The NSDL Strand Map Service:

A Networked Knowledge Organization and Visualization System for K-12 Education

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Overview

- Background
  - National Science Digital Library
  - AAAS Benchmarks and Strand Maps
  - Task-centered design
- Brief look at the Strand Map Service
- Our design process and methodologies
- Conclusions
  - benefits of ‘good’ design practices & products
  - impact on our partners (DLESE & AAAS)

National Science Digital Library (NSDL)

- Systemic improvements in science, engineering, technology, and mathematics education, at all levels, in formal and informal settings
- Distributed network: 120+ projects funded by the National Science Foundation (collections, services, targeted research, core integration, libraries)
- K-12: challenge is to help students master (nationally-)recognized learning goals and help teachers create inquiry-oriented science learning experiences

AAAS Benchmarks and Strand Maps

- **AAAS and Project 2061**: long-term vision of empowering teachers and school districts to design coherent curriculum
- **Benchmarks**: describe what learners should know, or be able to do, at key stages in their education across the STEM disciplines
- **Strand maps**: consist of node-link representations illustrating how student understanding changes over time around topics important to science literacy
- **Our mission**
  - AAAS perspective - maps as interface to library
  - NSDL perspective - develop a means of making benchmarks and maps available within the NSDL network

What is a Benchmark?

3-5

When warmer things are put with cooler ones, the warm ones lose heat and the cool ones gain it until they are all the same temperature.

K-2

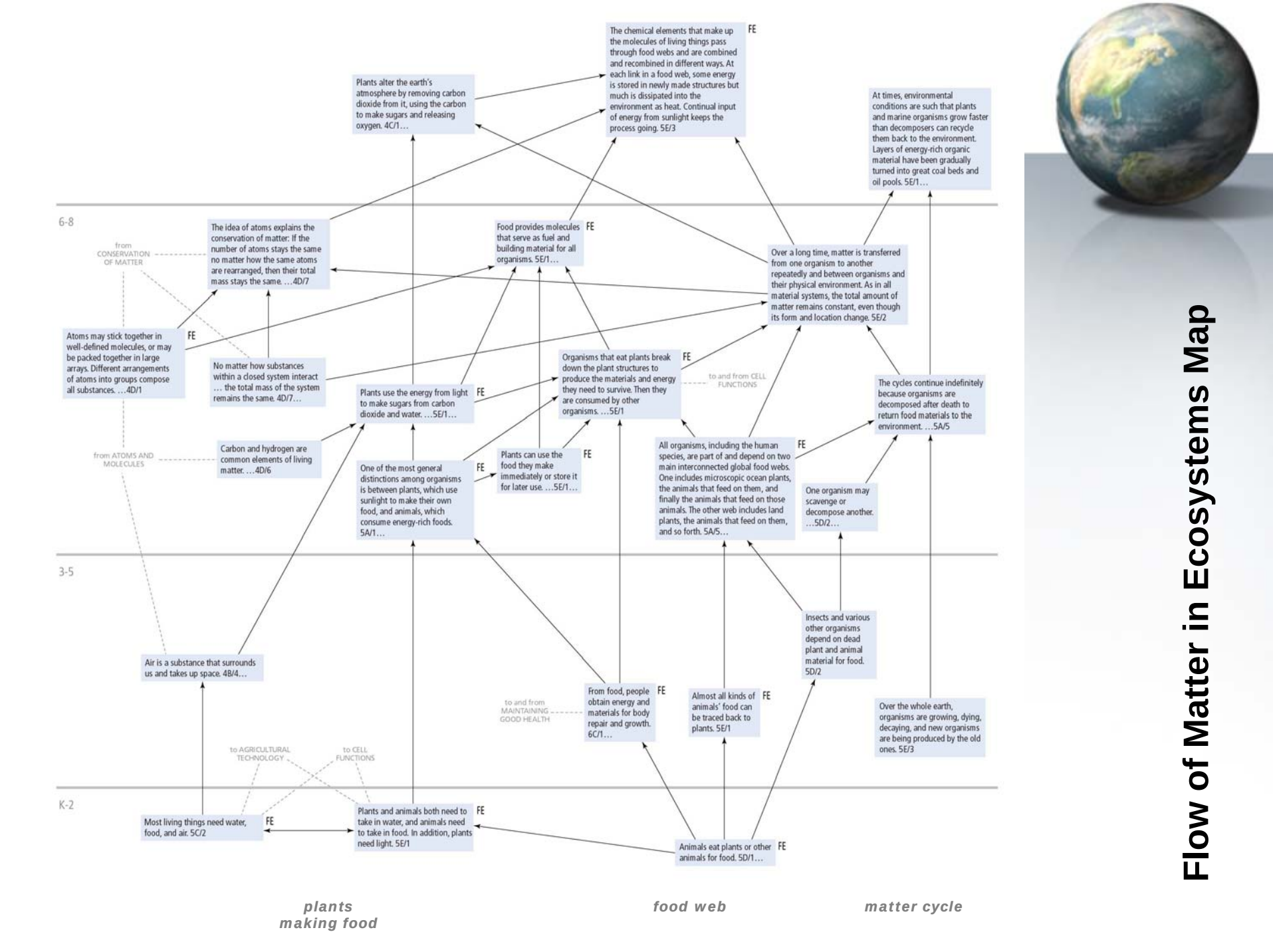
The sun warms the air, land and water.

