Cross-Disciplinary Molecular Science Education in Introductory Science Courses: An NSDL MatDL Collection

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Outline

- Digital libraries as cognitive tools
- Digital libraries as component repositories
- Digital libraries as knowledge networks

NSDL Materials Digital Library Pathway

- NSF MS Initiatives (NIRTs, MRSECs, IMIs)
  - Soft Matter Wiki
- Teaching Resource Development
  - MS Teaching Archive
- Stewardship
  - MatDL Repository
- Code Development
  - Matforge
  - NIST FiPy
  - CMU
  - DOE CMSN
- Virtual Labs
  - Intro to Solid State Chem
  - Intro to Bio Physics
  - Modern Chemistry

http://matdl.org/matdlwiki
http://matdl.org/virtuallabs
http://matdl.org/teaching.matdl.org
http://matdl.org/matdl.org
http://matdlforgo.org
Multidisciplinary, multi-institutional team
- MIT – Materials Science & Engineering
  - Fall’ 07 Introduction to Solid State Chemistry, 3.091
  - Don Sadoway, W. Craig Carter, Colin Ashe

- CMU – ChemCollective & NSF Center on Science of Learning
  - Spr’ 08 Modern Chemistry
  - David Yaron, Jodi Davenport, Michael Karabinos, Gaea Leinhardt

- KSU – BioPhysics & MatDL
  - Fall’07 Introduction to BioPhysics
  - Laura Bartolo, John Portman, Cathy Lowe
Digital libraries as cognitive tools

- Modality is that of virtual labs
  - Visualization and simulation tools
  - Common tools across disciplines, with discipline specific instruction (recurring patterns of molecular science)

- Context
  - Discipline specific courses: Chemistry, Biology, Materials Science (Physics..)

- Learning goals
  - Help novices construct expert mental models
Design Process

- Experts from multiple domains met to identify concepts/frameworks that are
  - Central to their domain
  - Have strong leverage
  - Are difficult to teach/learn
- Find intersections/overlaps
- Will cross-disciplinary design lead to more reusable learning objects?
Outcome of the Design Process

- Reaction paths and energy landscapes

- Used to describe, for example,
  - Organic chemistry reactions
  - Diffusion on surfaces
  - Protein folding/unfolding
Development process

- Analyze content with experts, novices and psychologists
- Sequential focus on aspects of the diagram
  - What is Q?
  - What is temperature?
  - Energy vs. free energy
What is the reaction coordinate $Q$?
Motion connected to a heat bath
Coordination
Entropy: Energy vs. free energy
Formative assessment

- Psychologists examine for coherence
- Trial in computer cluster
  - 15 students, 3 faculty, 2 developers, 1 psychologist
  - Filmed the activity and a group discussion
- Post survey
  - Meaning of representations
  - Self-perceptions of learning
  - Open-ended conceptual questions

http://matdl.org/virtuallabs
- **Student perception of learning**
  - Helped connect concepts in new ways: 3.6
  - Helped see how the same principles apply to different topics: 3.7
  - Was well organized: 3.6
  - Was easy to understand: 3.1
  - Was a good use of time: 3.0
  - Was fun: 2.7
  - Gave a deeper understanding of principles I already knew: 3.2
  - Gave a deeper understanding of principles I did not know: 3.5

- **Pre and post test (23 items, N=69)**
  - (M = .59, SD = .15) → (M = .67, SD = .12)
  - 2-tailed paired sample t-test, t(68)=4.638, p<.001
Future topics

- Molecular forces
  - How do intra- and inter- molecular forces lead to structure formation
- Economies of exchange
  - Similarities across heat, proton and electron exchange
- How natural and designed systems promote one molecular process over another
  - From molecular science to molecular engineering
Digital libraries as component repositories

- **Virtual Labs wiki** [http://matdl.org/virtuallabs](http://matdl.org/virtuallabs)
  - Support multidisciplinary development & use of VLs
- **Virtual Labs code development** [http://matforge.org/virtuallabs](http://matforge.org/virtuallabs)
  - Support collaborative enhancement of existing & new VLs
- **MatDL Repository** [matdl.org/repository/virtuallabs](http://matdl.org/repository/virtuallabs)
  - Support reuse of source code & teaching resources
- **Metadata & Dissemination**
  - In MatDL Repository & NSDL NDR
Digital libraries as knowledge networks

- Development around core set of visualization tools and virtual manipulatives
  - Does design for use in multiple contexts and disciplinary courses lead to more reuseable learning objects?
  - Does bringing together perspectives from different disciplines lead to more a coherent set of instructional materials?
Thank you & Questions?

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