
20. I have a good understanding of the Political Science field.	○	○	○	○	○
21. Engineers are valuable to society.	○	○	○	○	○
22. Political scientists are valuable to society.	○	○	○	○	○
23. Engineers should take more political science (or related) courses.	○	○	○	○	○
24. Political scientists should take more engineering, science, and math courses.	○	○	○	○	○
25. The ability to communicate across professions is a valuable skill to have.	○	○	○	○	○
26. Engineering is an honorable profession.	○	○	○	○	○
27. Political science is an honorable field.	○	○	○	○	○
28. Engineers are ethical.	○	○	○	○	○
29. Political scientists are ethical.	○	○	○	○	○
30. Engineers have good communication skills.	○	○	○	○	○
31. Political scientists have good communication skills.	○	○	○	○	○

32. Public education in the United States adequately prepares citizens to make technical policy decisions.	○	○	○	○	○
33. Public education in the United States adequately prepares citizens to make non-technical policy decisions.	○	○	○	○	○
34. It is important for engineers to understand how political scientists think and approach problems.	○	○	○	○	○
35. It is important for political scientists to understand how engineers think and approach problems.	○	○	○	○	○