Using Digital Libraries to Build Educational Communities: The Chemistry Collective

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Overview

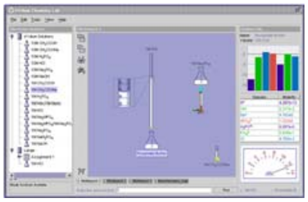
- Goal
  - Create community working together to develop, use and assess materials aimed at reforming introductory chemical education (high school and college)
- New project building on our Virtual Laboratory and authoring tools
- Features
  - Targeted community: group of users working together to meet a specific educational challenge
  - DL architecture that supports community authorship of active content
  - Phased community building model

Materials linked to learning challenges

- Two learning challenges facing chemical education
  - From mathematical procedures to chemical phenomena (*use in chemistry*)
    - Virtual laboratory
  - From chemical phenomena to real world (*transfer to real world*)
    - Scenario based learning

Use in chemistry: Virtual laboratory

- Flexible simulation of aqueous chemistry
- New mode of interaction with chemical concepts
- Ability to “see” inside a solution removes one level of indirection in chemical problem solving



Transfer to real world: Scenarios

- Scenario based learning
  - Embed the procedural knowledge of the course in a scenario that highlights its utility
  - Scenarios that touch down at various points in the course may promote coherence
  - Examples: forensics, biological and medicinal chemistry, environmental chemistry, space exploration/colonization

Challenges for active content in digital libraries

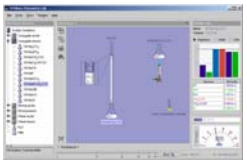
- Simulation and visualization tools often require a flexible development environment such as JAVA
- Evidence of a problem
  - Thousands of applets are available on the web
  - Indicates nascent developer community
  - But most applets are used only by team that developed them
- Root of the problem
  - Current development approach puts too much of the process in the hands of programmers rather than educators

Student interface as a dividing line

- Programmers develop components
  - Produce materials for use by instructors and curriculum developers
  - Takes advantage of their ability to produce interactive, domain-specific learning objects
- Curriculum designers provide student interface and activities
  - Provide student interface, guidance and scaffolding
  - Takes advantage of classroom and pedagogical expertise

Configuration as authoring

- A component that save its state to a file serves as a domain-specific “authoring tool”.



Other examples: Physletts (Davidson), Interactive Physics 2000, VGEE earth science project (UCAR)

Matlab, Mathematica, and SPSS can also be viewed as using “configuration as authoring”

Configuration as authoring

- Add chemical species and reactions (if desired)
  - Can create “fictional” proteins, drugs etc.
- Create Stockroom Solutions
- Specify available functionality
  - Viewers
    - For example, turn off “Solution Contents” for exercises involving unknowns
  - Transfer mode
    - Precise: student enters exact amount to transfer
      - Facilitates comparison with paper and pencil problems
    - Realistic: simulates accuracy attainable in real lab
      - Forces student to use correct apparatus (buret for titration)
- HTML problem description can be included
- Of 60 current problems, 30 are by community of users

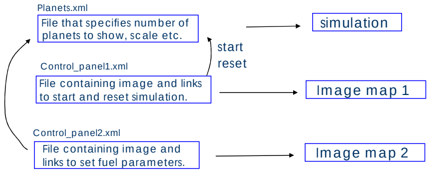
Linked active content

- Allow assembly of multiple components each of which is configurable and saves its state to a file

Simulation

Image maps with hotspots that send messages to the simulation

CREATE digital library architecture



Linked Active Content

Software Components

Planets.xml

File that specifies number of planets to show, scale etc.

Control_panel1.xml

File containing image and links to start and reset simulation.

