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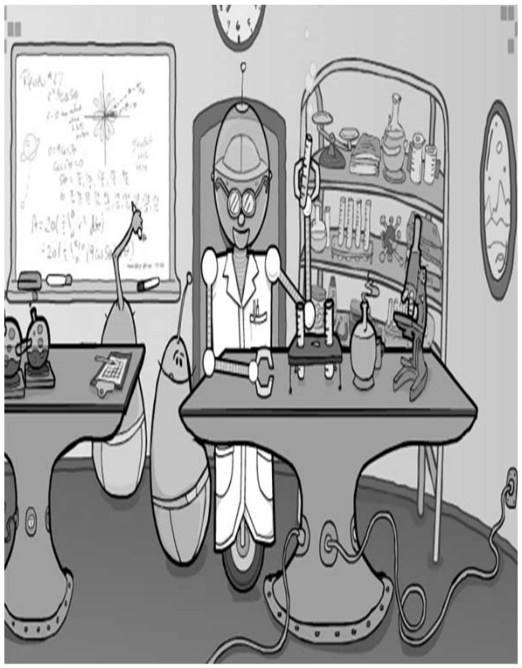
Ch4: Engineering as Social Experimentation

Contents

Engineering as Experimentation



All products of technology present potential dangers, regardless of how carefully they are designed, produced and used. Engineering should be considered inherently risky, and even consider experimental process

Engineering projects are experiments that involve technology development and humans

(experiment on social scale involving human subjects)

Engineering as Experimentation

- Experimentation is playing an essential role in the design process.
- The normal design process is thus iterative (doing something again and again, usually to improve it), carried out on trial designs with modifications being made on the basis of feedback information acquired from tests.
- At the production stage further tests are run, until a finished product evolves.
- Beyond those specific tests and experiments, however, each engineering project taken as a whole may be viewed as an experiment.

Similarities to Standard Experiments

1) Ignorance

Any project is carried out in partial ignorance. There are uncertainties in the abstract model used for the design calculations; there are uncertainties in the precise characteristics of the materials purchased.

Engineer's success lies in the ability to accomplish tasks safely with only a partial knowledge of scientific laws about nature and society

2) Unpredictability

The final outcomes of engineering projects, like those of experiments, are generally uncertain. Often in engineering it is not even known what the possible outcomes may be, and great risks may attend even seemingly benign projects.

3) Novelty

Effective engineering relies on knowledge gained about products both before and after they leave the factory-knowledge needed for improving current products and creating better ones.

Similarities to Social Experiments

1) Ignorance

   They are carried out in partial ignorance.

2) Unpredictability

   They have uncertain out comes

3) Novelty

   They require monitoring and feedback

4) Informed Consent

   They mandate obtaining informed consent from those affected.

Learning from the Past

- Usually engineers learn from their own earlier design and operating results, as well as from those of other engineers, but unfortunately that is not always the case.

- What hinder learning from the Past?!
  - Lack of established channels of communication.
  - Misplaced pride in not asking for information.
  - Embarrassment at failure or fear of litigation(the process of taking a case to a law court so that an official decision can be made)
  - Neglect.

Learning from the Past

Examples

1) The Titanic *lacked a sufficient number of lifeboats* decades after most of the passengers and crew on the steamship Arctic had perished (pass away completely) because of the same problem

Titanic was proclaimed the greatest engineering achievement ever.

length of almost three football fields;

the *Titanic* was believed to be virtually unsinkable.