Research on the cognitive and scientific basis

Research on student misconceptions

Strategies to check student understanding

Assessment activities

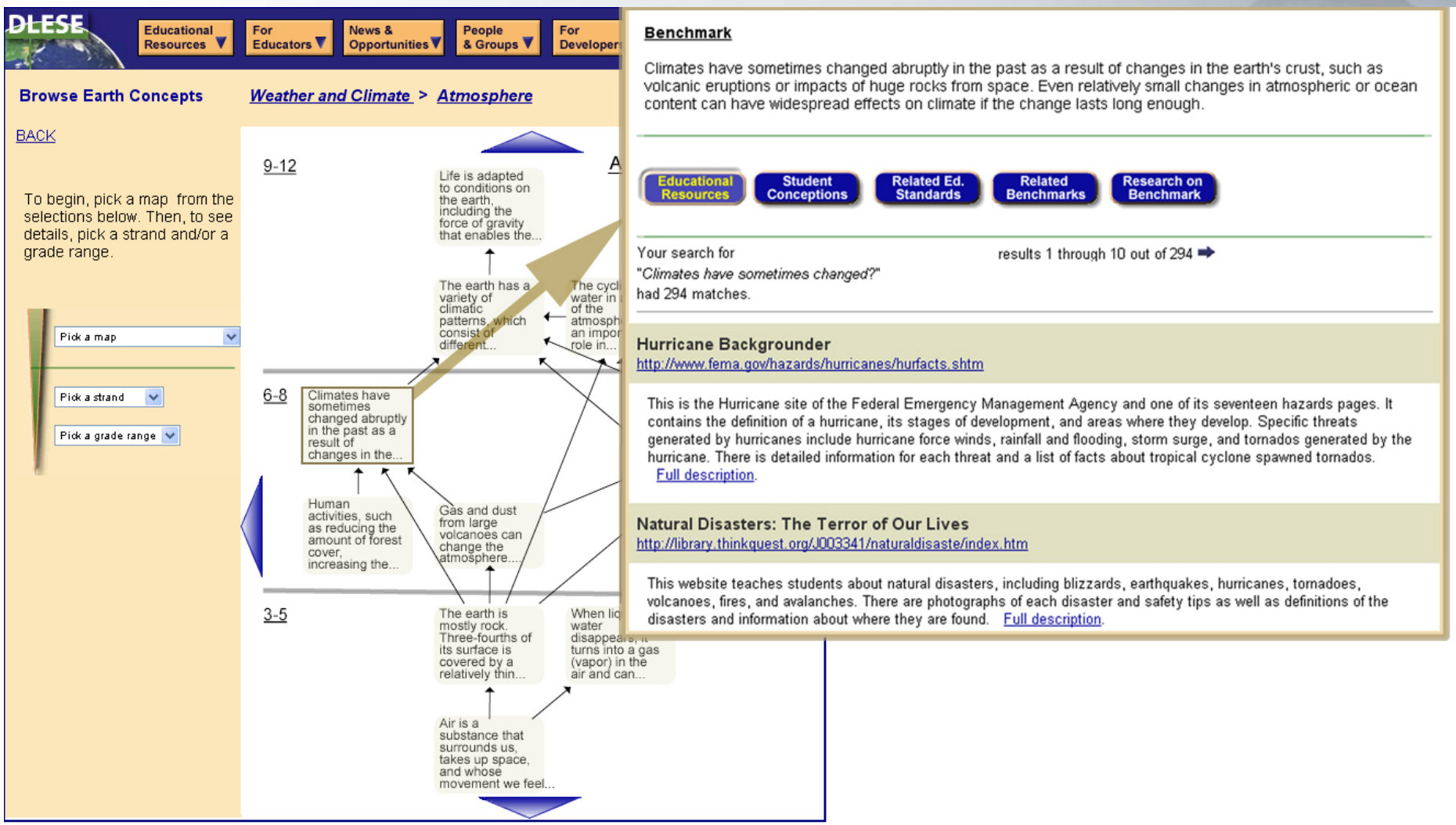


Flow of Matter in Ecosystems Map

Task-centered Design

- Lewis & Rieman, 1993
  - Involve users early and often
  - Focus on real needs and concrete tasks
  - Iterative design guided by frequent formative evaluation
- Analytic tools: inspections (cog WT, prog WT), ‘think-aloud’ verbal protocols, etc.
- Expanded view of interface and system

The Service in DLESE



NSDL Strand Map Service

Service components	User constituency
• Visualization interfaces →	• K-12 teachers and students
• Web service protocol →	• Library developers
• AAAS information model →	• AAAS map makers and other staff

Visualization Interfaces Methodology

- Design, Develop and Evaluate a set of visual components which could be interconnected together usefully and usably
- Task-Centered Design
  - Requirements analysis - interview teachers
  - Design & Evaluation of Low-fidelity Mockups
  - Design & Evaluation of High-fidelity Interactive Prototypes
  - Integration Experiments
  - Demonstrator Interface for feedback at geoscience educator conference
  - Pilot study on how interfaces affect cognitive strategies
- Primary design outcome: set of components that protocol should support (expressiveness)

