Tacit Knowledge Emergence

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This Plenary session is on ***Human Resources and Infrastructure—Meeting the Challenge***, which begs the question: What challenge? You need people? How many? For what? When? What level and type of training and education? Do you know the answers to these questions? Well, do you? If you don't know the answers to these questions, then who does? So tell me, what sort of Highly Qualified Personnel should universities and colleges provide? An answer of "Lots of all kinds of people now" is a useless answer. It is too imprecise.

I have been involved with the University Network of Excellence for Nuclear Engineering (UNENE) for the past 6 years and have been a professor in Nuclear Engineering for the past 25 years. I have asked these questions repeatedly and have not received answers that have any significant level of precision in them. So I am giving up asking. We are trying to develop models but it seems we cannot be predictive in anything other than the broadest terms.

So if we cannot be predictive, we will need to be adaptive. Just in time delivery and all that. We need agility.

Outline

- Tacit Knowledge Transfer Failures
- The Carpenter's Rule
- What is Mastery? Who Cares?
- Industrial Needs. Professional Development
- CANTEACH, UNENE and all that
- Stewardship
- Tacit Knowledge Emergence

So today I'll talk a bit

-About what hasn't worked

-About a notion called Mastery and why it is important

-About what systems we have in place to produce these agile minds.

But mostly, I want to talk about the agile minds themselves. We may not be able to talk about the house we need to build but we can talk about the carpenter and his tools who builds that house. We can talk about the notions of Mastery, of Tacit Knowledge, of Caring. We can talk about something called Emergence.

Definition

- Tacit Knowledge is “knowledge that we have without knowing we know it and that once we know we know it, it becomes harder to know how we know what we know”.
- “We know more than we can tell” – Polanyi. [Smith 2003]
- We learn by doing. Knowledge is not a thing; it is a process.

Tacit Knowledge Transfer Failures

- Review in Norway [Nilsen 2005] reveals:
  - Most efforts at Tacit Knowledge transfer failed.
  - Main conclusion: No consensus on how to do it, what the consequences [of the demographics] might be and what should be done about it.
  - Knowledge assets are not taken into account in financial book keeping *[hence not properly valued].*
- In this room, we are in danger of losing 400x20=8000 person-years of tacit knowledge unless 'shift happens'.

10 Case studies:

- Tokaimura/TEPCO (Japan)
- GRS (Germany)
- TVA (US)
- EPRI (US)
- NRC (US)
- IAEA
- BNFL (UK)
- EdF (France)
- Temelin (Czech Republic)
- Tractebel (Belgium)

Pop Quiz

- Think of the things that went very wrong in your organization in the past.
  - Isotope business, MAPLE, feeder thinning, Darlington fuel failures, Pt. Lepreau plywood dam, Bruce A drum humping, ….
  - Main cause?
    - Lack of explicit scientific and engineering knowledge? Lack of research?
    - Or improperly implemented knowledge?

List of possible ways knowledge can be implemented incorrectly:

-Not properly weighing the risk of pushing a design too far

-Not ensuring the organizational structure has appropriate access to knowledge

-Ie you knew the technical limitations but didn't factor it in properly

-False confidence

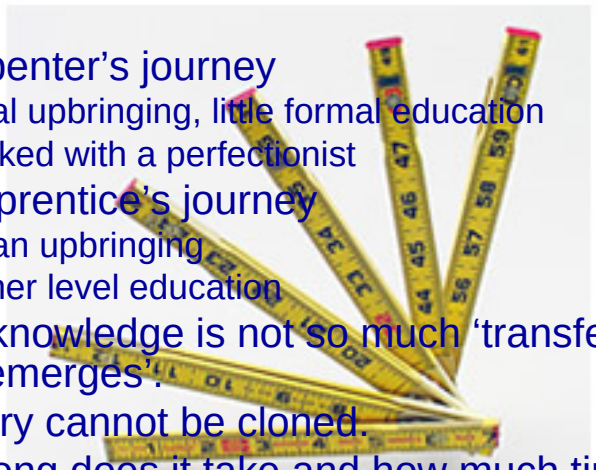
-In short – the experience factor

-It seems that the problem is not so much our limited knowledge as it is the failure to adopt a mindset that works with and within the limits of our knowledge.

What was learned in Norway?

- Knowledge is not really the asset, but the people owning the knowledge and able to exploit it are the asset.
- Knowledge is not only explicit, but also implicit and tacit, actually it could happen that the most valuable knowledge is tacit and so people started to suggest that an important part of knowledge could never be codified.
- Knowledge is extremely dynamic, technology often ended in creating repositories difficult to update.
- Instead of managing knowledge it is necessary to look at the knowledge process.

The Carpenter's Rule



- A carpenter's journey
  - Rural upbringing, little formal education
  - Worked with a perfectionist
- An apprentice's journey
  - Urban upbringing
  - Higher level education
- Tacit knowledge is not so much 'transferred' as it 'emerges'.
- Mastery cannot be cloned.
- How long does it take and how much time do we have?

