An Integrated Approach to General Education in the Sciences

The Lipscomb University Initiative

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Background

- Science Education in the US
  - A Nation at Risk—1983—the system of science education is not producing enough science and engineers
  - In 1996 the National Research Council of the National Academy of Sciences recognized problems with science literacy in the U. S. and recommended introducing integrated science courses for non-science majors
  - A Gathering Storm—2006—not much has been done to rectify the situation
- General Education at LU
  - Current gen ed program adopted in 1975
  - Little change since then
  - Universal requirements for BA/BS degrees include six science hours (2 courses)
    - 1 lab required
    - 3 required biology hours,
    - 3 hours of either chemistry, physics or astronomy
- General Education Renewal
  - In 2006, the Provost commissioned a subcommittee of the General Education Council to investigate reform of the general education curriculum
  - While the General Education Renewal effort is still in progress, there is significant interest in a one-year integrated science sequence that would cover the gen ed science curriculum
- Integrated Science: Experience at Other Institutions
  - The idea of integrated science was previously explored at LU in 2000 by Jim Arnett. He surveyed the issues and experiences at three other undergraduate institutions (Mercer, George Mason and Pepperdine) with IS courses.
  - Major issues identified in that study
    - Process (development of scientific thinking) vs. content (development of scientific knowledge) – Which is more important?
    - With respect to science necessity of, a list of minima for the educated non-scientist
    - Science as discovery – a case-study approach helped students engage in active learning
    - Administrative and budgetary – how are staffing and load computed? How are departmental contributions recognized? Are adequate resources available for faculty development and curricular revision?
    - Cost of investment – this approach is likely to take more investment of time and resources by faculty and administration when compared to the historical approach. There are also political and/or cultural issues in the development phases.
    - Perception of lack of academic rigor
    - Significant institutional benefit could result even if a pilot program was unsuccessful
- Some IS Courses Currently in Place
  - Life Science 1a—biology and chemistry introductory science—topically presented using HIV and cancer—Harvard University
  - Frontiers of Science—topically presenting using astronomy, climate change, biodiversity, neuroscience, nanoscience and biophysics—Columbia University
  - An Integrated, Quantitative Introduction to the Natural Sciences—introduction to physics and chemistry drawing on examples from biology, i.e. genetics, how did the zebra get its stripes, etc.—Princeton University
  - Great Ideas in Science—provide framework to deal with scientific problems in public debate including electricity illustrated through a nerve cell, electromagnetic radiation illustrated through the human eye and its evolution of life on Earth
- Current texts based on IS
  - *Integrated Science* by B. Tillery, E. Enger, and F. Ross, 2008, 3rd edition, McGraw Hill—1st edition in 2001—topical organization including motion, electricity, nature of living things, human biology (sex and nutrition).
  - *Conceptual Integrated Science* by Hewitt, Lyons, Suchocki, Yeh, 2007, Addison Wesley—subject organization including physics, chemistry, biology, astronomy and earth science
  - The Sciences: An Integrated Approach by R. Hazen, J. Trefil; 5th edition, Wiley; organization by science topics including energy, the stars, strategies of life, molecules of life

Our Approach

- Transdisciplinary
  - "Complex, active learning based on significant issues, tasks, questions or problems, each delivering a range of learning outcomes deriving from several key learning areas; ideas that draw on knowledge and methodologies from several disciplines."

    [http://ltag.education.tas.gov.au/glossary.htm]
  - Case studies chosen to engage learners in broad civic issues that involve at least two combinations of the natural sciences (biology, chemistry and physics)
- Integrated
  - Students encouraged to pursue questions requiring synthesis of fundamental knowledge in each natural science
  - Earth science, astronomy, environmental science, nutrition and other sciences incorporated where appropriate to a case study
- Format
  - Case Studies
    - Problem scenarios lead students to awareness of need for basic scientific understandings of underlying fundamental principles
    - Where appropriate, provide samples, guest speakers, or other real-life connections to case study for hands-on investigation
  - Research-Based
    - Information Processing Theory of Learning
    - Constructivism
    - Classroom applications of brain research
      - Absence of threat
      - Meaningful content
      - Adequate time
      - Choices
      - Enriched environments
      - Immediate feedback
      - Mastery
      - Collaboration
      - Mnemonics
      - Rehearsal strategies
  - Lecture/Discussion/Recitation
    - 2 hours per week
    - Team-taught
    - Professors from each discipline represented in present case study on hand to…
      - Provide brief lecture on basic principles
      - Encourage pursuit of basic concepts to address case issues
      - Facilitate small group discussions
  - Laboratory
    - 1 credit hour/3 weekly contact hours
    - Labs address case study problem scenarios
    - Open-ended
  - Writing/Journaling and Presentation
    - Writing-to-Learn Strategies
      - Response journals
      - Double-entry journals
      - Express writing
      - Exit slips
      - Analogies
      - Retell
  - Learning Communities
  - Reciprocal Teaching
  - Field Trips
- Assessment Intensive
  - Assessment of peers given substantial weight in grade determination
  - Assessment of faculty includes performance analysis
  - Feedback provided to students early and often
  - Diagnostic, formative, summative, authentic, reflective, peer-assisted

