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Complex Adaptive Systems and Quantitative Reasoning in an Interdisciplinary STEM Mathematics Classroom

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INSTITUTE *for* INTERDISCIPLINARY **STEM** EDUCATION

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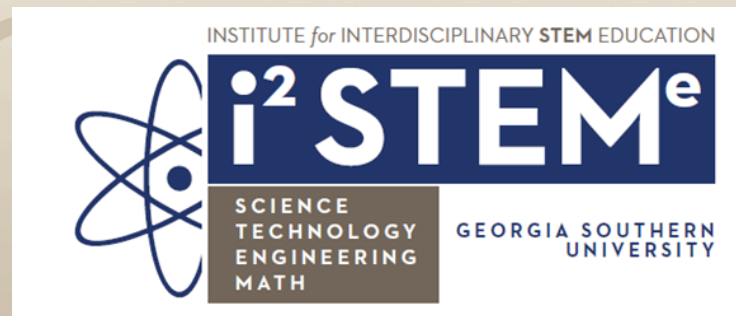
Our goal: Interdisciplinary real-world STEM in the classroom

Our plan:

1) Introduce <u>Complex Adaptive Systems</u> as a driver for interdisciplinary learning:

➤ engage students through place-based education (PBE)
➤ teach for understanding, assess through performance tasks (Understanding by Design UbD)
➤ let real-world problems drive the teaching and learning through problem-based learning (PBL)

2) Develop students <u>Quantitative Reasoning</u> Skills

➢ Use math to conceptualize an object
➢ Use math to compare, contrast, and combine
➢ Use models to make predictions
➢ Use math to create representations

What are complex adaptive systems?

They aren't….
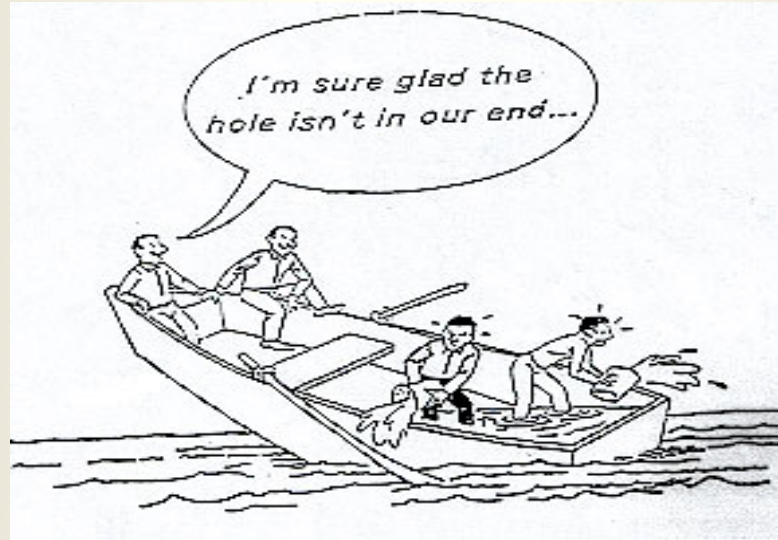
isolated from their parts

They are:

    1) the Butterfly Effect

        http://www.youtube.com/watch?v=8qD6RWlDeuY

    2) By nature interdisciplinary; system is not the sum of the parts but a product of the parts and their interactions (Davis and Simmt)

    3) Causing adaptions through small changes over time
        - evolution, health, classrooms

    4) Everywhere

DON'T BRING A COOKIE CUTTER TO A COMPLEX ADAPTIVE SYSTEMS CLASSROOM

In Complex Systems:
1) Rigid demands are counterproductive
2) There is uncertainty in work
3) The parts cannot be separated from the whole
4) Success is not guaranteed
5) Concepts are not taught from a one discipline perspective.