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Let me tell you about one particular carpenter. He was born in 1922 and grew up in Ochre Pit Cove, a little fishing village on the east coast of Nfld. His father had to work on the mainland some of the time – usually Boston - to get some cash money. So, still a boy, he tended to the horse, the cow, got the wood in for the winter and so on. He stops his formal schooling at grade 8. Few in his era and location went farther. He helped his father make caskets. Ernest Perfect and Son, Casket Makers. His mother made the shrouds. Then, as a young man he had the good fortune to get hired on in the big city, St. John's, as a carpenter apprentice for the provincial government. His boss was a perfectionist and it was with him that he mastered his trade. Just like his carpenter's rule, his life unfolded. Structured but flexible. About 72 inches tall.

I happened to marry his daughter and I became a willing but not so able apprentice. My upbringing was totally different. Born and raised in the city and had lots of formal education. I tried my best but there was no way I could become Gordon Perfect, master carpenter. No way. I might clone his techniques perfectly, but I would not clone him. I never experienced a horse and cart in the deep woods snow and I never solved any of the related problems. So I could never solve carpentry problems like he did. But he never had advanced mathematics and he could not resolve the forces in a free body diagram. So I could do some things that he could not.

My point is that he did not transfer knowledge to me so much as he encouraged it to emerge in a way that made sense to me. That's what his teacher taught him and that is what he taught me. Tacit Knowledge Emerges. No wonder that past efforts on Tacit Knowledge Transfer in the nuclear industry has failed miserably.

So how long does it take to master a discipline?

Master your profession…

- How long does it take?
  - About 10 years.
- And how much time do we have?
  - The average experienced person in this room has about 10 years left.
  - They are not available to mentor.
- We have not articulated what we need to transfer, we don't know how to do it and we have little time anyway.
- That, I suppose is the challenge that this session is referring to.

So how long does it take to master a discipline?

Well, let's assume this carpenter's rule is a lifetime. 3 score and 12 years. Okay, we can expect to live longer than that but let's assume that most of us will want to slow down by age 72.

What's the average age in this audience? 48? Let's say that because the rule bends at 48.

By 66 the average person is retired.

So, we have this much of our life left, on average, to do something productive.

It takes 10 years to master a subject. I'd say we are at severe risk of irreparable loss of our tacit knowledge.

So where are we? We don't know what we specifically need in terms of HQP, we can't force a transfer of knowledge even if we knew what to transfer, and we have little time anyway. Nothing like a challenge to bring out the best.

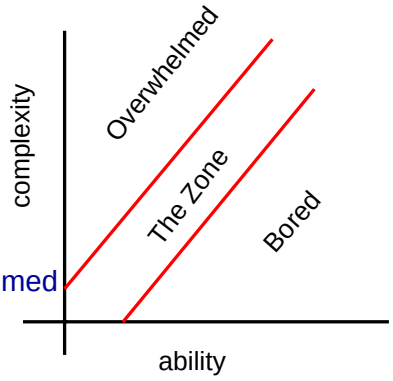
Our main tool is a sharp, agile and motivated mind. Let's look at that.

What is that Mastery mindset?

- It's that feeling and mindset when you are 'into' whatever you are doing and lose track of time.
  - You enjoy the process and it is more like play than work.
- People talk of being
  - in the groove
  - in the sweet spot
  - in the zone
  - in the flow
- The literature refers to this as 'Flow: the optimal experience'
- This is joy. It applies to human interaction as much as it does to work and play activities.

How to get the flow experience?

- Be in the now
  - Focus on the job at hand
    - Need to remove distractions
  - Proceed at the optimal pace
    - Too slow and you get bored
    - Too fast and you get overwhelmed
  - Strive for quality
    - Master the task at hand
- So this is what you do: proceed with a sense of quality. Care.
- More than anything else, it is a state of mind.



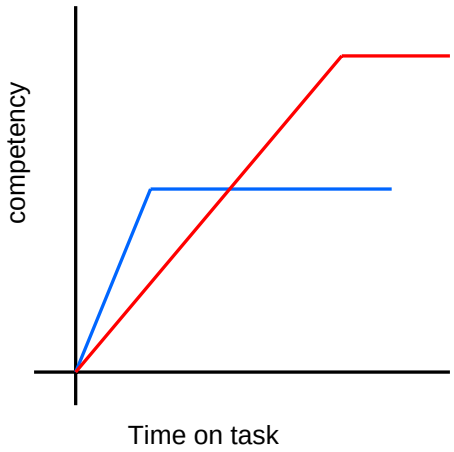
Can get large effects for small changes in mindset.

It is a question of encouraging the emergence of the desired patterns of behaviour.

