Forum on Science, Mathematics, Technology, Teaching and Learning

Manitoba Education Research Network (MERN)

Centre for Research in Youth, Science, Teaching and Learning (CRYSTAL)

Imperial Oil Academy for the Learning of Mathematics, Science and Technology (IOA)

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EST. 1877

UNIVERSITY OF MANITOBA

the NATURAL STEP

MB Conservation

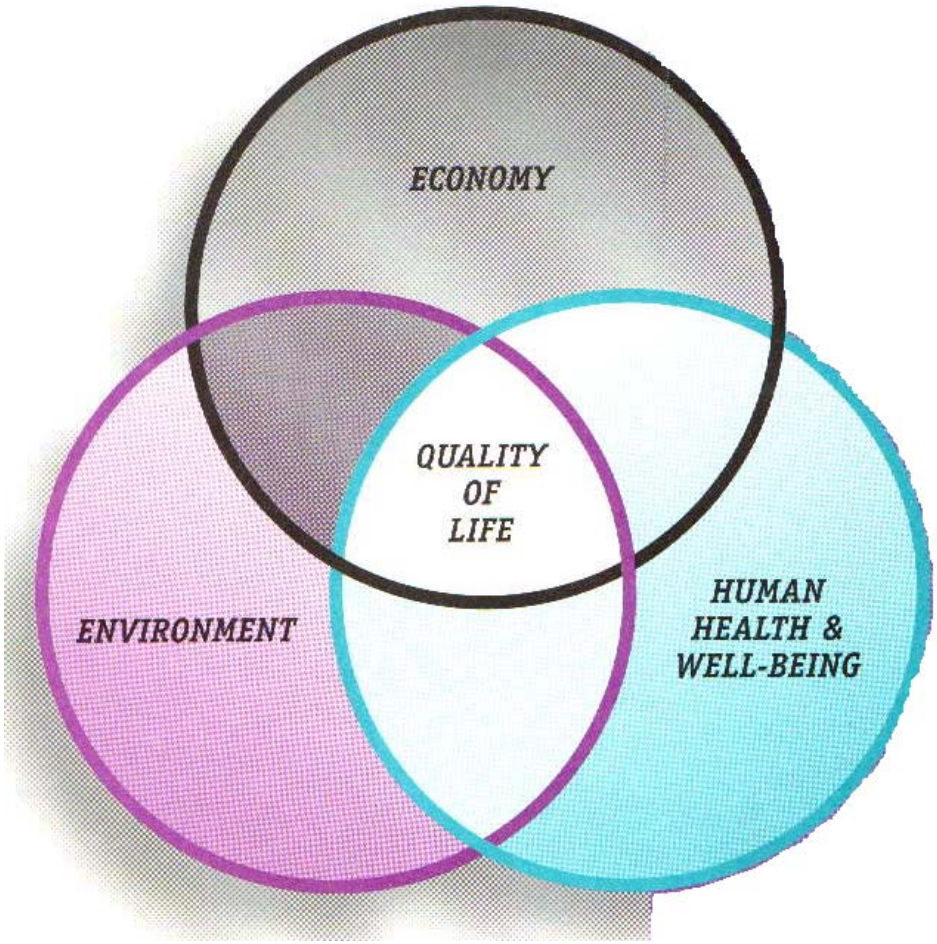
NSERC CRYSTAL

CRSNG CREAS

Science and Sustainability: Reliable Friends?

Within the "...dichotomy created by the holistic nature of the problem of sustainability and the structural arrangements of subject divisions within secondary schools" (Cross, 1998, p.51), the use of sustainability contexts to teach science content continues to be awkward

Experiences in Manitoba



Grade 11

Current Topics

*context-oriented

Chemistry

*content-oriented

Science – reliable friend

"Western science has been phenomenally successful in its goal of unlocking nature's secrets…The diversity of aspects of the natural world that fall under the spell of numbers and mathematics is astonishing, ranging from light and magnetism and chemical reactions to the laws of biological inheritance"

(Goodwin, 2000, ¶30).

Science: an “unreliable friend” to environmentalism

Pepper (1996)

- Anti-science sentiment (commercialized, politicized, arrogant, reductionist)
- Ambivalence (sci/tech)
- Confusion/green fatigue

- Green Consumerism
- Lite Green to Bright Green
- Privatization of responsibility for sustainability
- Individualism
- Capitalism

American Association for the Advancement of Science

"Science, energetically pursued, can provide humanity with the knowledge of the biophysical environment and of social behavior needed to develop effective solutions to its global and local problems; without that knowledge, progress toward a safe world will be unnecessarily handicapped…"

(Rutherford & Algren, 1990).

