2006-1838: KATRINA IN THE CLASSROOM: ENGINEERING AND PUBLIC POLICY THROUGH PROJECT-BASED LEARNING

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Katrina in the Classroom: Engineering and Public Policy through Project-based Learning

A Note on Engineering and Public Policy
We assume that engineering educators have two sorts of interest in public policy

1. What and how to teach students about the role of public policy in engineering and technology and vice versa. This is our focus in this paper.
2. Public policies that concern engineering education

Public policies are the policies of public institutions that affect our lives including, but not limited to, federal, state and local governments. Public universities and utilities, and NGOs may also be included. Since government policies affect and are expected to constrain and shape private institutions be they universities or corporations, then these institutions constitute a second order domain for public policy.

Central to the first interest is how the expertise of engineers (and applied scientists) informs public policies. Does the right knowledge connect with the right policy makers, is the expertise well developed and appropriate to the subject, is it understood, is it followed, who participates in the connections, how effective are the connections, does it result in enlightened polices and are these policies followed? There are, clearly, many steps and many opportunities for success or failure.

As more knowledge comes in, and a lot is coming in, Katrina seems to be a superb case study of exactly what should never happen: where everything that policy makers needed to be told by the experts before it happened was told - and done so for a considerable length of time, many decades, beforehand. The information was clearly understood and it had obvious and serious policy implications. But the desirable responses were not forthcoming. Even immediately before and during the emergency itself, the correct information was flowing – until it hit political walls far more effective than any flood wall in New Orleans.

Introduction
In response to the devastation caused by Katrina, two different first year classes used the disaster as an opportunity to learn through a major project for the Fall semester of 2005. Neither taught public policy explicitly. One class approached it as a problem in engineering design. The other addressed it in terms of the emergency preparedness and planning effort in New Orleans. The latter is certainly closer to public policy than engineering design is, but it still focused more on what happened rather than what was planned or what policies drove the planning.

In fact, the unfolding events and coverage, which still continues, made a top down approach rather impractical. Yet both instructors found that a great many policy issues were raised by the students in their projects and these are summarized and reported here. This is, then, an inductive and student centered approach to engineering and public policy. We report on a “found policy” equivalent to what is sometimes termed “found art,” namely what people see in what has already occurred without prior actions by them or the use of pre-selected analytical and conceptual
policy tools. Inevitably the students’ opinions and knowledge get shaped by what they find in the media and the challenge is to guide students both to diverse and to better sources. We do not advocate it as a stand-alone method for teaching policy but rather a way of indicating how easily policy issues resonate with our students. It is a good way to lead into a second part of a course or a second course in which public policy is then taught to a sympathetic audience. And Katrina is a very rich event for a case study for engineering and public policy in the future. The two courses are described below.

EGEE 110: *Safety science for the rest of your life* is a survey of applications and technologies associated with safety in our every day life with associated review of scientific principles and economic, social and political impacts. It is offered as a general science course in the Department of Energy And Geo-Environmental Engineering in the College of Earth and Mineral Sciences. The students did an incident investigation/ critical analysis of what went wrong with both the emergency planning and preparedness and with the actual response (semester long project).

ED&G 100: *Introduction to engineering design* is a project based course in the College of Engineering where students are introduced to the methods and skills of engineering design. It is required of all but one major in engineering. Each section has 32 students and one of these sections, which included a Katrina refugee from a university in New Orleans, took on the task of redesigning New Orleans as their major project. There was one coordinating team and 5 specialty teams.

The two instructors had hoped for collaboration between the classes but only a little occurred. Some resources were shared and at least one student and both instructors sat in on the presentations of the other class. The collaboration between the two classes from two different colleges was not forced for the sake of the project. It was rather, encouraged as a means of developing and sharing information. This project was one of exploration versus one of strict requirements on approach. The authors plan to further their collaboration between the two course since design and operational safety have a clear relationship. System design, for example, cannot be taught or practiced without considering the operational design. And design for safety is one of many requirements that designers must consider.