Prototype I

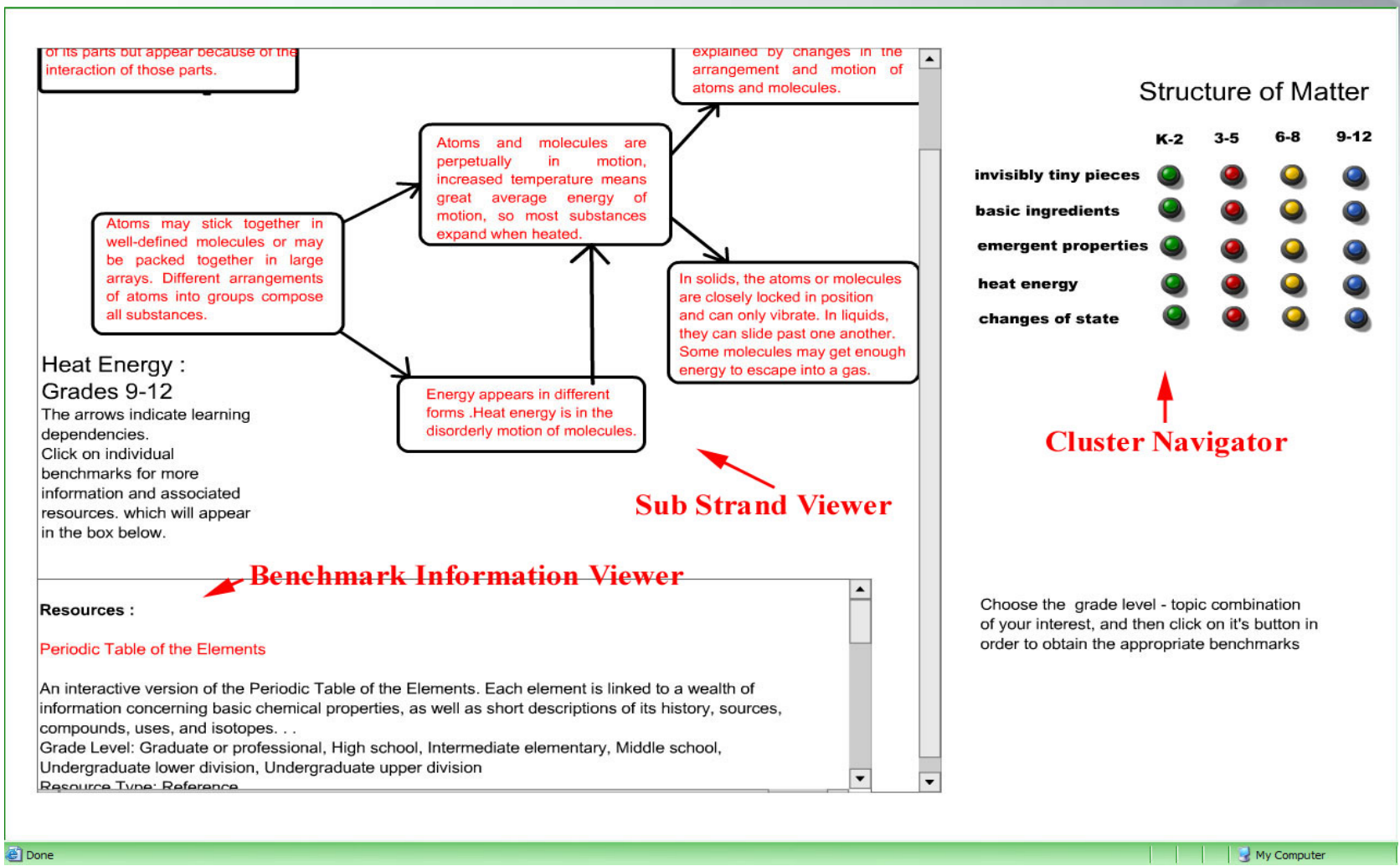
AAAS Standards - Index of Benchmarks

- **Nature of Science**
  - Scientific Inquiry (Evidence and Reasoning in Inquiry, Scientific Investigations, Scientific Theories, Avoiding Bias in Science)
- **Nature of Mathemetics**
  - Mathematical Inquiry (Mathematical Processes, Mathematical Models)
- **Nature of Technology**
  - Design and Systems (Design Constraints, Design Systems)
  - Issues in Technology (Interaction of Technology and Society, Decisions about using Technology)
- **The Human Organism**
  - Physical Health (Disease,Maintaining Good Health)
  - Mental Health(Coping with Mental Distress,Diagnosis and Treatment of Mental Disorders)
- **Common Themes**
  - Systems
- **Habits of Mind**
- **The Physical Setting**
  - The Universe (Gravity, Solar System, Stars, Galaxies and the Universe)
  - Processes That Shape The Earth (Changes in the Earth's Surface, Plate Tectonics)
  - Structure of Matter (Atoms and Molecules, Conservation of Matter, States of Matter, Chemical Reactions)
  - Motion (Laws of Motion, Waves)
- **The Living Environment**
  - Heredity (DNA and Inherited Characteristics, Variation in Inherited Characteristics)
  - Cells (Cell Function , Cells and Organs)
  - Flow of Matter and Energy(Flow of Matter in Ecosystems, Flow of Energy in Ecosystems)
  - Evolution of Life (Biological Evolution, Natural Selection
- **Historical Perspectives**
- **The Mathematical World**
  - Mathematical Representation(Graphic Representation, Symbolic Representation)
  - Proportional Reasoning(Ratios and Proportionality, Describing Change)
  - Statistics(Averages and Comparisons, Correlation, Statistical Reasoning)
- **Human Society**
  - Behaviour(Heredity and Experience Shape Behaviour, Culture Affects Behaviour)
  - Social Change(Influences on Social Change, Social Decisions)
- **The Designed World**
  - Agricultural Technology
  - Communication and Technology(Communication Technology, Computers)

