Complex Systems

Research on Learning Conference

Wingspread July 2002

Presenters:

Janice Gobert, Joel Michael and Richard Turetich

(Notes not on wall charts)

Barriers:

- lack of instructional and assessment resources for Earth Systems and other complex systems
- cognitive issues

  -language for Earth Systems

  -integration of many facets of domain

  -misconception –content and epistemological

- instructor issues

  -lack of faculty commitment and training from Earth Systems perspective

- nature of discipline

  -representational issues –difficulty for students

  -systems have no obvious starting point

Existing research

Relevant research on …

- cognitive and education

  -learning with models

  -work on visual representations

  -inquiry, collaboration, etc.

- learning environments
- sociological research

  -group interactions

  -faculty development

  -instructional change in education

- disciplinary research on geoscience education

New Work Needed

- Models

  -what are they good for?

  -how to improve them?

  -how to scaffold them?

- Assessment

  -of learning environments

  -of learning experiences

- Connections b/w parts of system

  -feeback look in E.S.

  -how do students work with feedback systems?

- Expert-Novices differences

  -what do expert geologists think about this?

Next Steps

- Development of support community
- Institutional incentives
- Building bridges to other communities
- Developing geoscience professional who can teach E.S.

POSTERS:

Critical barriers to learning:

1. Compartmentalization [text books]

2. Learning the language

3. Presence of misconceptions

4. Conceptually – difficult integration of may facets of domain (e.g. spatial, causal,. dynamic, temporal)

5. Data representations

- disembedding
- coordinating
- choosing right data
- reasoning with

6. Lack of faculty commitment to learning (Earth system learning)

7. Lack of student motivation

8. Design of physical classroom

9. Today's faculty didn't learn geoscience themselves from an Earth Systems perspective

10. Faculty current experience (research) also may not have an Earth Systems perspective.

11. Lack of good materials for teaching of complex systems (textbooks, labs, problem sets, student projects, assessments (research)

12. Lack of assessment of instructional approaches - e.g. longitudinal

13. You have to think about a lot of different things at the same time (e.g. multiple causes for the same observable)

14. Systems to learn are too complex

15. Systems are not linear

- no starting point
- need to know whole to understand parts

16. Misconceptions on the nature of knowledge they are learning and how they will learn it

Existing research

1. Misconceptions/conceptual change

2. Collaboration/cooperative/case-based/problem based learning/inquiry

3. Learning with models, visualizations, etc. (mtv.concord.org)

   - generating and manipulating models
   - resource model research
   - complexity theory research
   - how people read maps-Uttal
   - brain theory

4. Transfer of knowledge from macro to micro from physics/chemistry

5. Concept tests research [Mazur's Project Galileo]

6. Cognitive psychological research on understanding representations -e.g. Uttal, B Tversky, Hegonty, Tufte

7. Organizational change research (from <u>academia,</u> business) (Kottel)

8. Research on design of learning environments

9. Research on design of student projects/research

10. Research on novice/expert differences,expert/non-expert differences

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Wide variety of relevant research

-cognitive

-education/learning/learning environments

-sociological: group integration, faculty development, institutional change

-disciplinary

New Work Needed (Complex systems)

1. Expert/novice differences

2. Transfer of geo/math to physics/chemistry

customizing??

3. Types of qualitative models necessary for learning in Earth Systems

    - for scientific literacy
    - for geology majors

4. Feedback loops (in Earth Systems)

    - How do students learn to recognize reinforcing and counteracting feedback loops
    - Having learned to recognize a feedback loop, how do they learn to use that information to reason about the natural system

5. Analogies

    - designing
    - when do they help? when do they mislead?

6. How do we help students make connections (e.g. across "spheres," across disciplines)

7. Usability studies. Complex, dynamic simulations

8. Knowledge of what knowledge, resources and skills students enter with

9. How modeling is taught and critical evaluation of the model and its outcomes

10. How to use model to teach about Earth

11. How do people understand causality?

12. Sequencing: Parts first or system?

13. Assessment instruments

    - Content
    - Inquiry skills
    - Epistemological gains
    - application to real world

14. Scaffolding –what works for complex systems and for learning with models

15. What are the paradigmatic models at different levels of instruction?

16. How to prepare teachers to teach complex models

SUMMARY

◙ Models (14,15,16,9,10)

What are they good for?

How can we make them good?

◙Assessment (8,13)

of the learning environment

of the learning experience

◙Connections (4,6,2,11)

Next Steps: for research and all communities

1. Informing geo faculty (faculty development)

2. Building community

3. More and deeper collaborations with learning scientists (this research feeds back into 1 &2)

4. Building institutional support for instructional change. Professional rewards

5. Mobilizing faculty and professional societies to facilitate "reform" and publications

6. Reforming culture, building bridges between education and phys. geo with research, chemistry, math, engineering, biology

   Establish ethic of helping each other understand and share experience and understanding

7. Establish/re-establish programs (e.g. PFSMET, K12) which encourage education and geoscience interactions (collaborations)

8. Use existing resources (JGE,EOS,Geotimes, Geology)

9. Statement on geoscience education research (analogous to physics education research) (AGU)

10. Develop interactions with biology educators regarding complex systems

11. Concept maps

12. EMBED research into all next steps