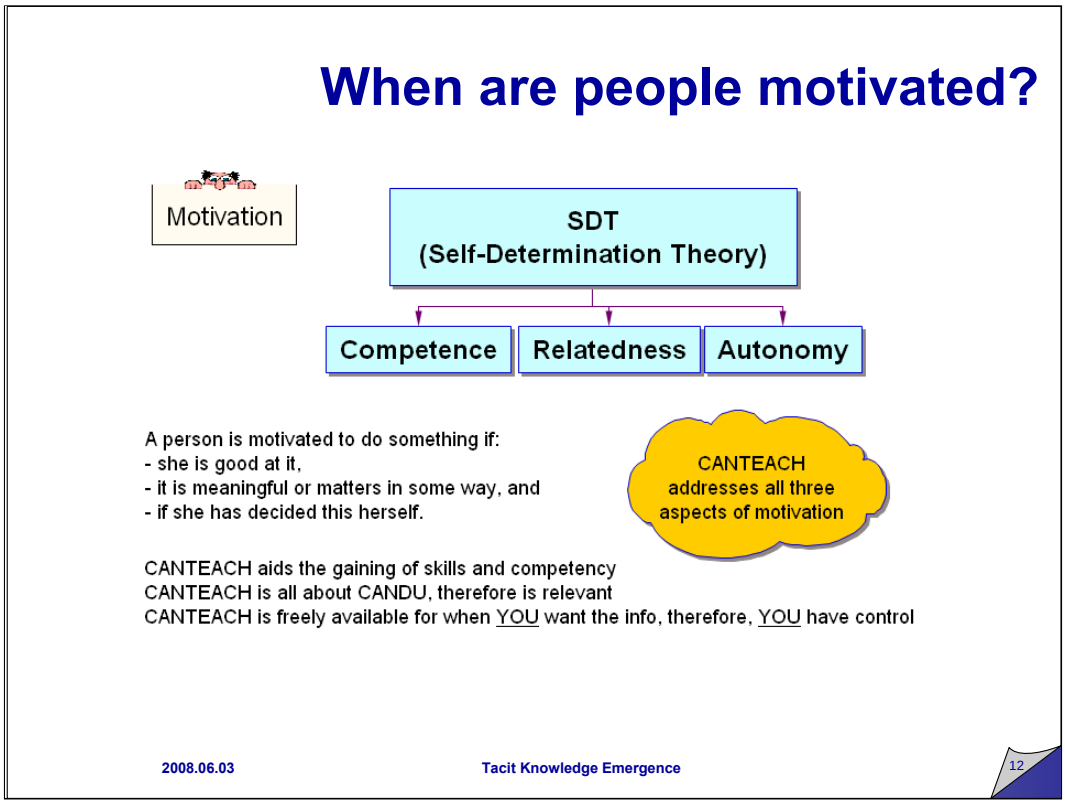
It doesn't cost you anything!!

The tortoise and the hare

- Some people learn slower than others.
- Some people have lower ultimate capability than others.
- But a slower person can have higher ultimate capability.
- Often, a person is slower because he or she is thinking more deeply. It takes time to integrate new ideas into what you already know and believe.
- So don't be swayed off your path by the apparent speed of others.



I drew it as linear monotonic functions. It is not. It is highly non-linear and situational dependent, which further obscures true measures of the person.



Competence is related to being in the zone.

Thus schools don't measure / filter in ways that relate to a working environment.

How this relates to the workplace

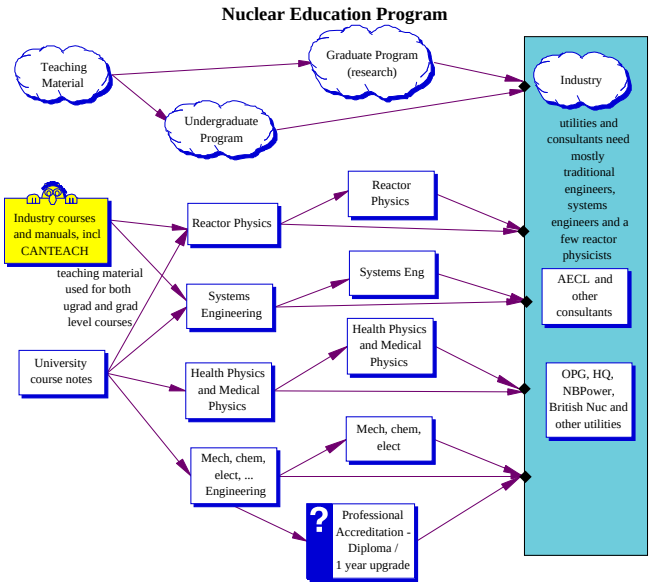
- At work, you have goals and objectives to achieve.
- In 'goal mode' you work toward a future goal.
  - Enjoyment comes for that brief period after attaining the goal and before you realize that the next goal awaits.
  - That is a depressing and draining way to live.
- The irony is that mastery mode gives better results in the long term.
  - Mastery is empowering and energizing.
  - There is nothing to stop you from working toward goals while mastering the techniques and carrying out the tasks needed.
- Important side effects:
  - This is contagious – others will sense it and value it.
  - Remember, your company is seeking quality work and will reward quality.

The single biggest reason why people choose an employer is personal growth opportunity.

It is also the single biggest reason why they stay – and leave.

This makes the notion of Mastery very important to the workplace.

What's the education situation?



What's the problem?

- Professionals come from the universities
  - Inadequate preparation for industry
  - Research emphasis over development and teaching
  - Lack of systems approach
  - Self-reinforcing myopia
  - No upgrade path for C students
  - Grades not a good measure of the person
  - System shuts out and destroys people
- University is not going to change its mandate or structure for industry
  - It is answerable to the public, not to industry

Where is industry in all this?

- Industry is faced with a huge hiring and expertise gap problem
  - They can ill afford the training cost
  - Industry time horizon is too short
  - Industry cannot give accredited courses
  - Big mismatch between what industry needs and what universities supply

What do we need?

- We are not going to change industry or the university mandates
- Therefore, need
  - Access to information
  - Professional development upgrade path
  - Access to mentors and apprenticeship
  - Better measures of the person
  - Remedial programs
  - Bridging programs
- And it all needs to be (and can be) done with a Mastery mindset.