**Katrina**

Most of the numbers and assessments describing Katrina and its aftermath still vary considerably. However, in the first flood of information, some things were frequently observed,

- Katrina was one of the most powerful hurricanes on record and was level 3-4 when it hit New Orleans with a level 5 storm surge that would have been even worse if the eye of the storm had passed approximately 40 miles further west
- Levees gave way or were overtopped so widely that 80% of New Orleans was flooded often to the eaves of the houses. Many survived only by accessing their roofs, often by breaking a hole through the roof to get out.
- Transportation and communication resources became limited or non-existent
- Hospitals and first responders (police, fire, ambulance) were overwhelmed with a dramatic increase in need combined with a dramatic decrease in resources such as
personnel and usable police stations. For at least a week the survivors in New Orleans were on their own making new decisions under new circumstances, usually dire.

- There is a history of poor (under) design, poor construction and maintenance, poor planning, and a clear cognizance of the vulnerability of New Orleans to a strike by a major hurricane. The only unknown was when it would happen. The prior situation, in sum, looks like institutionalized malfaisance.
- About 100,000, over 20%, of the population stayed, largely because they were poor and had no means of transportation and none were provided. They were quite literally forgotten in the planning. Over 1,300 are known to have died and similar numbers are still missing as of March 2006.
- The permanent displacement of people from New Orleans has been so large that it has provided a measurable boost to housing sales nationally. At the same time, many will not return and the population of the city has been significantly reduced.
- The return of people to New Orleans is a return to destroyed and heavily damaged homes not designed to survive one foot of water let alone 10-15 feet of water. Their history embodied in personal possessions has often been lost.
- It is estimated that most homes, ~200,000, were damaged and up to 100,000 new homes are needed.
- The city became what some termed a toxic waste dump with toxins, debris, and disease that made all activity hazardous in much of the city.
- The wetlands that protect New Orleans took another big hit and unless their decline is reversed the coastline of Louisiana will be far north of New Orleans by the end of this century. That is, the protection of New Orleans is part of a larger story.

There seems to have been a major disjuncture between public policy and engineering and scientific expertise in the planning for the defense of a one of America’s most famous cities. The experts testified repeatedly. Officials and politicians repeatedly failed to act. The primary ingredient in the past defense of New Orleans has been the Army Corps of Engineers, and any new initiative must review their role because they failed to protect New Orleans because they were only authorized to design against a category 3 hurricane.

This failure to plan and the inability to respond, threw images around the world that looked like an underdeveloped country. By comparison, the Netherlands have an extraordinary system of levees and dams to protect their country, half of which is below sea level. [This is the same small country that alone had the capacity to bring the USS Cole back to the United States. Link ] Some of the World’s most ambitious projects are being built where water once stood in the Persian Gulf, Hong Kong Harbor and Tokyo Bay. The images of New Orleans at least suggest that the opportunity costs of wars abroad and other expenditures, and tax cuts, include the massive neglect of the security of at least one major city at home. The neglect suffered by New Orleans no doubt has many causes, and it has a long history, but the catastrophic blow it suffered, which was avoidable, is dramatized in an era when homeland security has been raised to such a high profile. The frequent narrowing of focus to portray the incompetence of the Bush administration has been observed to have significantly lowered his approval ratings, made even worse in early March 2006 when tapes of him being briefed ahead of time became public. It is now one of the most salient issues of technology and public policy, but that is no guarantee of a brighter future for New Orleans.
Responses have included the idea of abandoning New Orleans, but that would represent a massive defeat in global prestige for the world’s leader in technology and has not been the path taken so far. However, poor planning and funding for reconstruction may contribute to a permanent decline in the population, largely among the middle class, and some abandonment of areas that were populated. Given the increased vulnerability of New Orleans because of Katrina, another similar hurricane strike in the next few years might force the issue unless a major reconstruction program begins very soon.

In the rush to condemn public policies and practice it should not be overlooked that the private sector did not fare well either. Oil production rigs blew ashore from up to 60 miles out. Refineries producing 25% of high grade fuel in the US flooded and were shut down. The oil corporations are among the most wealthy and profitable corporations in the world. They have far less red tape to deal with and few stakeholders to negotiate with. And they have plenty of engineers and scientists. Why did they not plan better? Why did the telephone companies lose both land lines and cell phone towers? Did no one use fail safe design and planning?

The two authors, among many others, were so concerned with the catastrophe, independently, that they discussed it with their students and decided to use their first year classes to study it – with the enthusiastic support of their students. They know of other faculty who did similar things and it may be that Katrina had one of the largest impacts on the classrooms of American universities of any disaster. If true, it is clearly worth developing a case study for it and many probably will do that.

