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

Joint Conference on Digital Libraries

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Outline

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

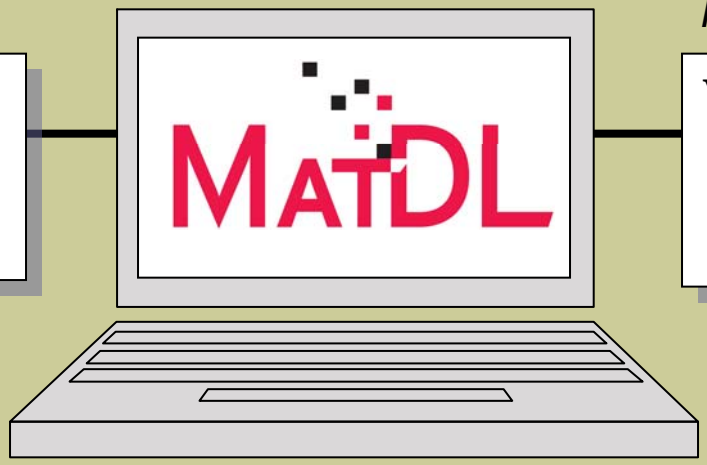
Sumner, T. & Marlino, M. 2004. Digital libraries and education practice: A case for new models. Proceedings of the ACM/IEEE-CS Joint Conference on Digital Libraries, 170-178. Tucson, AZ USA. Association for Computing Machinery, Inc. (ACM).

MatDL
Materials Digital Library Pathway

NSF

NSDL

NSDL Materials Digital Library Pathway



http://matdl.org/matdlwiki

NSF MS Initiatives (NIRTs, MRSECs, IMIs)
- Soft Matter Wiki

http://matdl.org/virtuallabs

Virtual Labs
- Intro to Solid State Chem
- Intro to Bio Physics
- Modern Chemistry

Teaching Resource Development
- MS Teaching Archive

http://teaching.matdl.org

Stewardship
- MatDL Repository

http://matdl.org

Code Development
- Matforge
  - NIST FiPy
  - CMU
  - DOE CMSN

http://matdlforge.org

NIST National Institute of Standards and Technology
KENT STATE UNIVERSITY
MIT Massachusetts Institute of Technology
UNIVERSITY OF MICHIGAN
PURDUE UNIVERSITY
Carnegie Mellon
IOWA STATE UNIVERSITY

- 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

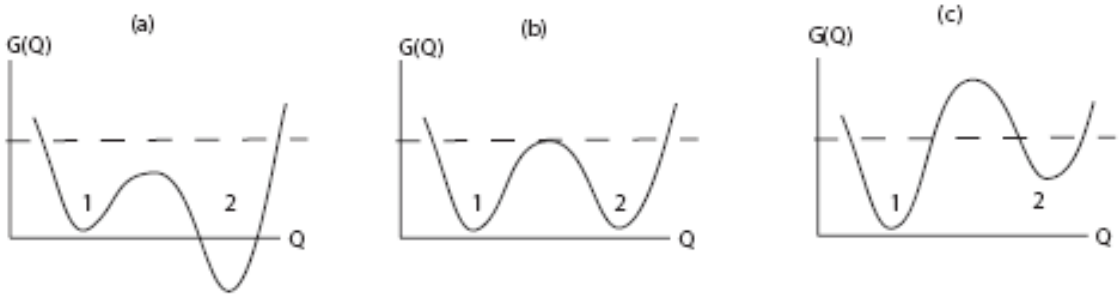
- Modality is that of virtual labs
  - Visualization and simulation tools
  - Common tools across disciplines, with discipline specific instruction (recurring patterns of molecular science)
- Context
  - Discipline specific courses: Chemistry, Biology, Materials Science (Physics..)
- Learning goals
  - 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