How to finance?

-Need a learning grant system that operates like the current research grant system

-Industrial funds can thus be leveraged.

But remember – the mindset change is free.

Opening Supply Pathways

- PEO
  - Nuclear Engineering Syllabus prepared and accepted May 22, 2008
- Degree standardization globally
  - WNU Academic Council (UNENE is a member)
- International networking
  - WNU Summer Institute
- National networking
  - Get involved with the CNS
- What else can we do?
  - Let's look at some of the things already underway.

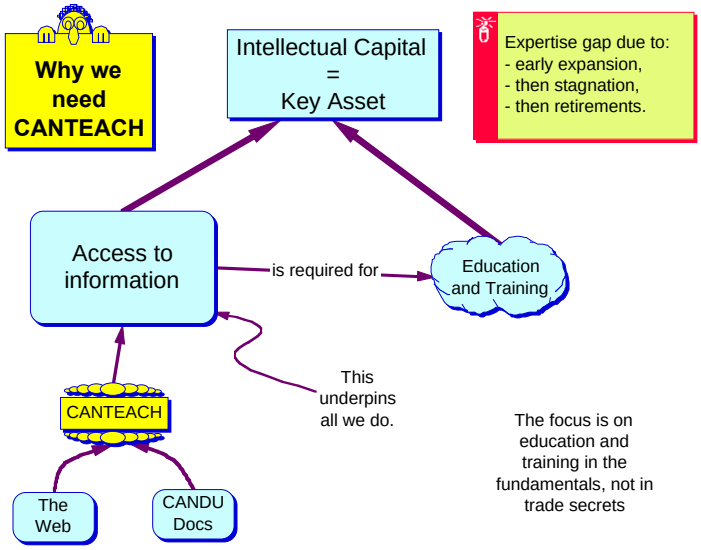
Canadian Initiatives

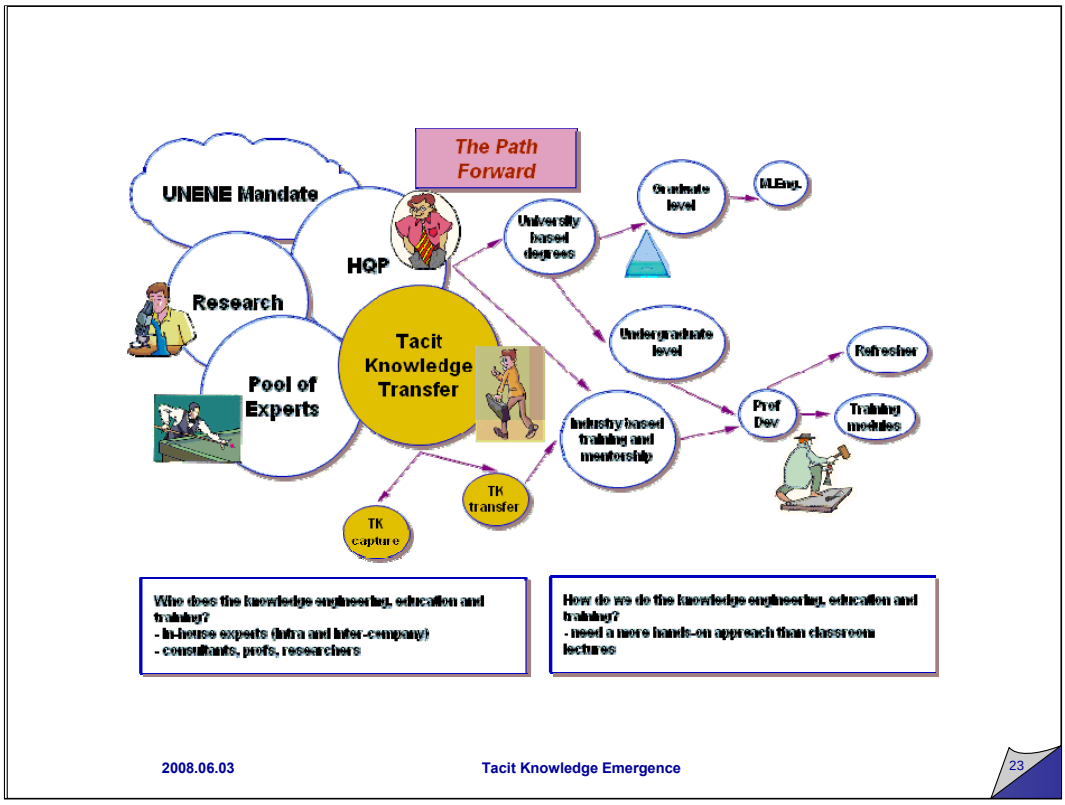
- In Canada, we have these uncoordinated nuclear elements:
  - CANTEACH – an open CANDU document repository (2001)
  - UNENE – a nuclear centre of excellence (2002)
  - NUCENG – an university based portal and repository (1998)
  - CNS – a society of nuclear individuals (conferences, bulletin, …) (1979)
  - COG – an industrial consortium of operators and designers (1984). Sponsors CANTEACH and member of UNENE
  - OCI - provides a forum for exchange of information related to technical and quality issues with particular regard to the potential impact of such issues on the supply base for its members' products and services.
  - Nuclear Canada portal – a wiki based portal to the Canadian Nuclear Enterprise.