Control_panel2.xml

File containing image and links to set fuel parameters.

start
reset

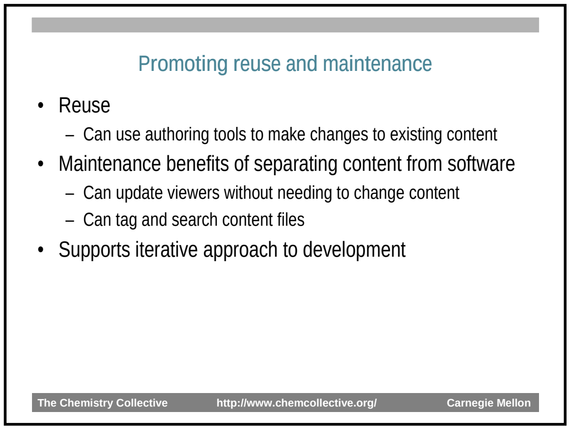
simulation

Image map 1

Image map 2

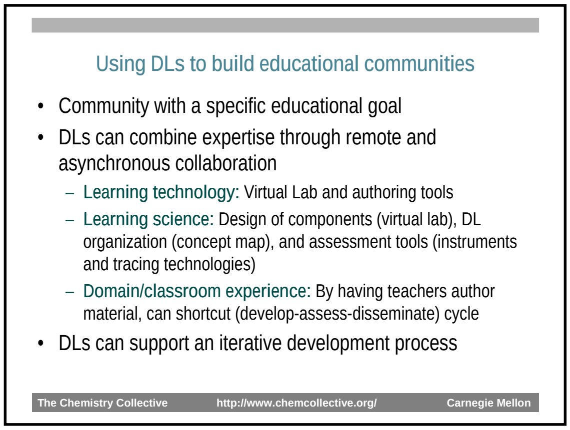
- Content files and software are stored separately in the digital library collection

Mixed reception



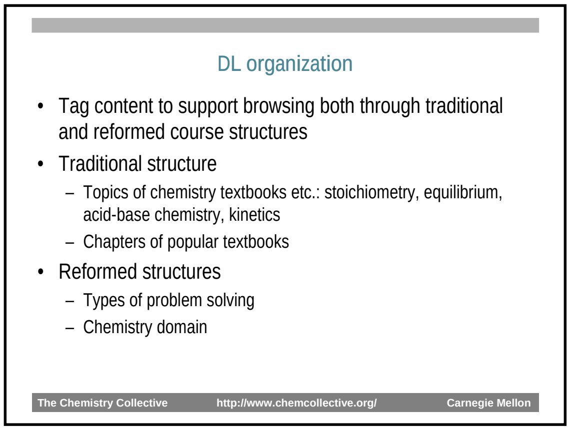
Promoting reuse and maintenance

- Reuse
  - Can use authoring tools to make changes to existing content
- Maintenance benefits of separating content from software
  - Can update viewers without needing to change content
  - Can tag and search content files
- Supports iterative approach to development



Using DLs to build educational communities

- Community with a specific educational goal
- DLs can combine expertise through remote and asynchronous collaboration
  - Learning technology: Virtual Lab and authoring tools
  - Learning science: Design of components (virtual lab), DL organization (concept map), and assessment tools (instruments and tracing technologies)
  - Domain/classroom experience: By having teachers author material, can shortcut (develop-assess-disseminate) cycle
- DLs can support an iterative development process



DL organization

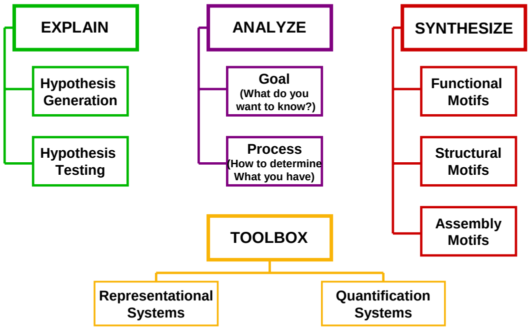
- Tag content to support browsing both through traditional and reformed course structures
- Traditional structure
  - Topics of chemistry textbooks etc.: stoichiometry, equilibrium, acid-base chemistry, kinetics
  - Chapters of popular textbooks
- Reformed structures
  - Types of problem solving
  - Chemistry domain

DL organization: Domain map

- Evidence of the domain as practiced
  - Nobel prizes for past 50 years
  - NY Times Science Times for 2002
  - Scientific American News Bites for 2002
- Evidence of the domain as taught
  - CA state content standards
  - Best selling textbooks

