Science of Nuclear Energy and Radiation

Introduction

1. Why should we be interested in this course on the science of nuclear energy and radiation?

prepared by
Dr. Jerry Cuttler,
Technical Services Manager, AECL

- There is scarcely a subject that has been more closely studied than nuclear energy and the effects of radiation on matter and living things.
- Most people know very little, if anything at all, about nuclear science and technology.
- Many people are afraid of nuclear technology; they do not accept it.
- Nuclear will play an important role in the 21st century; it's very important that we understand it.
- It is very important to introduce the young people now in schools to this subject.
- Understanding this technology enables us to answer questions from the students.
- Negative information is being disseminated on the subject which is raising concerns.
- This course will provide factual information on the subject and the issues.
- A relationship will be started with scientists who will help you with on-going support.
- Nuclear fission is already an important source of energy in the world and its use will continue to grow.
- You will come to understand why nuclear plants are a clean, safe and inexpensive way to make electricity.
- Radiation is common in nature and is also produced by humans for many important applications.
- Canadians use large amounts of energy, especially electricity, for homes and industry.
- In Ontario, we use electricity generated by:
  - nuclear power plants >60 %
  - hydro-electric power plants ~25 %
  - coal/oil/gas fuel-burning power plants ~15 %
  - "renewable" energy power plants few %

- The US and most other countries use mostly fossil-fuel burning power plants.
- We all have concerns about the health effects of pollution from burning fossil fuels.
- Many environmentalists have concerns about global warming due to buildup of CO_2.
- Developing countries want a higher living standards and will use more energy.
- World population growth, from 6 to 10 billion in 50 y, will put pressure on existing energy resources.
- World production of oil is expected to peak in the year 2003 - the end of cheap oil.
- There is a global need for desalinated water for homes, industry and agriculture.
- Nuclear energy will be an important part of the solution of supplying the energy need.
- Canada has invested in nuclear science and technology over the past 54 years and has developed exceptional applications for:
    - electricity generation - the CANDU reactor
    - nuclear medicine - we supply ~60 % of the world medical radioisotope market
    - industrial applications - food processing, gauges, agriculture, sterilization, etc.
    - nuclear fuel - Canada supplies ~30 % of the world's uranium market
- Nuclear technology is a high-tech industry that employs 50,000 in Canada, mostly in Ontario.
- This industry provides opportunities for well-paying, interesting jobs for our children.
- Canadian export business is currently $1 billion/y; with potential for growth.
- We need to understand this technology in order to answer questions from our students.

2. Why are McMaster University and the Canadian Nuclear Society providing this course?

prepared by
Dr. Jerry Cuttler,
Technical Services Manager, AECL

- We believe it is very important for science teachers and the students to know more about nuclear science and technology, for the reasons given to the previous question.

- We believe that science teachers would like to know more about this subject, so we decided to provide a convenient, low-cost opportunity for you to do so.

- The nuclear industry is preoccupied with meeting the following important challenges:
  - marketing and sales of nuclear products in the very competitive world market
  - developing better technology to compete with other energy options
  - reduced parliamentary appropriations, which impact on R&D budgets
  - impact of management problems at Ontario Hydro on CANDU product image
  - addressing concerns about aging and life extension of existing nuclear plants
  - addressing concerns about long-term management of used nuclear fuel
  - addressing concerns about disposal of radioactive wastes
  - responding to damaging myths and rumours disseminated by the media
  - other changes impacting the industry

- Thus the nuclear community has been too inward-looking. We'd like to change that.

- So we decided, with our very limited means, to try to address this need. The nuclear industry is cooperating with this pilot project.

- We'd like to discuss the myths and paradigms that are damaging public acceptance of nuclear technology.

- "Public acceptance of the nuclear option is the single largest challenge facing the nuclear industry. Public faith in nuclear energy is delicate, to say the least." - a quote from the speech by the Minister of Natural Resources Canada, 1998 Nuclear Energy Winter Seminar, Ottawa.

- We want to learn how to communicate better with teachers. We hope to learn important lessons from giving this course, and we will modify the course accordingly.

- The Canadian Nuclear Society would like to encourage more of its members to volunteer for educational initiatives organized by science teachers.

- We would like to stimulate your interest and your questions, and we'll try to answer them. We will not know all the answers, but we will learn from the exchange of ideas.

- We want to encourage students to actively assess nuclear issues.

3. How should the subject matter be treated?

prepared by
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Philosophical underpinnings are required in this course because, ultimately, the acceptance or rejection of nuclear power depends on the fundamentals - philosophy and value systems.

! Doubt

- When all is said and done, there remains doubt - it is the one thing that I am sure of. There will always be considerable uncertainty and, hence, risk.
- Doubt is heaven to some because it gives the potential for change.
- Doubt is hell for others because of the hazards of uncertainty.
- The question is: "How do we best proceed?"
- Basically we need to minimize risk and maximize benefit. The two are not necessarily the opposite of each other.

