

TECHNOLOGY FOR NON-TECHNICAL STUDENTS: ADVENTURES ON THE OTHER SIDE OF CAMPUS

John A. Pearce¹

Abstract - *The average engineering major knows more about the humanities than the average humanities major knows about science and engineering. As engineering educators we too seldom interact with students from non-technical majors. This gives us a narrow perspective and exacerbates the problem.*

I have designed and offered a course centered on the development of technology and its affect on society and public policy. We study the effects of steam power and electrification and draw parallels with recent technological developments. The course has been presented twice and is open to students from engineering, science, business, arts and humanities majors. Substantial thought must be given to class topics and exercises appropriate for this diverse group of students.

INTRODUCTION

The course in technological development issues is titled "Steam Power and Electricity Generation" and is offered at the University of Texas at Austin as a second semester freshman Tutorial Course in the Plan II honors program. It is one of several "substantial writing component" courses in the curriculum. The Plan II honors program consists of demanding courses in literature, philosophy, sciences and mathematics in addition to the requirements of any standard baccalaureate major. The classes are intentionally composed of mixed majors to provide a broad perspective in the discussions.

In this class I use the hind-sight experience of 18th to 20th century technological development to illuminate trends and effects in recent technological innovations. The number of close parallels in events between the rapid development of railroads in the past and information technology today is striking, to say the least.

I found the style of teaching required to be a refreshing change from my usual classroom experience. The standard engineering lecture format is, of necessity, used sparingly during the course. Nonetheless, a core subset of very basic lectures on introductory thermodynamics and structural mechanics is essential. The key message of the lectures is that the ability to calculate, predict and quantitatively evaluate the performance of machines is an essential component of engineering design — and this ability is what makes rapid progress possible. The downside is that new technology invariably seems to create new problems, both social and environmental.

The generation and execution of appropriate classroom exercises required considerable planning and creativity. Grading a writing course required adjustment and re-education on my part. A

significant portion of the grade, 55%, is determined from class participation, the rest from the papers.

CLASS WORK

Primary texts for the class are those by Billington [1] and Nye [2] and the novel *Atlas Shrugged*, by Rand [3]. Supplemental class materials are derived from the internet, and Lambert [4], Adams [5] and DeCamp [6] are also used. The Billington text is an effective teaching instrument for engineering and non-engineering students alike and is interesting and useful even at the freshman level.

Formal papers 5 to 8 pages in length are required on three topics. The papers consist of a graded draft and final paper. Topics are: 1) select one person, either someone studied in class or another figure from science or engineering, who has made the most important contribution to technology, either in comparison to his contemporaries (i.e. horizontally) or over ensuing decades (i.e. vertically) and defend your choice; 2) Ayn Rand's work is either teleology or tautology — select one of these descriptions and defend it or refute the assertion that it is one or the other; 3) identify the technological development which has had the most significant impact on either the state, the nation or the world and support your choice with a well-reasoned argument.

Classroom exercises include discussion periods and more substantial role-playing exercises. The role-playing exercises are by far the most engaging for the students. Each exercise is a realistic civic and/or social problem. The class is divided into instructor-selected groups and individuals are assigned roles within the groups. The problem situation is designed to convey a sense of jeopardy on the part of the participants. That is, the consequences of poor decision-making or problem resolution are obvious and non-trivial. The groups know that they are being graded individually and collectively on the quality of their participation. Problems are designed to approach a situation from at least three separate and often contradictory (or at least potentially adversarial) points of view. Each group is provided with common information about their collective situation. Individual students are given specific information which they should reveal, about themselves and others, and information about themselves which they may not want to be generally known. Clues are placed in the information packages which are designed to lead the students to inquire into the motivations and practices of strategic members of the other groups. The problems are: a board of enquiry into steamboat explosions; an ethical dilemma; the St. Louis traction worker's strike of 1905.