Presented this morning: S279: Karen Evans, Chemistry in the Field and Chemistry in theClassroom: A Disconnect? [Tues 10:45, Scheman 275]

Chemistry Domain Map

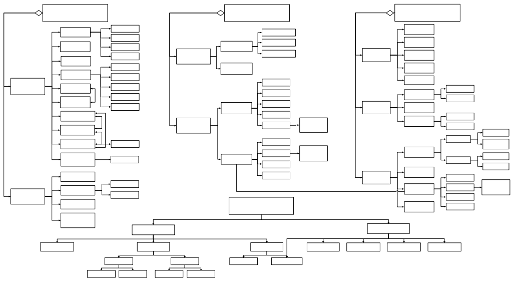


- **EXPLAIN**
  - Hypothesis Generation
  - Hypothesis Testing
- **ANALYZE**
  - Goal (What do you want to know?)
  - Process (How to determine What you have)
- **SYNTHESIZE**
  - Functional Motifs
  - Structural Motifs
  - Assembly Motifs
- **TOOLBOX**
  - Representational Systems
  - Quantification Systems

DL organization: Domain map

- Domain as practiced
  - Scientific literature spread equally between these three subdomains
- Domain as taught
  - Textbooks and standards found only in Toolbox and Analyze subdomain

Full domain map



Community building strategies

- Web site ir.chem.cmu.edu → www.chemcollective.org
  - 1000 page requests per day, 125 instructors on mailing list, 36 requests to become test sites next year
  - >10,000 students have performed one or more activity in the virtual lab
- Booths at conferences
  - Demonstrate materials for about 75 instructors per day of 3 to 4 day conference
  - Branching out to regional meetings
- Workshops [W58: Wednesday 2-5pm in 2264 Hoover Hall]

Modes of user participation

- Use activities and give feedback
  - Current: Amazon-style comments
  - Future work: Aggregation of assessment data (currently have ability to trace all student interactions with virtual lab)
- Modify and create activities
  - Current: Virtual lab activities
  - Future work: Scenario collections
- Low-volume, high-quality discussions
  - Current: Experiences with particular activities
  - Future work: Strategies for teaching specific topics

posed of

EXPLAIN

Is composed of

ANALYZE

Hypothesis Generation
(Frameworks an expert sifts through to construct an explanation)

Types of Reactions

Radioactivity

Acid and Base

Redox

Precipitation

Periodicity

Stoichiometery

Properties of Matter

Properties of Gasses

Acids and Bases in Solution

Electro-magnetism

What is a Metal, Crystal, Salt?

Properties of Atoms and Molecules

Properties of Solutions

Phases of Matter Liquid, Solid, Gas

Equilibrium

Thermodynamics Heat and Energy

Kinetics

Catalysis

Structure Property Relationships

Similar structure as an explanation

Hypothesis Testing

Radio Label

Scavenge O_2

Selectively shut down pathways

Block a functional group

Correlate Observables

Hold one thing fixed while changing another

Goal
(What do you want to know?)

Method
(How to determine what you have)

Qualitative Analysis
(What is its Structure)

Super Molecular Structure

Molecular Structure

Atomic Structure

Quantitative Analysis
(How much do you have)

Investigation

Radioactive Dating

Microscopy Techniques

Scattering Techniques

Titration

Spectroscopy

Separation

Extraction

Chromatography

Distillation

Filtration

TOOLBOX

Representational Systems

Nomenclature

Structure

Reactions

Atomic Structure

Molecular Structure

Format

Stoichiometery

Orbitals

Configuration

Lewis Dot

VSEPR

Summary

- Our goal is a digital library of virtual labs and scenario based learning activities that
  - Provides tools to support modification and creation of activities
  - Supports browsing of activities through both traditional and reformed course structures
  - Allows instructors to give feedback through both informal comments and formal assessment data

Current and Previous Team Members

Carnegie Mellon

- Donovan Lange
- D. Jeff Milton
- Michael Karabinos
- Jordi Cuadros
- Tim Palucka
- Emma Rehm
- Rea Freeland
- Jef Guarent
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