What does a complex adaptive classroom look like:

- Internal Diversity
  - Variation among the students = novel problem solving
- Redundancy
  - Commonness of experiences among students = shared community
- Decentralized Control
  - Student self-management = classroom collective
- Organized randomness
  - Rules determine boundaries but not limits
- Neighbor Interactions
  - Students need time to share concepts with one another
- Interdisciplinary Teaching and Learning = Students see how all disciplines work together

(Davis and Simmet)

Quantitative Reasoning
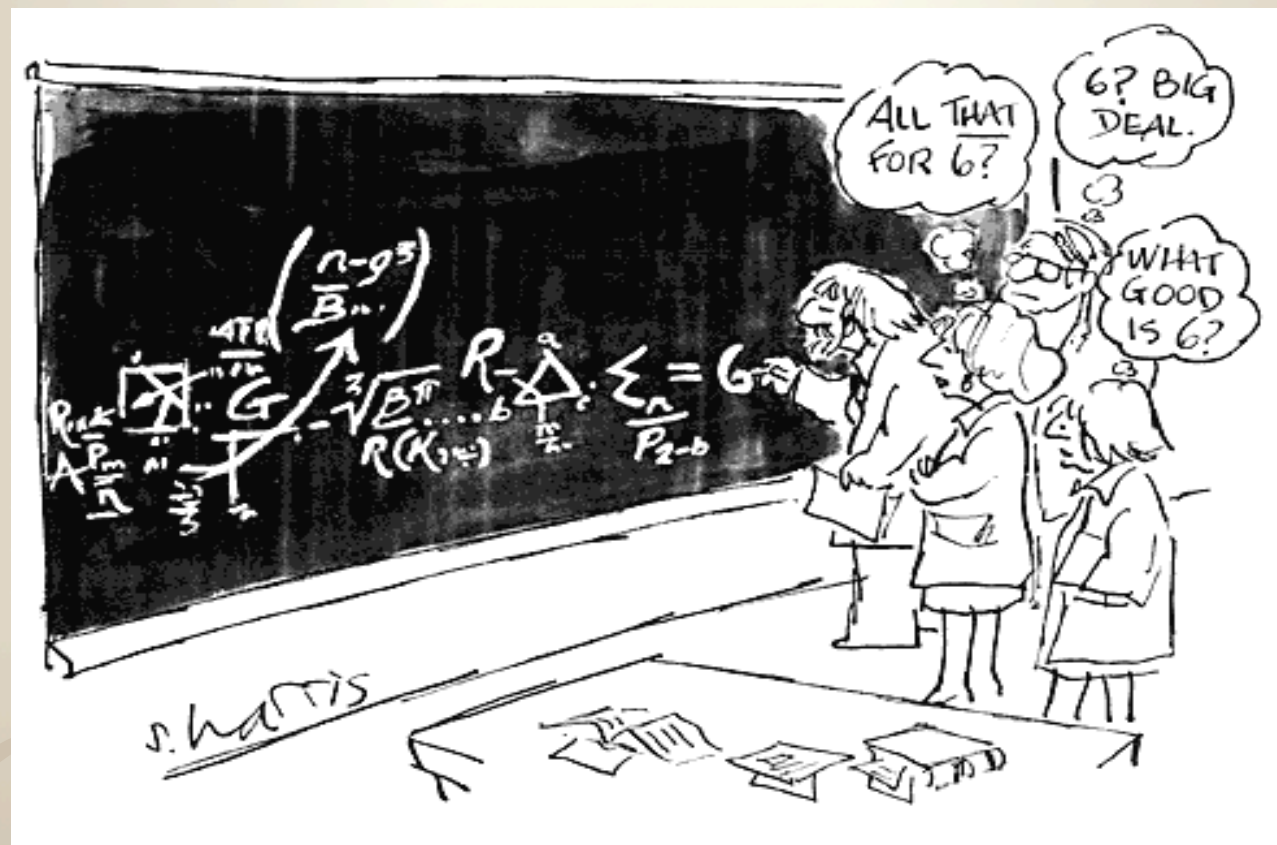
Quantitative understanding, also called numeracy, is traditionally taught through work in mathematics and statistics courses, but it can often be learned more effectively through work in courses within the …context of courses of interest to the student. "To be useful for the student, numeracy needs to be learned and used in multiple contexts—in history and geography, in economics and biology, in agriculture and culinary arts. Numeracy is not just one among many subjects but an integral part of all subjects." (Diefenderfer, Doan, Salowey)