Existing Networks

- UNENE – University Network of Excellence in Nuclear Engineering, Canada (2002)
- WNU - World Nuclear University (2003)
- ENEN - European Nuclear Education Network (2003)
- ANENT - Asian Network for Education in Nuclear Technology (2004)
- NTEC - Nuclear Technology Education Consortium (UK) (2005)
- RANSE - Russian Association of Nuclear Science and Education (2005)

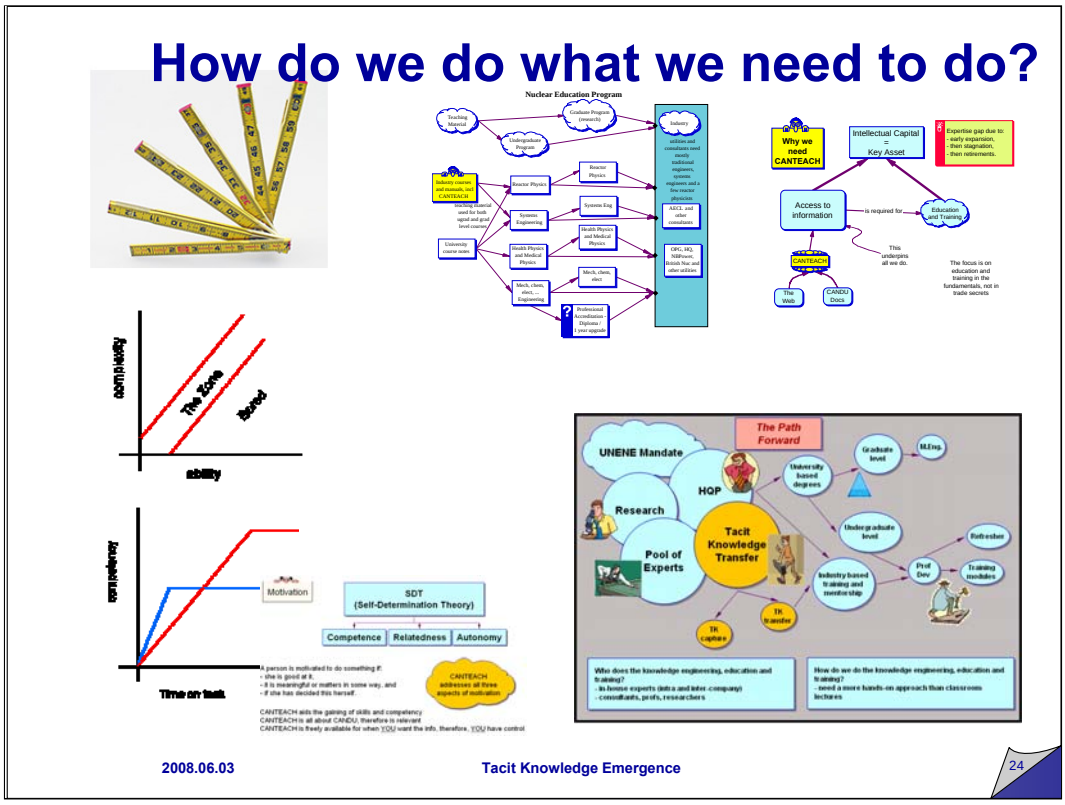
CANTEACH Justification





Involve the experienced people in the process of tacit knowledge transfer via emergence.

Use any and all opportunities



-Tacit knowledge hard to transfer

-Tacit knowledge emerges from a sense of Mastery.

-Proceed with a sense of quality

-Different people learn at different rates and to a different degree

-People are motivated to do things they value, are competent in and that they choose to do.

-Mandates of universities and industry are different. Need to address professional development

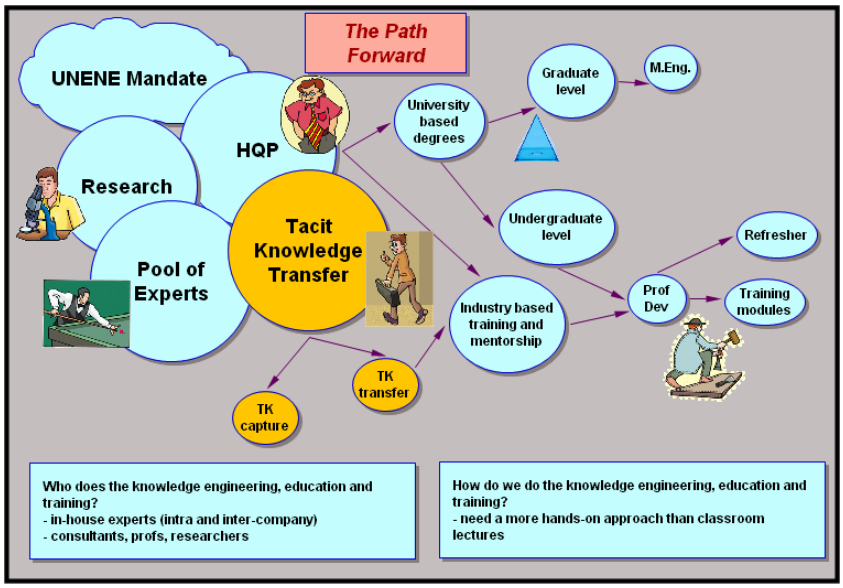
-Activities like CANTEACH and UNENE are part of the mix, as are COG, OCI, CNS, CNA, etc.