UNDESD

- United Nations Decade of Education for Sustainable Development (UNDESD) 2005 - 2014
- primary goal "…encourages Governments to consider the inclusion … of measures to implement the Decade in their respective education systems and strategies and, where appropriate, national development plans…" (UNESCO, 2005)
- implications for Manitoba science education and all areas of curriculum

“Report on Evolution of Student Interest in Science and Technology Studies”

- Over the past 15 years, most OECD economies have experienced an absolute increase in the number of students in science and technology (S & T) though the proportion of S & T students has steadily decreased during the same period (Rutherford & Algren, 1990)

- “…very often attributed to the uninteresting and difficult content of science courses…” (OECD, 2005)

Reductionist Thinking → Systems Thinking

1) we see what we see
2) the whole is more than merely the sum of its parts
3) limits to prediction (70s)
4) complexity theory (80s, 90s)

Goodwin's 4 awakenings

1) We see what we see

“There is no absolute frame of reference, no preferred perspective that gives one observer authority over another in observing natural processes. Each observer is free to choose whatever frame of reference is most convenient and elegant for describing whatever is being observed, and consistency with other observers' chosen reference frames depends upon relations defined by a mathematical transformation” (Goodwin, 2003).

2) The Whole > Sum of its Parts

One is unable to predict the coherent behaviour of the entire system despite being able to understand the behaviour of all the elements in isolation and having a perfectly clear understanding of their individual rules of interaction (Goodwin, 2003).

3) Deterministic Chaos

"the laws governing the motion of the planets and the dynamics of the weather include the possibility of what is called deterministic chaos, which means that their behaviour cannot be predicted accurately beyond a limited period of time" (Goodwin, 2003)

- due to "**sensitivity to initial conditions**"
- Henri Poincaré, Edward Lorenz

4) Complexity theory

“flocks of birds, social insects such as ants and termites, evolving ecosystems, and the dynamic patterns described in Lovelock's Gaia hypothesis, reveal that the Earth is like a living organism; the patterns are often unexpected but can be understood after one sees their behaviour. However, the slightest change in the properties of the components or their rules of interaction can produce quite unpredicted behaviour. These unexpected phenomena are known as **emergent properties** of complex systems. They give us insights into the natural creativity of the world, and urge caution in how we interact with it”

(Goodwin, 2003)

Reductionist Thinking	Systems Thinking
From parts	**to the whole**
From objects	**to relationships between objects**
From objective knowledge	**to contextual knowledge**
From structure	**to process**
From contents	**to patterns**

No Longer Adequate

"The traditional **reductionist methods** of the physical sciences and engineering **are no longer adequate** …Today's problems are **complex** and **nonlinear**, they involve phenomena on **multiple length and time scales**, and their analysis can extend well beyond the realm of textbook mathematics. Industry requires access to qualified mathematical scientists… who have been trained to capture the essence of an industrial problem in mathematical terms, who can apply methods of contemporary mathematics, and who are familiar with the latest advances in scientific computing and numerical algorithms. Only such people can produce the transformative new ideas that drive future innovations" (OECD, 2008, p.6).

Results

- **Motivation/Engagement**
  - **consumer to producer**
  - **student “choice” of product/ organization**
  - **context extended into other courses (organically)**
  - **diverse projects rather than homogeneous**
- **Opportunities for participation**
- **Long-term “cumulative effect” for behavior change -thematic approach**

Lack of Curricular “Time” to Develop Sustainability Context

Chemistry

- content then context squeezed in (application)
- reduction of content to provide curricular “space” for context

Capacity of students to think in systems

- Liquid Crystal Display (LCD) television
- “chemistry” what it was made of → how it created a picture→ original summary of the polarization of light → “physics”

*unaware of the artificial boundaries imposed by decontextualized content

Further Integration of Sustainability - Chemistry

- 2008-2009 school year: *"…start at the beginning of the year and do a little bit each week, covering more…lessons"*
- "*Was the project educational and worth while? Yup. Would it be better a second time? Yes for sure, I have lots of things I would like to improve on. Thanks so much for opening my eyes ...I was really looking for something interesting to add to the organic chem. unit and this was it!!!"*

Culture of “Distaste” for Content

Current Topics

- Science content: “…sometimes I have to blend it sometimes camouflage it and sometimes I can simply teach it...”
- a great deal of the students taking the course are taking it because they do not want to take organized science courses
- Impact when human systems involved

Further Integration of Sustainability- Current Topics

"Where I want to take it now is I have been visiting various local businesses that are striving toward sustainability and I have talked to the media people at the school to set up a time in which to create video-taped interviews of these small-business owners"

- videos integrated as a resource into 2008-2009 implementation of the learning resource (grade 11 Current Topics course and grade 12 Interdisciplinary Topics)

According to students…

- Physical actions, completed individually, are the most effective strategy
- Persuasive and civic action seen as “annoying”, “complaining”
- Science was seen as an effective start to inciting action but was critiqued for being “all talk no action”
- Suggestions to improve the effectiveness of science-based educational actions related to making science findings more accessible to students

  *more readable

  *more readily available in formats such as popular magazines and media

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