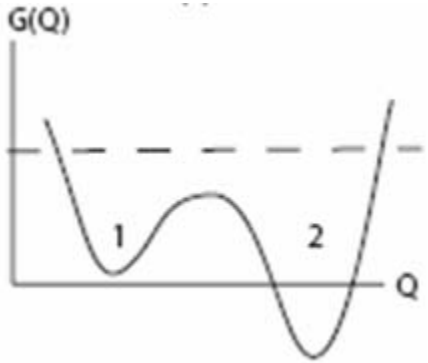
- Reaction paths and energy landscapes



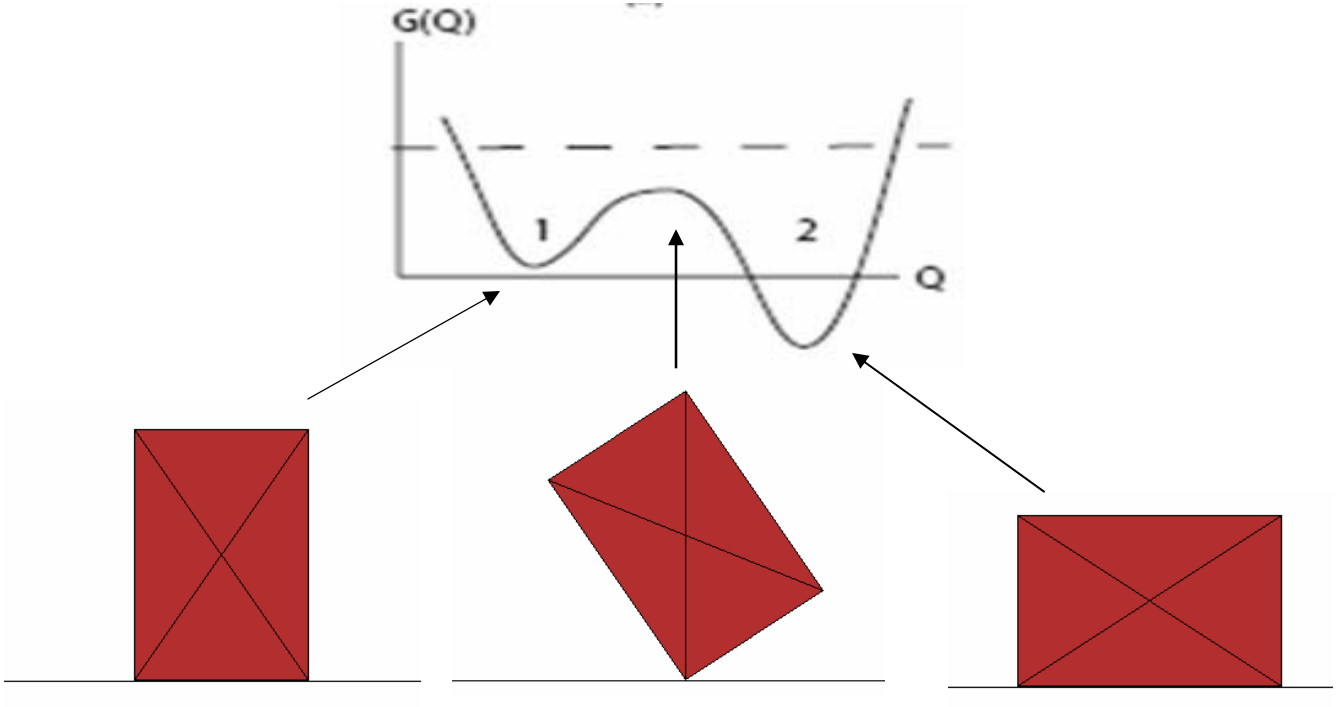
- Used to describe, for example,
  - Organic chemistry reactions
  - Diffusion on surfaces
  - Protein folding/unfolding