-These are all elements in making tacit knowledge emerge.

-But it all hinges on the Mastery mindset.

Some questions for you

- Who are the stewards of the discipline?
- What are we as individuals trying to do?
  - Be the best artists?
  - Or are we trying to further the art?
- What mindset will enable Tacit Knowledge to emerge?
  - I think it is the Mastery mindset.
  - Proceed with a sense of quality.


The Path Forward
UNENE Mandate
HQP
Research
Pool of Experts
Tacit Knowledge Transfer
University based degrees
Graduate level
M.Eng.
Undergraduate level
Refresher
Prof Dev
Training modules
Industry based training and mentorship
TK transfer
TK capture
Who does the knowledge engineering, education and training?
- in-house experts (intra and inter-company)
- consultants, profs, researchers
How do we do the knowledge engineering, education and training?
- need a more hands-on approach than classroom lectures

Questions?

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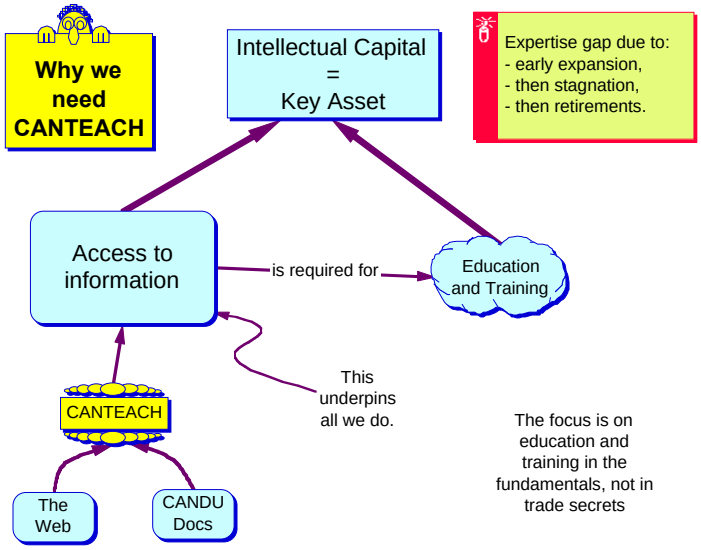
Further reading…

- Smith, M. K. (2003) 'Michael Polanyi and tacit knowledge', *the encyclopedia of informal education*, www.infed.org/thinkers/polanyi.htm.
- "Knowledge Management in Nordic NPPs: Summary report of the findings from the workshop", by Svein Nilsen, Institute for Energy Technology, Halden, Norway, Nordic nuclear safety research, NKS-102, ISBN 87-7893-161-4, April 2005. http://www.nks.org/nordisk/R-delen/resultater.htm
- "Flow: The Psychology of Optimal Experience" by Mihaly Csikszentmihalyi found at http://www.siliconyogi.com/andreas/it_professional/sol/complexsystems/FlowThePsychologyofOptimalExperience.html
- "Mastery: the Keys to Success and Long-term Fulfillment" by George Leonard found at http://www.vnoel.com/content/view/137/54/

CANTEACH Target Audience

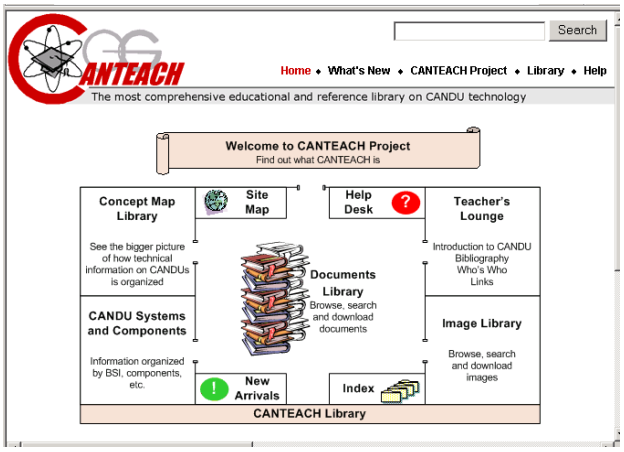
- **Mission** To preserve technical knowledge of CANDU nuclear-electric generating system for use by present and future members of the CANDU community.
- **Mission** To train Highly Qualified Personnel.
- Thus target audience is primarily at the level of the working professional.
  - ***NOTE:*** ***<u>This target, as it turns out, leads to the identification of a serious problem that needs to be addressed.</u>***
- Aimed at capturing Know-how and Know-why.

CANTEACH Justification



CANTEACH Web Site Tour

http://canteach.candu.org



The site contents and this talk fit onto one CD -- about 600 MB

UNENE

University Network of Excellence in Nuclear Engineering

- CANTEACH is about info. Low budget ($100k/yr)
- UNENE is about delivery ($3M/yr).
- UNENE generates Highly Qualified Personnel.
- Hope to make CANTEACH the repository for UNENE.

- CANTEACH is about info. UNENE is about delivery. They are complementary.

- UNENE viewed as a product yields research reports and course calendars. UNENE viewed as a process yields HQP (highly qualified personnel).

- trying to promote the vision of CANTEACH as the repository for course and other info that is generated by UNENE.

What is UNENE?