! Life is Complex

- Many interconnected spheres
    - biosphere
    - stratosphere
    - ecosystems
    - social systems
    - legal systems
    - judicial systems
    - economic systems
    - etc.
- Given our lack of knowledge (doubt again) about how the spheres work, we need to adopt a "Respect for all Things in Life".
- Ultimately, everything is important. But, practically, we need to set priorities. We need a methodology to do this - a management system.

! Specialization

- Given the doubt and complexity, specialization is required to manage the practicalities of life.
- This implies:
    - organization
    - coordination
    - process
    - rules
    - procedures
    - enforcement
    - learning
    - measurement
    - faith / trust in others
- Specialization implies certain individuals or groups will be in positions of privilege, eg. Teachers, doctors, engineers, etc.
- This raises social issues of rights, responsibilities, freedom, equality, empowerment, etc.
- Need a methodology to make decisions regarding risks vs benefits (both of which are value laden).

! Process Specification - a suggestion

- Should be non-biased (ie, no a priori preference)
- Ultimately, making a choice boils down to a numerical assignment - whether you think so or not!
- The scorecard process
    - Numerically-based algorithm makes the process explicit so. At the very least, the biases are made visible and provides a basis for discussion.
    - Need to enumerate the attributes of importance.
    - Pre-assign attribute weights.
    - Enumerate the alternatives
    - Set the goal. Best? Least worse? RMS?
    - Score each attribute for each alternative according to an explicit scoring algorithm.
    - Exclude immediately any alternative that excluded if it fails to meet the minimum requirement for any attribute, eg, a car is excluded if you need a truck.
    - Rank the remaining alternatives using a simple scorecard.
- This is a reasonable process given the errors in evaluations of attributes and in the weights chosen.
- Pros and cons are equally pursued for all options commensurate with the probability of success. For example, cars running on water should not be investigated without some evidence that it is viable. Or, if the public has voted that there will be no nuclear reactors, then that option is a non-starter.
- In short, the choice should be made based in an explicit and unbiased comparison of the alternatives.
- Value systems enter via the attributes selected, the weights chosen and the goals set.

! Rights vs Responsibilities

- The more rights / privilege/ authority one has, the more responsibility / obligation / accountability one has.
- This implies that those responsible for power production must have the authority and the means to do so. This implies privilege. Equally, they are to be held accountable.
- This also implies that those who object or oppose a privileged group are also accountable for their actions since the right to oppose implies responsibility.

! Empowerment

- Those invested with a responsibility or otherwise externally obligated must be empowered to carry out that obligation by those from whom the obligation arose.
- Self-appointed obligations do not imply that others must empower the self-appointed. Eg, a special interest group has no right to public funding. But a publically formed watchdog does have a right to public funding.

! Freedom vs Equality

- Freedom and equality are incompatible.
- The more free people are, the less equitable things are.
- The more equitable things are, the more restricted people are.
- Empowered, privileged groups are necessarily inequitable compared to the masses.