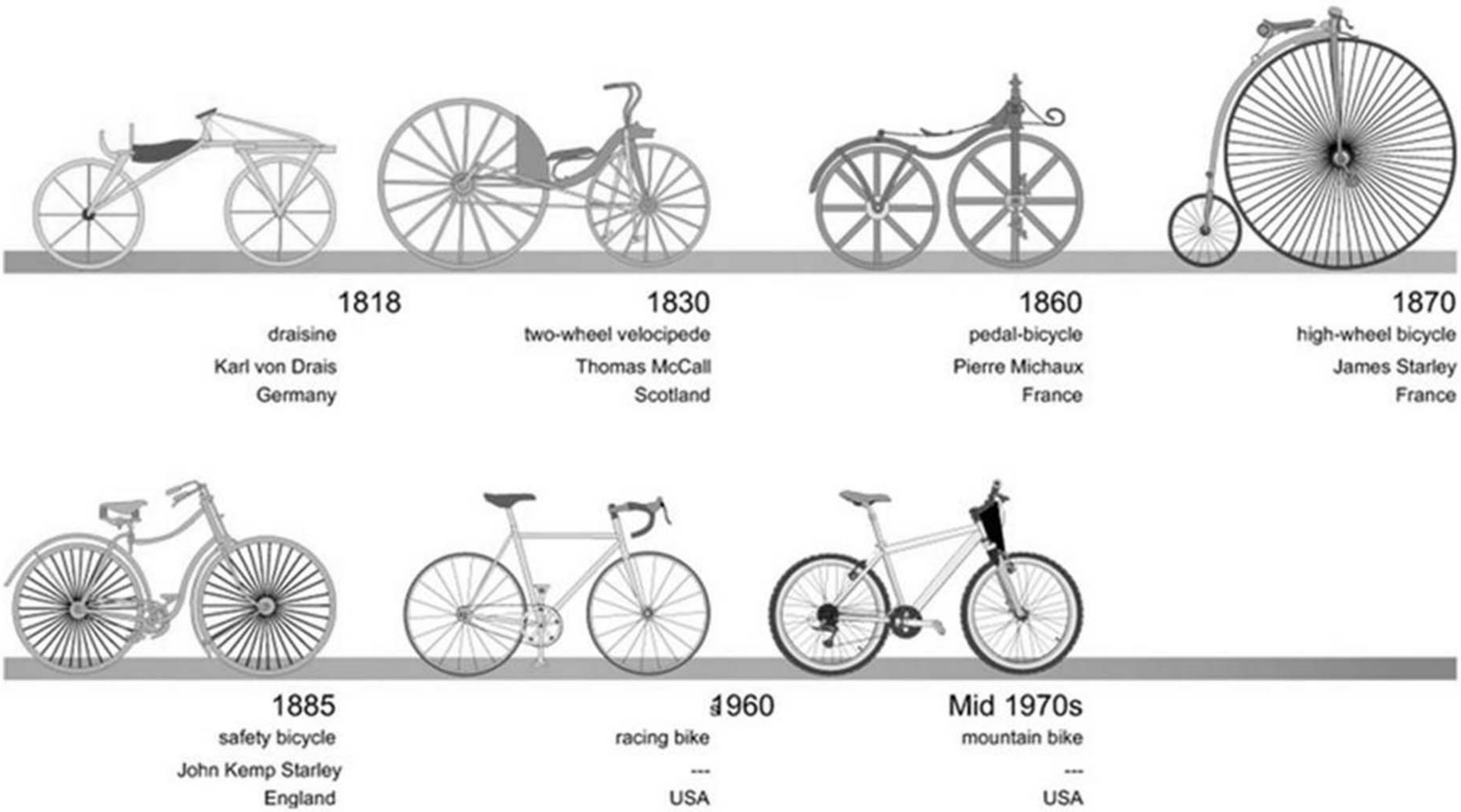
April 1912, buoyed by such confidence, the captain allowed the ship to sail full speed at night in an area frequented by icebergs, one of which tore a large gap in the ship's side.

Learning from the Past

2) "Complete lack of protection against impact by shipping caused Sweden's worst ever **bridge collapse** on Friday as a result of which eight people were killed." Thus reported the New Civil Engineer on January 24, 1980. Engineers now recommend the use of *floating concrete bumpers* that can deflect ships, but that recommendation is rarely heeded as seen by the 1993 collapse of the Bayou Canot bridge that cost 43 passengers of the Sunset Limited their lives.

Learning from the Past

- **3**) *Valves* are notorious for being among the least reliable components of hydraulic systems. It was a pressure relief valve, and a lack of definitive information regarding its open or shut state, which contributed to the nuclear reactor accident at Three Mile Island on March 28, 1979. Similar malfunctions had occurred with identical valves on nuclear reactors at other locations.
- The required reports had been filed with Babcock and Wilcox, the reactor's manufacturer, but no attention had been given to them.


