Student Difficulties in Developing Rich Mental Models of Complex Earth & Environmental Systems

Karen S. Sell, Bruce E. Herbert, Carol L. Stuessy, and Janie Schielack

Information Technology in Science Center for Teaching and Learning, Texas A&M University

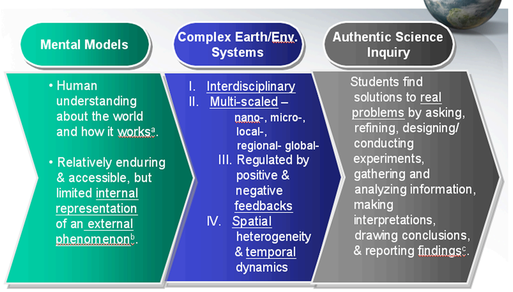
Abstract

The formation of authentic and accurate student internal (mental, conceptual) models of complex Earth systems present unique cognitive difficulties. Multiple representations, including both digital and physical expressions of Earth systems, can support students' abilities to connect rich internal models and real world phenomena.

Therefore, in order to facilitate enhanced student mental model development in undergraduate geoscience students, multiple representations were used as the pedagogical intervention in this work. The manipulation of multiple representations, the development and testing of conceptual models based on available evidence, and exposure to authentic, complex and ill-constrained problems were the components of the instructional framework.

Data based on rubric evaluations and principal component analyses suggest students' ability to learn during problem-based learning modules is highly influenced by their cognitive skills and content knowledge, where construction of their mental models is directly affected. Sub-clusters of principal component data suggest that students had difficulty with reasoning skills, critical thinking skills, cognitive load issues, linking large/small scale phenomena, and understanding of the characteristics and behaviors of systems. Further, multiple misconceptions and the lack of complexity and completeness in representations of the studied systems were revealed in student mental model expressions.

Background

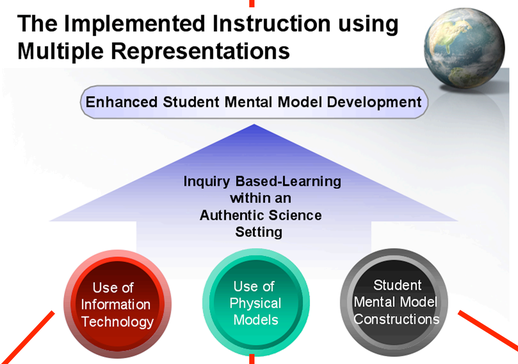


([a]Gentner & Stevens, 1983; [b]Doyle & Ford, 1998; [c]Krajick et al., 2000).

Implemented Modules

TOPIC	SYSTEM	SCALE	REPRESENTATION	LEARNING PRODUCTS
Sediment Biogeochemistry	Wetland & Estuarine Sediments	Local (m)	Physical model – Winogradsky Column	Written reports
Water Quality	Texas Coastal Margins	Spatial variability (km)	Visualization of complex data – IT (1)	Written reports
Land Use & Water Quality	South Platte, CO	Spatial variability (km)	Visualization of complex data – IT (2)	Written reports
Eutrophication	Texas Coastal Margins	Temporal variability (months)	Mental model - animation of system dynamics	Presentation of computer animation

The Implemented Instruction using Multiple Representations

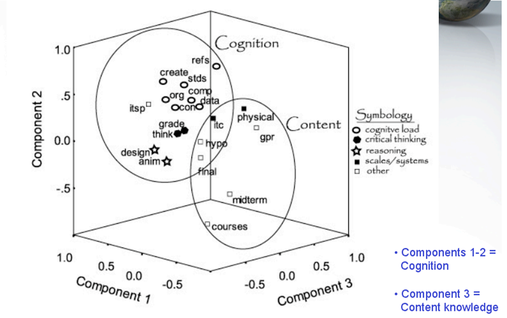


Student Imperfect Conceptions

- Student A - *The reason the bacteria degrade the molasses faster than the oil is because the oil **molecule** is **bigger** than the bacteria **cell** **(Linking Scales)**.*
- Student B - *A **reduced** environment has **aerobic** processes **(Content Knowledge)**.*
- Student C – ***Pyrite** exists where **oxygen** is readily available **(Content Knowledge)**.*
- Student D – *The **black** material produced in the sediment is **bacteria** **(System Understanding)**.*

- *Without allowing students to express their mental models, identification of these ICs would not be possible & the opportunity to meet the students' needs would not be available.*

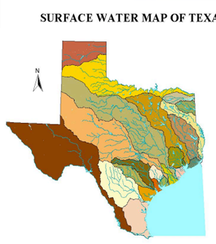
Factors Associated with Student Learning Difficulties



- Components 1-2 = Cognition
- Component 3 = Content knowledge

The Information Technology

ESRI ArcView, Excel, PowerPoint, Internet

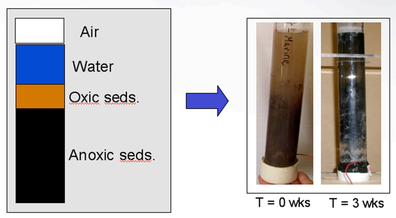


- Students analyzed large scale data sets.
  - Nutrient sources and sinks.
  - Land-use, TX geology, watersheds, population, seasonality.
  - Compared two Texas estuaries.
- Linked human impacts to the environment.

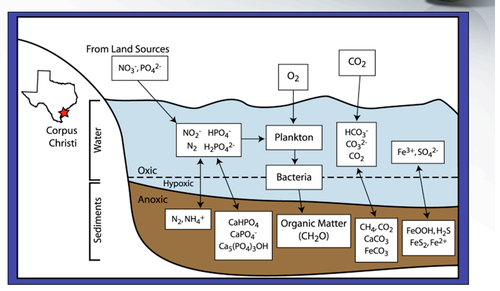
The Physical Model

Winogradsky Columns

- Temporal changes observed.
- Student treatments of cores: (organic matter, oxygen, soil type).



The Conceptual Model – Coastal Eutrophication



More Information

http://its.tamu.edu

Acknowledgements

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