4 fundamental components of QR

- **Quantification Act** (QA): mathematical process of conceptualizing an object and an attribute of it so that the attribute has a unit measure, and the attribute's measure entails a proportional relationship (linear, bi-linear, or multi-linear) with its unit

- **Quantitative Literacy** (QL): use of fundamental mathematical concepts in sophisticated ways for the purpose of describing, comparing, manipulating, and drawing conclusions from variables developed in the quantification act

- **Quantitative Interpretation** (QI): ability to use models to discover trends and make predictions, which is central to a person being a citizen scientist who can make informed decisions about issues impacting their communities

- **Quantitative Modeling** (QM): ability to create representations to explain a phenomena and revise them based on fit to reality

(Mayes, Forester, Christus, Perterson, Bonilla, and Yestness)

QR and CAS: A Perfect Match

- Numbers are everywhere in systems: environmental trends, financial matters, consumer choice, health care, economics, science, and everyday issues (Lutsky)

- Inform and Influence

- Key conceptual tools in modeling and simulation for both real and artificial problems (Jacobson and Wilensky)

In Practice

- Real STEM
  - Collaborative between scientists, teachers, and University faculty
  - Applied learning through real-world place-based problems in the environment
  - Using numeracy to develop hypothesis, expand findings, and make arguments
  - Student hypotheses drive their research

Practice Continued

- Our findings so far:
  - Teachers do not think from a systems perspective
  - Teachers have difficulty in putting quantitative reasoning into practice
  - Students will avoid anything which looks quantitative (avoiding math?) in favor or qualitative responses
  - There is a disconnect for teachers and students in reading and interpreting data (Quantitative Reasoning)
  - Teachers have a hard time tying local place problems to regional, national, or international challenges

Student Engagement

- Demographics of the project: rural school districts with low socio-economic populations; large under-represented populations; little access to business or industry; isolated communities with lack of transportation

Student Engagement

- Access to real-world data and scientists in the field (working side-by-side)
- Student buy-in to place-based learning making learning relevant to where they are
- Learning outside the classroom for both teachers and students
- Less "when am I ever going to use this"

Teacher Concern, Confidence, and Commitment

- Pre-/post- self scoring rubric
- Measures concern, confidence, and commitment on teaching for understanding, place-based education, problem-based learning, and interdisciplinary teaching
- Results were mixed and mostly positive

Teacher Concern, Confidence, and Commitment

- Final reports may show more difference
- While teachers reported mostly positive movement on all scales in practice they were still struggling to implement the concepts in their classrooms
- Disconnect between theory and practice? (I understand what I am supposed to do but don't truly know how to do it)

Continued Work

- Provide exemplars for teachers
- Provide professional development which models CAS and QR instruction
- Develop scaled-up courses which engage students through more hand's-on, real-world and relevant problem-based learning (for example: STEM in agriculture)

What are you thinking?

- What approaches are working best for your area to engage students in STEM Education?

- What are next steps to improving rural STEM education and developing collaboratives?
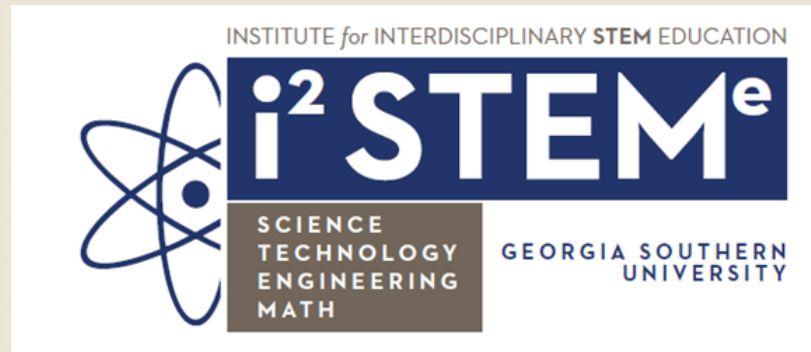
Thanks for attending. Let us know how the Institute can collaborate with you in improving STEM teaching and learning.

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