Development process

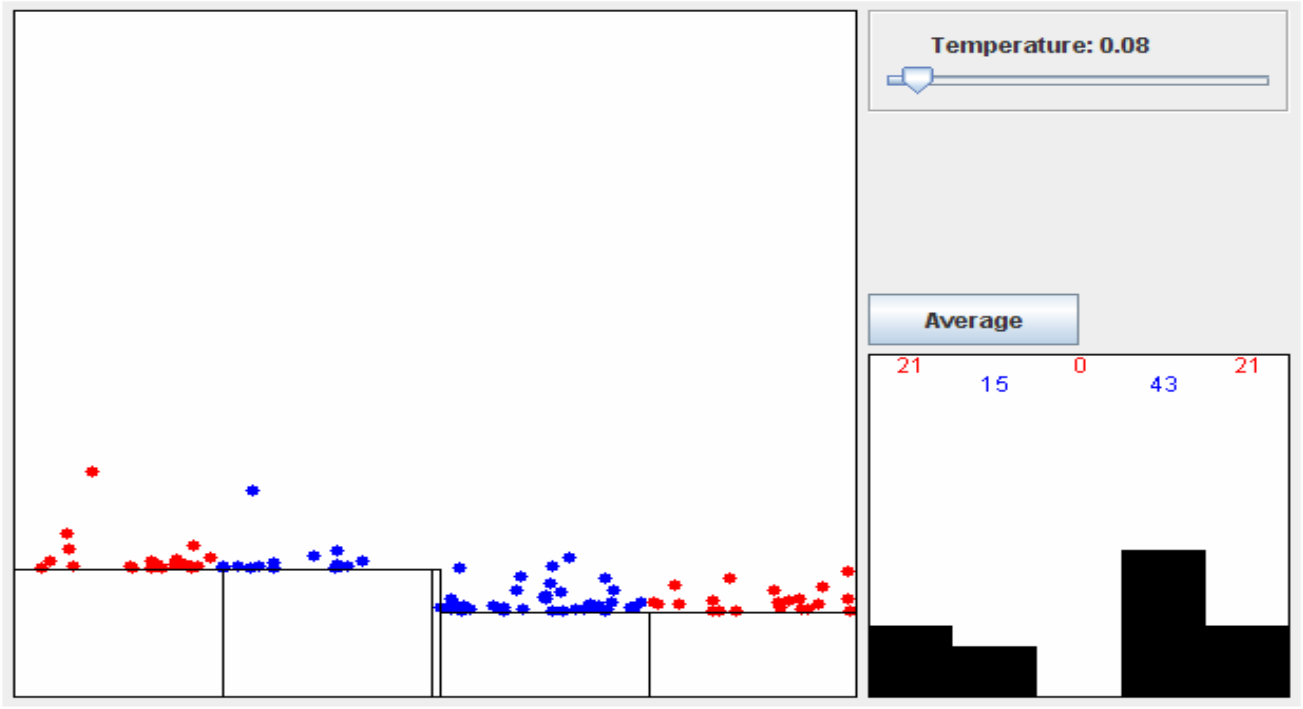
- Analyze content with experts, novices and psychologists
- Sequential focus on aspects of the diagram
  - What is Q?
  - What is temperature?
  - Energy vs. free energy



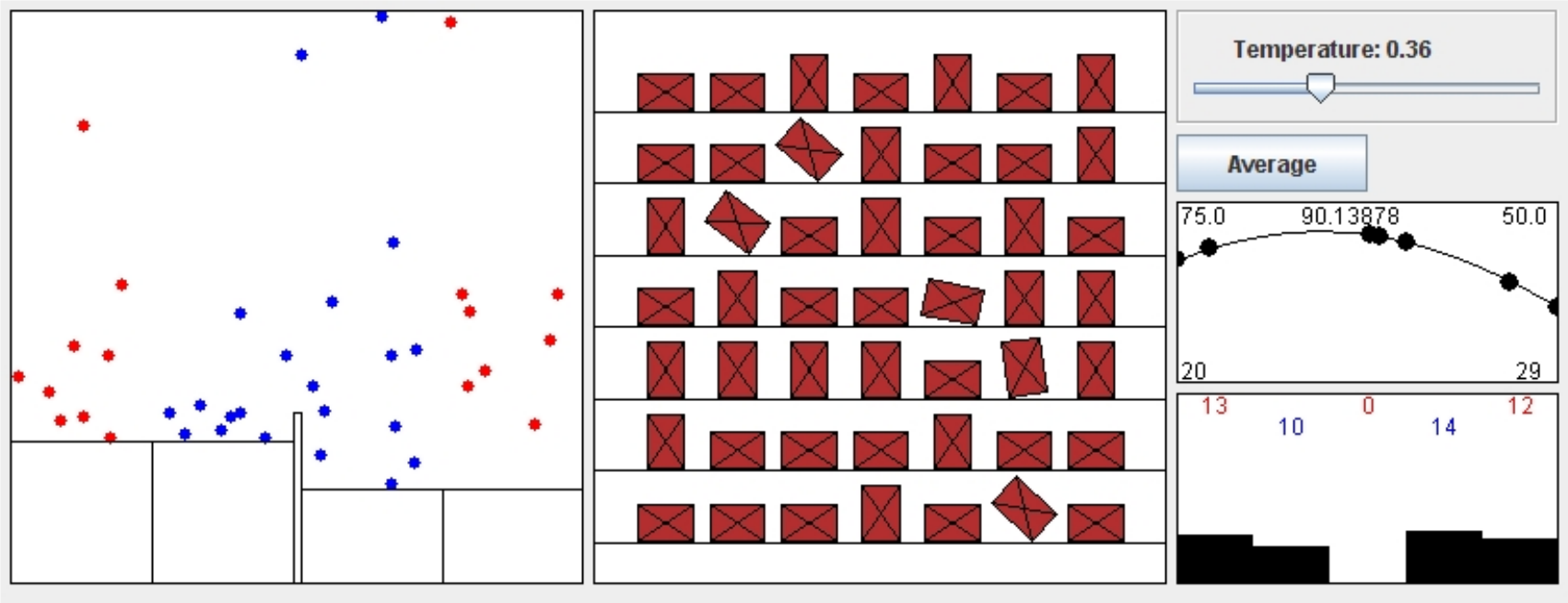
What is the reaction coordinate Q?