¹ Department of Electrical and Computer Engineering, The University of Texas at Austin, Austin, TX 78712

Problem 1: Steamboat Explosions, 1850

The time, 1850, is two years before passage of enabling legislation for the first federal regulatory board, the Interstate Commerce Commission. During 1850, 277 people died in boiler explosions and in 1851 a total of 407 people died. In the problem the specific steamboat company has a higher rate of boiler explosions than other companies operating on the Ohio River between Cincinnati and New Orleans. A Board of Enquiry has been convened immediately after a local boiler explosion resulting in substantial loss of life and property. The Board is charged with deciding whether sufficient evidence exists to refer the matter to criminal court, the Ohio River Company should be sent into receivership and disassembled, or some form of sanctions are warranted.

Class groups consist of: 1) a Board of Enquiry, composed of elected officials (state and federal) and judiciary from Kentucky and Ohio, 2) officials of the steamboat company (at least the Chief Executive Officer and the Principal Engineer in charge of construction), 3) concerned citizens from both states; farmers, city residents and local manufacturers. A few members of the "Board" and "Citizen" groups have had relatives injured or killed in steamboat accidents. Motivational factors include: greed, pride in workmanship, impending elections, transportation (market access) for agricultural and manufactured products. Ethical questions include: bonus payments for steamboat crews for short transit times between ports, some kickback from the boiler/steam engine manufacturer in exchange for information on the design safety factor, various amounts of stock owned by various participants in the company under investigation and other competing steamboat companies.

Situational dilemmas: 1) both the cargo and the boat were under-insured, 2) newspapers have fanned the flames of public resentment, 3) elections are eminent, 4) federal legislation is pending, 5) boiler safety (and safety factor) is a prime issue in Washington, 6) there is ill-feeling between Ohio and Kentucky, 7) a relative of one Board member works for a rival company and insists that the boilers are not safe enough, 8) another Board member owns a substantial amount of stock in the Company, 9) the Company has recently invested a large amount of money in upgrading their designs and fleet, 10) the Principal Engineer does not trust management and suspects that the actual boilers delivered are below specifications as (s)he was not allowed to see the test data — but needs the job very badly due to indebtedness.

Problem 2: Ethics

One of the criticisms of the "Objectivist" philosophy described in minute detail by Rand in the class novel (and others she wrote) is that it lacks any substantial or satisfying treatment of ethics — ethics in the sense of providing the tools to make decisions regarding a course of action given somewhat unclear or conflicting (but reasonable) requirements on at least two sides of an issue. The particular exercise is: given three people presently on hemodialysis all near death in end stage renal failure, the group must decide who is to receive a single available kidney for transplant. Characteristics are provided for each of the potential recipients. The students are asked to form three groups with two assignments each: 1) apply

the reasoning described in Atlas Shrugged by John Galt (one character) to the ethical dilemma, 2) choose the ethical method preferred by the group and make the same choice. Groups meet during class and between classes, if they wish, to make the decision. One class period is devoted to discussing the decisions.

Problem 3: St. Louis Trolley Strike, 1905

The overall design is similar to that of Problem 1, but the situation is one of historical importance. The strike actually occurred; however, the problem has mostly fictional (but reasonable) elements. The three groups are: 1) city government officials, 2) striking traction workers, and 3) the traction company.

There is a strike of traction workers, "motormen", mechanics and track workers, against the traction company. The workers are unhappy with working conditions, the number of hours worked each week, their rates of pay and worker and passenger safety. The traction company is unwilling to let the workers form a union and, in addition, the workers are demanding that the company become a "union shop". The city election is in one month. The traction company stock holder's meeting is in two weeks. There are rumors of outside labor agitators.

Situational dilemmas: 1) the government faces an enraged citizenry who can't get to work, a strong opposition party and elections for more than half of the elected offices, 2) the company management has invested considerable sums in the election (above and below the board) and to obtain expansion rights, the opposition party is decidedly labor-oriented, profits are down, and they have a ready supply of untrained workers due to immigration trends, 3) traction worker pay is below that of city employees in similar positions, working conditions are unacceptable to them, worker and passenger safety are demonstrably below acceptable levels, the opposition party has made overtures about future rewards if the strike is extended through the elections, and there is a rumor that the governor may call out the militia.