- UNENE = University Network of Excellence in Nuclear Engineering
- UNENE is an industry driven alliance of prominent Canadian universities and nuclear industry

UNENE has three distinct objectives:

- Enhance the supply of highly qualified graduates in nuclear engineering and technology.
- Reinvigorate university-based research and development in nuclear engineering and technology focusing primarily on mid to longer term research.
- Create a group of respected, university-based, nuclear experts for public and industry consultation.

Current Industry Membership

- Ontario Power Generation (OPG)
- Bruce Power (BP)
- Atomic Energy of Canada Limited (AECL)
- CANDU Owners Group (COG)
- Canadian Nuclear Safety Commission (CNSC)
- Nuclear Safety Solutions (NSS)

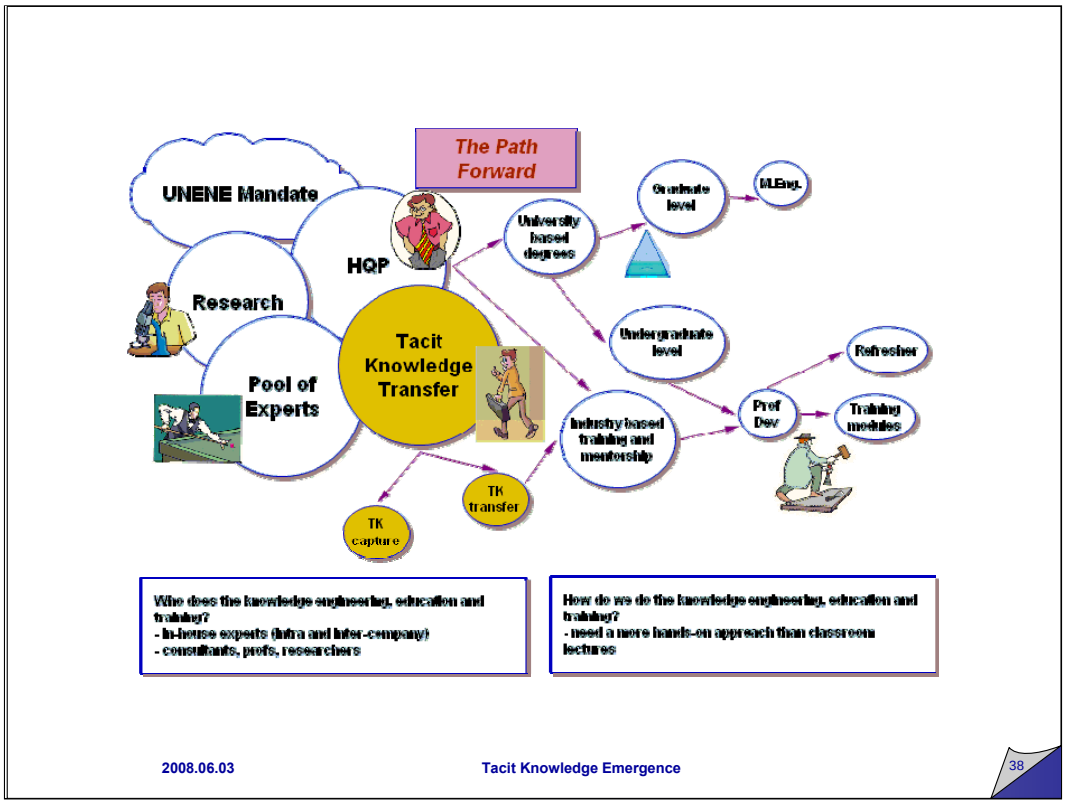
University Members

- McMaster University
- Queen's University
- University of Toronto
- University of Waterloo
- University of Western Ontario
- University of Ontario Institute of Technology
- Ecole Polytechnique
- University of New Brunswick
- Royal Military College
- University of Guelph

First Phase Funding

- Cash Funding (first phase)
  - Industry: $ 7.8 M
  - Universities: $ 0.81 M
  - NSERC: $ 7.12 M (estimated)
  - *(Not including other nuclear research chairs and programs)*
- Other In-kind Support:
  - Industry and Universities: $4.97M

Total impact ≥$20.7M



Involve the experienced people in the process of tacit knowledge transfer

UNENE Web Site Tour

http://www.unene.ca

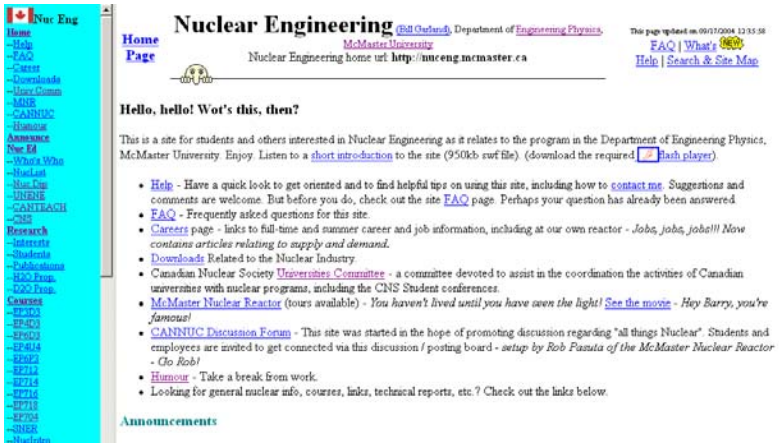
NucEng

Nuclear Engineering at McMaster University+

- CANTEACH is about info.
- UNENE is about delivery.
- NucEng is about students.
  - Courses
  - Who's Who
  - Careers
  - Links
  - Forums and List servers