1818
draisine
Karl von Drais
Germany
1830
two-wheel velocipede
Thomas McCall
Scotland
1860
pedal-bicycle
Pierre Michaux
France
1870
high-wheel bicycle
James Starley
France
1885
safety bicycle
John Kemp Starley
England
1960
racing bike

USA
Mid 1970s
mountain bike

USA

Learning from the Past

a) Problems

- Lack of established channels of communication
- Misplaced pride in (not) asking for information
- Embarrassment at failure
- Fear of litigation
- Simply neglecting to study previous situations

b) Solutions

- Learn from workers (who have a much different and more practical perspective than handbooks and software)
- Do quick ‘back of envelope’ calculations (to check lengthy complex calculations)
- Stay alert and well-informed at all stages of the project (including the history of the project)
- Freely exchange ideas with colleagues

Contrasts with Standard Experiments

1) Experimental Control

a) Typical standard Experiment

one group is subjected to a test, treatment or special situation (experimental subjects), while another group is held to the all the same conditions except for the special procedures being tests in the experimental group (control subjects) and both groups are selected randomly

b) Engineering as a Social Experiment

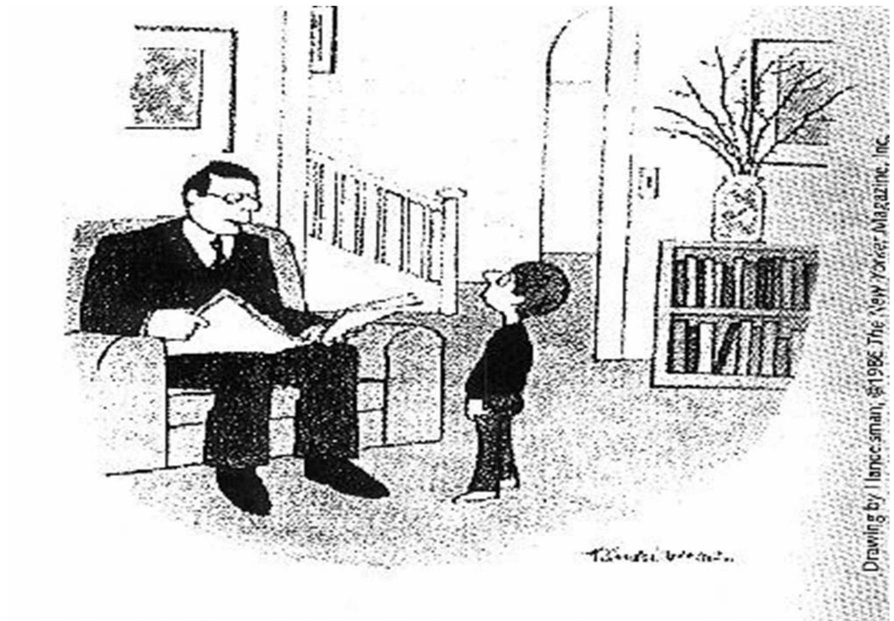
Experiment subject is out of the experimenter's control.

Impossible to obtain a random selection of participants.

Contrasts with Standard Experiments

2) Informed Consent

Viewing engineering as an experiment on a societal scale places the focus where it should be- on the human beings affected by technology, for the experiment is performed on persons, not on inanimate objects.



"I'm a social scientist, Michael. That means I can't explain electricity or anything like that, but if you ever want to know about people I'm your man."

Informed Consent

Basic features of valid informed consent:

1. The consent was given voluntarily.
2. The consent was based on the information that a rational person would want, together with any other information requested, presented to them in understandable form.
3. The consenter was competent (not too young or mentally ill, for instance) to process the information and make rational decisions.

Contrasts with Standard Experiments

3) Knowledge Gained

Scientific experiments are conducted to gain new knowledge, whereas "engineering projects are experiments that are not necessarily designed to produce very much knowledge.

"The best outcome in engineering activity is one that tells us nothing new but affirms that we are right about something".