Public Policy
Since the drama was unfolding while we studied it, we focused on understanding it rather than teaching it as a case study in public policy. Nevertheless public policy issues were raised in almost all the resources found by the students and almost all the redesign options they considered. We hope that here, and later, we can extract the lessons in public policy and develop it as a case study. Such a case study can always be brought up to date by future developments. So it will have currency for the foreseeable future and can develop a history of the reconstruction as it is used.

These are the very broad public policy issues that ran through the instructors’ minds as we ran our classes, despite our lack of a form approach to policy

1. How hard is it to design a socio-technical system for New Orleans that would be safe? What could first year engineers do to understand the problems and redesign New Orleans. Insofar as they succeed, the implications are that the considerable levels of complexity and technological difficulty are not the issue.

2. Is the image of a devastated New Orleans coupled with poor design, poor planning and a hapless response a public policy issue for engineering in the United States. How inept and uncaring do we look when compared to broadly similar technology in other parts of the world? Does this cause irreparable damage to the image of the US as the world leader in technology? Is there a need not just to rebuild New Orleans, but to do it in ways that are prestigious?
3. How hard is it to understand what is needed to respond to catastrophic emergencies such as Katrina that have happened before and which will happen again. If first-year students can understand what should be done, why wasn’t it done?

ED&G 100: Introduction to Engineering Design

Student Responses
This large difficult topic was tackled by the students in both cases with much enthusiasm. They were aided by the “flood” of public information that typically accompanies such disasters.

However, in the design class, the size of the task was too much for an 8 week design project. It was rendered somewhat manageable by breaking the class into 6 teams: Coordinating, Benchmarking, Levees, Structures, Transport and Communications, and Wetlands. Guest expert faculty members gave presentations on highway design, levee design, design of structures, wetlands [functions and restoration], and using the power of the tides for energy production. These were uniformly excellent and very well received by the students. The course was evaluated by the students well above average (6.0/7.0; the mean for the College of Engineering is 5.4). In their comments they mentioned these speakers as one of the best things about the class.

Most of the student work was spent on the problem development stage of design with some forays into benchmarking and idea generation. It would make a good two semester project. Nevertheless, the students did do good work, and they have at least prepared the groundwork for a discussion of public policy. All five teams engaged in commentary about public policy even without it being in their assignment. It was unavoidable.

By the end of the class several distinctions had been made by the students that bear directly on public policy

1. Safety comes first: New Orleans must be safe against a category 5 hurricane.
2. No repopulation can take place without reconstruction to make any given repopulated area safe. The geography of safe areas will likely be new.
3. Hospitals and first responders must have the technologies designed to support them during emergencies. This need is quite distinct from the needs of the general population.
4. Communications and transportation systems must be provided that work during such emergencies
5. Restoration of the wetlands has many economic benefits as well as providing indispensable protection for New Orleans: each 2.8 miles of Wetlands reduces the storm surge by one foot.
6. Other countries, notably the Netherlands, can provide consulting help in the redesign. [Some of their engineers have been very critical of the existing system that, rather than keep the sea out, provided a conduit for the storm surge.] Dutch consultants should be brought in.
7. Some solutions could be revenue producing such as a bullet train on the hurricane corridor from Houston to Miami that would run profitably in normal times. It might usefully extend up to the major cities of the east coast. Another would be generating energy from floating houses and other structures.
8. Some solutions (see #7) could be state-of-the-art and create an image of reconstruction that is visionary rather than remedial.
No formal assessment was carried out, but some students voluntarily provided commentary in the end of semester course assessments. Here are the three out of 29 who did this.

“I also liked our final project, the redesign of New Orleans. It is interesting to actually do a project that is on something so recent. I learned a lot about what failed and how to change it.

I like how we were allowed to take on large problems, for example the disaster with Hurricane Katrina, and attempt to redesign aspects that our crucial to our current society. It made it feel that as a freshman, we were still able to approach very important issues and attempt to fix them.

In our ED&G 100 section we took on a different project (hurricane Katrina redesign) than the other classes. I think this provided a good amount of diversity within the projects and within the classes. I think this should be applied to most of the sections.

The last comment was nice to receive since, from the instructor’s point of view, this project was tough to run.