NucEng Web Site Tour

http://www.nuceng.ca

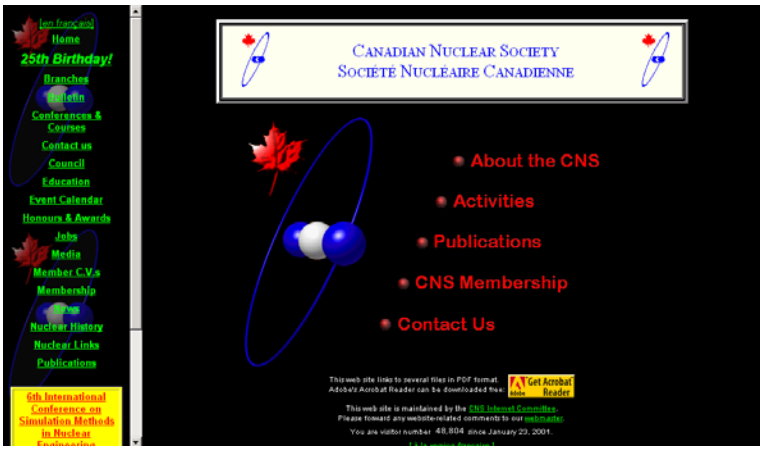


CNS
Canadian Nuclear Society

- CANTEACH is about info.
- UNENE is about delivery.
- NucEng is about students.
- CNS is about professionals as individuals.
  - Seminar type courses
  - Conferences
  - Fellowship and contacts
  - Forums and List servers

CNS Web Site Tour

http://www.cns-snc.ca



COG

CANDU Owners Group

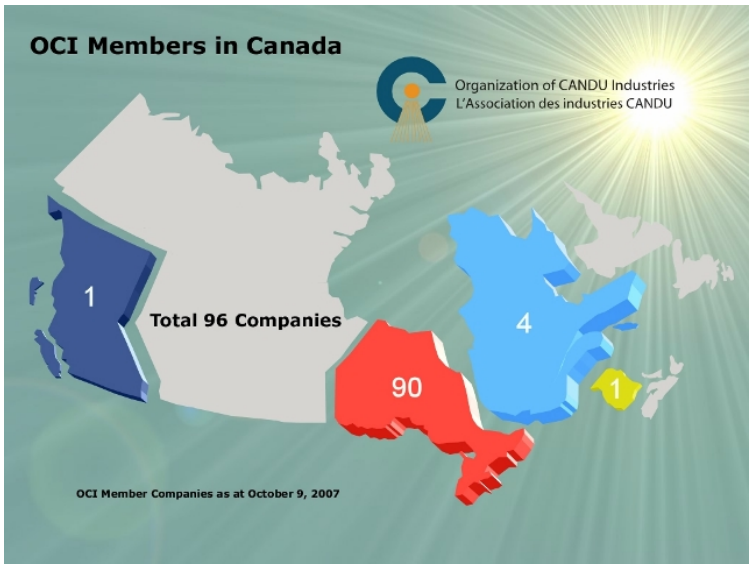
- CANTEACH is about info.
- UNENE is about delivery.
- NucEng is about students.
- CNS is about professionals as individuals.
- COG is about industrial partnerships in R&D
  - Shared R&D cost
  - Shared R&D facilities
  - Creation of and access to closed information databases

COG Web Site Tour

www.candu.org

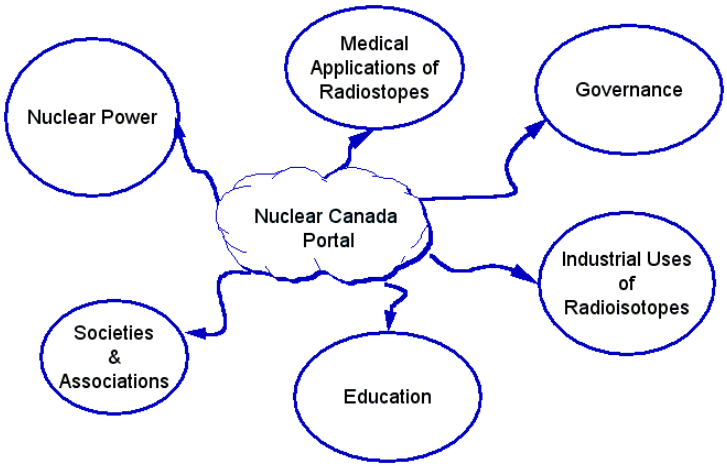
OCI – Organization of CANDU Industries

http://www.oci-aic.org/



Nuclear Canada Portal

www.nuclearcanada.ca



Where does the portal fit in?

- The portal needs to provide access to information on
  - Documentation (technical and otherwise)
    - Education and training based
  - Education and training programs
    - Emphasis on professional development
  - Information on education and training opportunities such as
    - Scholarships
    - Reciprocal agreements and exchanges
    - Etc.
  - Promotion of International accreditation
    - Provide information on what we should measure, etc.
  - Web enabled learning