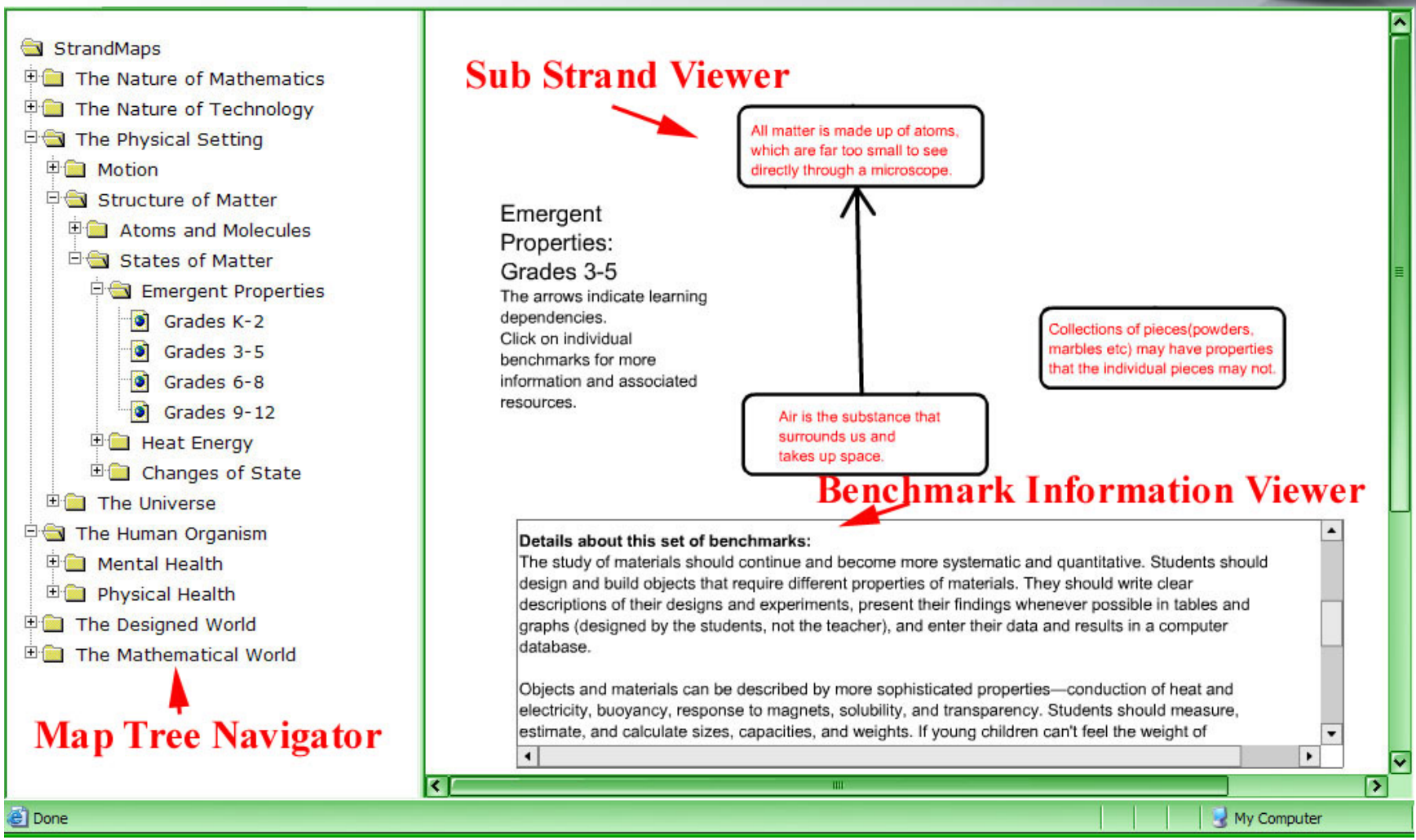
Whole Space Navigator

My Computer