Sample Case Study Scenario – Harpeth River Fish Kill

- Scenario

Issue:

A lead smelter (a smelter is a large furnace that produces lead products) operated in on the banks of the Harpeth River from the 1960's until the 1990's. The smelter took in used automotive lead-acid batteries, wrecked the batteries, and recovered the lead. During the '60's and '70's, the plastic chips from the battery casings were considered clean and were provided to members of the community to use as clean backfill for septic tanks, driveways, gardens, etc. Later these battery chips were found to be lead contaminated. Battery chips that could not be given away were placed in a landfill on the smelter property, adjacent to the Harpeth River. Over time the Harpeth River moved and eroded away the sides of the landfill. The contents of the landfill began to enter the Harpeth and battery chips have been found in the river up to a mile downstream of the smelter. The river flows through a major populated area, the city of Franklin, Tennessee, just a few miles downstream of College Grove.

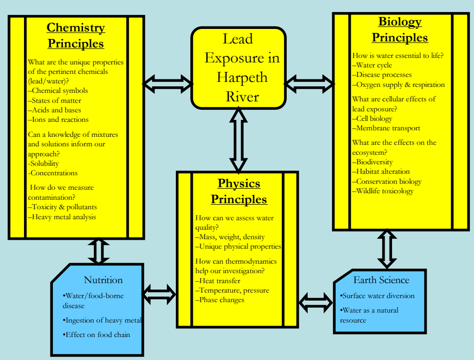
The lead smelter ceased operations in 2000. About this time, the EPA undertook emergency removal actions in the College Grove and Franklin communities and mandated clean-up of the Harpeth River.

- Scenario Presented
- Instructor-Led Brainstorming Session to Determine Relevant Questions
- Inquiry-based Instruction on Basic Concepts
  - Biology, Chemistry, and Physics basic concepts relevant to discussion
  - Earth science, environmental science, nutrition
  - Emphasis on potential relevance of concepts not apparently related
  - Emphasis on questions informed by multiple disciplines

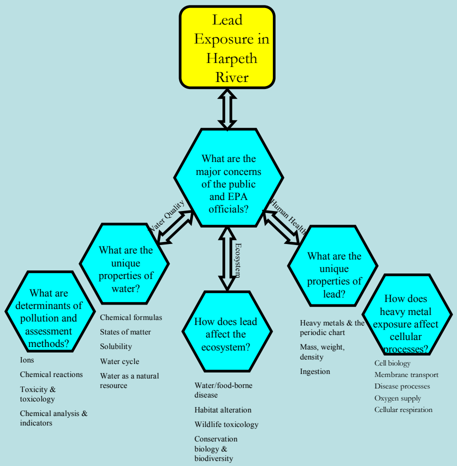
- Preliminary Investigation
  - Students form small groups and/or teams to gather pertinent historical and background data
  - Formulate hypotheses to address relevant questions
  - Action plan for investigation developed

- Laboratory and/or Field Exercises
  - Perform experiments to test specific hypotheses
  - Analyze data and report to small groups or teams
  - Review findings
- Assessment
  - Have students learned fundamental concepts while addressing pertinent civic issues?
  - Were case studies appropriate and sufficient for motivating important questions?

Disciplinary Organization



Investigatory Organization



Preliminary Results

- Student Satisfaction
  - Students more engaged with focus on experiential learning
  - Civic component appreciated
  - Hands-on learning and teacher engagement valued
- Learning Outcomes
  - Grades comparable to traditional courses
  - Other, more appropriate assessments incomplete
  - Pre- and post-tests will be administered to these students and to traditional students to allow comparison
- Faculty & Administration
  - Both teachers on team receive full load credit
  - Challenges with faculty load assignments in departments
  - Changes well received by general education program

Sample presentation from a student team investigating the use of corn for food or fuel.

(L) Concepts of energy conservation are investigated as the student teams design and construct devices that shoot Diet Coke into the air using Mentos candy. We also use these occasions to discuss the science behind the reaction. (R) We learn about centripetal force using pizza dough.

Challenges and Opportunities

- Current gen ed system
- Misconceptions
  - Students: Less work required
  - Faculty: Lack of academic rigor
  - Administration: Poor use of resources
- Cross-college Connections

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