Teaching 21st Century Reasoning Skills through an Authentic Interdisciplinary STEM Research Experience

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Real STEM
Real STEM Scale-Up

Authentic Learning Through
Scientific Research Experiences
Who’s Who

• Dr. Robert Mayes, PI (Bob)
• Dr. Jane Metty, Co-PI Mercer University
• Debbie Walker, Project Manager
• Dr. Charlie Martin & Haly Hicks – Evaluation team
• In the Office: Kania Greer, Lori Barfield, Melissa Rhodes
How did we get here?

- **Sept 2012** - Real Stem awarded to Dr Robert Mayes

- **School year 2013-14** – Implement Scientific Research III course at Statesboro HS, Burke County HS, Camden County HS and Ware County HS – implement a module/unit at Snelson-Golden MS, Brantley County MS, South East Bulloch HS

- **School year 2014-15** – Implement Scientific Research III course at SHS, BCHS, CCHS – Implement module/unit at SGMS, BCMS, Langston Chapel MS, William James MS, Lewis Frasier MS, Richmond Hill MS, Metter HS

- **Jan 2015 – Dec 2016** – Real STEM Scale Up – partners: Bulloch County (SHS, LCMS), Burke County (BCHS,BCMS), Bryan County (RHHS, RHMS), Fulton (Tri-Cities HS, Paul D West MS)
What are we supposed to do????

- 1 day PD
- Interdisciplinary STEM PLC meetings – collaborative planning
- Implement a module/unit
- Summer PD
- Implement a scientific research course
What are our goals?

• Increase the STEM Career Pipeline
• Develop STEM Literate citizens
• Develop 21\textsuperscript{st} Century Problem Solving/Reasoning Skills in students
• Increase student participation, engagement, and performance in STEM
Let’s get started.....
Setting the stage.....
Is there a critical need for Real World, Authentic STEM Learning?
How do we get started?

Tenets of the Grant

• Place Based Education (PBE)
• Problem Based Learning (PBL)
• UbD
• Interdisciplinary STEM Education
• 21st Century Problem Solving/Reasoning Skills
Let’s start with our “Place”

“is learning that is rooted in what is local – the unique history, environment, culture, economy, literature, and art of a particular place. The community provides the context for learning, student work focuses on community needs and interests, and community members serve as resources and partners in every aspect of teaching and learning. This local focus has the power to engage students academically, pairing real-world relevance with intellectual rigor, while promoting genuine citizenship and preparing people to respect and live well in any community they choose.” (Rural School and Community Trust, 2005)
Why Problem Based Education?”

• “learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem.” (Savery, 2006, p. 9)

• Long-term retention, skill development, and student and teacher satisfaction have been found to be benefits of problem-based learning when compared with traditional forms of instruction (Strobel & van Barneveld, 2009)
“Problems” in my “Place?”

Explore:
- Growing Today For Tomorrow
  https://www.youtube.com/watch?v=ym6biFbr3GQ
- One Hungry Planet
  https://www.youtube.com/watch?v=Jd48Zw0Tr4&feature=youtu.be
- Great Pacific Garbage Patch
  https://www.youtube.com/watch?v=2VrrxMliwgQ

Discuss:
Possible “Problem” topics
Source of Problems

Grand Challenges of Engineering:
- Make solar energy economical
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning engineer the tools of scientific discovery

National Academy of Engineering of the National Academies
www.engineeringchallenges.org
Source of Problems

GRAND CHALLENGES IN ENVIRONMENTAL SCIENCES

1. Biogeochemical Cycles
2. Biological Diversity and Ecosystem Functioning
3. Climate Variability
4. Hydrologic Forecasting
5. Infectious Disease and the Environment
6. Institutions and Resource Use
7. Land-Use Dynamics
8. Reinventing the Use of Materials
Source of Problems

THE DUPONT CHALLENGE:

• **TOGETHER, WE CAN FEED THE WORLD.**
  Ensuring that enough healthy, nutritious food is available for people everywhere is one of the most critical challenges facing humanity.

• **TOGETHER, WE CAN BUILD A SECURE ENERGY FUTURE.**
  With a growing population, we will need to use our existing resources as efficiently and effectively as possible and find better ways to harness renewable energy sources.

• **TOGETHER, WE CAN PROTECT PEOPLE AND THE ENVIRONMENT.**
  A growing global population places increased pressure on people and the environment, and as the world develops, humanity places greater value on both life and the earth we all share.

• **TOGETHER, WE CAN BE INNOVATIVE ANYWHERE.**
  Our passions for any topic in science, technology, engineering, and mathematics can lead to innovations that help to make the world a better place.

http://thechallenge.dupont.com/essay/challenges/
Who can help identify “Problems” in my “Place?”

1. area research institutes or universities
2. city engineer
3. DNR
4. County Extension agent
5. local business/industry
6. ??????
How do I approach a problem?

• **Interdisciplinary STEM** - Engage students in researching a challenging problem from all areas of STEM and integrating different STEM perspectives around a common problem.

• **Scientific reasoning** - Students will practice skills of designing and conducting experiments and analyzing and presenting their findings.

• **Engineering Design** - A process for constructing a solution to the problem identified by the research.
Scientific Reasoning

Figure 1.1
Stages of STEM Research

Generating ideas:
What do I want to learn?

Developing a research design:
- Determining variables to test and measure
- Identifying lab skills and lab resources

Knowing my topic:
- Background research on:
  - Independent and dependent variables
  - Entity being studied

Writing the proposal:
- Writing a hypothesis
- Performing pretrials
- Learning lab skills
- Scientific writing
- Addressing lab safety and ethical issues
- Determining best procedure

Statistical analysis:
- Running statistics
- Putting data in tables and graphs
- Looking for patterns

Setting up and conducting the experiment:
- Organizing the laboratory notebook
- Collecting data

Interpreting the data:
- What do the data mean?
-接受ing or rejecting the hypothesis
- How might the results be important in this field and others?

Report Results:
- Write a scientific research paper
- Design a poster or oral presentation

The STEM Research Process
Engineering Design

1. Identify the Problem
2. Identify Criteria & Constraints
3. Brainstorm Possible Solutions
4. Generate Ideas
5. Explore Possibilities
6. Select an Approach
7. Build a Model or Prototype
8. Refine the Design

Multiple Modes of Reasoning

• Scientific Reasoning
• Engineering Design
• Quantitative reasoning (QR) – mathematics and statistics applied to real-life
• Model-based reasoning – use of representations
• Complex Adaptive Systems (CAS) - study phenomena within a system, not in isolation
• Computational Reasoning– visualizations of data, simulations, thinking like a computer scientist
• Data-intensive science – use of large data sets
Soooo.....What are we doing?

- Middle and High School 1-3 week modules/units of scientific research
- Middle and High School Scientific Research course
Sample Lessons

1. Middle School Marine Debris
2. High School
Attribution Statement

- The contents of this power point were developed under a grant from the U. S. Department of Education. However, those contents do not necessarily represent the policy of the U. S. Department of Education, and you should not assume endorsement by the Federal Government.
Thank you for coming!
Debbie
Bob
Jane