EGEE-110 Safety Science

Critical Analysis - Emergency Response Planning and Actual Response to Hurricane Katrina

The EGEE-110 students were asked to do a critical analysis of both the emergency preparedness and planning effort and the actual response as they understood it from researching available documents and from watching and hearing about the actual response on the television news. The students were charged with evaluating the response by the city of New Orleans, the state of Louisiana and the federal government agencies such as the Federal Emergency Management Administration (FEMA). They were given relatively strict guidelines as to the format of the written results of their critical analysis, but were given no guidelines as to how to present their results to the rest of the class. They were encouraged to use their own creativity in presenting the results of their analysis and their recommendations for improvement.

Analysis Method and Guidelines for Report

Students were asked to perform the critical analysis and generate a report of their findings that included 4 main sections. The executive summary was to be created in the form of an abstract which was a mini summary of the entire paper. The paper was to contain an introduction to the problem (why was the analysis needed), the method of analysis used (students were asked to develop a time line of occurrences and to use such methods as gap analysis, plus/delta processes, root cause analysis techniques, etc.), a results section and most importantly, a conclusion section. This was expected to contain the student’s interpretations, fact-based opinions, conclusions and recommendations. Each student then presented a summary of their work and the recommendations to the rest of the class in a formal presentation. The students were encouraged to use any information resources that they could find on the subject as there were no limitations. Due to the relatively recent nature of the event, the news media both print and television were overwhelmingly the most available formats. While it would have been preferred
for the students to use more academic formats for their sources, such as those that undergo peer review and acceptance prior to coming out in print, it is nearly impossible to have it both ways for such a recent event. Such recent events have not yet received the scrutiny or have not been studied long enough to have successfully generated extensive peer reviewed literature.

**Assessment Method (including Rubrics)**
The assessment of the project was accomplished using several inputs for both the written work and the oral presentation. The averaged grades given by two professors provided for a balanced assessment. Each professor reviewed the written analysis by each student and offered a points-earned per 20 possible points for each of five categories (100 points maximum). The assessment categories;

- Content Quantity (not the more-the-better, but appropriate amount) and Quality,
- Technical Accuracy,
- Factual Treatment of Media Reports, Soundness of Conclusions and Reasonableness of Recommendations
- Format (content and references), Grammar, Spelling, Writing Style and Efficiency

The oral presentations of the results of the critical analysis were evaluated by two professors and the grades were averaged. The assessment was similar to the written report in that students could earn a possible 20 points in each of five evaluation categories with a total possible 100 points. The categories for the oral presentation were:

- Thoroughness and effectiveness of the presentation
- Quality of visual aids
- Technical merit and accuracy of the critical analysis
- Soundness of problems determined and the feasibility of recommendations made
- General overall impression

**Excerpts from the EGEE-110 Course Syllabus**

**“Course Description**
For an understanding of how humans interact with their working and living environment, one has to understand the basic sciences of physics, biology, chemistry, mathematics and psychology as well as some of the traditional engineering disciplines. This general education course EGEE-110 is intended to provide students with a basic understanding of how these science and engineering principles are applied in a safety context to every day life, products, hobbies, finances and human interaction. The course offers exposure to the fundamental science and engineering principals behind each applied safety-related activity discussed. Since the course content includes engineering principles, collaboration with the College of Engineering’s Engineering Design Course ED&G-100 is explored each semester.

**Course Objectives:**
At the conclusion of the course, participants should be able to:
1. Demonstrate an understanding of how the dynamic processes of the natural and man-made worlds impact our safety and well being in every-day working and playing lives.
2. Demonstrate an understanding of the foundation of and reasons behind the existence of the complex, inherent and manufactured hazards of today’s industries, residences, transportation systems, natural environments, health care operations, etc.

3. Demonstrate an understanding of the life long benefit of having the knowledge and ability to understand and apply hazard protection measures to hazards and risks to self, family, friends and co-workers while transitioning through the day.

Projects
A project may be team based and if so, each team will be asked to select a topic for in-depth study. The topic will be chosen from several different possibilities in which a real, well-known accident or incident occurred or a real situation in which an accident could happen but has not yet. They could also choose a case or situation in which at least one of the group members was involved or is intimately familiar. Student teams will gather and evaluate relevant data and descriptive information about the case, compare these data with known acceptable or unacceptable limits to determine what about the case went wrong or could go wrong in leading to the failure or accident. They will be asked to render an opinion as to the cause of the accident and to justify it with data and other forms of deductive and inductive analysis. They will then be expected to develop appropriate corrective measures and describe these measures quantitatively and qualitatively in detail. The teams will explain how these measures will be implemented and justify their effectiveness and expected costs. Each team will present findings in class or develop a web page to reflect on the findings. This assignment will be carried out in collaboration with the Engineering Design Course ED&G-100 to help students potentially in future policy influencing positions to interact with students who may be in future positions of influencing such societal-based designs and infrastructure as roadways, bridges, mines, communication systems, levees, transportation systems, etc.”