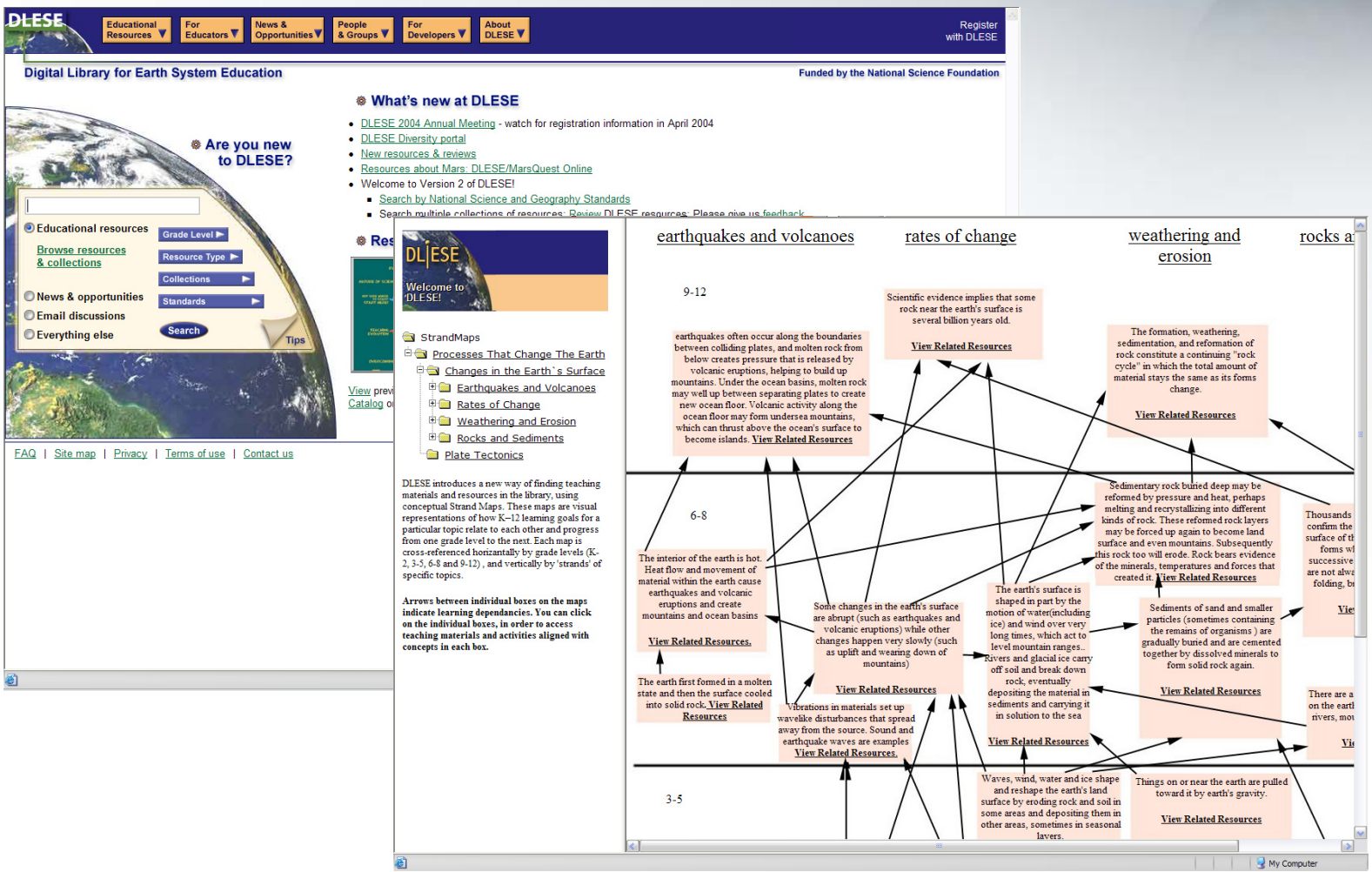
Prototype I (contd.)