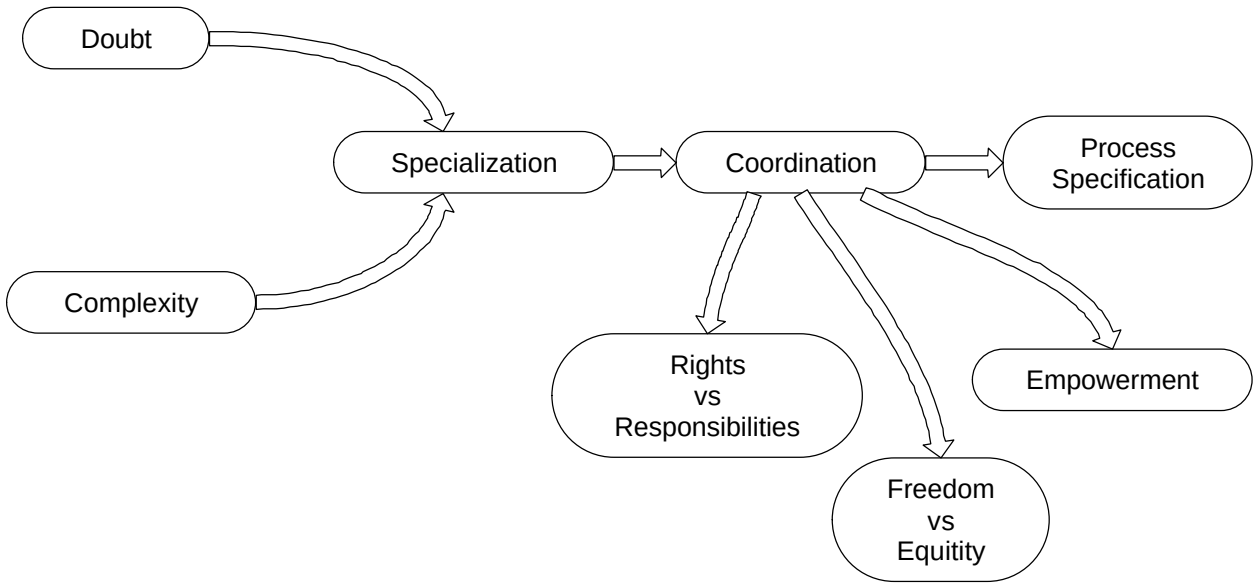

Figure 1 The “etymology” of Western reductionism ... Or how we have been hoisted by our own petard.

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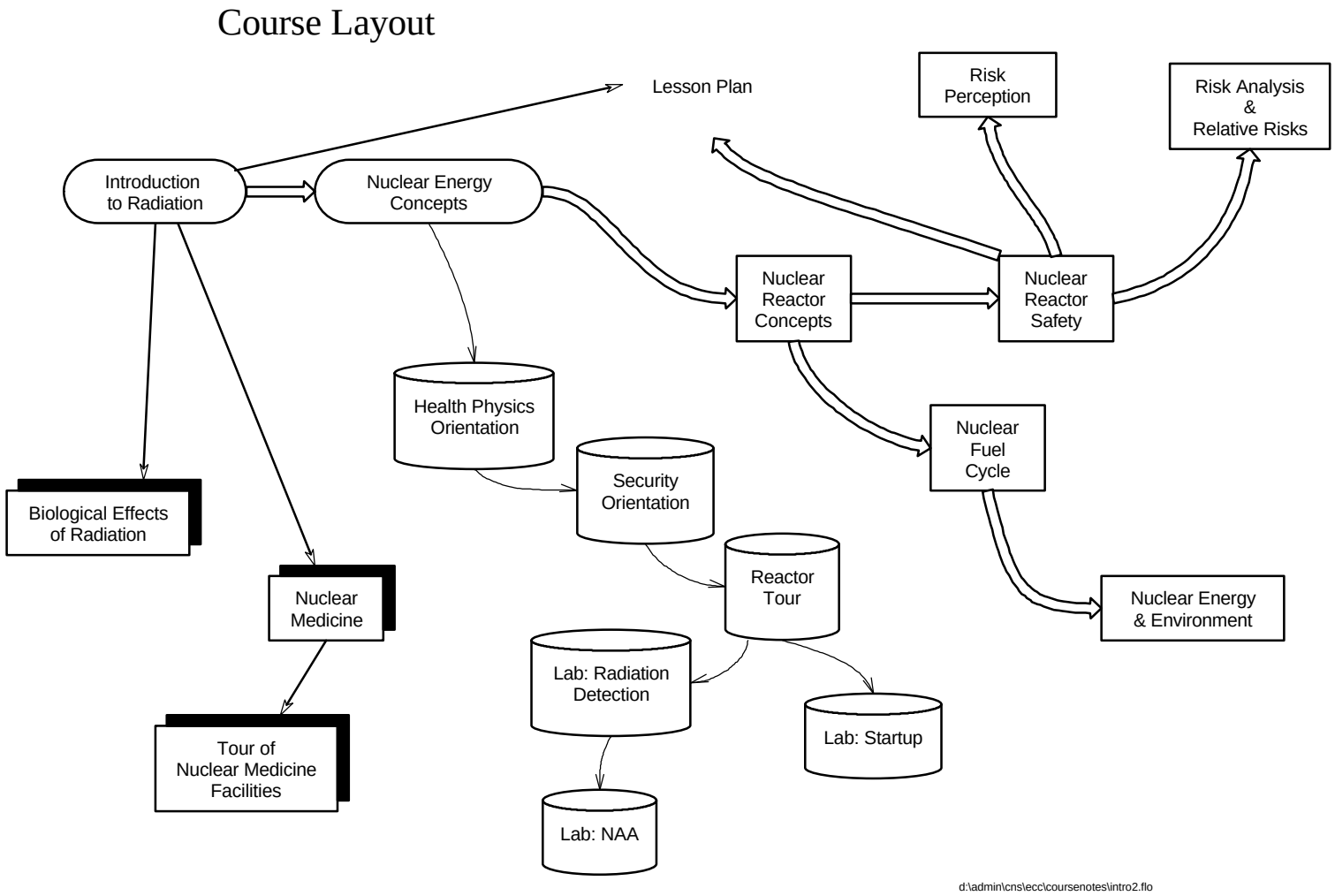

Figure 2 Course Layout