Taft Broome

Engineering/Experimentation Comparison

Engineering	Experimentation
Objective is to solve problems which often involves:	**Objective to find new knowledge or answers which also involves:**
- unknowns - uncertain outcome - monitor, learn from past experiments - human subjects / participants often unaware, uninformed - often don't recognize all variables - natural experiment	- unknowns - uncertain outcome, test hypothesis - draw conclusions or verify hypothesis based on experience / evidence - "informed consent" of subjects - try to control all variables - controlled experiment

Engineers as Responsible Experimenters

- From the perspective of engineering as social experimentation, **four features** characterize what it means to be a responsible person while acting as an engineer:
  - A conscientious commitment to live by moral values
  - A comprehensive perspective
  - Autonomy
  - Accountability
- Or, stated in greater detail as applied to engineering projects conceived as social experiments.

Engineers as Responsible Experimenters *'Style of Engineering'*

1. **Conscientiousness**: A primary obligation to protect the safety of human subjects and respect their right of consent .
2. **Comprehensive Perspective**: A constant awareness of the experimental nature of any project, imaginative forecasting of its possible side effects, and a reasonable effort to monitor them.
3. **Moral Autonomy**: Autonomous, personal involvement in all steps of engineering project .
4. **Accountability:** Accepting accountability for the results of a project .

A Balance Outlook on Law & Industrial Standards

(1) Conscientiousness

- sensitivity to the full range of moral values and responsibilities relevant to a given situation, and the willingness to develop the skill and expend (to use or spend especially time, effort or money needed to reach a reasonable balance among those considerations.
- Conscientiousness implies consciousness: open eyes, open ears, and an open mind **(i.e., moral vision, moral listening, and moral reasoning)**

(2) Comprehensive Perspective

- Conscientiousness is blind without relevant factual information.
- Hence showing moral concern involves a commitment to obtain and properly assess all available information that is pertinent (relating directly to the subject being considered)

(3) Moral Autonomy

- People are morally autonomous when their moral conduct and principles of action are their own.

- Viewing engineering as social experimentation can help overcome this tendency and restore a sense of autonomous participation in one's work.

(4) Accountability

- Too often "accountable" is understood in the overly narrow sense of being culpable (deserving to be blamed or considered responsible for something bad) and blameworthy for misdeeds.

- But the term more properly refers to the general disposition (a natural tendency to do something, or to have or develop something) of being willing to submit one's actions to moral scrutiny the careful and detailed examination of something in order to get information about it)and be open and responsive to the assessments of others.

Engineering as social experiment

Engineering as social experimental process should always seek **Safe Exits.**

Safe Exits: design and procedures ensuring that if a product fails it will fail safely and the user can safely avoid harm from the failed product.

A Balanced Outlook on Law

- The legal regulations that apply to engineering and other professions are becoming more numerous and more specific all the time.
- We hear many complaints about this trend, and a major effort to deregulate various spheres of our lives is currently under way.

A Balanced Outlook on Law

- For example, one of the greatest moral problems in engineering is that of **minimal compliance.**
- This can find its expression when companies or individuals search for loopholes (a small mistake in an agreement or law which gives someone the chance to avoid having to do something) in the law that will allow them to barely keep to its letter even while violating its spirit.

A Balanced Outlook on Law

- Engineering as social experimentation can provide engineers with a proper perspective on laws and regulations in that rules that govern engineering practice should not be devised or construed as rules of a game but as rules of responsible experimentation.

- Such a view places proper responsibility on the engineer who is intimately connected with his or her "experiment" and responsible for its safe conduct.

A Balanced Outlook on Law

- In areas where experimentation is involved more substantially, however, rules must not attempt to cover all possible outcomes of an experiment, nor must they force engineers to adopt rigidly specified courses of action.
- It is here that regulations should be broad, but written to hold engineers accountable for their decisions.

A Balanced Outlook on Law

What are the solutions to problem associated with Code of Ethics?

- Reasonable Lows
- Specific Laws and Rules

A Balanced Outlook on Law

Conclusion

Reasonable laws and sanctions are appropriate components of engineering, but laws set the rules for minimal compliance rather than providing the full substance of engineering ethics

Industrial Standards

- Product standards facilitate the interchange of components, they serve as readymade substitutes for lengthy design specifications, and they decrease production costs.
- Examples range from automobile tire, sizes and load ratings to computer protocols.
- Standards are established by companies for in-house use and by professional associations and trade associations for industry- wide use.

Conclusions

- Engineer as responsible experimenters
- Discuss Challenger Case Study(we will study this case in more detail later in the semester)