Problems that Arose in the Dispatch of the Assignment
Unfortunately, the most used media (the TV, print or internet news) contains as-of-yet, undeveloped facts and bias and can sometimes be sensationalized in the name of selling more “copies.” It is difficult for first year college students to distinguish between bias and unbiased reports, therefore, some of the bias showed up in the results of the students’ analyses.

The results of many of the students’ analyses contained a noticeable bias towards the discrimination issues proposed by many in the news media. Some of the students seemed to focus too little on the system based problems that allowed the evacuation process to fail and too much time on a position taken in many news reports that said the problems were a purposeful attack on certain groups. This view was reported by some of the students as intentional decisions being made not to evacuate and then not to rescue certain groups in an effort to harm them or that certain groups of people weren’t worth the effort or the risk of rescuing them. It was interesting to see how much influence the news media had on these students. In essence, this media phenomenon appeared to cloud the students’ ability to do a true and thorough critical analysis of the facts (versus opinions) of the event. This appears to be a function of the information resources available to the students. While it would have been preferable to see that all of the students in fact did complete a pure critical analysis based on facts surrounding the
failed levees, communication break down, etc. the students did highlight the fact that perception can translate into very real problems.

**Results of the Students’ Findings**

While some of the students did allow bias to get the better of them in their analysis, a large number did address some of the real and major problems that will be important for the city of New Orleans and the State of Louisiana to address. While the recommendations developed and proposed by the students were simplistic, as one might expect from first or second year undergraduate college students, many of them did get to the heart of main problems. Many of the students addressed the communication system and network, the communications interface between city, state and federal agencies, the infrastructure issues such as low lying roadways, the planning problems associated with the failure to address the levee systems that were known to be designed for a lesser storm than what Katrina was projected. Some addressed the problems associated with evacuating hospitals, nursing homes and prisons. It is not expected that any of the recommended solutions would solve the emergency response problems associated with this hurricane however; it was refreshing to see that even these young students were able to determine the specific areas where New Orleans and the State of Louisiana will have to focus their emergency response resources for the future.

**Summary of Student Recommendations:**

- Improve communication systems
- Improve communication interface and links between agencies, including national weather service
- Inspect and upgrade levee system (suggested prior to the availability of the Army Corps of Engineer’s inspection reports)
- Develop and implement interagency emergency response drills on a regular basis and critique the drills using third party experts to evaluate, not only the drill but the interagency communication and cooperation
- Re-evaluate evacuation plans for nursing homes, hospitals, extended care facilities – hire outside expert to evaluate and upgrade existing plans and consider developing a set of emergency response plan criteria that must be met by all medical care facilities
- Evaluate the feasibility of an elevated evacuation route with multiple access point along the entire New Orleans metropolitan area

**Concluding Remarks**

There is a direct link between the layout, elevation and the physical design of a municipality and its emergency response plan. Much of what is done in an emergency response is a function of the physical layout, the elevation, the communication system, the transportation system (air, rail, road, water, etc.). When there is a short fall in the physical make up of a city, such as low lying elevation (such as is the case for New Orleans), the emergency planning and response has to consider and account for that. The planning must address the levee system, it must address the fact that low lying evacuation routes will be under water, it must address the fact that underground hard wire communication systems may be damaged in flood waters. It is essential that collaboration between agencies and groups responsible for development and maintenance of these systems, infrastructure and policies take place.
Therefore, it stands to reason that facilitating this collaboration between the people (the young students) who will represent these groups in the future is a valuable approach in the preparation of future engineers and future planning and policy developers. This assignment was developed with this future preparation in mind as the students also learned the primary lessons of the assignment, such as the design process and performing critical analysis in the face of little available information.

The challenge for public policy is how to take what was known before as well as what has been learned again from Katrina and decide which governing groups should be used or established to make which decisions to achieve which outcomes. In answering these questions, we need to devise processes and that must include the most affected parties since those who suffered the most appeared to be those who were the most disenfranchised, and our students were quick to realize that.