The class exercise is a round table negotiation session during which the strike must be settled. Certain selected facts about each of the other groups are given out to bring out hidden motivations. No individual characteristics are provided for any of the roles — groups are free to designate spokespersons and otherwise organize themselves as they wish. The grade is based mostly on the effectiveness of the in-class negotiating session.

The class exercises have been well-received and enthusiastically engaged by the students. In some instances the students took their assigned roles a little too seriously, and this is to be avoided. The best feedback is that the students were forced to look at the problems from different perspectives. In observing their work on the problems I have been amazed at the depth to which they have absorbed class concepts and are able to apply them to the problems. The thoughts they come up with during discussions are eye-opening, to say the least.

LABORATORY WORK

We are fortunate to have available a local tourist railroad, the Austin & Texas Central Railroad, for laboratory purposes. The A&TC operates weekend passenger service between Cedar Park and

Burnet, Texas. The motive power is typically provided by Southern Pacific number 786, a USRA light Mikado (2-8-2 wheel arrangement) steam engine built in 1916; but is occasionally a diesel-electric type SW-1500 from the 1940's. I volunteer on that railroad and am qualified as an engine watchman and studying to be a fireman. The watchman fires up the locomotive prior to a run, approximately a four-hour process. During operation, the fireman maintains firebox draft, oil burner status, steam pressure, boiler water level and works closely with the engineer to ensure operating safety.

Each semester the class is taught we visit the A&TC railroad. During the first class offering (spring semester 1998) we toured the locomotive while it was steamed up between runs in downtown Austin. The sights, sounds and other sensual experiences made a substantial impact on the students. When it goes off at 200 psi, the five-chime Nathan steam whistle will intensely stimulate the sympathetic nervous system of even the most lethargic among us. Review of the structure and function of the safety appliances and operating machinery previously discussed in class comprised most of the 45 minute laboratory session.

The full realization of the actual physical size of a locomotive surprised most of the students — and this example is not a very large locomotive by railroad standards. Feedback from the spring 1998 experience was overwhelmingly positive.

This semester (spring 2000) will be different. The steam locomotive is undergoing major structural repairs — a crack initiated from old collision damage threatens to separate the left power cylinder from the engine frame. The engine is partially disassembled in the railroad yard at Cedar Park. This semester's laboratory session (to be conducted in the coming month, at this writing) will be modified to focus on the internal construction details of the steam engine and on the structural mechanics issues discussed in class. If our timing is good, we may be able to discuss the diesel-electric locomotive as it is prepared for the morning departure.

EVALUATION

Student feedback has been overwhelmingly positive. The students almost uniformly express their appreciation during the class and at the conclusion. Of course, they are freshmen and not yet jaded by their experiences. Even so, it is not quite uniform — there always seems to be a small percentage who loathe it. The hardest part seems to be to convince liberal arts majors to take the class. Those who do take it like it and do well as a group. For the record, the fraction of students from engineering majors who dislike the class is the same as for non-engineering majors.

The in-class exercises are the most well-regarded, but the laboratory session gets high marks as well. I am always surprised and amazed by how well the students, engineering and non-engineering alike, are able to relate the topics discussed in class to the exercise problems. The exercises tell me important omissions in class material — for example, I must introduce the concept of safety factor more carefully in future. It makes an excellent "bone of contention" in Problem 1.

This course was, for me, a rare chance to transcend the intense content-oriented classroom lecture environment of a standard engineering class and to try out some new and unfamiliar teaching techniques. It is a treat to read early papers by some of the most interesting minds in the University. I would commend the experience to anyone so inclined. I am firmly convinced that in some small way such a class helps to break down the artificial barriers between our professions. The most difficult thing about offering it is to convince the non-engineering majors that they won't be chewed up in the course — there is pervasive avoidance behavior among them. Non-engineers who take the course like it. I think I must change the title in future.

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