Prototype II



Integration Experiment: DLESE



CSIP Web Service Protocol

Balance expressiveness with facility

- expressiveness -> visual components
- facility -> programming walkthrough

- Representational State Transfer (REST)
- Protocol consists of three services
  - Service Description
  - Submit Resource
  - Query

```
<Query DetailLevel="Detailed" Format="SVG" Scope="MAP">
<Content-Query>
 <Name MatchType="Equal">Weather and Climate</Name>
 </Content-Query>
 </Query>
```

Programming Walkthrough Analysis Guidelines

- How long is the process?
- Are there opportunities to eliminate steps by changing the design?
- Are there steps for which it was not possible to describe knowledge that would guide their selection? (these steps will require extensive problem solving by programmers)
- Conflicts among points of guiding knowledge?
- Conflict between guiding knowledge and the knowledge user brings with him?
- Unclear correctness of steps
- Are there steps that require knowledge that programmers are unlikely to have?

Programming WT Process

- Two rounds, with changes after each
- Round 1: Two walkthroughs (3 and 2)
  - Each group asked to perform 5 tasks
  - About 2 - 2.5 hours to complete
- Round 2: Two walkthroughs (2 and 1)
  - same tasks

CSIP Evaluation Results

- No major expressiveness issue found

- Facility
  - × Documentation issues
  - × Terminology issues
  - ✓ Adequate design guidance
  - ✓ Standardized query construction approach
  - ✓ No major design issues revealed

AAAS Information Model

- Methodology
  - Iterative model
  - Participatory design - map maker part of team which also included metadata experts, developers
  - Analysis tool: Concept Space characterization matrix
  - Rubric Evaluations
- Outcome: Concept Space Metadata Framework v1.0, preliminary best practices, and confidence that the AAAS map makers could catalog to this

CSMF Evaluation Rubric Questions

- Set of relationships. Do we have expressive enough relationships to capture all aspects of concept maps and AAAS project 2061 domain?
- How to express relationships that will maintain the concept map structure and require minimal effort in cataloging
- Test external standard relationship field and check for its adequacy
- Test external resource relationship field and check for its adequacy
- Try out narrative (Student | Examples | Assessment | Instructional | Clarification) ideas and define their usability and exact semantics and best practices
- Check the appropriateness and completeness of data that form basis of Strand Map Service
- Check completeness of admin fields
- Check for redundancy and anomalies in fields
- Identify cataloging sequence (top-bottom, bottom-top, parallel etc)
- Make sure when a complete range of objects are cataloged they make a coherent navigable, discoverable and logical path

CSMF Evaluation Results

- No major design alteration

- Minor issues revealed
  - Communication
  - Best practices
  - Benchmark to Strand relationship

Conclusion

- Pilot research study results on cognitive strategies are encouraging
- We have a growing list of partners for the Service
  - Deployment cases are next step - TCD process continues but in more operational contexts
  - Major research projects
- Generalizability to other concept spaces
- Impact on the mindset and practices of our partners