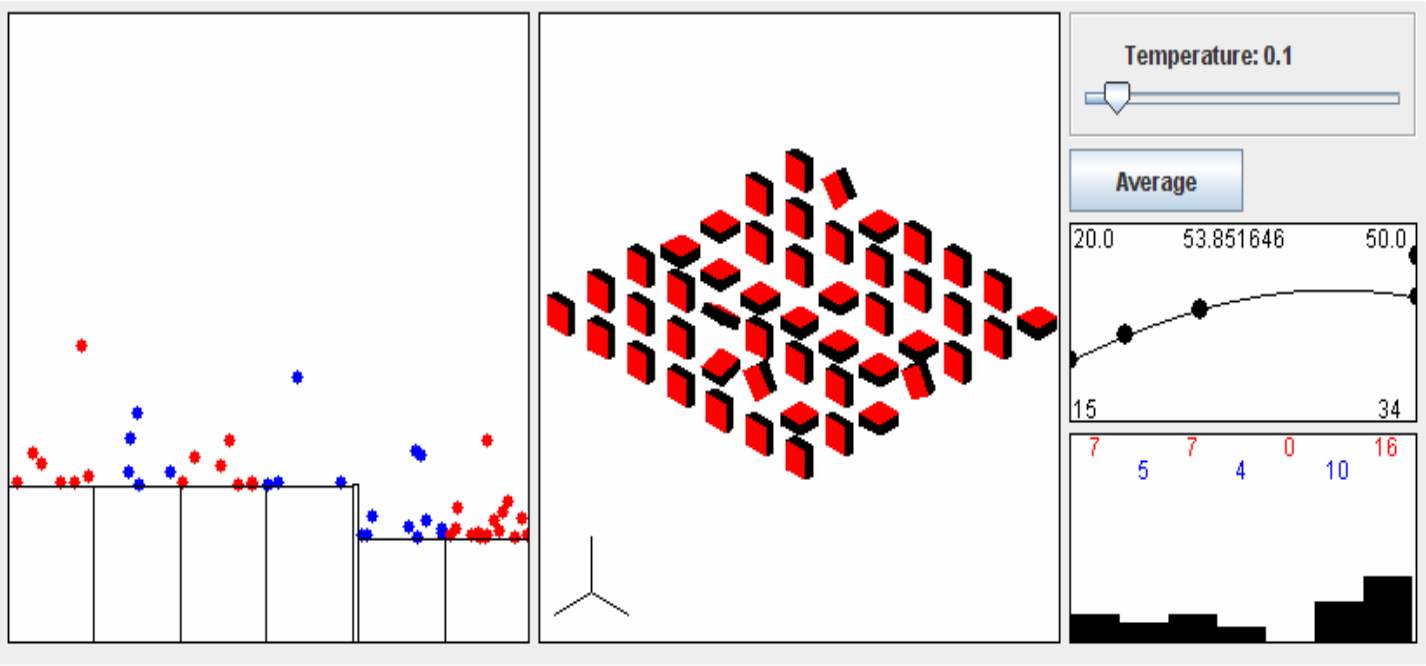
Motion connected to a heat bath



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
  - Support multidisciplinary development & use of VLs
- Virtual Labs code development http://matforge.org/virtuallabs
  - Support collaborative enhancement of exisiting & new VLs
- MatDL Repository 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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